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„The world as we have created it, is a process of our thinking. It cannot be changed without changing our thinking.“

Albert Einstein

(Source: http://www.ideachampions.com)

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Key Terms and Abbreviations

CBA	Cost Benefit Analysis
ChL	Chemical Leasing
CIA	Chemical Industries Association (UK)
CMS	Chemical Management Services
CP	Cleaner Production
CSP	Chemicals Strategies Partnership
CSR	Corporate Social Responsibility
CPS	Chemical Product-Services
DEFRA	Department of Environment, Food and Rural Affairs (UK)
ECHA	European Chemicals Agency
EE	Energy Efficiency
EIP	Eco Industrial Parks
EMA	Environmental Management Accounting
EMS	Environmental Management Systems
EMAS	Eco-Management and Audit Scheme
ESCo	Energy Service Company
ES	Energy Services
EC	Energy Contracting
ESC	Energy Supply Contracting
EPC	Energy Performance Contracting
ESM	Environmentally Sound Management
EST	Environmentally Sound Technologies
GEF	Global Environmental Facility
GHS	Globally Harmonized System of Classification, Labelling and Packaging of Chemicals
GPP	Green Public Procurement
HSE	Health, Safety and Environment
IOMC	Inter-Organisation Programme for the Sound Management of Chemicals
IP	Investment Promotion
IPP	Integrated Product Policy
ISID	Inclusive and Sustainable Industrial Development
KPI	Key Performance Indicators
LCA	Life Cycle Analysis
MEP	Member of European Parliament
MSDS	Material Safety Data Sheet
NCPC	National Cleaner Production Centre

NCPP	National Cleaner Production Programme
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
PSS	Product-Service-Systems
POP	Persistent Organic Pollutant
R&D	Research and development
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RECP	Resource Efficient and Cleaner Production
RoHS	Reduction of hazardous substances
SCP	Sustainable Consumption and Production
SD	Sustainable Development
SI	Sustainable Innovation
s-LCA	social Life Cycle Analysis
SIRM	Sustainable Industrial Resource Management
SVHC	Substances of Very High Concern
TBL	Triple Bottom Line
TSA	Total System Analysis
UN	United Nations
UNCHE	United Nations Conference on the Human Environment
UN DESA	UN Department of Economic and Social Affairs
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
WCED	World Commission on Environment and Development
WSSD	World Summit on Sustainable Development

Preface and Acknowledgement

On my long and winding road to finish my theses I had a lot of support from many people, I would like to thank: up and foremost my supervisor Prof. Hans Schnitzer for his patience when things did not move on.

Thanks to my former colleagues at the (no longer existing) Institute for Sustainable Techniques and Systems at JOANNEUM RESEARCH, where the idea for this thesis was born and thanks to projects partners (Mark, Fritz, Rainer, Uli, Barbara, Andi and Angelika) with whom I have intensively worked on the topic of Product-Service-Systems in different fields for many years. Sincere thanks to Christine Jasch for many interesting talks and a memorable stay in Belgrade, teaching Chemical Leasing in 2009.

Many thanks also to Jill Kauffman Johnson and all the other people at CSP (Josephine, John and others) for the chance to stay with them in San Francisco, for their warm welcome and their support and patience in answering all my questions. There, I also had the luck to meet Tom Votta, who gave me an insight into CMS at several occasions, before he died unexpectedly in 2009.

It was also in San Francisco, where I met Steffen Säcker, with whom I had many interesting discussions about Chemical Management Services and Chemical Leasing and who brought me in touch with Hans-Norbert Adams, who in turn introduced me to Petra Schwager from UNIDO in 2006.

A special thanks goes to Petra who gave me the opportunity to be part of the success story of Chemical Leasing, and enabled me to conduct the three evaluations which are the basis for this thesis. Thanks also to Christina, Pilar, Maria and Nils who have been (or still are) my companions on that way for many years. Many thanks to Reinhard Joas from BiPRO for sharing his knowledge with me at many occasions. I'm also very thankful to all the people from the NCPCs all over the world who I got to know well during all these years, who answered in detail and with patience to all my questions and requests – some of them became real friends for life (thanks Voijka!). Rest in peace, Yuan.

Last but not least I would like to thank the Government of Styria (Abt. 3 – Wissenschaft und Forschung) for their funding which enabled my research stay in San Francisco in 2005 and which made it possible to present the first results of my thesis at the Global Cleaner Production and Sustainable Consumption Conference in Sitges in 2015.

This thesis is dedicated to my parents who always supported me with their love and who always believed in me.

Executive Summary

"Life is all chemistry", is a quote, accredited to Antoine Laurent de Lavoisier, one of the fathers of modern chemistry. And in fact, chemicals are around us all the time: we use them to live a better and more comfortable life, to cure diseases, and to fight against pests that destroy the crops we need for food. On the other side, if we don't use chemicals with care they can cause a lot of harm and damage, both to humans and the environment. This has been realised when environmental damages like air and water pollution or the death of many people after chemical disasters could not be ignored anymore.

To handle chemicals with care is one approach; the other is to use them reasonably and in a sustainable way. An interesting concept that entered the stage in the early 2000s is a new business model for sustainable chemicals management: Chemical Leasing. The goal of this thesis is to explore, if this concept is really sustainable and how that can be verified, what the success factors and barriers are and what the future perspectives of Chemical Leasing could be.

The **first and theoretical part** (Pat A) of the thesis is about determining the State of the Art, describing different sustainability concepts, regulations, conventions and initiatives that are in place to control chemicals consumption. It further assesses innovative concepts that have been set up in the past in several sectors were chemicals are used, like Chemical Management Services and Chemical Leasing. This analysis of literature and other materials (e.g. reports, articles and project documents) is the basis for Part B of the thesis.

The **main and practical part** (Part B) of the thesis is the assessment of the Chemical Leasing program, its tools and cases. Based on that assessment, a new set of Key Performance Indicators is developed and a blueprint of a data collection and monitoring plan and the outline of a roadmap for the next years of Chemical Leasing is designed.

The assessment of the Chemical Leasing program was done through three evaluations that were conducted by the author between 2008 and 2014 with the representatives of the National Cleaner Production Centres (NCPCs) who are responsible for the implementation of the Chemical Leasing program within UNIDO. The comparison of the results from the evaluations and the literature research from Part A of this thesis discloses that Chemical Leasing could definitely contribute to main corner posts that are said to stand for (more) sustainability: resource efficiency, life-cycle thinking, including all three dimensions of sustainability, a radical change in thinking and a change in how to do business.

All the different tools to disseminate Chemical Leasing that are already in use are examined in a next step. Through this it is possible to define some weak points and barriers that might be the reason why Chemical Leasing has not had its breakthrough so far. Success has been gained in many projects but still the documentation is not satisfactory.

The evaluation of the cases discloses that data collection and the different numbers and types of indicators in Chemical Leasing are two of the weak points. Although many indicators are being collected in the case studies, they are not

being measured and described in the same way and to the same extent, which makes a comparison between cases difficult.

As one of the main results of the thesis, a new set of Key Performance Indicators (KPIs) is being developed. Therefore, an Excel-Sheet is being designed, making savings and benefits through the implementation of Chemical Leasing visible and comparable. At the beginning, a baseline from where to start data collection has to be set, clear targets for savings have to be defined and a monitoring and evaluation scheme has to be determined. Ideally, this Excel-Sheet should then be used in the implementation of all future Chemical Leasing cases.

In a second step, a roadmap is being developed on how to further promote and advance Chemical Leasing. This roadmap translates experiences and key lessons from the evaluations into key recommendations for both, UNIDO and the National Cleaner Production Centres. Some of them have already been integrated into of the new strategy for Chemical Leasing UNIDO started to develop in 2015.

Nevertheless, there is still room for further work and research: the newly developed tool should be tested thoroughly with companies, including an evaluation on how information and data are being collected and assessed and where difficulties do occur. Based on this, a comprehensive database should be built up, including data and description of current and past Chemical Leasing case studies to have a good reference. Also a list of sectors qualifying for Chemical Leasing and a list of chemicals already covered by Chemical Leasing should be part of that database.

Zusammenfassung

“Alles Leben ist Chemie” ist ein Ausspruch der Antoine Laurent de Lavoisier, einem der Väter der modernen Chemie zugeschrieben wird. Und tatsächlich sind Chemikalien in unserem täglichen Leben allgegenwärtig: Wir verwenden sie, um ein besseres und angenehmeres Leben zu führen, Krankheiten zu heilen und um Schädlinge zu bekämpfen, die unsere Nahrungsmittel bedrohen.

Wenn wir diese Chemikalien jedoch nicht mit der nötigen Sorgfalt verwenden, können sie sowohl für Menschen als auch die Umwelt großen Schaden und Leid verursachen. Dies wurde spätestens erkannt, als Umweltschäden wie Luft- und Wasserverschmutzung oder der Tod vieler Menschen nach großen Chemieunfällen nicht mehr ignoriert werden konnten.

Chemikalien mit Sorgfalt zu behandeln, ist ein Ansatz; ein anderer ist, sie vernünftig und nachhaltig einzusetzen. Ein interessantes Konzept, das Anfang 2000er Jahre bekannt wurde, ist ein neues Geschäftsmodell für ein nachhaltiges Chemikalienmanagement: Chemikalienleasing. Ziel dieser Arbeit ist es nun, zu erforschen, ob dieses Konzept wirklich nachhaltig ist und wie dies gemessen werden kann, wo Erfolgsfaktoren und Barrieren liegen und welche Zukunftsperspektiven Chemikalienleasing haben könnte.

Der erste und theoretische Teil der Arbeit (Part A) beschäftigt sich mit der Bestimmung des Standes der Technik und beschreibt verschiedene Nachhaltigkeitskonzepte, Gesetzgebungen, Konventionen und Initiativen, die es bereits gibt, um den Verbrauch und den Einsatz von Chemikalien kontrollieren zu können. Weiters werden verschiedene innovative Geschäftsmodelle untersucht, die bereits in einigen Sektoren und Bereichen, wo Chemikalien eingesetzt werden, eingeführt wurden. Beispiele dafür sind Chemical Management Services und Chemical Leasing. Diese Analyse der wissenschaftlichen Literatur und anderer Unterlagen wie Berichte, Artikel und Projektdokumente sind die Grundlage für den zweiten Teil der Arbeit.

Der Hauptteil - und praktische Teil - der Arbeit (Part B), besteht im Wesentlichen aus der Evaluierung des Chemikalienleasingprogramms, seiner Instrumente und diverser Fallstudien. Darauf aufbauend wird ein neues Indikatorenset sogenannter „Schlüsselindikatoren“ erarbeitet und ein Datenerfassungs- und Monitoringinstrument sowie ein Fahrplan für die Weiterentwicklung des Chemikalienleasingkonzepts entwickelt.

Die Evaluierung des Chemikalienleasingprogramms erfolgt durch drei Befragungen, die die Autorin dieser Arbeit in den Jahren 2008 bis 2014 mit den Vertretern der National Cleaner Production Centers, die für die Umsetzung des Chemikalienleasingprogramms innerhalb der UNIDO zuständig sind, durchgeführt hat. Eine Gegenüberstellung der Ergebnisse dieser Befragungen und der Ergebnisse aus der Literaturrecherche aus dem ersten Teil der Arbeit ergab, dass Chemikalienleasing tatsächlich etliche wichtige Elemente enthält, die für mehr Nachhaltigkeit stehen: Ressourceneffizienz, Lebenszyklus-Denken, die Einbeziehung aller drei Dimensionen der Nachhaltigkeit sowie eine radikale Veränderung des Denkens und der Art ein Unternehmen zu führen.

In einem weiteren Schritt werden die verschiedenen Instrumente und Werkzeuge, die zur Verbreitung des Modells bereits verwendet werden, untersucht. Dadurch

ist es möglich, Schwachstellen und Hindernisse zu erkennen, die der Grund dafür sein könnten, warum Chemikalienleasing bisher nicht den großen Durchbruch erlangen konnte. Es wurden zwar in den meisten Fallstudien zum Teil gute Erfolge erzielt, die Dokumentation und die Vergleichbarkeit mit anderen Fallstudien ist aber derzeit noch nicht zufriedenstellend.

Die Analyse der Fallstudien hat gezeigt, dass die Datenerhebung und die Art und Anzahl der verwendeten Indikatoren im Chemikalienleasing Schwächen aufweisen. Obwohl in den Fällen jeweils etliche Indikatoren erfasst wurden, wurden diese nicht in allen Fällen einheitlich verwendet, was einen Vergleich zwischen den Fällen schwierig macht.

Ein Hauptergebnis der Arbeit ist die Entwicklung eines neuen und detaillierten Sets von Schlüsselindikatoren. Dazu wird ein Excel-Sheet erstellt, das einfach zu befüllen ist und Einsparungen und Nutzen durch die Implementierung von Chemikalienleasing sichtbar und vergleichbar macht. Zu Beginn müssen eine sogenannte „Baseline“, also ein Startpunkt von wo die Messungen beginnen und klare Ziele für Einsparungen definiert werden, sowie ein Monitoring- und Evaluierungsschema festgelegt werden. Dieses Excel-Sheet sollte dann idealerweise in allen zukünftigen Chemikalienleasingprojekten zur Datensammlung eingesetzt werden.

Ein weiteres Ergebnis der Arbeit ist die Entwicklung einer Roadmap, eines Fahrplans für die Weiterentwicklung des Chemikalienleasings. In dieser Roadmap sind alle Ergebnisse und Empfehlungen aus den drei Befragungen zu konkreten Umsetzungsempfehlungen zusammengefasst. Praktische Empfehlungen wurden sowohl für die UNIDO als auch die National Cleaner Production Centres formuliert, einige davon wurden bereits in die gerade laufende Strategieentwicklung 2015 - 2024 der UNIDO für das Chemikalienleasing übernommen.

Dennoch gibt es noch Raum für weitere Arbeiten und Forschung: das neu entwickelte Werkzeug sollte gründlich mit Unternehmen getestet werden, und es sollte auch erhoben werden, wie die Informationen und Daten gesammelt und bewertet werden und wo Schwierigkeiten auftreten. Darauf aufbauend sollte eine umfassende Datenbank aufgebaut werden, die alle vergangenen und aktuellen Fallstudien zum Chemikalienleasing enthält, einschließlich aller Daten, um eine gute Referenz für zukünftige Projekte zu erhalten. Zusätzlich sollte eine Liste der für das Chemikalienleasing geeigneten Sektoren und eine Liste der Chemikalien, die bereits durch Chemikalienleasingmodelle abgedeckt werden, Teil dieser Datenbank sein.

PART A - State of the Art

1. Introduction

Chapter 1 is a short introduction to the development and the scope of the thesis and describes the way the thesis has developed. It gives an overview on issues that led to this work, depicts the aims and objectives of the thesis, presents the research problems, questions, the methodology and methods and finally provides the structure of the thesis.

1.1 Problem outline

In the second half of the 18th century, a radical change in the social and economic system began to evolve: the Industrial Revolution. First in England, followed by the United States and other Western European countries, it changed life and the whole world much more than everything else since mankind has settled down and became farmers. Could until that time consumer goods only be produced as individual items by specialised craftsmen, now also non-skilled workers could produce goods in big quantities and at a low price due to machine production. Trade expanded widely and within one century, a highly cross-linked global economy arose.

Totally different working methods occurred, the transformation from raw materials into products was done in factories, was mechanised and fragmented into several production steps. This changed the way of working but even more, all this had tremendous effects on everyone's personal lives: living and working conditions were miserable but nevertheless promised a better life for all the people that have been harassed by brutal landlords and have suffered from prevalent crop failure. People moved into the cities, the model of extended families vanished and old social structures were disrupted. But the other side of the medal showed increasing wealth for (almost) all and a stimulus for economy.

Hand in hand with the industrial boost, the chemical industry developed and became an independent industrial sector around 1850 in Europe and the USA alike (Amecke, 1987). Even earlier, together with industrialisation and an increase in population, new goods and products – especially based on chemicals – entered the economic cycle. Around 1820, chemical factories in Germany started producing sulphuric acid, a basic substance essential for the bleaching of paper, the finishing of cotton cloth and the isolation of ore, as well as a pre-product for sodium carbonate. This so-called "white gold" was an all-purpose substance, needed for dyeing and printing of fabrics, for the production of glass or soap and as a detergent. Residues of production like hydrogen chloride or calcium sulphide went untreated into rivers nearby. Sodium sludge was stored in open fields from where toxic vapours rose and poisonous elutions drained away into the soil. Carbon black and sulphuric smoke swirled out of the chimneys of coking plants, ironworks and steel mills, and came down again as acid rain, withering forests and orchards in the proximity. Despite these visible negative impacts, the natural environment was for a long time seen as an unlimited source for materials needed and as an infinite sink for unwanted residues.

For a long time, the “natural environment” simply was not considered at all. For example, in production theory (Wohinz et al., 2010/2011), environment was seen as a “free good” which was not scarce at all, had no economic value and therefore did not cause any economic costs. This proved to be wrong. Environmental damages like forest dieback, air and water pollution, etc. at some point in time could not be ignored anymore and an undestroyed environment became a rare and therefore a valuable good, worth of protection. So the question was not any more *“whether action was necessary”* but “*what kind of action should be taken*?*”* to sustain our environment for future generations.

In the 18th century, Hans Carl von Carlowitz postulated the first thoughts to what we today call “sustainability”: in his book “Sylvicultura Oeconomica”, published in 1713, he demanded that there should only be logged as many trees as grow back (Carlowitz, 1713). This is all the more remarkable, as this book was written from an economic viewpoint. Apparently, it was clear already at that time, that forests could not be saved alone by forestry but that it was a “duty of society” to do so, as Grober (2013) puts it.

Although the beginning of environmentalism or environmental protection can be traced back at least to the 18th century to Jean-Jacques Rousseau (postulating “Back to Nature”), John Ruskin (“Europe's first great environmentalist“[1]), John Muir and Henry David Thoreau (in his book „Walden“) in the United States, it was the publication of Rachel Carson’s “Silent Spring” (Carson, 1962), followed by the report of the Club of Rome 10 years later (Meadows et al., 1972) which made environmental problems present in people’s perception and advanced the environmental movement.

One of the main problems identified by Meadows was the evermore-increasing resource exploitation (Meadows et al, 1972). To stop exploitation and to reduce resource-use significantly, a certain dematerialisation has to take place. Dematerialisation is only possible through innovative approaches towards Sustainable Development (Stahel, 1998). Sustainable Development needs radical changes, needs new ways of thinking like decoupling economic success from resource consumption. This means to change the focus from selling products towards selling performances. But a concept that provides a function instead of a product requires a redefinition of the system that may deliver it (Stahel, 1998).

This so-called “service economy”, in the sense it is used here, is an economy that optimises the use (or function) of goods and services and thus the management of existing wealth (goods, knowledge, and nature). As Stahel (1998) points out, “the economic objective of the service economy is to create the highest possible utilization value for the longest possible period of time while consuming as few material resources and as little energy as possible. Such a service economy is therefore considerably more sustainable or dematerialized, than the present industrial economy, which is focused on production as a means of creating wealth and on the optimization of the production process in order to achieve economic growth”.

This concept of a service economy was the basis for the development of Product-Service-Systems (PSS). A Product-Service-System is a challenging concept, which changes the current way of delivering the value of products to customers.

[1] http://www.cornell.edu/video/the-first-ecologist-john-ruskin-and-the-futures-of-landscape

Examples show that it is possible to get profit from providing use-value without selling any product. When there is no physical product involved, in theory, this can also contribute to a reduction of resource-use as well as to a reduction of environmental burden (Mont, 2004). Through the years, Product-Service-Systems evolved in various production sectors. Among them, services around chemicals are one of the most often mentioned examples of market success (Kortman et al, 2006).

Chemical Management Services (CMS) and Chemical Leasing (Chemical Leasing) are the two best-known and most promising Product-Service-System models, applied in sectors where chemicals are used, attempting to optimise chemical consumption patterns. The assumption is that Chemical Management Services and especially Chemical Leasing can help to reduce the volume of chemical consumption, waste streams and emissions and therefore make a significant contribution to a more environmentally friendly way of using chemicals and thus to more sustainability. This is the more the case as chemicals are related to environmental and occupational health concerns. Both models work by changing the relationship between chemical suppliers and chemical users and providing incentives to both parties to reduce the quantity of chemicals used.

1.2 Research aims and objectives

The idea for this thesis developed more than a decade ago, starting with the OECD (The Organisation for Economic Co-operation and Development) conference “Experiences and Perspectives of Service-oriented Strategies in the Chemicals Industry and related Areas” in Vienna, in 2003. The author had already been working on the topic of service-oriented or Product-Service-Systems in different industrial sectors for a while and at this conference it was the first time for the author that the concept was mentioned in relation to chemicals. In 2005, the author was on a research visit in San Francisco at the Chemicals Strategies Partnership (CSP), a non-profit organisation and major player in the US in the field of Chemical Management Services (CMS). At that time, Chemical Management Services were somehow on its peak in the US and yearly conferences were held. During the research visit, the author made a lot of contacts to US researchers and practitioners as well as to company representatives. Through these contacts, she was invited by UNIDO (the United Nations Industrial Development Organisation) in 2006 to work as national consultant for the Chemical Leasing programme and is still doing so.

UNIDO has done a lot to bring Chemical Leasing forward since 2004 and a lot of success stories were only made possible due to the Chemical Leasing program of UNIDO which is the main subject of this thesis. From the beginning, the **hypothesis** was that Chemical Leasing can change the use of chemicals towards more sustainability in all three dimensions: economic, ecologic and social.

The following main assumptions have led to this hypothesis:

- The way chemicals are handled and used strongly influences if a process is sustainable or not;
- Chemical Leasing is a program that includes all three dimensions of sustainability;
- Therefore, Chemical Leasing paves the way to sustainability.

The purpose of the thesis is to find out if the Chemical Leasing concept, further developed and intensively pushed by UNIDO, can really contribute to more sustainability in the chemical industry. Chemical industry in this context does not only cover companies that *produce* chemicals but all sectors that *use* chemicals in their processes in one way or the other.

Therefore, the Chemical Leasing program with its tools and case studies is put in context with concepts and approaches that stand for sustainability, like Sustainable Development, Cleaner Production, Circular Economy, Green and Sustainable Chemistry, etc. Furthermore, this thesis thoroughly analyses UNIDO's Chemical Leasing business model as it has been implemented during the last 10 years, its successes and the problems and barriers that are still there. The aim is to find out *if* actually and if yes, *what* makes this concept so special, "trendsetting" and sustainable and what could be done to make it more widespread. In addition to that, tools and case studies are analysed and amendments are suggested where useful. The final goal of the work is to formulate recommendations and to develop a roadmap for the next years how Chemical Leasing can really act as a change agent and how the model could be amended to better fit to this aim. Also new sectors and processes that could be suitable for the implementation of Chemical Leasing and helps to extend it, are analysed.

To summarize it, the **objectives** of the research are:

- to identify concepts and approaches referring to sustainability where Chemical Leasing can be linked to;
- to analyse UNIDO's Chemical Leasing model during the past 10 years (mapping the development in the past and the current Status Quo), also in matters of sustainability;
- to assess the relevance of the model and its influence on a sustainable chemical strategy (findings and answers to the research questions, develop a road map and formulate recommendations).

Figure 1-1 shows how the different pieces of research were put together to form this thesis.

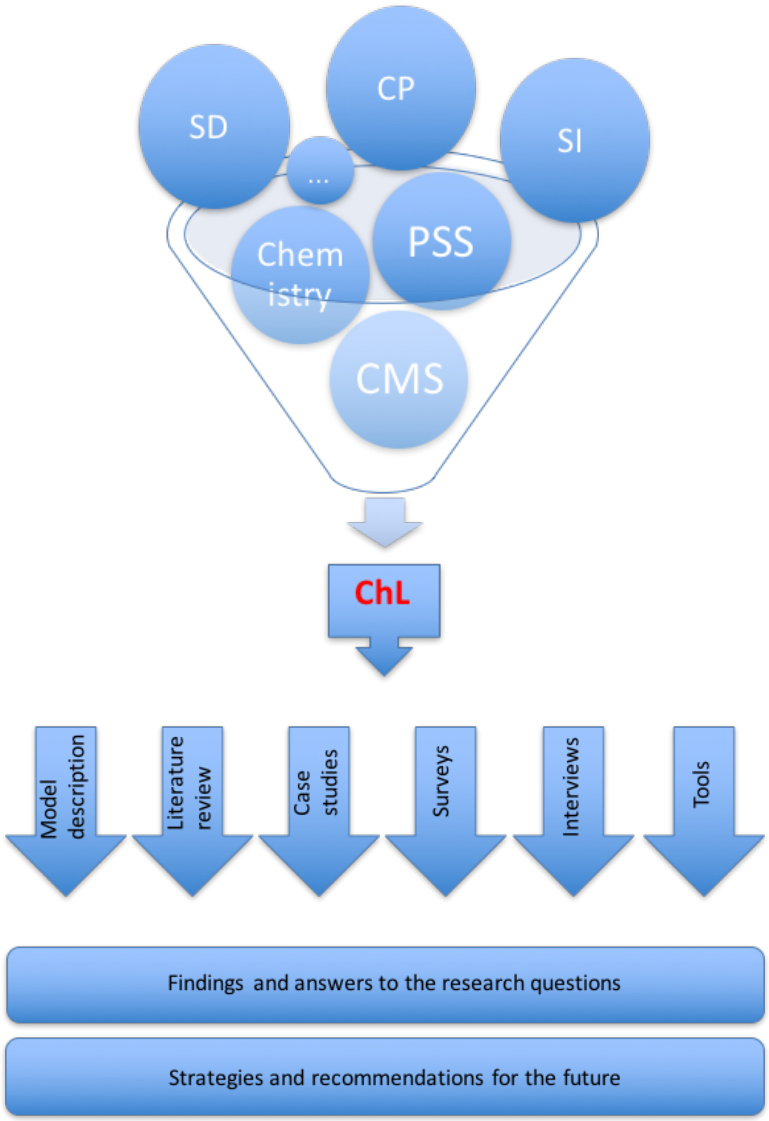

Figure 1-1: Elements of the thesis

SD	Sustainable Development
CP	Cleaner Production
SI	Sustainable Innovation
PSS	Product-Service-Systems
CMS	Chemical Management Services
ChL	Chemical Leasing
…	Other concepts (e.g. Circular Economy)

The **relevance and benefits** of the research can be defined as follows:

- it provides a summary of the development of the model, which has not been there in this depth before, with a comprehensive analysis of qualitative and quantitative data. For the first time a Product-Service-Systems model in the field of chemicals is described in detail with all its implications, with tools and case studies, successes and failures, trying to verify if Chemical Leasing can contribute to a more sustainable use of chemicals.

- The research also provides an overview of links between Chemical Leasing and concepts in industry and research, that are somehow linked to sustainability, such as Sustainable Development, Cleaner Production and Product-Service-Systems.

There are also some **limitations** that are caused by the special setting of Chemical Leasing: data is collected in UNIDO cases only, where the author has access to through her work with UNIDO and its National Cleaner Production Centres (NCPCs). All these cases were done in developing countries and countries in transitions. A deduction from these experiences for industrialised countries might be difficult and needs to be handled with care.

Data from companies is mostly "second hand" data for the author, meaning that data in all UNIDO cases were collected via the NCPCs and the author had (except in a few cases) no direct contact to the companies.

During the last years, more and more cases were discovered which were conducted without the assistance of UNIDO. These cases were detected, among other sources, through the applications for the Global Chemical Leasing Award. The author is aware of these cases but due to limited access to data, these cases are not analysed in more detail in this thesis.

1.3 Research Problems and questions

The introduction showed that there are severe environmental problems connected to chemicals but also some approaches and possible solutions to these problems where Chemical Leasing can play a significant role. To see how and where Chemical Leasing could provide some input, the following **research questions** were formulated:

1. Does Chemical Leasing **contribute to Sustainable Development**, the concept of Sustainability? Is Chemical Leasing able to reduce the burden chemicals put on our environment and how can we measure this?
2. What are **success factors** (economic, ecologic and social benefits) and the **difficulties** in implementing Chemical Leasing, and how can they be overcome to make Chemical Leasing a sustainable program, fit for the future?
3. What are **future perspectives** of Chemical Leasing (e.g. Chemical Leasing in new sectors), what are **recommendations** for the program and is there (and in which aspects) a need for **further research**?

1.4 Research Design

The design of this research comprises scientific as well as descriptive parts. As the design is strongly depending on the research questions, the following research design was developed to reach the goals of the research and to answer the research questions. The thesis was developed in 4 steps:

The first step, the conceptual phase, is dedicated to establish a kind of framework for Chemical Leasing and to explore in which concepts Chemical Leasing can be integrated or linked to, by reviewing literature on Cleaner Production and

Sustainable Development, Circular Economy, Green and Sustainable Chemistry, Product-Service-Systems and of course, on chemicals. It comprises the theoretical part of the thesis.

Steps two to four represent the empirical part of the theses as the work is strongly based on the analysis of the practical implementation of Chemical Leasing. In step two (model analysis phase), the Chemical Leasing model is studied thoroughly by analysing the different tools and stakeholders involved. In step three (case study analysis phase), several case studies are being analysed with regards to barriers and success factors and to sustainability criteria. The last step is the interpretation of the gained experiences and results. Table 1-1 shows the different phases of the thesis:

Table 1-1: Research Design

	Conceptual Framework PART A	**Empirical Part PART B**		
		Chemical Leasing model and Tool Analysis	***Case Study Analysis***	***Interpretation***
Goals	Exploration of fields that can be related to Chemical Leasing (e.g. CP, SD, PSS, chemical regulations)	Description and Analysis of the Chemical Leasing business model with its tools	Identification of barriers and success factors and sustainability indicators in the different cases	Development of a Roadmap for Chemical Leasing for the next 5-10 years
Sources	Literature, experts, researchers, authorities, institutions	Experts (from UNIDO and NCPC)	Case studies, reports, other collected data	Collected information from the other phases
Methods	Review of literature, interviews with experts	Three evaluations between 2008 and 2014	In-depth analysis of selected case studies	Interpretation of interviews and evaluations
Results	Review of different concepts where Chemical Leasing can be linked to and can help to address different issues	Clear picture of Chemical Leasing, the roles of different actors, usefulness of different tools	Clear picture of success factors, strengths, barriers and failures of Chemical Leasing cases	Roadmap, Recommen-dations

1.5 Research Methodology and Methods

The research **methodology** in this thesis is based on the use of multiple methods to examine the research questions from different angles. Both, qualitative and quantitative methods are used. In literature, the terms “triangulation” and “mixed method approach” are used similarly for this kind of methodology, although they are not exactly the same. Both methods have in common, that this kind of approach helps to overcome the limitations of a single design and to “enhance confidence in the ensuing findings” (Bryman, n.n.) . It can help to a certain degree to generalize qualitative data and to facilitate the comparison between subjective information (e.g. from interviews) and objective data. In this research, the author uses the term triangulation for her research methodology.

There are different definitions by different authors for triangulation, among them Altrichter et al. (2008) who say that triangulation "gives a more detailed and balanced picture of the situation” or Audrey Erina (2013, cited in Ndanu and Syombua, 2015) who says, “triangulation also crosschecks information to produce accurate results for certainty in data collection”. The most common meaning with which triangulation is associated is “..the combined uses of two or more research methods within a strategy of convergent validity” (Bryman, n.d.). Triangulation is mostly used in social sciences, but the term originally comes from navigational and land surveying techniques where it describes „a method of finding a distance or location by measuring the distance between two points whose exact location is known and then measuring the angles between each point and a third unknown point“[2].

From the four types of triangulation Denzin (1970) identified, two are used in this thesis:

- **Data triangulation:** using different data from one source or different data from the same source at different points in time, in different social situations and by asking and comparing people with different views.
- **Methodological triangulation:** using more than one method to gather data, such as interviews, questionnaires, observations, etc.

Critics are, that two sets of findings may be inconsistent, but as Webb et al. (1966) observed “such an occurrence underlines the problem of relying on just one measurer or method”.

Following the triangulation approach, both qualitative and quantitative data gathering methods are being used in this research.

Quantitative data, meaning data on the outcomes of the program and economic and ecologic savings are used to analyse the benefits of Chemical Leasing, these data were mostly gained from the annual and half year reports and other monitoring tools, partly developed and applied by the author herself during her work with UNIDO.

Qualitative data, gained from surveys and interviews are dealing more with the understanding of and a “feeling” for the model, to describe and understand the approaches from different people towards Chemical Leasing.

[2] http://www.merriam-webster.com/dictionary/triangulation

In the written questionnaires within the three evaluations, a mix of open and closed questions with the possibility to add own ideas and comments ae used. Closed questions are used to ask for facts and numbers, open questions are asked to receive a broad variety of opinions and views on a certain field ("to give people a voice") which is important to develop the road map at the end of the research. The answers of all surveys and interviews are reported and categorised and a general statement and recommendations are deducted.

Data gathering in this thesis is also a mix of **primary and secondary data gathering**. Primary data in this thesis includes in-depths interviews and surveys, using direct communication with involved people, done by the author. Secondary data are gained from case studies, different documents, articles, project descriptions, annual reports, etc., using published and unpublished sources of information. This approach seems to be the most suitable for the data already available in the field of Chemical Leasing and data that could be gained during the research.

The following **methods** were chosen to gather information and data and, in the end, provide answers to the research questions:

Literature Review

Literature reviews is being conducted throughout the whole thesis and throughout all topics and chapters of this thesis. Literature is being scanned to put Chemical Leasing in the context of concepts and initiatives like Cleaner Production, Sustainable Development, Green Chemistry, etc. as well as to draw a comprehensive picture of Chemical Leasing and its development over the years. Literature in the sense it is used here means all kinds of books, periodicals, scientific magazines and journals, online articles, newsletters, different types of reports (from projects or annual reports of different institutions), company reports, websites, background papers of different topics, conference proceedings and presentations. Some of them are off-record due to confidentiality reasons.

Surveys

During the thesis, three major surveys have been conducted by the author if this thesis, in 2008, 2009 and 2014. They all represent different phases of the Chemical Leasing program. In all three surveys, a questionnaire was used and sent to the representatives of the NCPCs that were part of the program in the respective year and personally known to the author. The questionnaires contained open and closed questions and the possibility to comment on the questions and add own ideas. The number of questionnaires sent out and the response rate is summarized in table 1-2.

Table 1-2: Overview on surveys in the thesis

Year of survey	Number of questionnaires	Response rate
2008	3	100%
2009	7	100%
2014	10	90%

Interviews and personal talks

All phases of the thesis employ structured and unstructured interviews or personal talks on certain topics by the author of this thesis. Unstructured interviews were conducted especially at the beginning of the thesis, when the topic was not yet developed to such a great extent. In total, 10 interviews were conducted with experts in CMS and with representatives from companies in the US in 2005 at the CMS workshop in San Francisco. Structured interviews were conducted with five experts in Chemical Leasing and CMS in 2013 and 2014. The results of the interviews went into the evaluation of the program, the tools and the case studies.

Countless informal interviews and personal talks were conducted during the past ten years with different people, most of them representatives of NCPCs on the different questions and issues of Chemical Leasing, at different occasions (Annual Meetings, workshops, etc.) due to the author's work with UNIDO.

Case Study Analysis

Case studies are being analysed in two different ways:

- Three case studies for Chemical Management Services are analysed to point out the main characteristics of the CMS model.
- Five cases of Chemical Leasing are analysed in depth, to reveal the strengths and weaknesses, the opportunities and failures of the model.

Figure 1-2 shows the main research methods:

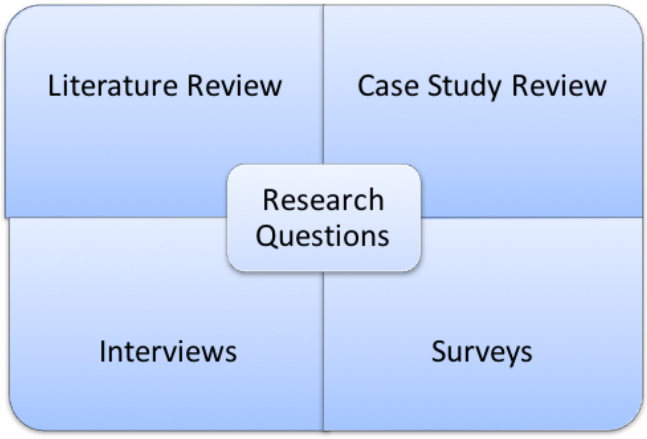

Figure 1-2: Main research methods

In this research a **deductive approach** was chosen, which means going from general to specific, testing theory and how this theory fits for a special example (in this case Chemical Leasing).

Data collection and evaluations were done until the end of 2014, all new developments within Chemical Leasing have not found their way into this thesis.

1.6 Structure of the thesis

Chapter 1 presents the scope of the research problem addressed in this work. It further addresses the aims and goals of the research and its limitations, describes the research design, methodology and methods, formulates the research questions and provides an outline of the thesis.

In chapter 2, an overview on different approaches is given. It comprises the development of environmentalism, the way through Sustainable Development, Cleaner Production and Sustainable Innovations in search of some solutions for today's environmental problems.

Chapter 3 describes the concept of Product-Services-Systems (PSS) in detail: after a short introduction, different types of PSS are presented and main aspects of each type are described. One subsection especially deals with PSS in the chemical sector. The chapter concludes with a description and analysis of success factors and barriers of Product-Services-Systems.

Chapter 4 deals with the role of chemistry in our lives and in industry. It also touches upon regulations for hazardous and dangerous chemicals, different initiatives for a safer chemistry and the European Union's regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). It also links chemicals to the field of Product-Service-Systems and explores some sectors where PSS and chemicals could be linked or have already been implemented.

Chapter 5 is dedicated to Chemical Management Services: it presents the history, the concept and main ideas, main actors and case studies. Special attention is given to the baseline setting and cost models, which will also play an important role in Chemical Leasing in the following chapters. The chapter finishes with a description and analysis of success factors and benefits, barriers and drawbacks.

In chapter 6, Chemical Leasing is described in detail. It starts with the concept and main ideas and a short history of its evolvement. A special focus, as in CMS, is given to the payment basis and getting the Status Quo, but also to the social dimension. The main players in this field are presented and cases studies described. After a subsection on success factors and barriers, this chapter concludes with a comparison between Chemical Leasing and CMS.

Chapter 7 presents other models than Chemical Leasing and Chemical Management Services and their characteristics to allow a distinction between similar models.

In chapter 8, the Chemical Leasing business model as it has been used and further developed by UNIDO for the last 10 years is being described in detail, including the three cycles of Chemical Leasing and a timeline over the last 10 years.

In chapter 9, criteria and indicators for the assessment of the Chemical Leasing program, the tools and the case studies are defined.

Chapter 10 then focusses on the measurement of sustainability of the Chemical Leasing program, summarizing the three evaluations made in 2008, 2009 and 2014.

Chapter 11 is analysing the Chemical Leasing tools, whereas in chapter 12, five case studies are presented and analysed.

Chapter 13 summarises and discusses the findings of the research and presents the lessons learned. Furthermore, answers to the research questions are provided.

This leads to the development of an indicator set and a roadmap in chapter 14, to be used for a better data management and recommendations for further improvements.

Chapter 15 concludes the thesis, highlighting the main research contributions and providing suggestions for further research.

This chapter is followed by the References (chapter 16) and the Annexes (chapter 17), where additional material which was used in the research is collected (questionnaires, Excel sheets,).

The thesis is completed by lists of tables and figures and a glossary of terms and abbreviations, frequently used throughout the work, which can be found at the beginning of the thesis.

Chapter 1 gave an overview on the problems that formed the basis of this thesis and some approaches that seem to be promising. The assumption is that there are promising models (especially Chemical Management Services and Chemical Leasing), applied in sectors where chemicals are used that can optimise chemical consumption patterns and can help to reduce the volume of chemicals, waste streams and emissions and therefore make a significant contribution to a more environmentally friendly way of using chemicals and thus to more sustainability.
Furthermore, aims and goals of the thesis were introduced, the research questions, methods, benefits and limitations of the research were described and an outline of the work was given by the author.

2. Sustainable Development, Cleaner Production and Sustainable Innovations

In Chapter 2, the birth and rise of environmentalism and how that path led to approaches like Sustainability and Sustainable Development is described. Concepts like Cleaner Production, Sustainable Innovation and Circular Economy present elements that have already contributed to a more sustainable development in industry over the past 25 years. It is the aim of this chapter to show how these terms are related to the topic of the thesis and why they are important for it.

2.1 The birth of Environmentalism

Our natural environment (ecosphere) has, according to Nosko (Nosko, 1986, cited in Wohinz, 2010/2011) three main functions to fulfil:

- It provides resources (material and energy) as an input for industrial production
- It takes up residues from production and residues that stem from the use and consumption or after life of goods
- Our ecosphere is the natural habitat for all beings, humans, animals and plants

For a very long time, even dramatic increase in human activities seemed to have no influence on the environment. It appeared to have limitless ability to supply us with necessary resources and to absorb unwanted releases. “Environmental systems tend to be highly complex, inter-related and show changes only over a long timescale” (Wong, 2004). However, there is a general consensus among many academics and governments that industrialisation is, at least in parts, responsible for many problems like climate change, ozone layer depletion, loss of biodiversity, land over-use, water scarcity and adverse effects of chemicals on human health.

For many scholars, the modern environment movement kick-started with Rachel Carson’s book “Silent Spring” (Carson, 1962). Her book was the first “attack to the deathly elixirs” of the chemical industry (Grober, 2013). Starting in the 1950, chemicals for plant protection and for pest control have been applied ubiquitously. It was recognised, that after applying Diclorodiphenyltricloroethane (better known as DDT) on the fields, songbirds have disappeared within a year (Carson, 1962). It became clear that industrialism in general, and the chemical sector in particular, are having a serious and increasingly negative impact on the environment. Pesticides and herbicides do not just harm the environment, they also harm humans who apply these toxins on the fields. One of the main messages of the book is “not to assume that substances are benign just because they are legal, profitable or promoted as scientific progress” (Carson, 1962).

Rachel Carson approached the term “sustainability” from the ecological side, as she wrote about the “conservation of the earth for future generations” (Carson, 1962). At the beginning of her book, in her dedication to Albert Schweitzer she

writes: “Man has lost the capacity to foresee and to forestall. He will end by destroying the earth” (Carson, 1962). If this sentence is read against the grain, these lines obtain a perfect definition of sustainability: it is the ability to look ahead and to make provisions (Grober, 2013).

A second event during the last 50 years changed the view on the world considerably: in 1968, for the first time it was possible to get a picture of the earth from above. The Apollo Program of NASA started in 1963, after President John F. Kennedy had announced in 1961, that before the end of the decade, astronauts would land on the moon. Apollo 8 was the first manned mission to the moon, but the astronauts only orbited the moon and did not land on it. Taking pictures of the earth from above was not explicitly planned but of course done by the astronauts. One of these pictures is named “Earthrise”, a photograph of the earth that was taken by astronaut William Anders on December 24th 1968 during the Apollo 8 mission. Nature photographer Galen Rowell declared it "the most influential environmental photograph ever taken.”[3] The figure below shows the position the picture originally was taken, normally it is shown rotated by +90°.

Figure 2-1: „Earthrise“(Source: http://www.abc.net.au/science/moon/earthrise.htm)

It was this and other pictures together with the reports from astronauts that changed the attitude towards our planet. The earth from above looked quite vulnerable in the dark universe. A year later, in spring 1970, the first Earth Day was held which somehow marked the start of the environmental movement. In the same year the Environmental Protection Agency (EPA) in the US was established, and in 1971, Greenpeace was created as “.. an independent, campaigning organisation, which uses nonviolent, creative confrontation to expose global

[3] http://www.nasa.gov/centers/johnson/home/earthrise.html#.VPacPBb_7Ic

environmental problems, and to force the solutions which are essential to a green and peaceful future" (Greenpeace website, 2016)[4].

In 1972, another widely distributed picture became the icon of environmentalism, the picture of the earth as a "Blue Marble", because earth from above looked like a glass marble. One of the astronauts on this mission, Eugene Cernan said in this context: "We went to explore the Moon, and in fact discovered the Earth."[5]

Figure 2-2: AS17-148-22727 (taken by Harrison Smith, December 7th, 1972, 10:39 UTC, source: http://de.wikipedia.org/wiki/Blue_Marble)

The illuminated earth with the dark universe behind sustainably changed the perception of our planet. 15 years after the last mission to the moon, the so called "Brundtland Report" was published in 1987 (WCED, 1987) and its first sentences already show how deeply the two pictures coined the new view of the world:

> *"In the middle of the 20th century, we saw our planet from space for the first time. Historians may eventually find that this vision had a greater impact on thought than did the Copernican revolution of the 16th century, which upset the human self-image by revealing that the Earth is not the centre of the universe. From space, we see a small and fragile ball dominated not by human activity and edifice but by a pattern of clouds, oceans, greenery, and soils. Humanity's inability to fit its activities into that pattern is changing planetary systems, fundamentally. Many such changes are accompanied by life-threatening hazards. This new reality, from which there is no escape, must be recognized - and managed" (*WCED*, Article 1, p. 11, 1987).*

[4] http://www.greenpeace.org/international/en/about/our-core-values/
[5] http://www.hohlwelt.com/en/interact/context/sbrand.html

2.2 Sustainability and Sustainable Development

The term “sustainability” is being used in a lot of different but also similar contexts. How different they might be, they are all an “antonym to collapse”, they locate the term in the human search for security and safeness (Grober, 2013). It took some time until the principle of “precautionary thinking” resulted in one term: “sustainability”. A whole field of related terms evolved under this umbrella: ecology, environment, life quality and even management were used with “sustainable” as a prefix (Grober, 2013).

The term “sustainable” is often used together with the term “development” and the term “sustainability” is often used as a synonym for “sustainable development”. In their first report to the Club of Rome in 1972 (“The Limits to Growth”), Donella Meadows and her co-authors identified five major trends of global concerns as the main problems of our future: accelerating industrialisation, rapid population growth, widespread malnutrition, depletion of non-renewable resources, and a deteriorating environment (Meadows et al, 1972). They developed a model, which showed that factors like world’s population, food production and environmental pollution are not isolated but dynamically interdependent from each other. In their report, the term “sustainable” was used for the first time in its modern, extended meaning (Meadows et al, 1972, p.158):

“We are searching for a model output that represents a world system that is:

1. sustainable without sudden and uncontrollable collapse; and
2. capable of satisfying the basic material requirements of all of its people.”

Following this publication, calls for zero-growth strategies started to get louder. However, the “limits to growth” argument was subject to much criticism as well(e.g. Baker, 2006). It was said to solely concentrate on the physical limits to growth, ignoring the possibility of technological innovations leading to new ways of addressing pollution or using resources in production more efficiently (Baker, 2006).

One definition for sustainability, according to the US EPA, the Environmental Protection Agency of the United States, is:

> *“Sustainability is based on a simple principle: everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have the water, materials, and resources to protect human health and our environment”*[6].

[6] http://www.epa.gov/sustainability/basicinfo.htm

Also in 1972, the United Nations Conference on the Human Environment (UNCHE) took place in Stockholm and created the UN Environment Program (UNEP). The conference produced the Stockholm Declaration with 26 principles and an Action Plan with 109 recommendations.

On March 5th 1980, finally the term “Sustainable Development” was officially born (Grober, 2013): the “World Conservation Strategy (WCS) - Living Resource Conservation for Sustainable Development” was presented. For the first time, “Sustainable Development” was used intentionally and as a clearly defined term.

Years later, in 1987, the Report of the World Commission on Environment and Development (WCED, 1987) “Our Common Future” (also known as the “Brundtland Report”) was published and took up the term sustainability. The well-known and often-cited key sentence can be found in Chapter 2: Towards Sustainable Development, Article 1, p. 37:

> *“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”*

In a whole chapter (Chapter 8: Industry: Producing more with less, p. 143 ff.) the impact of industry and its products on the natural resource base, from raw material exploration to production and further to the disposal of products by the consumers is described. But also the fact is being stressed that “Industry also responded to these problems by developing new technologies and industrial processes designed to reduce pollution and other adverse environmental impacts. Expenditures on pollution control measures rose rapidly in some highly polluting industries; and corporations began to set up their own environmental policy and control units. [..] (Article 15, p.146).

Chapter 12 (Towards Common Action: Proposal for Institutional and Legal Change, Article 75, p. 223) also made clear that “Industry is on the leading edge of the interface between people and the environment. It is perhaps the main instrument to change that affects the environmental resource base of development, both positively and negatively. Both industry and government, therefore, stand to benefit from working together more closely.”

The first multi-dimensional illustration of sustainability came up in the mid 1990ies, it was the “triangle of sustainability”. The triangle is derived from a number of significant reports, among them the Brundtland Report. This report already showed the diversity of possible viewpoints, such as environmental, economic and social aspects. These cannot be seen independently from each other but are interlinked. The illustrations as well as the terms differ slightly at the different sources. Some see the origin of the triangle of sustainability with professor Bernd Heins from Oldenburg, some others say, the triangle was first introduced by the United Nations in the Agenda 21 (UN 1993) and by the German Enquete Kommission “Schutz des Menschen und der Umwelt (1998) (IHK Nürnberg, 2000 – 2015). The Verband der Chemischen Industrie (VCI) also played an important role when he claimed in 1996 that "economic, ecologic and social aspects should

be considered equally[7]. We see sustainability/sustainable development not only as single-edged ecological but as a holistic future concept as each of the three dimensions contribute to a long-term and sustainable development". VCI brought this model into the discussion at the Enquete Kommission in 1998 through which it became part of the public discussion[8].

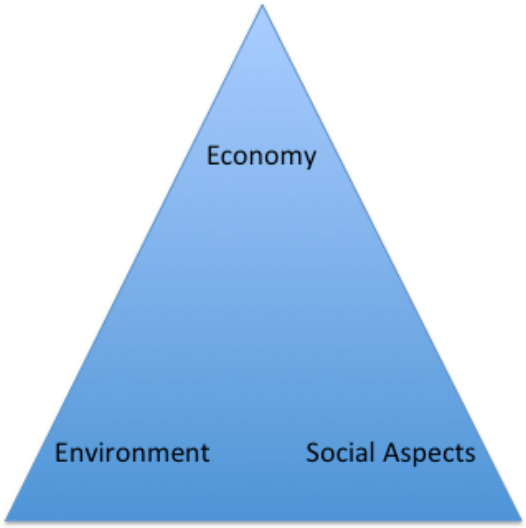

Figure 2-3: Triangle of Sustainability

The model was further developed and became the 3-pillar model, where ecology, economy and social dimensions are equal pillars, showing on the one side that society is unstable if one of the three pillars is weak but on the other hand the pillars look quite separate from each other with only the same roof they share.

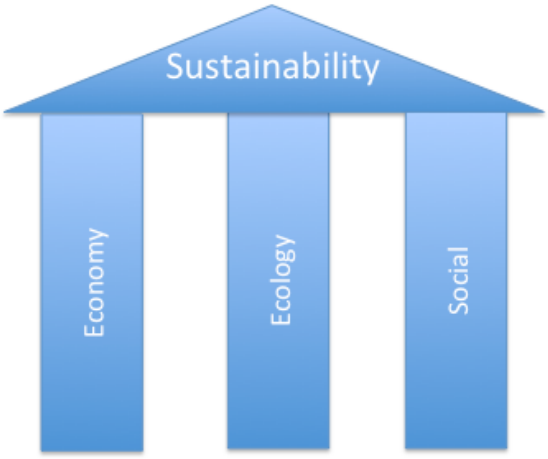

Figure 2-4: The three pillars of Sustainability

A more integrated model is the "3-overlapping circles" - model that shows a linkage between the economic, environmental and social factors, pretending that the parts of the circles that do not overlap can exist on their own. All the different illustrations, with circles in different sizes, depending on where the focus lies, have one thing in common: the three circles overlap in the middle, there is

[7] https://www.nachhaltigkeit.info/artikel/nachhaltigkeitsdreieck_1395.htm
[8] https://www.nachhaltigkeit.info/artikel/nachhaltigkeitsdreieck_1395.htm

sustainability/sustainable development, emphasising the interlinkages and interdependencies of the three circles.

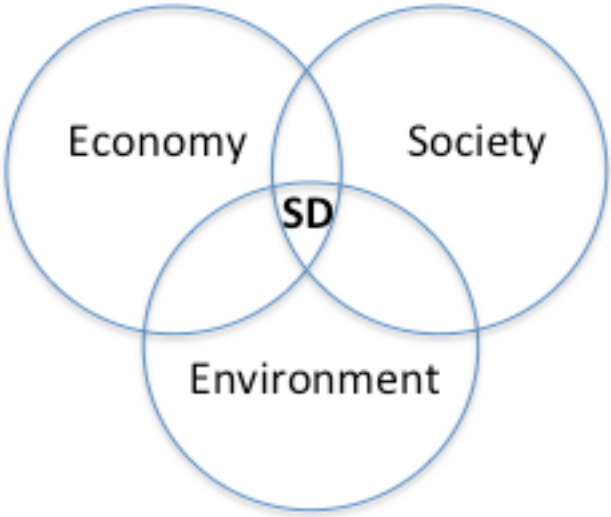

Figure 2-5: The "3-overlapping circles" model

A more recent and more accurate illustration is the "3-nested-dependencies" -model. This model shows the dependency of society and economy from the environment. Without food, water, air and other resources from this environment we are not able to survive.

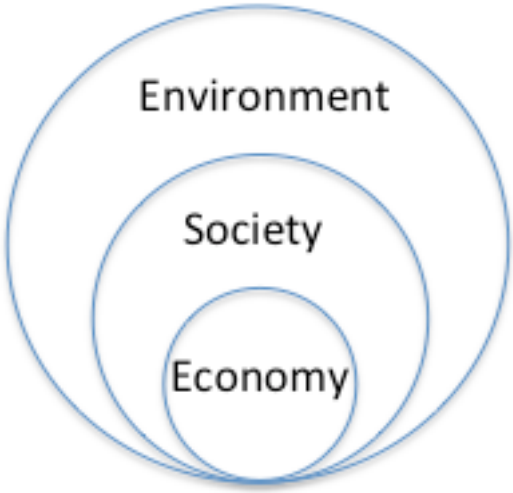

Figure 2-6: 3-nested-dependencies model of sustainability (based on Doppelt, B., 2008 and Senge at al, 2008)

In recent times, sustainability is sometimes broadened by adding a fourth "dimension", e.g. culture, ethics or even time (e.g. Lozano, 2009) or even a fifth dimension, the human dimension (Seghezzo, 2009). This will not be discussed any further in this thesis.

Another term that one often come across in this context is the “Triple Bottom Line” (TBL) and therefore it should be mentioned shortly here: already back in 1994, John Elkington coined this term, that became well known after the publication of his book “Cannibals with Forks” (Elkington, 1997). It is an accounting framework, that incorporates three dimensions of performance: social, environmental and financial, also named “People, Planet, Profit” or the “3Ps”. The concept of the Triple Bottom Line says that the responsibility of a company lies with the stakeholders rather than the shareholders, stakeholders being anyone who is directly or indirectly affected by the actions of a company (Elkington, 1997). This concept is also closely linked to the one of Corporate Social Responsibility (CSR).

The terms “Sustainability” and “Sustainable Development” have appeared with increasing frequency in academic studies and in government reports, in many cases undifferentiated and interchangeably (Baker, 2006). What both terms do have in common is that they take into account environmental considerations (Waas, 2011). “Sustainability is the underlying goal and sustainable development is the path that leads there. Sustainable development describes the process to meet the requirements of attaining sustainability”, writes Omann (2004). Sustainable development is the way towards sustainability and sustainability is the state defined in terms of criteria used to describe sustainability goals. “The basic goal of sustainability in turn is to maintain the functions and characteristics of the world’s complex and open systems in the long run so that they can evolve and develop such that “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 37).” (Omann, 2004)

Nevertheless, sustainable development is not a static but a dynamic concept. It is an on-going process, which is also depending on different social, political, cultural and historical contexts (Baker, 2006).

2.3 Cleaner Production – A move towards Sustainability

It is evident that environmental and societal problems must be tackled to ensure a liveable environment for mankind and it is also evident that industry has a key role to play in solving these problems. “Cleaner Production” is the term that is most connected with this and which is a preventive, company-specific environmental protection initiative.

The United Nations Environment Program (UNEP) in 1990 defined “Cleaner Production” as “.. the continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment”.[9]

- In production processes, Cleaner Production addresses the saving of raw materials, water and energy, the elimination of toxic and dangerous raw materials and a reduction in the quantity and toxicity of all emissions and wastes at source during the production process.
- In product development and design, Cleaner Production aims to reduce the environmental, health and safety impacts of products over their entire life cycle, “from raw materials extraction, through manufacturing and use, to the ‘ultimate’ disposal of the product” (UNIDO, 2002).

[9] http://www.unep.fr/scp/cp/

- In services, Cleaner Production addresses the incorporation of environmental concerns into designing and delivering services (UNIDO, 2001, 2002).

Up to this definition in the 1990ies, conventional environmental technologies have mostly worked on the treatment of waste and emissions by air filters, wastewater treatment and waste incineration at the end of the production cycle. This is also referred to as “end-of-pipe technology” and characterized by additional expenses to the companies due to additional treatment and by shifting the problem e.g. by producing sewage sludge through waste water treatment which has to be treated afterwards. The key difference between this pollution control approach and Cleaner Production is that pollution control is a “react and treat” approach after “things” have happened, whereas Cleaner Production is a precautionary “anticipate and prevent” philosophy (UNIDO, 2001, 2002).

Cleaner Production aims to integrate environmental objectives already into the production process in order to reduce waste and emissions already at the source and not to do pollution control at the end of a production process. One of the central questions is “where do waste and emissions come from?” instead of “how can we treat existing waste and emissions?” Cleaner Production has several advantages (UNIDO, 2001):

- It stands for action (instead of re-action);
- It avoids potentially toxic processes and materials;
- It reduces material and energy consumption and therefore can reduce costs for materials and energy, for waste handling and insurances;
- It creates a better image among society, resulting in less problems with neighbours;
- Environmental problems are tackled at multiple levels, not only technologically;
- Environmental protection becomes an integral part of product design and process engineering.

The major goals in CP are to find measures to tackle the problem at the source, which may include modifications of the production process as well as the product itself.

Product modification in this context is not that common as many companies are reluctant to change their product, meaning a partly or totally new product design, using different raw materials or even replacing the whole product by a more environmentally friendly one.

Process modification is a much broader field and comprises a whole set of possible measures. Good housekeeping of raw and process materials is in most cases a “low-hanging fruit” or a “quick-win” and can easily be put into practice. These measures may include training of personnel, amendments in handling instructions or changes in the operation of the equipment. A next step can be to substitute raw or process materials which are toxic or problematic by less harmful ones, helping not only to reduce waste and emission volumes but also avoiding legal problems. The most far-reaching step would be to consider technological modification. These may range from simple reconstruction activities to comprehensive changes of the production process. “As a rule, one can say that

the closer to the root of the problem and the smaller the cycles, the more efficient the measures will be" (UNIDO, 2001).

Some of the main fields that are (should be) tackled within Cleaner Production are:

- Energy Efficiency;
- Process and Resource Efficiency;
- Waste Reduction;
- Environmental, Health and Safety Issues (EHS);
- Chemical Management (UNIDO, 2001).

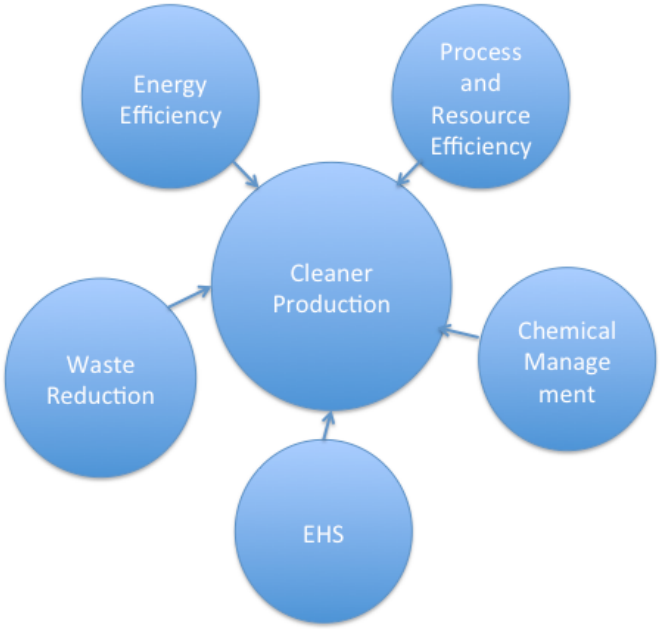

Figure 2-7: Cleaner Production and some of its main fields

According to Thorpe (1999), the following are the four key principles and elements that form the concept of Cleaner Production, especially set in context with hazardous substances:

- *The Precautionary Principle*
  This principle states that action has to be taken *before* damage to the environment (or humans) happens.
- *The Preventive Principle*
  Prevention involves using safer chemicals and eliminating hazardous chemicals or substituting them right from the start. If this cannot be done for whatever reasons, it is required that spills and accidents are avoided until safer alternatives are found and implemented.
- *The Democratic Principle (Public Participation Principle)*
  Public access to information about emissions, about the amount and types of chemicals used in production processes and the chemicals in products is necessary.
- *The Holistic Principle*
  Cleaner production is an integrated approach to production, always looking at the whole life cycle. It is therefore necessary to think in terms of

integrated systems, which is how our world functions. Otherwise the chance is big to create new problems by trying to solve old ones.

So in relations with hazardous substances, the following elements make a production process "cleaner" (Thorpe, 1999):

- An evaluation of the need for chemicals is necessary in the first place: are (all) the chemicals really needed? If needed and toxic, can others, nontoxic ones, replace them or, if that is not possible, can they be avoided by changing the production process or the product itself?
- The use of non-hazardous chemicals in the production process as well as in product design is required, meaning that no persistent, no bio-accumulative or toxic, no carcinogenic, mutagenic or reproductive toxins, no neurotoxins, no endocrine disrupting chemicals nor chemicals of similar concerns should be used.
- The precautionary principle is implemented to substances and material selection as well.
- The whole life cycle (following the holistic principle) should be taken into account, e.g. how are chemicals and materials extracted, how are they transported, stored, handled and how are they treated at the end of their lives?
- Products should be designed in a way that they do not release any hazardous substances during their entire life time, from raw material extraction, over transport, manufacturing, use and recycling or dumping.

The definition of Cleaner Production by UNEP (1990) has been used as the working definition for all UNEP programmes related to the promotion of Cleaner Production and still continues to be a valid definition. New impulses have been provided during the last years and the transition towards more sustainable industrial systems and a so-called "Green Industry" has been promoted. This has required the broadening of the definition of Cleaner Production to Cleaner and Sustainable Production and to include resource efficiency, which is a key element of the transition towards **Green Industry** and **Green Economy** (UNIDO, 2010; UNIDO, 2011a).

UNEP has developed a working definition of a Green Economy in 2008 ".. as one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In its simplest expression, a green economy can be thought of as one, which is low carbon, resource efficient and socially inclusive"[10].

The European Environmental Agency defined Green Economy: „A "green" economy can be understood as one in which environmental, economic and social policies and innovations enable society to use resources efficiently - enhancing human well-being in an inclusive manner, while maintaining the natural systems that sustain us" (EEA, 2012; EEA, 2013).

Green Industry, by definition of UNIDO[11] means "economies striving for a more

[10] http://web.unep.org/greeneconomy/what-inclusive-green-economy
[11] http://www.unido.org/greenindustry/green-industry-initiative.html

sustainable pathway of growth, by undertaking green public investments and implementing public policy initiatives that encourage environmentally responsible private investments. Greening of Industry is a method to attain sustainable economic growth and promote sustainable economies. It includes policymaking, improved industrial production processes and resource-efficient productivity" (UNIDO, 2010).

2.4 Sustainable Innovations – the solution?

For a long time, there has not been any sufficient or established definition of the term "Sustainable Innovation" (SI) which is symptomatic for the general difficulty to define the concepts of sustainability and sustainable development (Charter and Clark, 2007). Nevertheless, Sustainable Innovation is a critical part of Sustainable Development (SD) and for achieving Sustainable Consumption and Production (SCP) (Charter and Clark, 2007).

Martin Charter set up one definition for Sustainable Innovation (Charter and Clark, 2007):

> *"Sustainable Innovation is a process where sustainability considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialisation. This applies to products, services and technologies, as well as new business and organisation models."*

Charter and Clark also stated (2007) that "Sustainable innovation is not yet applied as a mainstream practice and rarely at the radical level required or the transformation to SCP and SD". There is a need of "Factor X" reductions (see Factor 4 (1995) or Factor 5 (2010) by Ernst Ulrich von Weizsäcker et al.).

"Sustainable solutions for sustainable development problems also require sustainability-oriented business models, like sustainable Product-Service-Systems (PSS), designed to satisfy functional needs through lower or non-material services rather than through physical products" was postulated by Charter and Clark (2007). Experience and analysis of PSS case studies give us an idea that the solutions for sustainability problems are not simple. It also shows that services do not necessarily have a lower environmental impact, as many of them still need some additional physical product to satisfy the addressed needs. Nevertheless, Product-Service-Systems are a promising new approach to create better, more innovative and more sustainable solutions.

The core drivers for Sustainable Innovation were studied by the Centre for Sustainable Design and were summarized in their publication (Charter and Clark, 2007). Most of the drivers mentioned are definitely of environmental origin:

- "Increasing consumption of energy and materials associated with a growing global population especially in China and India
- Climate change has now become a concern for a variety of stakeholders
- Increasing costs of petroleum dependency: besides climate change these include potential economic and social destabilisation, and military tension

and conflict
- Water shortages are becoming a global concern with increasing demand and potential drought resulting from climate change
- Pollution and loss of biodiversity" (Charter and Clark, 2007).

Other drivers that were analysed, like Sustainable Consumption and Production (SCP) policies, product policy initiatives and financial and market drivers are not further described in this thesis.

Among other barriers like market and financial barriers, organisational obstacles are most interesting: outside of leadership companies, senior level management shows little commitment to sustainability and therefore also to sustainable innovation. Sustainability is still more a threat than a business opportunity and awareness and understanding of it and how to apply it is generally weak in many old-style companies. The conference summary of the Centre for Sustainable Design (Charter and Clark, 2007) also states that "simple, practical and pragmatic tools to help them develop and implement solutions" are needed (Charter and Clark, 2007).

In general, a lack of common language between academia and business people could be detected (Charter, 2007). Terms like innovation, sustainability and Sustainable Innovation incorporate many different concepts and terms, which have been adopted only in few businesses, and makes communication between academia and business rather difficult. Businesses usually do not use the (academic) PSS terminology, also because they think that it is a sophisticated wording for something that they are already doing. "Many companies are developing and implementing PSS as part of "value-added" thinking – but from a business and not a sustainability perspective" (Charter and Clark, 2007).

Successful sustainability-driven models and cases are evolving slowly. But measuring the sustainability performance of sustainable products and services and PSS "is complex due to a lack of good quality life cycle data and information" (Charter and Clark, 2007). There is a need to produce and document (more) success stories and to create a network to "bring together the right stakeholders to facilitate and catalyse sustainable innovations" (Charter and Clark, 2007).

An alternative but not totally equivalent term to Sustainable Innovation is **Eco-Innovation**. Eco-innovation has been described as:

> *"The process of developing new products, processes or services which provide customer and business value but significantly decrease environmental impact (Fussler and James, 1996, cited in Charter and Clark, 2007)".*

"Eco-Innovation is any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, through reducing impacts on the environment or achieving a more efficient and responsible use of natural resources, including energy"[12].

Both terms are often used interchangeably, although Eco-Innovation only addresses environmental and economic dimensions while Sustainable Innovation

[12] http://europa.eu/rapid/press-release_IP-11-1547_en.htm

broadens the definition by social and ethical dimensions (Charter and Clark, 2007). “Finding solutions to environmental problems through Eco-Innovation has been, and is likely to remain, the primary focus for Sustainable Innovation while aiming to achieve social benefits” (Charter and Clark, 2007).

2.5 Circular Economy

Circular Economy is another term often cited recently. The European Commission has started to actively promote the concept of “Circular Economy” in 2014. It is a concept that is close to the PSS concept, concerning its goals and applications. Since the Industrial Revolution, industrial economy has not changed much, meaning that it still follows a linear pattern: companies extract or harvest material, use them in the production of products and sell these products to the consumers, who at the end of the product’s life, dispose them. This linear model “.. assumes that resources are abundant, available and cheap to dispose of” (European Commission, 2014). In contrast to that, “.. a transition to a circular economy shifts the focus to reusing, repairing, refurbishing and recycling existing materials and products. What used to be regarded as “waste” can be turned into a resource. All resources need to be managed more efficiently throughout their life cycle” (European Commission, 2014).

Circular economy shifts consumption patterns away from traditional ownership towards using and sharing products. Not only should products like cars, computers, etc. be designed „with durability, reuse, repair, re-manufacturing and recycling in mind “but circular economy also fosters greater cooperation within and across supply chains to cut costs, waste and environmental harm. Circular economy is also able to open up new markets, moving away from selling products towards selling services and “develop business models based on leasing, sharing, repairing, upgrading or recycling individual components“ (European Commission, 2014).

Innovation of any kind, be it sustainable or not, is difficult and complex, with a high potential to fail. It can take decades for radical innovations to become mainstream and some of them will never be adopted by industry. Concepts like PSS do not always deliver real sustainability benefits but they have the potential to create new concepts for more sustainable solutions (Charter and Clark, 2007).

Key elements and main characteristics of Sustainable Development, Sustainable Innovation, Cleaner Production and Circular Economy:

Sustainability and Sustainable development

- Importance of industry to develop new technologies and industrial processes.
- Multi-dimensional illustration of sustainability, including ecology, economy and social aspects (People, Planet, Profit).
- An on-going process, which is also depending on different social, political, cultural and historical contexts.
- Sustainable Development needs radical changes, needs new ways of thinking like decoupling economic success from resource consumption. This means to change the focus from selling products into selling performances.

Cleaner Production

- Critical but important role of industry
- A preventive, company-specific environmental protection initiative
- application of an integrated environmental strategy to processes, products and services
- An increased efficiency and reduced risks to humans and the environment.
- Action instead of re-action.
- CP avoids potentially toxic processes and materials.
- It reduces material and energy consumption and therefore can reduce costs for materials and energy but also for waste handling and insurances.
- Environmental problems are tackled not only from a technological point of view but at multiple levels.
- Environmental protection is an integral part of product design and process engineering.
- CP tackles the problem at the source, which may include modifications of both, the production process and the product itself.
- Substitution of hazardous chemicals.
- Public access to information about emissions, about the amount and types of chemicals used in the production processes and the chemicals in products is necessary to bring the move towards safer alternatives forward.
- A holistic principle, always looking at the whole life cycle.

Sustainable Innovation

- Sustainability considerations (environmental, social, financial) are integrated into company systems from idea generation through to research and development (R&D) and commercialisation.
- Sustainability-oriented business models are designed to satisfy functional needs through lower or non-material services rather than through physical products.

Circular Economy

- Circular Economy shifts the focus to reusing, repairing, refurbishing and recycling of existing materials and products.
- All resources need to be managed more efficiently throughout their life cycle.
- It shifts consumption patterns away from traditional ownership towards using, reusing and sharing products, and contribute to more and better employment.
- Circular Economy enables to open up new markets, moving away from selling products towards selling services.

In chapter 2, the author presented the State of the Art, concerning terms and fields that are important for the theses. Sustainability and Sustainable Innovation were described in their relevance for the thesis, as well as the concepts of Cleaner Production and Circular Economy. Thus it could be shown that sustainable solutions require sustainability-oriented business models, like Product-Service-Systems as will be described in chapter 3.
This chapter is closed by a list of key elements and main characteristics of the topic of this chapter.

3. Product-Service-Systems

Chapter 3 leads the way to specific Product-Service-Systems in the chemicals sector. It starts with an introduction to functional economy and servicizing and gives definitions for the terms that are most commonly used in that context, but often misunderstood or misinterpreted.

More room is given to the description of Product-Service-Systems and their special forms in the chemical sector (Chemical Management Services and Chemical Leasing) with their drivers and barriers.

With the establishment of the Precautionary Principle of Cleaner Production, industrial production processes and products became cleaner and more efficient some time ago. However, this approach is often being contradicted by an ever more-increasing consumption. This phenomenon of counteracting the efficiency benefits by increasing consumption is known as the “rebound effect”. It is often said that an increasing consumption is necessary for economic growth, which is in turn linked to prosperity and social stability. On the other hand, it is obvious that increased consumption is contributing to an increasing environmental burden, no matter how clean a process or product might be. If we are talking about sustainability, it is necessary, not only to have a look at the production side but also at the consumption side, including private consumers and companies. Yet, in this thesis the focus will be on companies only.

There has to be a turnaround and a change of focus from processes to consumption patterns (UNEP, 2002). Material flows in production as well as in consumption have to be decreased by providing products and services that have the “same level of performance” but causing less stress to the environment (Mont, 2002). But what can foster such radical changes to a totally different system?

Until the end of the 1950s, industrialisation in Europe was accompanied by an increasing demand of workforce in industrial production. Since then the number of employees in industry has started to decrease. What was important at the time of the industrial revolution, to be able to produce standardised mass products, is not the only important task nowadays. The capability for continuous innovation, improved design and quality and customised goods became more important (Mont, 2002) and a change towards a so-called “service economy” slowly took place.

Walter Stahel coined the term “service economy” in the 1990s. The shift to a service economy should enable sustainable development (Stahel, 1997). It is a shift in the role of the manufacturer or supplier from a provider of a product to a provider of a service. Stahel (1997) set a clear distinction between an “industrial economy” and a “service-oriented economy”: in an industrial economy the exchange of products that are *consumed* is central, whereas a service-oriented economy is based on the *utilisation* of a product, which makes it a performance-driven approach. The customer pays for the utilisation of a product, the function of the product to satisfy consumer’s need is essential. The service economy is often also named functional economy, where the product and the technology are means to provide a function (Mont, 2002). The user is interested in the service a product provides and the satisfaction it can give rather than in the product itself. Examples

are given in Figure 3-1: consumer pay for cleaning services instead of washing machines, they pay for Chemical Management Services instead of chemicals, for document reproduction instead of copy machines and mobility services replace the possession of a car. This whole system is based on a system where users pay for the benefit of using a product without wanting to own the product itself (Stahel, 1997). Therefore, ".. a functional economy has the potential to be more environmentally benign because it addresses current levels of material/resource consumption, seeking options that may provide function/service to consumers without minimising their level of welfare. But realisation of this potential is not automatic" stated Mont (2002).

Examples:	**Examples:**
Buying washing machines	Buying cleaning services
Buying chemicals	Buying Chemical Management Services
Buying copy machines	Buying document reprodcution services
Buying cars	Buying mobility services

Figure 3-1: The Functional Economy (White, Stoughton and Feng, 1999)

Another term used in this context is the term "Servicizing" ("beyond product in a box"), a term specifically used in the US and defined as "..the emerge of a class of product-based services; manufacturer who traditionally delivered "products in a box" are increasingly viewing products as a vehicle or platform to deliver service or function." (White, Stoughton and Feng, 1999). Servicizing, as defined in White, Stoughton and Feng (1999), is a process of change. Although similar, servicizing and so called "Product-Service-Systems" (PSS) (as will be described later in more detail) are not identical.

The more inclusive PSS concept in Europe became the umbrella term for "sustainable service-led business model" research and became the standard term in research and policy analysis, citing the US concept of servicizing as a reference (White, Stoughton and Feng, 1999). A lot of research was done under EU's 5th Framework Program (FP 5) (and therefore mostly in Europe), and led to a better defined understanding of the many possible combinations of products and services, creating environmental performance improvements (EPA, 2009). It was strongly indicated that a broader scope is necessary to get the full range of service-led environmental performance improvements over „business as usual" (White, Stoughton and Feng, 1999).

This “sustainable service-led business model” research became also popular in Japan and Korea a few years later, there under the name servicizing with the connotation (as in White, Stoughton and Feng, 1999) of *changes* from business as usual that result in service-led alternatives to traditional means of fulfilling economic functions. In Japan, servicizing is used in a broader sense than in the US, generally covering the full range of the PSS concept (Stoughton, personal information, 2006).

For White, Stoughton and Feng (1999) Product-Service-Systems comprise a class of product-based services, with emphasis on the business-to-business markets. These include different kinds of services, from well-known and accepted warrantee and maintenance agreements to the less familiar services as Chemicals Management Services or Mobility services (White, Stoughton and Feng, 1999). What all these services have in common, according to White, Stoughton and Feng (1999), is “that for the consumer, consumption shifts from purchase and use of a product to purchase of a service.” On the side of the manufacturers and service providers, the “involvement with the product is extended and or deepened in phases of the product life cycle. A service orientation therefore involves a greater involvement with the product in its use phase than does the provision of product in a box” (White, Stoughton and Feng, 1999). Main driver for this approach has been business and not environmental concerns. A certain potential for environmental gains through servicizing is seen in the extended product responsibility that is part of the concept. The main point lies in reducing the absolute impact, regarding the production, the use and the disposal of a product. Experience has shown that servicized products require a closer cooperation between suppliers and users and an increase in trust between them. Another point is that these services also demand a better understanding of costs than is typical for the conventional seller-buyer relationship (White, Stoughton and Feng, 1999). The key point is the change in compensation for the supplier from “volume of product supplied” to “utility/quantity of services provided”.

As mass production moved to a more customised production, manufacturers became more interested in adding value to their products by adding services that broaden the spectrum of their products (Mont, 2002). In addition, value is also added through technological improvements, through brand names and product image, which are all non-material aspects of products. These aspects help to distinguish products from the ones of the competitors and can better respond to customer’s needs (Mont, 2002).

More than a decade ago, the concept of Product-Service-System (PSS) started to be seen as a possible way towards a more sustainable society. It is known that users in most cases are not interested in the product itself but in the results it offers (e.g. washing machine against clean laundry). The boundary between service and product is kind of fuzzy though: workers in production also perform services, ranging from product and process design to production-related activities like research, transportation, and maintenance, and to supportive services, like accounting, financing, law services and personnel functions (Mont, 2001). But services require the use of some tangible elements or products, like the premises where they are offered or the machines with which the service is performed. In chapter 3.2 the concept of PSS will be described in detail.

3.1 Some Definitions

The introduction of this chapter made clear that a lot of terms are used, meaning the same or similar things, so it seems both, useful and necessary to have a look at them and define and explain them shortly before going into the topic more deeply.

3.1.1 Service, Product Service System, Functional Unit

Goedkoop et al. (1999) were among the first that defined some terms in the context of PSS: “a **product** is a tangible commodity manufactured to be sold” (Goedkoop et al, 1999). Examples mentioned by Goedkoop are raw materials that have been processed by human activity but also ingredients and auxiliaries.

A **service** is according to Goedkoop et al. (1999) “.. an activity (work) done for others with an economic value and often done on a commercial basis”. Hrauda and Jasch (1998) broadened this definition: „Traditionally it is considered that services differ from products in four main respects. First, (1) they are intangible, and (2) in many service operations, production and consumption cannot be separated. Customers are involved and participate in the production process (e.g. personal energy consultation to the resident). (3) Services are experienced differently by different customers (for instance, customers who cannot distinguish between physical goods, e.g. the TV set off the same production line, will normally be able to distinguish between services, e.g. the different maintenance persons of the maintenance firm). Finally, (4) services are perishable, i.e. they cannot be stored” (Baron and Harris 2003, Zeithaml and Bitner 1996, Payne 1993, cited in Hrauda and Jasch, 1998).

The **functional unit or unit function fulfilment** is “a standardised quantity of measurable function fulfilled by both, the Product-Service-System and a reference system” (Goedkoop et al., 1999).

A **product system**, according to Goedkoop et al (1999) is a “set of material products needed to jointly fulfil a user’s needs”. A **Product-Service-System (PSS)** therefore „is a marketable set of products and services capable of jointly fulfilling a user’s need. The PS system is provided by either a single company or by an alliance of companies. It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product. And product and service can be equally important for the function fulfilment.” In Product-Service-Systems, services are beyond the minimum services required for the distribution of the product.

Hockerts and Weaver (2002) came up with some different definitions: “a pure product system is one in which all property rights are transferred from the product provider to the client on the point of sale [..]. A pure service system is one in which all property rights remain with the service provider, and the clients obtain no other right besides consuming the service. A Product-Service-System is a mixture [..] of the above. It requires that property rights remain distributed between client and provider, requiring more or less interaction over the life time of the PSS.”

Another definition on PSS is given by Ezio Manzini in UNEP (2002): „A Product-Service-System can be defined as the result of an innovation strategy, shifting the business focus from designing and selling physical products only, to selling a

system of products and services which are jointly capable of fulfilling specific client demands."

One of the most often used definitions is maybe the one by Mont (2004):

> *"PSS is a system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy customers' needs and have a lower environmental impact than traditional business models."*

SusProNet (see Box 1), the network of PSS researchers and consultants established as part of EU's 5th Framework Program PSS research, came up with a provisional definition of product services (PS) as "tangible products and intangible systems designed and combined so they are jointly capable of fulfilling specific customers' needs" and for Product-Service-Systems (PSS) as „the product-service including the network, technological infrastructure and governance structure (or revenue model) needed to "produce" a product service" (Tukker and Tischner, 2006). This definition of PSS sounds rather abstract but one has to keep in mind that PSS in their various peculiarities have been part of all economies (no matter if developed or developing) for a long time. Car rentals and pizza delivery are all examples of PSS that are very much "business as usual" in the US (White, Stoughton and Feng, 1999). But in some cases, the services have been reverted into product use again: laundries, public baths, and public transport systems have been more and more replaced by less eco-efficient but more convenient private ownership of products and infrastructure as private washing machines and private cars (White, Stoughton and Feng, 1999).

As the last pages showed, there is a vast amount of different and similar definitions and even more can be found in literature. There is not *the* one and only, universal definition but this is not "a major barrier to identifying sustainable emergent and innovative PSS business models" (White, Stoughton and Feng, 1999). What became clear through all the research activities is that PSS are not more eco-efficient and have no better environmental performance just due to the fact that they are PSS. What PSS *do* have is the *potential* to be so. PSS can offer a promising concept in the direction of sustainability and they can help to change unsustainable trends in production and consumption into (more) sustainable Product-Service-Systems (e.g. Jasch et al, 2007).

The crucial point in all the discussion is the ownership. Friend (1994 and 1996, cited in White, Stoughton and Feng, 1999, p. 13), for example, noted that "what the customer ultimately wants is not ownership of products, but the utility or functions provided by the products". Nevertheless, there are some reasons why consumers might prefer ownership. Prestige and status or simply convenience are reasons for private users, security and control over the processes are reasons that concern companies so that they prefer to own products rather than have a service instead. For example, in the case of chemicals, industrial firms may want to have the value of a chemical as a detergent, as a cleaner or as a paint and not to have to worry about procurement, proper handling and storage, waste disposal and liabilities, but they also want to be sure that their requirements on quality are met (White, Stoughton and Feng, 1999).

3.1.2 Green, eco-efficient and sustainable services and their classification

Concerning Product-Service-Systems, there is a need to distinguish or at least define some other terms that are used interchangeably.

Sustainable Services

To be sustainable, a concept or development has to address all three dimensions (ecology, economy and social) of sustainability, according to the claim of the Verband der Chemischen Industrie of 1996 that "economic, ecologic and social aspects should be considered equally". Consequently, for a service to be classified "sustainable", it should have a positive impact on each of the three areas of sustainability as well.

Green Services

"Green Services" is another term for services, which have economic, ecologic and social sustainability as core-criteria (Cocca and Meiren, 2013). Varying sets of standards define "green" for particular products or services. Suppliers of green services try to provide a holistic view on economic, ecologic and social sustainability. The term "Green Services" is used for manifold services in many different sectors, examples are e-mobility, energy saving services and "Green IT". All these services have in common that they – like sustainable services - promote the principle of sustainability.

Eco-Efficient Services or Eco-Services

According to Halme et al. (2004), the ideas for eco-efficient service thinking come from many sources. One of its roots is the so-called "factor discussion" that urges to decrease the use of materials radically by a factor of four (von Weizsäcker, Lovins and Lovins 1995) or even by a factor of ten (Schmidt-Bleek 1998). Services instead of products fulfil the needs of customers and shall help to achieve dematerialization and a decrease in energy consumption. These services, that replace products fully or to a certain degree and thus "..reduce the material and energy needed to perform an economic activity (e.g. moving, living, cooking), are often called eco-efficient services, or shortly, eco-services" (Halme et al., 2004).

Halme et al. (2004) differentiate several types of Eco-Services, coming from traditional and well-known forms as renting or leasing to "selling solutions", like for example, an integrated pest management (Hockerts, 1999). Halme et al. (2004) came up with an integrative classification, which is based on studies of Hockerts (1999), and Heiskanen and Jalas (2000). These authors classify services in two main categories, primary and secondary services. Primary services are "classical" or pure services that are not connected to any product and cannot be substituted by one (e.g. consulting services) and will not be further examined within this thesis. Secondary services or product-oriented services can be sub-divided into product-supplementing services and product-replacement or substitutional services (as shown in Fig. 3.2, taken from Hrauda and Jasch, 1998). Authors like Behrendt et al. (2003) stated that secondary services do contain a product component and are a combination of products and services.

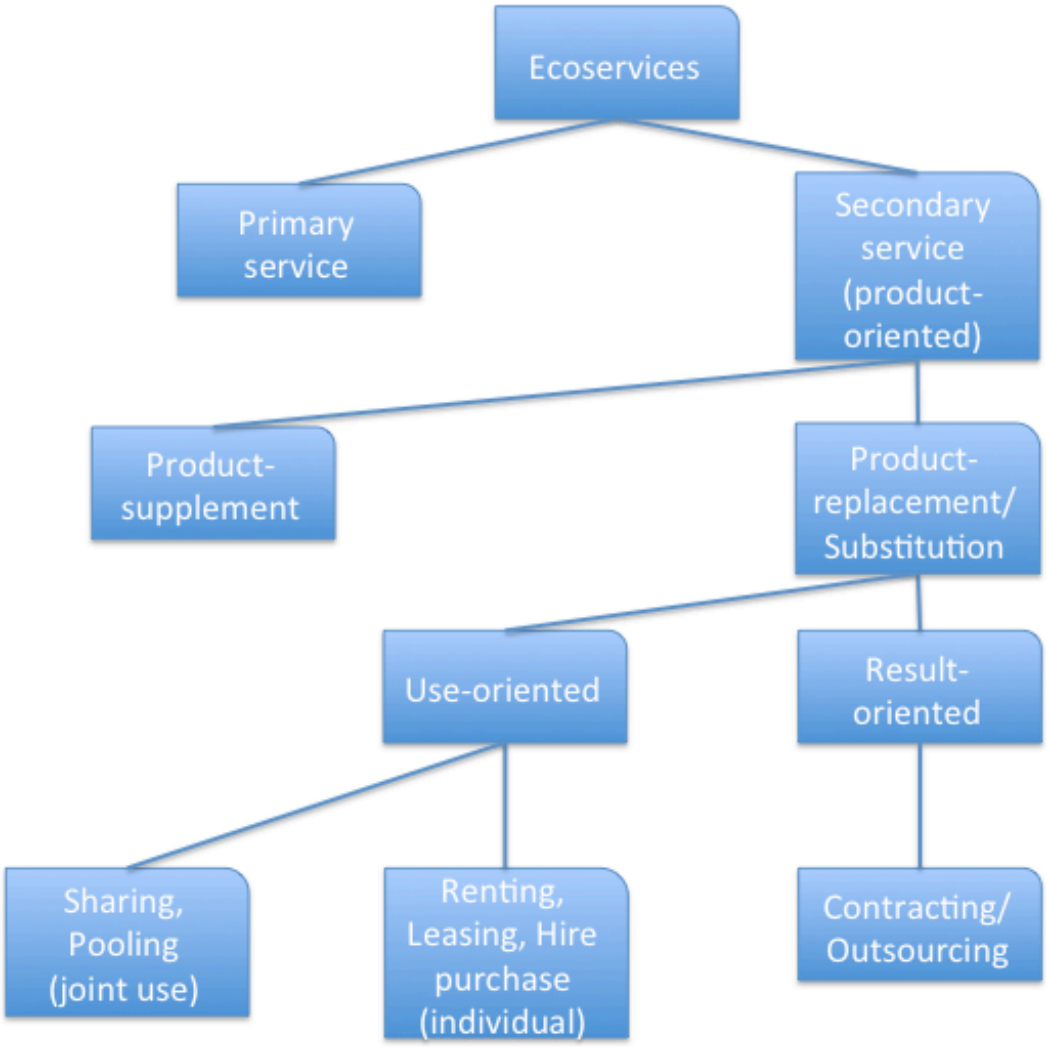

Figure 3-2: Classification of eco-services (Hrauda and Jasch, 1998)

The substitution of the product may be use-oriented: the use of a product supplements its purchase (e.g. rental services) or may be result-oriented, completely transferring the responsibility for the product to a different entity (Hrauda and Jasch, 1998).

Result-oriented Services

In the case of result-oriented services, the consumer is not interested in the use of the product, but in the service that goes with the use of the product, e.g. taxi rides and other forms of transport or heat supply. Instead of the product or the use of a product, the *result* of the product is sold. In the case of result-oriented services, the responsibility for supplying the goods required for the service lies with the service supplier; he is still the owner of the products, which are used. “For example, the customer may purchase an outsourced activity from a third party (e.g. cleaning) or buy a predefined functional result (e.g. cooling)“ said Tukker and Tischner (2006). And Hrauda and Jasch (1998) wrote that “this way, the supplier is no longer tied to the production of one product. His main task is to put the best system components together to satisfy customer specifications and ecological aspects and to find the best overall system solution”. Examples for result-oriented

services are outsourcing and contracting.

- **Outsourcing and Contracting**

In business, if a process step like the manufacturing of parts, is transferred to a third party company by a subcontract, it is called “outsourcing”. Outsourcing sometimes involves transferring employees from one firm to another, but this is not mandatory. In all cases, outsourcing is done to avoid costs by paying only for services that are really needed. Only non-core activities should be outsourced. One well-known example for outsourcing a service is energy contracting. The idea of energy contracting is almost as old as industry itself. Yet James Watt promoted a certain type of outsourcing and energy contracting:

> *"We will leave a steam engine free of charge to you. We will install these and will take over for five years the customer service. We guarantee you that the coal for the machine costs less, than you must spend at present at fodder on the horses, which do the same work. And everything that we require of you, is that you give us a third of the money, which you save."*
> (Cited in Grazer Energieagentur, 2009)

„Energy Contracting - also labelled as ESCo or Energy Service - is a comprehensive energy service concept to execute energy efficiency projects in buildings or production facilities according to minimized project cycle cost. An Energy Service Company (ESCo) implements a customized energy service package (consisting of planning, building, operation and maintenance, optimization, fuel purchase, (co-)financing, user behaviour ...). The ESCo provides guarantees for all-inclusive cost and results and takes over commercial and technical implementation and operation risks over the whole project term of typically 10 to 15 years” (Bleyl et Schinnerl (2008), cited in Grazer Energieagentur, 2009).

Two main business models can be distinguished: Energy Supply Contracting and Energy Performance Contracting. In Energy Supply Contracting, the supply of energy such as heat, steam or compressed air is contracted, whereas Energy Performance Contracting aims at reducing energy consumption on the demand side, setting energy efficiency measures. (Grazer Energieagentur, 2009).

Use-oriented services

In the case of use-oriented services, the user wants to use the product himself but is not interested in owning it. The use of the product is sold and not the product itself, which changes the ownership structure significantly, away from the traditional selling and buying activities. Use-oriented services can be distinguished in individual use and joint use: leasing, renting and hire purchase are forms of individual use, whereas sharing and pooling are forms of joint use. Also different types of payments are possible, e.g. per time unit or per service unit (Halme et al., 2004).

- **Renting**

If a product is rented, the ownership remains with the supplier. A certain product is rented out to someone for a certain period of time, and in most cases, for several

times to different renters. For the supplier this might be an incentive to design and manufacture his product that it can be used intensively and for a long time (Hockerts et al, 1995, cited in Jasch and Hrauda, 2000). To use a product by several users consecutively helps to save resources. Nevertheless, environmental burden due to transport between different users have to be taken into consideration. This can be reduced if renting is organised locally. Concepts that fulfil this are also called “Eco-rent“ (Hockerts et al, 1995, cited in Jasch and Hrauda, 2000).

- **Hire Purchase**

This is a legal term for a special contract where a buyer, instead of paying for a good in one sum, pays a monthly amount plus interest for an agreed period of time. The ownership remains with the seller until the last payment is made and the original sum of the good plus interest is paid.

- **Leasing**

The term “leasing” is not defined consistently in literature. Some authors define leasing as the “leasing or renting of capital assets by financing institutions and other institutions that operate leasing (see Perridon and Steiner, 1999, cited in Marek, 2001), others define leasing as the time-limited licence for movable and immovable investment and consumer goods, regulated by a contract (Büschgen, 1998, cited in Marek, 2001). In all cases, there is a contract between the lessee and the lessor, which might be cancellable or not. The core of leasing is a “benefit-oriented payment”.

Leasing can be seen as a synonym for “not owning”. First evidence for leasing as a “use without ownership of consumer goods” is more than 5,000 years old. The first law that dealt with leasing is from King Hammurabi, known as the “Codex Hammurabi”. Leasing as we know it today can be traced back to 1877, when the Bell Telephone Company used the term “leasing” for the first time. The company did no longer sell their telephones but rented them out. Soon, other companies followed, e.g. the United Shoe Machinery Corporation, which rented out their expensive machinery to little shoe manufacturing and repair shops. At that time, leasing was an economic necessity and operated as a “manufacturer leasing”. These manufacturers made their customers dependent on their service and thus safeguarded patents and monopoles. The main motivation for leasing was to protect licences and to better satisfy the needs and demands of their customers. In the 1940’s, the leasing of cars started to boom, starting again in the US. Due to the quick technological progress equipment became out-dated very quickly, and led to problems in financing new equipment. Leasing became an independent type of business. Leasing developed over the years and was broadened by a larger offer of services and a better marketing of the products (Marek, 2001).

Classical (financial) leasing of cars, machinery etc. is primarily a financing model, where the lessee gets the benefit of a product without acquiring the ownership. Instead of a purchasing price a leasing rate is paid. The differentiation to renting or hire purchase, where the product remains in the ownership of the lessor, is that with leasing, the product – after amortisation through the leasing rates – might be transferred into the ownership of the lessee. In classical leasing there is no technical optimisation, only an “economical improvement” takes place. It also does not lead to a better use of a product in ecological terms and gives no incentives for the lessor to provide long living, repair-friendly or recycling-friendly products

(Behrendt and Pfitzner 1999). On the contrary, it can stimulate even more consumption and more environmental burden due to an easier financing concept.

There also exists “Eco-Leasing”, which is a totally different form of leasing and ecologically more benign as the classical leasing. The term is only used in the case where there is no option for purchase after the end of the leasing contract, if the producer is the lessor himself and if the producer has any kind of re-use or recycling concept in place (Behrendt and Pfitzner 1999).

Nowadays, new sectors for leasing are opened up; besides the leasing of cars, computers and machinery one can lease software, animals, film rights, power supply systems, and also chemicals, just naming a few. It has to be noted, that “leasing” is not used in the context of chemicals in the US. For Stoughton and Votta, 2003, the term „leasing“ implies a transfer of liabilities from manufacturer to supplier that is often not possible in the US regulatory context.

- **Sharing**

Sharing is a common use of one good by more than one person. A good is provided for a certain group of users (e.g. a washing machine in a housing block is normally only to be used by the residents of this building).

- **Pooling**

The difference to sharing is that pooling is the use of *several* goods by *several* users. Examples are car sharing or the shared use of holiday apartments. Sharing and pooling are both examples for a joint use, which “... lead to a more intensive use of fewer products by several consumers” (Behrendt et al. 2003). Joint use often includes a social component (Jasch and Hrauda, 2002).

3.2 The Universe of Product-Service-Systems

Product-Service-Systems (PSS), although still not widely used in industry, have been elaborated in academia a long time ago. In 1994, Schmidt-Bleek et al. wrote about PSS as being “.. known and acknowledged as effective means towards more sustainable production”. And in 1998, Walter Stahel was writing about service economy, where the “economy [..] focuses on the optimisation of the utilisation (or performance) of goods and services.” Also Goedkoop et al. (1999) mentioned that adding services to products to increase the value of it is not new. What was new was the “.. recognition, that the service-based strategy could be a powerful concept towards sustainability” (Goedkop et al., 1999). And Manzini (1998, cited in Goedkoop et al, 1999) put it as being “… about doing sustainable business, which means doing business enabling clients to live better, consuming less.”

The idea behind the concept of Product-Service-Systems is providing the customer not with a product but a service, which is giving away a “product” or better to say a “good” to be used by the customer. The producer or supplier remains the owner of the good and is interested in its longevity and an intensive use. He will also be interested in producing it in a way it can be taken back and be recycled and will therefore contribute to sustainability. There is a great variety of business models for product-service combinations. In a first step, the suppliers often start to offer extra services along with their products. The next step is to sell the use of the product while still having the ownership.

The main idea behind PSS is that the profit of both the supplier and customer are coupled primarily to the quantity and quality of services delivered and not to the volume or quantity of products being sold. Reasons for shifting to PSS are manifold, there are marketing, technical, environmental, economic or regulatory reasons but also the aim to differentiate from competitors and to open up new markets (Mont, 2002; Hrauda and Jasch, 2002; Halme et al., 2004).

Heiskanen & Jalas (2000) see PSS as part of a wider structural change. They summarise this change as the "explicitly political, macro-economic programme (e.g. Jokinen and Koskinen, 1997) aiming to speed up the shift from an economy based on heavy process industries and intensive energy use to an information-intensive and service-intensive society". To get there, an optimization of production and consumption patterns is essential. "Not the product itself is essential but the need it satisfies" (Singhal, 2003). So addressing the satisfaction of needs instead of focusing on products can reduce the material demand.

Not always do PSS deliver sustainability benefits but "... PSS thinking can create novel concepts for more sustainable solutions" (Charter and Clark, 2007). A major point of this change is dematerialisation, which "… can be interpreted as leaning of the material content of products" (Singhal, 2003).

"Product-Service combinations are not new. What is new is the notion that product-service combinations may prove to be an important business model to help to reach a more sustainability level of business according to the triple bottom line through:

- reduction of material and energy input, toxic emissions and waste (Planet);
- better health and safety conditions in companies (People);
- and more industrial competitiveness (Profit)" (Kortman et al., 2006).

Literature research (e.g. Hrauda and Jasch, 2002; Singhal, 2003; Mont, 2004; Halme et al., 2004) revealed some sources as well as practical examples, which show that Product Service Systems, going beyond business as usual could be a possible solution to reduce resource input and to make production processes more environmentally friendly.

Product-Service-Systems (PSS) have popped up during the last years in various sectors, among them the food sector, housing sector, chemicals, mobility and energy supply, to name a few. They vary in their specific sectorial characteristics but have a lot in common. Some main points about PSS have been collected throughout the Sustainable Innovation conferences hosted from 2003 – 2006 by the Centre for Sustainable Design (Charter and Clark, 2007):

- "Businesses do not use PSS terminology and see it as an academic definition for something that they are already doing! Many companies are developing and implementing PSS as part of "value-added" thinking – but from a business and not a sustainability perspective.
- In many firms it appears that PSS development may not be as integrated, systematic and structured as it could be e.g. those responsible for the development of product component of a PSS often act separately from those responsible for the implementation of the service component of a solution.
- PSSs are not necessarily more sustainable as much depends on the "system design" and impacts are very case dependant. Designing a "unique

system" can also help protect against copying – but if one component of the system does not function then the system may collapse – financially, socially and/or environmentally.

- Thinking in PSS terms will often mean focusing more closely on customer needs and relationships which can lead to improved loyalty and greater probability of repeat purchase. Moving in this direction will require a cultural shift from "product-orientation" to "service- orientation" – which will mean a change in mind-sets amongst various business functions in organisations e.g. from salesmen selling outright purchase of units to selling cash flow over time.
- Opportunities for more sustainable PSS are likely to be industry/need specific but at present there are a lack of successful sustainability-driven cases to learn from
- PSS has a range of benefits but its real strength is that it helps companies to focus on the final need, demand or function and can create novel concepts for more sustainable solutions."

In Box 1, two main initiatives, which were established to bring PSS forward, are described:

Box 1: SusProNet and SCORE!

Within the last years/decade, some initiatives to push PSS were installed. Two of them will be presented here in brief. The information was taken from the websites and other information material on these initiatives.

SusProNet (2002 – 2000)

SusProNet (Sustainable Product. Development Network) was the first European Network on Sustainable Product-Service Development and played a central role in the field of Product-Service-Systems (PSS) design and development. SusProNet was funded under the European Commission's 5th Framework Programme. The network was organized around a core group of 7 scientific institutions (TNO-STB, the TNO/TU Delft Ecodesign Centre Kathalys (NL), VITO (B), econcept (D), CfsD (UK) and INETI (Pt) plus O2, a world-wide representative organization of professionals in EcoDesign and 25 industrial organisations (e.g. AEG, Agfa, Nokia, various SMEs, etc.), several industry associations such as the World Business Council on Sustainable Development (WBCSD), an NGO and a training provider.

Central in the network were industry sector-oriented work groups covering five need areas that aimed at making best practice available and carrying out research.

When industry slowly started to switch from products to services, it became clear that this required an innovative and creative capability of the industry to further develop the concepts in order to combine sustainable development with the ability to compete. However, as the experience in this area were (and are still) very scarce, the EU decided to provide more funding for projects in the field of Product-Service-System (PSS) design and development, within the 5th Framework program.

The purposes of SusProNet were to:

- Exchange, analyse, integrate and make easily available information on “Best Practice” examples of Sustainable Product-Service-Systems, already developed;
- Identify research needs to create an expertise as broad and as consolidated as possible on the Development of Sustainable Product-Service primarily in Europe;
- To contribute to various EU policy objectives, such as e.g. Integrated Product Policy, Sustainable Development, and to increase competition.

The networking process focused on providing a series of industry sector oriented workshops and conferences that aimed at providing best practice examples, in order to form a platform for information and experience exchange, and to develop training courses. By opening up key activities to external experts, the Network acted as virtual organization for an additional 100 professionals in this field. SusProNet provided manuals on the methodology of product-service-systems, facilitated the exchange of expertise and results and organized, along with the EU, a final conference on interchange and dissemination of information for all the projects involved with the development of sustainable Product-Service-Systems.

During project time, three workshops, two conferences and a final dissemination event at the end of the project were held.

The project website www.suspronet.org is no longer available after the end of the project.

SCORE! (2005-2008)

The Network project “Sustainable Consumption Research Exchanges” (SCORE!) acted as one of the EU’s central support structures for the UN 10 Year Framework of Programs for Sustainable Consumption and Production (SCP). In a series of workshops and conferences, the State of the Art in SCP research was analysed, and cases of (radical) sustainable consumption for mobility, agro-food and energy (areas, which cause about 70 to 80% EU’s environmental impact) were promoted.

SCORE! was funded in EU’s 6th Framework Programme and gathered around 200 experts in the field of sustainable innovation and sustainable consumption. “The SCORE! philosophy was that innovation in SCP policy can only be achieved if experts that understand business development, (sustainable) solution design, consumer behaviour and system innovation policy work together in shaping it. Sustainable technology design can be effective only if business can profitably produce the products and consumers are attracted to them. To understand how this might effectively happen, the expertise of systems thinkers must be added to the mix.

The SCORE! experts were working with actors in industry, consumer groups and eco-labelling organisations in the key consumption areas of mobility, food and agriculture, and energy use and housing - responsible for 70% of the life-cycle environmental impacts of Western societies - with the aim of stimulating, fostering or forcing change to SCP theory in practice” (Tukker at al., 2008).

Four books were published under the title „System Innovation for Sustainability“.

The project website is still accessible: http://www.score-network.org/score/score_module/index.php?cat_name=cat_t_sco_home

3.3 PSS in the Chemical Industry

Chemicals are an important part of our daily lives and are used in many processes in one way or the other to provide various functions and to make life easier and more comfortable. Nevertheless, chemical industry has been facing critical concerns due to the impacts of chemicals on human health and the environment through the last decades. As will be shown in chapter 4, the chemical industry started some campaigns to enhance chemicals safety and the reputation of the whole industry sector. A contribution to that was, at least to a small extent, that during the last years a growing interest in Product-Service combinations for the applications of chemicals could be created. There were various projects and events on Chemical Management Services in the US, starting mostly in the mid 1990s, leading also to a crossover in London in 2003 with the (more European) approach of Chemical Leasing. Also in 2003, a thesis was elaborated by Pranshu Singhal on the „Transition to Chemical Management Services. Opportunities, Barriers & Drawbacks in a European Context" at the IIEEE at Lund University (Singhal, 2003). In 2003, an expert inquiry on 36 innovation options carried out by the Institute for Prospective Technological Studies have shown that **Chemical Product-Services (CPS)** could be seen as an important innovation in the chemical industry and promises benefits not only in economic but also in environmental aspects (Singhal, 2003).

Chemical Product-Services can reduce production costs and develop new market niches if they are developed in close cooperation between suppliers and customers. In reducing the use of chemicals and waste streams, ecologic benefits can be gained and costs can be saved.

Various typologies are used to describe the models for Chemical Product-Services. Toffel (2002) distinguishes two types:

- The manufacturer-user models where the supplier manages and applies the material and
- The customer-user models where the customer manages and applies the material.

White, Stoughton and Feng (1999), also propose a classification of Product-Services in two main groups, depending on the ownership of the product:

- "Product extension services" where the customer owns the product and
- "Product function services" where the service provider remains the owner.

Examples for product extension services are warranties, maintenance agreements and IT services, whereas examples for product function services are traditional and non- traditional leasing concepts (White, Stoughton and Feng, 1999).

From December 2004 to October 2005, a research project, funded by the Joint Research Centre of the European Commission was carried out about "Chemical Product-Services in the European Union" (Kortman et al, 2006). The main objective of the study was a comprehensive analysis of the potential of chemical

product-services in both, economic and ecological terms. During the study, the importance of these chemical based models for the European chemicals market was assessed, their possible environmental benefits and their contribution to better competitiveness as well as drivers and barriers were analysed and future markets explored. The study was restricted to business-to-business markets in the EU (Kortman et al., 2006).

Based on the criteria of ownership and liability, two major groups of models for CPS could be recognize, according to Kortman et al. (2006): “CPS-I” and “CPS-II”. The authors distinguish the two models as such:

“In **CPS-I** models chemical products are still sold by volume. In addition, extra services related to the managing of chemicals are also sold on itemized basis or by higher chemical prizes. The customer is responsible for the application of the chemicals in the production. Suppliers can be responsible for certain tasks related to the chemical management, such as inventory, storage, advise, recycling and waste treatment. In CPS-I models suppliers offer expertise to performing chemical management previously handled by the customer. In the contract it is possible to state goals for chemical use reduction. Gains from efficient use of chemicals can contribute to the alignment of supplier and customer’s goals.

In **CPS-II** models, suppliers are responsible for the application of chemicals in certain parts of the production process of the customer. They are paid to meet the “performance needs” of the customer. For example, in the case of a paint supplier who takes over the car painting process in the customer plant: the paint supplier is rewarded on the basis of the number of car painted that fulfils the customer’s performance requirements. Suppliers retain ownership of the chemical and are responsible for the management of the chemicals. Suppliers and customer’s goals related to the volumes of chemicals can be more financially aligned, giving that in this model the quantity of chemical used becomes a cost for the supplier.” (Kortman et al., 2006).

Two widespread models for CPS-I and CPS-II can be found in literature, supported by several case studies:

- Chemical Management Services (CMS) and
- Chemical Leasing (ChL)

There are also other models like shared savings contracts, service contracts, servicing, performance contracts, contracting, Total Care and total gas and chemical management, which are all except the last one rather general and can be used for other services than chemicals as well.

The two main approaches can be distinguished as such:

Chemical Management Services (CMS), representing CPS-I, according to the differentiation above is the term most commonly used in the US for chemical product-services. According to CSP (2004), a CMS is “a strategic, long-term relationship in which a customer contracts with a service supplier to supply and manage the customer’s chemicals and related services”. Under a CMS contract, the supplier gets paid for quantity and quality of the service and not for the volume of chemicals that are sold. (Kortman et al., 2006). The focus of CMS is, according to White, Stoughton and Feng (1999), on “managing chemical procurement, delivery, inspection, inventory, storage, labelling and disposal for industrial customers and seeking for process efficiency improvements.“ “Compensation can

be based on cost savings delivered, not volume sold" (Hopkinson and James, 2001, cited in Kortman et al, 2006). It is assumed that the application of PSS in the chemical sector can provide solutions to various environment, health and safety problems by changing the relationship between the supplier and the customer. If they are willing to cooperate and to realign their incentives, a reduction and better efficiency in chemicals consumption could be achieved (Kortman et al., 2006).

In the US, the Chemical Strategies Partnership (CSP), a project of the Pew Charitable Trusts and Heinz Endowments that promotes CMS, has already documented several cases where savings and reductions of environmental impact have been realized (CSP, 2004). CMS will be explained and analysed in more detail in chapter 5.

The other term and concept is **Chemical Leasing (ChL)**. Jakl (Jakl et al, 2003) defines it as a business model in which "suppliers in fact furnish individual substances in order to render a service, while continuing to be the owner of these substances – which are returned to them and recycled - and also stand by the customers as advisors". Chemical Leasing is therefore representing CPS-II. Jakl et al (2003) identify two main dimensions in Chemical Leasing: "on the one hand, the business transaction is based on the use of the chemical performance [...], and, on the other hand, the change of ownership becomes redundant." Authors like Joas and Schott (in Jakl et al, 2003) conceptualize the aim of Chemical Leasing as "to develop new forms of labour division such that economic and ecological improvements can be generated by focusing on the use of chemicals." Throughout the years, it became clear that the change in ownership (the user becomes the owner of the chemical) is still necessary whenever the chemical goes into the final product, due to liability reasons. This fact, nonetheless has no influence on the effectiveness of the Chemical Leasing model.

In 2003 the concept of Chemical Leasing was presented at a conference in London followed by a presentation in the same year at a conference hosted by OECD, the Austrian Ministry for Agriculture, Forestry, Environment and Waste Management and the Austrian Federal Economic Chamber (OECD, 2003). At this conference, a study on Chemical Leasing as a model for a sustainable material management, funded by the Austrian Ministry for Agriculture, Forestry, Environment and Waste Management was presented. The study was summarized and complemented in the book "Chemikalien-Leasing – Modell für eine nachhaltige Stoffwirtschaft" (Jakl et al, 2003) which built the basis for all following Chemical Leasing activities.

A representative of UNIDO, who was present at the conference, found the concept very interesting and in 2004, UNIDO elaborated the first project document on Chemical Leasing. In 2005, first Chemicals Leasing projects started in Mexico, Russia (St. Petersburg) and Egypt. More on the development of Chemical Leasing under UNIDO can be found in chapter 6.

Chemical Leasing and its implementation in Austria was also subject of a research project "Erfahrungsbericht Chemikalienmanagement - Innovative Ansätze im Chemikalienmanagement" in 2009, realised by the Institut für Ökologische Wirtschaftsforschung (IÖW) and JOANNEUM RESEARCH (Jasch and Kaltenegger, 2009).

3.4 Drivers and Barriers for CPS

"Sustainable business models for chemical consumption must necessarily include intensive interactions between all stakeholders, and a close cooperation that pools on the combined knowledge and experiences of all users/suppliers" (Kortman et al, 2006). This "forced" close collaboration and the change from the selling of products to the selling of Product-Services does not take place without resistance as they imply a more or less radical change in how to do business. In literature and case studies as well, there is evidence on drivers and barriers, which are summarized in this chapter and refer to CSP in general, to CMS as well as to Chemical Leasing.

3.4.1 Drivers

Many authors (White, Stoughton and Feng, 1999; OECD, 2003; CSP, 2004; Jasch et al., 2007) point out that the main drivers for implementing Chemical Product-Services (CPS) are economic reasons: cost savings for customers and an improved market value for suppliers. A reduction in environmental impact is at best a side effect as CPS reduces the use of chemicals simply due to economic reasons.

Without doubt, one of the most important drivers for customers is the possibility to concentrate on their core business, as most companies are experts in other fields than in the management of chemicals. In addition, regulations on chemicals are far more manifold and complex than in any other industrial sector and require a lot of expert knowledge. This encourages customers to outsource chemical operations to experts to be able to concentrate on their core business (OECD, 2003). Getting expertise from the chemical's suppliers, processes are often being improved in their efficiency and the customer can save costs, as the supplier will try to fulfil his tasks with as few chemicals as possible. Depending on the initial situation of the company, cost reductions can be gained in many ways, be it through the need for less storage space, through better organisation of chemical purchase or through the reduction of the amount and numbers of chemicals. (Kortman et al., 2006).

An additional benefit through the closer cooperation between supplier and customer can be gained in terms of substitution of hazardous chemicals by less hazardous ones (Kortman et al., 2006). Other drivers for suppliers might be the chance to get an extra market value, enter and/or create new market niches and a higher loyalty from their customers as they can offer knowledge and expertise. Higher loyalty from the customer's side often goes hand in hand with long-term contracts and the possibility of the suppliers to better understand and consider the needs of their customers.

3.4.2 Barriers

The transition from selling a product to selling a Product-Service-System changes a lot. The most challenging part is finding a new unit of payment: how is the combination of a product and a service to be priced? When chemicals are purchased or sold, they are priced by volume or quantity but pricing a service in combination with a product is a challenging task as the value of the service is not only related to the quantity but also to qualitative aspects, such as responsibility, liability and the quality requirements for processes and products set by the

customer (Kortman et al., 2006). To avoid conflicts in this new type of relationship from the beginning, a good contract, containing responsibilities of all partners and technical and liability specifications is needed (Kortman et al., 2006). Bilateral dependency is another barrier, as the “profitability of each party is highly dependent upon the other’s action” (Toffel, 2002, in Kortman et al., 2006).

Another big issue and a barrier is the lack of visibility of chemical management costs and other costs related to that, like high transaction costs to implement CPS, and operational risks (Kortman et al., 2006). As oddly it sounds, reducing chemical management costs is generally not a customer’s priority or better to say, it is not totally in their influence. The task of the purchase department of the customer is to get chemicals at the best price but people there are in most cases unaware of the real costs of the chemicals, related to storing, handling, recycling, etc. This is because these costs are normally bundled in “overhead accounts” and are not visible (Kortman et al., 2006). The perceived costs of purchasing and managing chemicals are often calculated as less than 1% of operating costs (Kortman et al., 2006). However, studies estimate that the costs of chemical management can range from one to ten times the purchase costs of chemicals (CSP, 2004). In addition to that, many companies believe that they are already doing the best they can and do not see room for any improvements (Kortman et al., 2006).

It is also a fact that customers don’t want to give their suppliers insight into their processes without any good reason. Giving away the own know-how and let people from outside get inside looks at the company’s way of doing business often seems to feel like a loss of control over the process and a dependency on one supplier (White, Stoughton and Feng, 1999).

For suppliers, barriers are investments in equipment, infrastructure and labour costs, internal resistance to change, dependency on the production of customers and a complex legislation (Kortman et al., 2006). If a CPS is not regulated in contracts or based on mutual trust, the supplier can end up in being replaced by another supplier before he has earned his expected return. For the customer the exclusive and close relationship and the insight of the supplier might cause the fear that after a while the supplier sells the know-how he got at that specific customer to other customers as well. This is one of the reasons that justify long-term and sophisticated contracts between supplier and customer.

Table 3-1 gives an overview on drivers and barriers in CPS, the table is taken from Kortman et al. (2006).

Table 3-1: Drivers and barriers for CPS (Kortman et al, 2006)

	Drivers	Barriers
General	Aligned incentives for customers and suppliers	Contracting CPS is more complicated than selling/buying products
	Strong environmental legislation in favour of CPS	Bilateral dependency between customer and producer/supplier
	Better environmental performance	Diversity in standards and administrative procedures in EU countries
	Partnership for innovation between customer and chemical suppliers	Transactional costs
	Health and safety regulatory pressure	Fear of labour conflicts
		Lack of adequate liability allocation
Customer	Concentration on core business	Long-term contract; difficulties to switch to other suppliers
	Efficiency improvement of production	Difficulties of trust of suppliers with confidential process information
	Reduction in production costs	Lack of visibility of total costs of chemical management
	Reduction of chemicals costs	Dependency on supplier
	Reduction of complexity of chemical management	
	Limitation of liability costs	
	Environmental, health and safety advantages	
Supplier	Consolidation of the market	Extra investments for equipment, infrastructure and labour
	Development of new market niches	More fixed costs
	Enhance customers loyalty	Limited scale of chemicals by customers
	More value from their human resources: expertise and know-how	Dependency on the production of the customer
	Survive in the declining markets	Internal resistance of change
	Capture added value from customers	

Key elements and main characteristics of PSS

- The customer pays for the utilisation of a product and a service, the function of the product to satisfy the consumer's needs is essential.
- PSS include intensive interactions between all stakeholders, and a close cooperation that pools the combined knowledge and experiences of all users/suppliers.
- PSS require a cultural shift from "product-orientation" to "service-orientation" and a change in mind-sets.
- This shift does not take place without resistance due to a more or less radical change in how to do business.
- Value is added through technological improvements.
- It requires that property rights remain distributed between client and provider, requiring more interaction over the life time of the PSS
- Different types of payments are possible, e.g. per time unit or per service unit
- profit of both the supplier and customer are coupled primarily to the quantity and quality of services delivered and not to the volume or quantity of a product that is sold.
- Main drivers are economic reasons (saving costs), a reduction in environmental impact is a side effect.
- Processes are often being improved in their efficiency.
- Higher loyalty from customers as suppliers can offer knowledge and expertise, coupled with long-term contracts and the possibility of the suppliers to better understand and consider the needs of their customers.

Chapter 3 tried to give an overview on the universe of Product-Service-Systems (PSS), how this topic developed and how it can be connected to chemicals and the chemical industry. Drivers and barriers of PSS in general were described as well. The main types of Product-Service-Systems in the chemical industry, Chemical Management Services (CMS) and Chemical Leasing (ChL) will be described in more detail later-on.

As in chapter 2, this chapter is also closed by a list of key elements and main characteristics of the topic of this chapter.

4. Chemicals and the link to PSS

This chapter is about some basics of chemicals, some data that undermine the importance and the ubiquity of chemicals in our daily life, it explains some terms and describes initiatives and regulations that should help to keep chemicals and its impacts under control. The chapter ends with a description of the sectors and chemicals that are most promising for the implementation of any kind of Product-Service-Systems in that field.

"Chemicals are an integral part of daily life in today's world, in private households as well as in industry. There is hardly any industry where chemicals are not used and there is no single economic sector where chemicals do not play a role at all" (UNEP, 2013). Through chemicals, millions of people all over the world live a more comfortable and healthier life. Chemicals can cure deadly diseases and safe crops from damage through pests. On the other side, chemicals are also the source of injuries, illness and death. Chemicals are used in many products and manufacturing operations and are therefore "a possible source of risks to human health and safety and the environment, if not managed soundly" (Schwager, Decker and Kaltenegger, 2016).

No one knows the exact number of chemicals used globally, but at least 143,835 chemical substances have been pre-registered under the pre-registration requirement of the European Union's chemicals regulation, REACH (UNEP, 2013). UNEP (2013) also stated in their Global Chemicals Outlook that there is a dramatically growing demand for chemical-based products and processes, which started already back in the 1970s. The global chemical output (produced and shipped) was valued at US $ 171 billion in 1970 and increased to US $ 4.12 trillion in 2012 (UNEP, 2013). This means wealth on the one side but more and more the tolls it takes are visible: climate change, pollution, increasing resource use cannot be ignored and can often be traced back to the (extensive) use of chemicals. Studies are already available that predict a growth in global chemical sales of about 3% per year to 2050 (UNEP, 2013). These studies also reveal that the production as well as the use of chemicals will shift from highly industrialised to developing countries (UNEP, 2013).

From the beginning of the Industrial Revolution, where the production of chemicals became a major industry, until the late 1950ies, the production of chemicals was seen as a high-tech industry (Johnson, 2012). In 1935, DuPont launched their slogan "Better Things for Better Living ... Through Chemistry", which they used until the early 1980ies and which showed that chemistry was seen as "progressive and even cool" (Johnson, 2012). But the reputation of chemistry already started to decline with the publication of Rachel Carson's Silent Spring in 1962, then accelerated with the disaster in Seveso, Italy, in 1976, where a TCP (2,4,6-Trichlorophenol) reactor near Milan, Italy exploded and released a toxic cloud containing TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), a carcinogen, followed by the Bhopal disaster in India, where in 1984, a pesticide plant set free around 32 tons of toxic gases, including methyl isocyanate gas, highly toxic and extremely harmful for humans.

There is a clear interest of society to reduce the total use of chemicals, and to be sure that chemicals are handled and managed in a professional way. A "sound

management of chemicals and wastes" (UNEP, 2013) has the potential to support relevant sustainable development goals. Right after the Seveso incident, the EU launched their "Seveso Directive" in 1982 (Directive 82/501/EEC) which was amended after Bhopal and other disasters, resulting in Seveso-II (Directive 96/82/EC) in 1996 and Seveso-III (Directive 2012/18/EU), aiming "at the prevention of major accidents which involve dangerous substances, and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner" (Directive 96/82/EC)[13]. A variety of other regulations and laws have become effective since for the production, transport, use and disposal of chemicals, the most important being the three chemical and hazardous waste Conventions, the Conventions of Basel, Rotterdam and Stockholm (see chapter 4.1).

What might sound logical and self-evident is, that of course companies and also programs that want to be called "sustainable" have to comply to international and national laws first of all. The most important of these regulations will be described in the following (sub)-chapters in brief.

4.1 Governmental initiatives and regulations

To get chemicals under control, many initiatives by governments as well as from industry have been started during the last decades. National governments and the EU have put in place strict regulations on consumer and environmental protection, occupational health, chemical processes and transport and the management of chemical substances. At an international level, the industry also complies with a number of programmes and conventions.

4.1.1 The Basel Convention

An important step in regulating chemicals was the Basel Convention ("Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal") of 1989[14]. It was one of the first legal instruments to directly target the management of hazardous wastes at the international level. It is a global treaty "that grew out of the need to stop the dumping of hazardous waste by the developed countries in developing countries that were ill-prepared to deal with its impacts" (Lloyd-Smith and Fry, 2007). The primary objective of the Convention, according to the Chemical Conventions Handbook (Lloyd-Smith and Fry, 2007) "is to minimise, with the aim of eliminating, the generation and transboundary movement of hazardous and other wastes and obliges its parties to make sure that such wastes are managed and disposed in an environmentally sound manner. The Convention also aims at preventing illegal trafficking in waste".

"The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is the most comprehensive global environmental agreement on hazardous and other wastes. It has over 160 Parties and aims to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements and disposal of

[13] http://ec.europa.eu/environment/seveso/

[14] http://excops.unep.ch/index.php?option=com_content&view=article&id=71%3Athe-basel-convention&catid=42%3Athe-conventions&Itemid=27&lang=en

hazardous and other wastes" (UNEP, 2010). Environmentally Sound Management (ESM) is a central focus of the Convention, and is addressed primarily through an integrated life cycle approach that aims to control hazardous wastes from generation through to storage, transport, treatment, reuse, recycling, recovery and final disposal.

The Basel Convention entered into force in 1992, and the United Nations Environment Programme (UNEP) administers the secretariat.

4.1.2 The Rotterdam Convention

The Rotterdam Convention (formally, the "Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade") was established in 1998 in order to monitor and control the trade in certain hazardous chemicals[15] (UNEP and FAO, 2008). It is a multilateral agreement that promotes shared responsibilities in the international trade of certain hazardous chemicals and to contribute to the environmentally sound use of those chemicals by facilitating exchange of information about their characteristics (UNEP and FAO, 2008). This shall enable importing parties to decide which chemicals they are able to handle properly and to refuse those they cannot manage safely. Exporters of hazardous chemicals are requested to use proper labelling, provide directions on safe handling, and inform their clients about restrictions or bans.

"The Convention creates legally binding obligations for the implementation of the Prior Informed Consent (PIC) procedure"[16]. "The PIC procedure is a mechanism for formally obtaining and disseminating the decisions of importing parties as to whether they wish to receive future shipments of those chemicals listed in Annex III of the Convention and for ensuring compliance with these decisions by exporting Parties" (UNEP and FAO, 2008). This includes a mutual information exchange of all issues regarding the trade of hazardous chemicals. The Rotterdam Convention entered into force in 2004.

The United Nations Environment Programme (UNEP) and the Food and Agriculture Organization of the United Nations (FAO) administer the Secretariat of the Rotterdam Convention.

4.1.3 The Stockholm Convention

The "Stockholm Convention on Persistent Organic Pollutants" is the most significant global legally binding instrument for targeting Persistent Organic Pollutants (POPs), to protect human health and the environment[17]. In implementing the Convention, governments have to take measures to eliminate or at least reduce the release of POPs – especially the "Dirty Dozen", the twelve worst ones - into the environment. Over 150 countries signed the Convention and it entered into force on 17 May 2004. "It sets up a system for tackling additional chemicals identified as unacceptably hazardous". The Stockholm Convention has

[15] http://www.pic.int/Portals/5/ResourceKit/A_General%20information/b.Overview/OVERVIEW_En09.pdf
[16] http://www.pic.int/TheConvention/Overview/tabid/1044/language/en-US/Default.aspx
[17] http://www.unido.org/en/what-we-do/environment/capacity-building-for-the-implementation-of-multilateral-environmental-agreements/the-stockholm-convention.html

five essential aims:

- “Eliminate dangerous POPs, starting with the 12 worst
- Support the transition to safer alternatives
- Target additional POPs for action
- Clean-up old stockpiles and equipment containing POPs
- Work together for a POPs-free future”[18]

Box 2: Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants (POPs) are organic (carbon-based) chemicals that persist in the environment, bio-accumulate through the food web, and bear the risk to have adverse effects to human health and the environment. “They are among the most hazardous compounds ever synthesized” (WHO, 2010).

POPs are components of pesticides and industrial chemicals and by-products of manufacturing processes and waste incineration. During the 20th century, POPs were “used for beneficial purposes such as increasing crop yields and killing unwanted pests and other vectors” (WHO, 2010). POPs are ubiquitous and remain in the environmental for a very long time. “POPs have low water solubility and high fat solubility and thus accumulate in fatty tissues of living organisms. POPs are transported in the environment in low concentrations by movement of fresh and marine waters. They are semi-volatile, enabling them to move long distances in the atmosphere, resulting in widespread distribution across the earth, including regions where they have never been used. Thus, humans and animals around the world are exposed to POPs at low levels for extended periods of time” (WHO, 2010).

Cancer, damages to the nervous system, reproductive disorders, or a disruption of the immune system are just a few of the well-known adverse health effects of exposure to high levels of POPs (WHO, 2010). POPs also have potential significant impacts on the environment.

Initially, twelve POPs have been recognized causing these effect and they were placed in 3 categories, some chemicals in more than one category, like hexachlorobenzene (3 categories) and Polychlorinated biphenyls (2 categories).

<u>Pesticides</u>

- Aldrin
- Chlordane
- p,p'-Dichlorodiphenyltrichloroethane (DDT)
- Dieldrin
- Endrin
- Heptachlor
- Hexachlorobenzene (HCB)

[18] https://www.unido.org/what-we-do/environment/capacity-building-for-the-implementation-of-multilateral-environmental-agreements/the-stockholm-convention.html

- Mirex
- Toxaphene

Industrial chemicals

- Polychlorinated biphenyls (PCBs)
- Hexachlorobenzene (HCB)

By-products

- Polychlorinated dibenzo-p-dioxins
- Polychlorinated dibenzofurans (PCDD/PCDF)
- Polychlorinated biphenyls (PCBs)
- Hexachlorobenzene (HCB)

From May 2009 onwards, in every meeting of the Conference of the Parties, amendments to the list were added. More information can be found at: http://chm.pops.int/TheConvention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx

The organisation of the Stockholm Convention was coordinated by UNEP, the Global Environmental Facility (GEF)[19] is the designated interim financial mechanism. GEF addresses global environmental issues while supporting national sustainable development initiatives. Being an independently operating financial organization, GEF provides grants for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.

4.1.4 Globally Harmonized System (GHS)

The "Globally Harmonized System of Classification and Labelling of Chemicals" (GHS) replaces various classification and labelling standards that were in place worldwide and initiates consistent criteria for classification and labelling on a global level (Cefic Website)[20]. Put in place in 2003, the main aim of GHS is to reach a better protection of human health and the environment during handling, transport and use of chemicals. "The classification of chemicals is based on their level of hazard. This harmonisation facilitates trade by increasing consistency between national laws that have different requirements when it comes to hazard" (Cefic Website).

4.1.5 IOMC and SAICM

Established already back in 1995, "the Inter-Organisational Program for the Sound

[19] https://www.thegef.org/about-us
[20] http://www.cefic.org/Regulatory-Framework/Governmental-Initiatives-and-Regulations1/Globally-Harmonized-System-of-Classification-and-Labeling-of-Chemicals-GHS/

Management (IOMC) was founded to strengthen cooperation and increase coordination in the field of chemical safety" (WHO Website)[21]. IOMC is the mechanism with which the WSSD (World Summit on Sustainable Development) 2020 goals for the sound management of chemicals shall be achieved by initiating and facilitation international actions. Among the 9 participating organisations are FAO, UNDP, UNIDO and WHO, which is the administering organization for the IOMC and provides secretariat services to the Inter-Organisation Coordination Committee (IOCC).

Adopted at the International Conference on Chemicals Management (ICCM) on 6 February 2006 in Dubai, United Arab Emirates, the Strategic Approach to International Chemicals Management (SAICM)[22] is a policy framework to foster the sound management of chemicals and to promote chemicals safety. In the Dubai Declaration on International Chemicals Management it was stated that: .. "the Sound Management of Chemicals is essential if we are to achieve sustainable development, including the eradication of poverty and disease, the improvement of human health and the environment and the elevation and maintenance of the standard of living in countries at all levels of development." (UNEP, 2006).

SAICM supports to achieve the goal that was agreed at the 2002 Johannesburg World Summit on Sustainable Development: to ensure that, by the year 2020, "chemicals will be produced and used in ways that minimize significant adverse impacts on human health and the environment." (WHO Website). SAICM is an example for an important multilateral environment agreement as the steering committee of SAICM consists of large international organisations, including the World Bank, the Inter-Organisational Program for the Sound Management of Chemicals (IOMC) and The United Nations Development Program (UNEP), who also administers SAICM.

4.1.6 The Marrakech Process and Sustainable Consumption and Production

The Marrakech Process (UNEP Website)[23] was a global multi-stakeholder process, started in 2003, led by UNEP and UN DESA (The UN Department of Economic and Social Affairs) to support the implementation of Sustainable Consumption and Production (SCP) and to elaborate a 10-years framework of programs on SCP. "The process responds to the call of the World Summit on Sustainable Development (WSSD) Johannesburg Plan of Implementation to support regional and national initiatives to accelerate the shift towards SCP patterns, thus de-linking economic growth from environmental degradation" (UNEP Website). The main goals of SCP are to "promote sustainable consumption and production by addressing social and economic development within the carrying capacity of ecosystems and decoupling economic growth from environmental degradation"[24].

[21] http://www.who.int/iomc/en/
[22] http://www.saicm.org
[23] http://www.unep.fr/scp/marrakech/pdf/MP%20Flyer%2019.02.10%20Final.pdf
[24] http://www.cefic.org/Regulatory-Framework/Governmental-Initiatives-and-Regulations1/Sustainable-Consumption-and-Production-SCP/

In 2008, the European Commission presented an European SCP Action Plan (EU Website)[25], which includes various proposals on how to implement SCP. The Action Plan seeks to help European industry take advantage of opportunities for innovation. This SCP Action Plan in Europe is based on two key pillars; Integrated Product Policy (IPP) and Green Public Procurement (GPP). Integrated Product Policy (IPP) aims to reduce the environmental impact of products. To do so, it seeks to influence every stage of a products' life cycle. Green Public Procurement (GPP) urges public purchasers to take account of environmental factors when buying products or services. GPP is "a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life-cycle when compared to goods, services and works with the same primary function that would otherwise be procured" (COM, 2008). Both principles are also valid for the purchase and use of chemicals.

4.1.7 REACH

REACH is the Regulation on **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emicals. It entered into force on 1st June 2007. It streamlines and improves the former legislative framework on chemicals of the European Union (EU)[26]. "The main aims of REACH are to ensure a high level of protection of human health and the environment from the risks that can be posed by chemicals, the promotion of alternative test methods, the free circulation of substances on the internal market and enhancing competitiveness and innovation" (EU Website)[27]. Under REACH, all companies that produce chemical substances of more than one ton per year in the European Union or import them are required to register these substances with the European Chemicals Agency (ECHA). "REACH makes industry responsible for assessing and managing the risks posed by chemicals and providing appropriate safety information to their users. In parallel, the European Union can take additional measures on highly dangerous substances, where there is a need for complementing action at EU level (EU Press Release, 2010)[28]. This regulation will also contribute to fulfilment of the Strategic Approach to International Chemical Management (SAICM) adopted on 6 February 2006 in Dubai.

The main steps and processes of REACH are in brief (more information can be obtained from the ECHA Website: https://echa.europa.eu/regulations/reach):

- **Registration**

Manufacturers and importers of chemical substances larger than (or equal to) one ton per year, will have to obtain information on the physicochemical, health and environmental properties of their substances and use it to determine how these substances can be used safely. A registration dossier, documenting the data and assessments of every substance, has to be submitted to ECHA, the European Chemical Agency.

[25] http://ec.europa.eu/environment/eussd/escp_en.htm
[26] http://ec.europa.eu/environment/chemicals/reach/reach_en.htm
[27] https://ec.europa.eu/growth/sectors/chemicals/reach_de
[28] http://europa.eu/rapid/press-release_IP-10-1632_en.htm?locale=en

- **Evaluation**

“ECHA, together with the member states, will evaluate the testing proposals by the registrant and check if the registration dossiers comply with the requirements. They will also clarify “if a given substance constitutes a risk to human health or the environment“(ECHA Website).

- **Authorisation**

“The authorisation procedure aims to assure that the risks from Substances of Very High Concern are properly controlled and that these substances are progressively replaced by suitable alternatives while ensuring the good functioning of the EU internal market” (ECHA Website).

- **Restrictions**

“Restrictions are a tool to protect human health and the environment from unacceptable risks posed by chemicals. Restrictions may limit or ban the manufacture, placing on the market or use of a substance“ (ECHA Website).

Communication along the supply chain is guaranteed as the suppliers of substances must pass on information on the health, safety and environmental properties and safe use of their chemicals to their downstream users (via a Safety Data Sheet or other means). Downstream users may only use dangerous substances if they apply risk management measures that were identified on the basis of exposure scenarios for their use. So REACH puts responsibility on all members of the supply chain and asks for intensive communication along the supply chain.

REACH is the most comprehensive and stringent European chemical legislation to date. Although the legislation has come into force already some years ago, it will probably not be fully implemented until the end of this decade, due to the huge amount of chemicals used in Europe.

4.2 Voluntary (Industrial) Initiatives and other approaches

The chemical industry has set up some voluntary initiatives to enhance chemicals safety, among them the Responsible Care® Global Charter, the Global Product Strategy (GPS), the Long-range Research Initiative (LRI) and the SusChem platform. In the following sub-chapters, the Responsible Care Initiative and the SusChem platform will be described in brief.

4.2.1 Responsible Care

„Responsible Care” is one of many industry sector responses to sustainability issues. The chemical sector was the first to provide a coordinated view already in 1985. It was an attempt to restore trust in the chemical industry, after several serious accidents like Bhopal. Responsible Care is a voluntary initiative, started in Canada. It is now active in nearly 60 countries all over the world, under the umbrella of the International Council of Chemical Associations (ICCA).

Figure 4-1: Source: http://www.cefic.org/Responsible-Care/

"Responsible Care commits companies, national chemical industry associations and their partners to (Cefic Website)[29]:

- Continuously improve the environmental, health, safety and security knowledge and performance of our technologies, processes and products over their life cycles so as to avoid harm to people and the environment.
- Use resources efficiently and minimise waste.
- Report openly on performance, achievements and shortcomings.
- Listen, engage and work with people to understand and address their concerns and expectations.
- Cooperate with governments and organisations in the development and implementation of effective regulations and standards, and to meet or go beyond them.
- Provide help and advice to foster the responsible management of chemicals by all those who manage and use them along the product chain" (Cefic Website).

4.2.2 SusChem

The European Technology Platform for Sustainable Chemistry (SusChem)[30], also an industry driven approach, brings together a broad spectrum of organisations and individuals looking to foster sustainable chemistry, industrial biotechnology and chemical engineering research, development and innovation in Europe (see also chapter 4.3). This is done with the goal to build up a supportive environment for innovation, research and society. SusChem was founded in 2004 by six European bodies representing the main stakeholders from academia and industry in the sector, among them Cefic, the European Chemical Industry Council, and DECHEMA e.V., the German Society for Chemical Engineering and Biotechnology, with financial and consultative support from the European Commission.

Strategic priorities for SusChem are sustainability and competitiveness, as the chemical industry sees itself as a vital part of the transition to a more sustainable development.

The Organisation of Economic Cooperation and Development (OECD) has also established a web-based Sustainable Chemistry Platform[31] „..to serve as a networking resource and a place to disseminate information about workshops, training courses, and other capacity building opportunities" which is not to be mixed up with the SusChem platform.

[29] http://www.cefic.org/Responsible-Care/
[30] http://www.suschem.org
[31] http://www.oecd.org/env_sustainablechemistry_platform/

4.3 Sustainable Chemistry

Sustainable Chemistry has been defined differently by different institutions:

The **Organisation for Economic Cooperation and Development (OECD)**[32] defines sustainable chemistry as: "... a scientific concept that seeks to improve the efficiency with which natural resources are used to meet human needs for chemical products and services. Sustainable chemistry encompasses the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes. Sustainable chemistry is also a process that stimulates innovation across all sectors to design and discover new chemicals, production processes, and product stewardship practices that will provide increased performance and increased value while meeting the goals of protecting and enhancing human health and the environment. Sustainable chemistry encompasses the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes. Within the broad framework of sustainable development, government, academia and industry should strive to maximise resource efficiency through activities such as energy and non-renewable resource conservation, risk minimisation, pollution prevention, minimisation of waste at all stages of a product life-cycle and the development of products that are durable and can be reused and recycled. Sustainable chemistry is also a process that stimulates innovation across all sectors to design and discover new chemicals, production processes, and product stewardship practices that will provide increased performance and increased value while meeting the goals of protecting and enhancing human health and the environment." (OECD, website)

SusChem, the **European Technology Platform for Sustainable Chemistry,** says that „essentially, sustainable chemistry is about doing more with less: reducing the environmental impact of processes and products, optimizing the use of finite resources and minimizing waste. Sustainable chemistry can ensure eco-efficiency in everything we do, both individually and as a society. Sustainable chemistry also means protecting and extending employment, expertise and quality of life. It provides a sustainable basis for the innovation needed to stimulate a competitive, knowledge-based, enterprise-led economy across Europe. But solutions provided by sustainable chemistry must also be acceptable to society: they must be trusted and designed according to what society wants and needs and they must be economically sound" (SusChem Website)[33].

In Germany, the concept of Sustainable Chemistry was defined in 2012 by the **Federal Environment Agency** (UBA, website)[34]: "[the] concept of sustainable chemistry [that] exists to link preventative protection of the environment and health with an innovative economic strategy that will also result in more jobs. Sustainable Chemistry is a broad-ranging area that concerns stakeholders in the scientific community, the economy, public authorities, and environmental and consumer advocate associations". In their approaches and objective, they also refer to the twelve principles of "Green Chemistry" by Anastas und Warner (Anastas and

[32] http://www.oecd.org/chemicalsafety/risk-management/sustainablechemistry.htm

[33] http://www.suschem.org/about-suschem/vision-and-mission-sustainable-chemistry.aspx

[34] http://www.umweltbundesamt.de/en/topics/chemicals/chemicals-management/sustainable-chemistry#textpart-1

Warner 1998) (see the following chapter 4.4). “Sustainable Chemistry (SC) is the part of chemistry which is essential to a sustainable society with a view to product design, manufacturing, consumption of resources, health and safety at work, economic success and technical innovation – not only in industrialized nations but in emerging and developing countries too. SC thus extends far beyond the application of ecological principles in chemical production” (UBA Website).

According to the definition by UBA, Sustainable Chemistry focuses on:

- “Qualitative development: Use of non-hazardous substances or – in cases where this is not possible – of substances which are less hazardous for man and environment as well as resource-friendly manufacture of durable and recyclable products.
- Quantitative development: Reduction of consumption of resources; use as far as possible of renewable resources; avoidance of emissions or discharges of chemicals or hazardous substances into the environment or – where this is not possible – corresponding reduction; these measures additionally help to save costs.
- Comprehensive life cycle assessment: Analysis of raw material extraction, manufacture, further processing, use and disposal of chemicals and products in order to lower resource and energy consumption and avoid hazardous substances.
- Action and not reaction: Avoid in advance that chemicals endanger the environment and human health during their life cycle and overburden the environment as source and sink; avoidance of damage costs and thus of economic risk for enterprises and clean-up costs for the state.
- Business innovation: Chemicals, products and manufacturing methods developed in line with the requirements of sustainability create trust amongst industrial users and private consumers and thus lever a competitive advantage” (UBA website).

In 2016, the International Sustainable Chemistry Collaborative Centre” (ISC3)[35] was established, an institution that „wants to support the global breakthrough of Sustainable Chemistry“ but which is still under construction.

4.4 Green Chemistry

The definition of Green Chemistry is, according to the American Chemical Society[36] “.... the design, development, and implementation of chemical products and processes to reduce or eliminate the use and generation of substances hazardous to human health and the environment” (ACS Website).

The concept of greening chemistry is a relatively new idea that developed in the mid-20th century. Green Chemistry is going one step further then regulating the generation and disposal of industrial wastes and emissions: Green Chemistry tries to design chemicals, chemical processes and commercial products in a way that, at the very last, avoids the creation of toxics and waste.

[35] https://isc3.org
[36] https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html?_ga=1.179270244.1950909121.1489399434

In the early 1990's, Paul Anastas, who was then the chief of the Industrial Chemistry Branch at the Environmental Protection Agency (EPA) in the United States, moved forward the concept of Green Chemistry. He, together with John Warner developed the 12 Principles of Green Chemistry, a framework to support pollution prevention when inventing new chemicals and materials (Anastas and Warner, 1998). The 12 principles are:

1. "Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Less Hazardous Chemical Synthesis: Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Designing Safer Chemicals: Chemical products should be designed to affect their desired function while minimizing their toxicity.
5. Safer Solvents and Auxiliaries: The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. Design for Energy Efficiency: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. Use of Renewable Feedstock: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce Derivatives: Unnecessary derivatisation (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Design for Degradation: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. Real-time analysis for Pollution Prevention: Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. Inherently Safer Chemistry for Accident Prevention: Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires" (Anastas and Warner, 1998).

In 2007, John Warner and Jim Babcock founded the first company completely dedicated to developing Green Chemistry Technologies, the Warner Babcock

Institute for Green Chemistry[37]. The mission of this institute is to develop non-toxic, environmentally benign, and sustainable technological solutions for society.

Paul Anastas said in December 2014 at the Chemical Leasing conference in Vienna: “Green Chemistry is chemistry for sustainability, it is chemistry for people, prosperity and planet and it is about chemical design for environmental, economic and societal benefit.”

4.5 Sectors and Chemicals relevant for CPS

Chemicals in our modern world provide a broad variety of services; they are used in manifold industrial sectors. Chemicals’ services range from cleaning and coating to colouring and greasing/decreasing and many other applications.

Chemical Product-Services (CPS) could be detected in several sectors with different chemicals. In the following, a short overview on the most important chemicals and sectors where Chemical Product-Services have already been (or could be) applied is given. What all of these chemicals have in common is that they are operation materials and supplies, not interfering with the core process of a company.

Adhesives

“Adhesives” is a general term for numerous products - also known as glue, cement, paste or mucilage - which bind together the surfaces of two materials. A classification can be made based on the adhesive’s main substance, its processing, its use or its delivery form (Amecke, 1987). Adhesives can be of natural or synthetic origin.

Adhesives offer many advantages over other binding techniques like screwing or sewing, like the ability to bind different materials together or the cost effectiveness of an easily mechanized process. Numerous ways of applications (especially of synthetic adhesives) came up since the last century and innovation in this field still continues.

The importance (also in economic terms) is not to be underestimated as adhesives have entered an increasing number of production processes and products. The application spectrum is manifold: adhesives used in CPS models can be typically found in automotive industry, printing industry, machine and electrical equipment industry, metal product parts, paper, cardboard and publishing industry (e.g. bottle labels, prefabricated parts in automotive or aeronautics industry, bonding of boxes or profiles in window frames).

Solvents

Solvents can be inorganic or (in most cases) organic liquids that have the ability to solve other substances, without changing themselves or the dissolved substance in its chemical composition (Amecke, 1987). One of the most multi-purpose solvents is water. The application spectrum in chemical industry is manifold. Solvents are primarily used as medium for chemical reactions, for purification and cleaning processes, in the cosmetics industry and for pesticides. Outside the chemical industry, solvents are used in dry cleaning (e.g. tetrachloroethylene), as paint thinners, (e.g. toluene turpentine), as glue solvents (acetone, methyl acetate,

[37] http://www.warnerbabcock.com

ethyl acetate) and in detergents (e.g. citrus terpenes). Inorganic solvents (other than water) are primarily used in chemistry research and some specific technological processes. Typical sectors where solvents are used in PSS models are the automotive, printing, machine and electrical equipment industry, metal product parts and petrochemical industry.

Solvents are worth special attention due to their potential hazardousness to health and environment. The use of very hazardous substances as benzene has been restricted, in other applications as dry cleaning or the degreasing of metal parts, solvents are not released in the environment anymore but recycled with activated carbon filters. In addition, recycling of solvents has also become economically reasonable. All this makes the implementation of PSS models appear promising.

Exact numbers of sales or consumption are hard to get, as most of the products are not only used as solvents; only for the US market, numbers are published in specific sector reports.

Paints/Coatings

Paints and coatings are industrial products, most commonly used to protect and/or colour different objects. Paints are one of the most interesting product groups in chemical industry, with a broad variety in chemistry and high economic importance (Amecke, 1987).

The most important sector in which CPS has been applied since many years in painting processes is the automotive industry. It started back in the 1980's at General Motors in the USA as part of its outsourcing strategy to reduce costs and gain value through the supplier's chain under a view of life cycle of the product. In that case, the main motivation for implementing CPS (under the name Chemical Management Services – CMS) was related to economic competitiveness: reducing the costs for material and energy, for administration and logistics, and waste management (Kortman et al., 2006). Environmental issues gained more importance during the 1990's and CMS became also a tool for reducing environmental impacts by reducing material and energy consumption and wastes (Knoblock, 2005; Kortman et al., 2006). From information obtained from expert judgments, between the 40 to 70% of painting processes in automotive industry are serviced. An expert (Benson, 2005, cited in Kortman et al., 2006) estimates that in aeronautics and aerospace industries, 30% to 45% of the companies have CPS schemes for painting in place.

Another sector where CPS models on paints (especially Chemical Leasing) were detected are the textile industry (dyes) and the printing sector (inks).

Agrochemicals

The term „agrochemicals" (or agricultural chemicals) summarizes various chemical products that are used in agriculture to protect plants from insects, fungi, pests, rodents, or nematodes. Also synthetic fertilizers, hormones or other chemical growth agents may be named in that group (Amecke, 1987). Chlorinated products have been the most important representatives of this group for a long time but have become more and more condemned due to their toxicity and the environmental problems they cause. Especially p,p'-Dichlorodiphenyltrichloroethane, also known as DDT has gained lots of publicity due to its impacts on human health and the environment (see also chapter 2). But also Aldrin, Chlordane and Dieldrin (all of them POPs) are critical.

In many countries, especially in developing countries and countries in transition, „agriculture is the largest economic sector, and accounts for the most significant releases of chemicals in the economy. Agriculture chemicals are among some of the largest volume uses of chemicals worldwide. World consumption of fertilizers is estimated to grow 2.6% per year in the period 2010 to 2014" (UNEP, 2013).

Agriculture requires large capital investments in machinery but also in chemicals and needs some expertise to use these chemicals in a safe and efficient way. This created a number of commercial service opportunities for downstream suppliers of agrochemicals products, especially in the field of Integrated Pest Management. These services do not explicitly attempt to reduce environmental impacts, although they may increase economic efficiency through better use of equipment and chemicals.

In the US, a move towards company-farmer "service contracts" has already been made. "Service contracts are seen as a mechanism that can stimulate farmers to apply best practices that allow the reduction of the use of agrochemicals" (Kortman et al., 2006). The company guarantees a certain performance of the crop concerning quantity and quality and in turn specifies the responsibilities and tasks of the farmer, noted in a detailed contract. A close cooperation between the farmer and the company, especially throughout the growing period, is the basis for success (Vorley, 1998).

Industrial gases

Industrial gases like specialty gases and carrier gases are used in the semiconductor industry and are often servicized. For Chemical Product Services in this industry, the term TGCM (Total Gas and Chemical Management) is often used. These activities cover more or less the whole chemical life cycle, including inventory, the whole management of the chemicals, distribution, tracking, maintenance and waste management and the operation and maintenance of gas abatement systems (Kortman et al., 2006).

Lubricants

Lubricants are substances that are mainly used to reduce friction between moving surfaces and are often servicized in the automotive sector. Different contract models are in use like management fee models, unit pricing models, and shared cost savings models (Kortman et al., 2006). Examples for the implementation of CPS (especially Chemical Leasing) models with lubricants are also known in sugar mills or in the beverage industry.

Water and waste-treatment chemicals

Water treatment is needed for fresh/drinking water as well as for wastewater, with different kinds of chemicals. Especially for Chemical Leasing, applications could be found in both areas in different countries. The most common disinfection method for fresh/drinking water involves some form of chlorine (liquid or gaseous) or its compounds such as chloramine chlorine dioxide. Instead of using the toxic gas, sodium chloride (releasing chlorine when in contact with water) can also be used, which is a rather save and inexpensive method. All forms of chlorine react with natural organic compounds in the water and create potentially harmful chemical by-products, like trihalomethanes, which are carcinogenic.

Wastewater treatment includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Wastewater treatment is a complex, multi-stage process (including sedimentation, filtration, disinfection, etc.), which will not be explained here any further. From a chemicals point of view, the part of disinfection is the most interesting one (also with regards to the implementation of PSS models). Common disinfections methods include ozone, ultraviolet light as well as chlorine and sodium hypochlorite as in the disinfection of drinking water.

Tanners

Tanning chemical are used in the leather industry to treat the skin of animals. Several CPS have evolved during the last years in several countries that are part of UNIDO's National Cleaner Production network, including Morocco and Peru.

Table 4-1 gives an overview of chemicals and sectors where Chemical Product-Services were implemented.

Table 4-1: Chemicals and sectors for CPS implementations

Chemicals	Sectors
Adhesives	Automotive, printing industry, machine and electrical equipment, metal parts, paper and cardboard industry
Solvents	Automotive industry, machine and electrical equipment, metal parts, dry cleaning of textiles, printing
Paints/Coatings	Automotive, metal parts, leather industry (coating), paper and cardboard industry
Agrochemicals	Farming, wine growing
Industrial gases	Automotive, printing industry, machine and electrical equipment, metal parts
Inks (in Printing)	Paper and cardboard industry
Lubricants	Automotive, metal parts, leather industry, sugar mills
Tanners	Leather industry
Water treatment chemicals	Automotive, metal parts, paper and cardboard industry

Chemicals are used in many industrial processes but in most of them they are not the core processes of a company and not always highly qualified people do handle chemicals.

Case studies for different chemicals and sectors have appeared here and there but according to Kortman et al., 2006, "… solid facts to support the claim that CPS can lead to the enhancement of the environmental performance of companies and their competitiveness are scarce". Nevertheless, there is evidence of successful case studies in CMS as well as in Chemical Leasing; some of the most interesting cases will be presented in chapter 5 on CMS and in chapter 7 on UNIDO's Chemical Leasing model.

Key elements and terms

- Compliance with international regulation and Conventions, like the Basel Convention, the Rotterdam Convention and the Stockholm Convention is a must.

REACH

- makes industry responsible for assessing and managing the risks posed by chemicals and providing appropriate safety information to their users.
- REACH puts responsibility on all members of the supply chain and asks for intensive communication along the supply chain.

Sustainable Chemistry

- a scientific concept, seeking to improve efficiency of natural resources.
- stimulates innovation across all sectors to design and discover new chemicals
- aims at protecting and enhancing human health and the environment
- doing more with less: reducing the environmental impact of processes and products, optimizing the use of finite resources and minimizing waste.
- provides a sustainable basis to stimulate a competitive, knowledge-based, enterprise-led economy across Europe.
- Sustainable Chemistry is a broad-ranging area that concerns stakeholders in the scientific community, the economy, public authorities, and environmental and consumer advocate associations.
- Use of non-hazardous substances or substances which are less hazardous for man and environment as well as resource-friendly manufacture of durable and recyclable products.
- Reduction of consumption of resources and saving costs.
- Comprehensive life cycle assessment.
- Business innovation.

Green Chemistry

- Based on prevention and precaution.
- Design for energy efficiency.
- Design of safer chemicals.

Chapter 4 introduced (policy) initiatives, which demand the introduction of safer alternative chemicals (e.g. REACH and Responsible Care) and, on the other side, science-based approaches, aiming at providing scientific solutions that are necessary to achieve those policy initiatives, like Green or Sustainable Chemistry. Another option is to introduce new business models that provide (service) solutions which help to promote knowledge transfer for an efficient use of chemicals and for reducing impacts on the environment and on people's health. These models will be further introduced in the following chapters.

5. Chemical Management Services

This chapter gives an overview of Chemical Management Services as an example for Chemical Product-Services as it is mainly implemented in the United States. It starts with the concept and main ideas of this model, a short historic review, the pre-conditions and the range of a CMS program and continues with the description of different cost models, setting a baseline and the benefits and barriers connected with implementation. It also presents the main players in CMS, some case studies that describe the model and its implementation in more detail. Finally, it summarizes the results of diverse studies and cases and paves the ground for a differentiation to the Chemical Leasing model that will be presented and analysed in the following chapters.

Quantitative and qualitative improvements concerning chemicals have been gained through diverse regulations like the Montreal Protocol, the Stockholm Protocol, and others, through which some of the most critical chemicals have been banned or substituted. Another approach is to reduce the volume of chemical's use, waste streams and emissions, enabling them to remain under the threshold for emissions and/or toxicity control requirements.

A reduction in the use of chemicals that are used in almost all manufacturing operations might be beneficial to manufacturers in both, financial and economic terms. However, traditional business models in chemical industry respectively in companies using chemicals do not provide any incentives to decrease the use of chemicals. The reason is that these models are based on the volume and value of the chemicals sold: "the more you sell the more you earn" (Stoughton and Votta, 2003). It even is the case that buyers can get bigger discounts for buying even more chemicals as the price per unit (kilograms, litres, etc.) goes down the more litres or kilograms are bought.

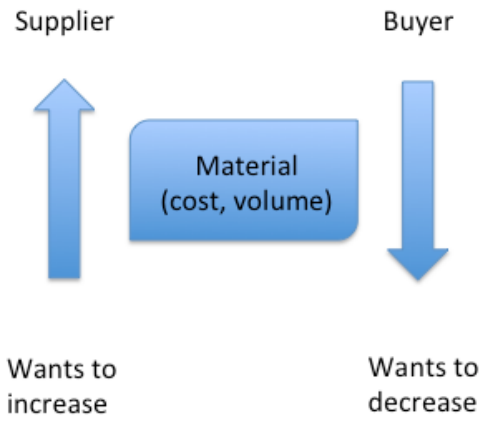

Figure 5-1: Conflicting incentives in the traditional chemical supplier-chemical customer relationship (Stoughton and Votta, 2003)

However, novel business models, bringing a real and radical change in dealing with chemicals, can gain even more optimisation potential, concepts, which make use of chemicals but in which the profit is not linked to the sales volume anymore but to the added value the chemicals create.

Business models according to the idea of Product-Service-Systems have slowly developed during the last years (see also chapter 3.3 on Chemical Product-Services). Suppliers don't sell their products anymore but provide them for different applications, remaining the owners, taking back the chemicals after use and providing also their know-how to the users. In the US, these kind of models in the chemical sector are known under the name "Chemical Management Services" or "Chemical Management Systems". In Austria, the working title "Chemical Leasing" was chosen for this type of business models, knowing fully well that not (only) classical leasing models are the basis for such business models (see Chapter 6).

5.1 Concept and main ideas of Chemical Management Services (CMS)

Not only are the suppliers usually highly interested in increasing the amount of chemicals sold, the responsibility of the supplier ends where the chemical is passed over to the customer. The customer becomes the owner of the chemicals and therefore becomes responsible for use and disposal of the chemicals.

From an environmental and economic point of view, a model where *more* economic gains can be earned by *less* use of chemicals would be preferable. Reducing the use of chemicals clearly could provide significant environmental benefits and contribute to a more sustainable chemical industry. The solution is to decouple volume from profitability and change the way of thinking: the suppliers no longer get paid based on how well they can sell but on how well they can manage their chemicals (Stoughton and Votta, 2003). This transition from selling a product to selling a service can lead to less material use, higher process efficiency, greater margins for the supplier and more cost savings for the manufacturer, and, along the way, comply with the principles of service of functional economy (Stahel, 1998). The producer mainly sells the functions performed by the chemical and functional units or so-called performance-based metrics and fees (e.g. number of pieces cleaned, amount of area coated) are the main basis of payment (e.g. UNIDO, 2016). This Product-Service-System has significant potential for chemicals use reduction and other environmental benefits.

The basic assumption of Chemical Management Services (CMS) is that the real value of a chemical is the function it performs, e.g. lubricating, cleaning, coating, etc. and not the chemical itself. Also, following the PSS approach, it is not the desire of the chemical's user to own the chemical. Stoughton and Votta, 2003 refer to this model as Chemical Management Services and define it as follows:

> *"Chemical Management Services is a business model in which a customer engages with a service provider in a strategic, long-term contract to supply and manage the customer's chemicals and related services."*

Another definition was created by the Chemical Strategy Partnership:

> *"A strategic, long-term relationship in which a customer contracts with a service provider to supply and manage the customer's chemicals and related services. Under a CMS contract, the provider's compensation is tied primarily to quantity and quality of services delivered, not chemical volume. CMS goes beyond invoicing and delivering product to optimizing processes, continuously reducing chemical life cycle costs and risk, and reducing environmental impact."*[38]

This definition was developed with input from leading service providers like Ashland Inc., Haas Cooperation or Quaker Chemical Corporation and most providers and customers in principle agree with this definition, with the remark that this definition describes the "ideal" CMS program. There exist several other, similar definitions and a broad range of services is currently available under the term "CMS".

Based on the experience obtained to date, Chemical Management business models have the greatest success when applied to processes that allow good recycling rates. This includes cleaning, greasing/degreasing, and cooling/heating. Painting operations, where the focus lies on service oriented payments, are also suitable for Chemical Management Services.

The following example is taken from Stoughton and Votta, 2003 and illustrates perfectly the difference between a traditional supplier-customer relationship and the service-based model:

Box 3: Chemical Management Services - an example

An automobile manufacturer needs to paint 100 car doors. Each car door requires about 4 litres of paint. The manufacturer has to purchase 400 litres of paint for these 100 car doors, assuming that there is no wasted inventory (e.g. expired shelf-life), nor application mistake (e.g. over-applied paint), nor unintended over-use (e.g. spills or accidents). The supplier pays 1 US $ for one litre of paint and sells it for 1,25 US $, so the manufacturer pays 500 US $ for the paint, but without taking into account the additional hidden and indirect costs of managing and applying the chemical in his own firm (e.g. costs for inventory, transport on-site, disposal of waste, etc.). The supplier profits 100 US $ from this transaction and has possible additional profits from any problems which results in increased paint use that might occur in the manufacturing company. To maintain its customer's loyalty, the supplier might make occasional suggestion on how to improve process efficiency, but it is not in his interest to see the customer improve the efficiency of the painting process and therefore buying less paint.

[38] http://www.chemicalstrategies.org/implement.php

In a service-based model the example above would look differently: the supplier than would be responsible for delivering painted car doors that meet the car manufacturer's specifications. The manufacturer in that case derives revenues from each car door that leaves the facility and so it is reasonable to compensate the supplier on that basis. If it costs the supplier 4 US $ to paint one door and he receives 5 US $, the supplier still profits 100 US $ as in the example above but the incentives with respect to chemical consumption are completely reversed. Instead of profiting more by increased paint use, he will gain more by decreased paint use: he will be paid 5 US $ no matter if he needs 3, 4 or more litres of paint to achieve the required results. But if the supplier sees a chance to only need 3 litres of paint, he now has an incentive to work with the manufacturer to seek for more efficient ways to apply paint to the car doors (Stougton and Votta, 2003).

CMS can reduce chemical usage by offering chemical solutions instead of chemical products (Bierma and Waterstraat, 1999; Stoughton and Votta, 2003). A crucial element of the CMS model is the external supplier who is an expert for chemicals.

In the service-based model, the supplier has to assure the manufacturer that chemical functions are provided by managing the handling, the use and the disposal of the chemicals in the plant. As the supplier's profits are linked to a better chemical performance, the supplier will do his best to look into opportunities of the entire chemical life cycle to improve efficiency and thus reduce waste. Central to CMS is that it involves optimizing processes of various kinds and a continuous reduction of chemical's life cycle costs and risks.

This model, as all PSS models, is based on a close cooperation between suppliers and users: the suppliers provide their expertise in reducing chemical's use, improving chemical's management and reducing the generation of waste. Together with the supplier the user is therefore able to identify opportunities to improve efficiency and reduce the use of chemicals and production of waste in his own plant. The supplier, on the other hand, can establish competitive advantage by providing these value-added services. It also helps the supplier in establishing long-term strategic relationships with customers and expanding revenues. The aim is to create a mutual beneficial relationship between user and supplier and change the model from "sell more" to "manage better". CMS goes beyond traditional supply chain greening as it redefines the nature of the transaction, not just the nature of the product to drive chemical use and risk reduction. It also goes beyond most "strategic sourcing" initiative, as it is not focused on one-time reductions on unit purchase prices but is focused on continuous improvement based on knowledge and information systems, not just materials management. "It is important to recognise that this is not simply an outsourcing model" (Reiskin et al, 2000). CMS adds resources rather than switching resources. To sum it up, CMS helps to redefine the traditional chemical industry business model by:

- fostering strategic alliances between producers and consumers to reduce the economic, environmental and social costs of using chemicals;
- helping producers and consumers to adopt new ways of working to reduce waste and improve profitability;
- stimulating cost-effective innovation through the development of a Product-Service-System approach.

"As such, CMS leads to significant sustainability benefits for chemical producers, consumers and the public" (Votta, 2003). The most interesting benefit of the model is that it aligns the incentives of the chemical suppliers and their customers for more process efficiency. The essence of this model is the gain-sharing agreement where the savings can be shared to further incentivize both supplier and buyer. These aligned incentives are the source of potential environmental gains and economic savings.

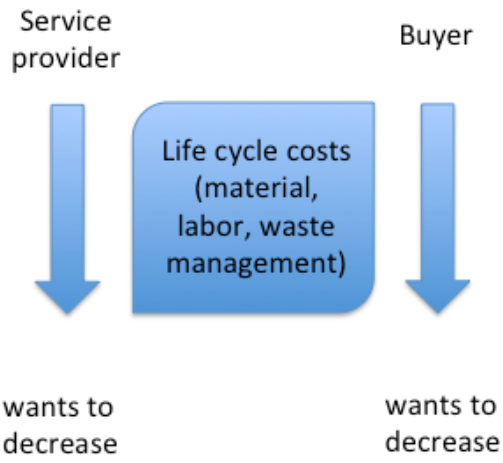

Figure 5-2: Aligned incentives in a "servicized" chemical supply relationship (Stoughton and Votta, 2003)

In 2004, CMS cases could be found in the following eleven sectors (CSP, 2004):

Table 5-1: Industry sectors for CMS applications (CSP, 2004)

Industry sectors for CMS application	
Automotive manufacturing	Electronics
Automotive suppliers	Energy/utilities
Heavy equipment	Steal manufacturing
Aerospace manufacturing	Food/beverage
Air transport maintenance	Research/Laboratory
Miscellaneous manufacturing and others	

5.2 A short history of CMS

Long time before it was scientifically analysed, this new model has been used in US companies, starting in the 1980s and 1990s. Around 30 years ago, General Motors (GM) realised that they had "thousands of individual suppliers providing them tons of thousands of different chemicals" (Kauffman Johnson, 2007). On the one hand they had legal obligations to track their chemicals on their way through their plants, on the other side they had huge financial impacts and risk issues to face due to the amount of chemicals present on their sites. They wanted to gain better control of their chemical throughput and turned to their suppliers to provide a solution. Several suppliers that had been asked started to purchase and manage

GM's chemicals for a fixed price, even agreeing to annual cost reduction goals. This simple shift in the supply chain relationship led to the birth of Chemical Management Services, CMS (Kauffman Johnson, 2007).

In 2007, GM had implemented CMS in nearly 90% of its plants worldwide. Wherever a CMS program is implemented, GM generally realizes a 30% reduction in chemical use and a 30% reduction of costs of purchased chemicals and associated management activities (CSP, 2004).

This program that worked so well for GM was transferred to other industry sectors like electronics. Seagate began its program in 2004 with similar results. Since 1996, CMS has been adopted not only by the automotive industry and electronics, but also by aerospace, air transport, utility, steel, semiconductors, as well as in research and biotech industries. The success of CMS seems to be based in the work program, tailored to the operating environment where it is implemented, each CMS program being unique for each company.

In 1996, Chemicals Strategies Partnership (CSP) in San Francisco picked up the idea and started to assist companies in their efforts to implement CMS (see 5.4.1).

Case studies have not only been detected in the US but also in other parts of the world, in Europe (e.g. Sweden, UK) as well as in Japan, Korea and Singapore. Chemical Strategies Partnership also supported some of the cases in Japan and Korea. These cases have not been further analysed in this thesis. More information on the European CMS cases can be found in Singhal (2003).

Meanwhile, CMS has become a whole industry (CSP 2000, 2004, 2005, 2009), but "it took ten years to get the program going" (Kauffman Johnson, 2009).

5.3 Implementing CMS

In the CPS Manual "Tools for optimizing Chemical Management" (Kauffman Johnson et al., 1999) three pre-requisites are named for a successful implementation of CMS: total chemical costs, defining the baseline and different cost models for invoicing the services.

5.3.1. Total chemical costs

In most cases, chemicals are not within the core competences of an automobile assembly plant or a company in the electronics and aerospace industry. Even environmental managers at such firms are often not aware of all the costs chemicals cause during their life cycle, from procurement to delivery, from application to disposal or treatment. Even if chemicals are an important part of the manufacturing process, they are often managed less efficiently and cost effectively as it could be. This surprises as especially highly specialized chemicals are expensive and often demand more attention in storage, legal compliance, handling and disposal. One reason is that chemical costs are distributed among many departments in a company. In addition, departments often have to pay a certain "overhead" which might include chemicals as well as costs for energy, waste management, etc. (Kauffman Johnson et al., 1999). Moreover, the purchase department of the customers does not generally work in close cooperation with the quality, maintenance, production, and waste management departments and is, thus, not aware of the real costs related to chemicals. This leads to a situation

where the purchase department just focuses on the price offered by the suppliers rather than the value added services provided by them.

Chemicals cause costs in every stage of their life cycle (see Figure 5-3), costs for labour, materials, equipment, but also costs for floor space, capital, and liability and on every stage there is potential for reducing the use of chemicals, and for reducing risks and costs.

Figure 5-3: The chemical life cycle (Kauffman Johnson et al., 1999)

CMS providers, offering chemical services can step in at nearly every stage of this life cycle: they can purchase and deliver chemicals, collect waste and dispose it or they can even be environmental engineering firms that offer a whole range of services to manage a company's chemicals. They can also be responsible for process efficiency improvement or data collection for environmental monitoring and reporting (Kauffman Johnson et al., 1999). The term "Chemical Services" can cover a narrow or a broad range of services. Usually, CMS providers begin by offering a narrow range of Chemical Management Services and later-on might expand their work scope by including services such as research for chemical substitutes and process efficiency improvements (Kauffman Johnson et al., 1999).

Several studies (Kauffman Johnson et al., 1999; CSP, 2004) have revealed that (internal) chemical management costs can range from 1 to 10 times the purchase costs of the chemicals. Very few firms use their suppliers' knowledge to reduce costs and volumes of chemicals. The suppliers are seen as experts in handling chemicals but often companies do not think that the supplier would share information on possible benefits and lower chemical costs. The (usually) existing relationship between the suppliers and the customers wherein the customers do not have full trust in the supplier and maintain secrecy about processes has been identified as a significant barrier for suppliers to provide process improvements.

For companies it is essential to know about their total chemical costs, as this is a pre-requisite to talk about implementing a CMS program with their suppliers. The assumption is that not many companies realize and track the true costs of chemicals. True costs are usually hidden costs tied to chemicals use, which can include compliance, safety, disposal, storage, training, etc. "Without the appreciation of life cycle costs, companies focus on "integrated supply" strategies to attain one-time unit-cost reductions on purchased chemicals which is not CMS" (Stoughton, n.d.).

5.3.2 Data colletion - Defining a Baseline

The CMS model sees the analysis of the chemical costs as one of the most important parts of the entire process (Kauffman Johnson et al., 1999). To define a baseline (which means to survey the current Status Quo) is essential, to "baseline" the cost data is the foundation of a CMS program. This exercise tracks back the

costs chemicals cause throughout the different stages of the life cycle. The result of it is a (hopefully) complete documentation of the existing system of managing chemicals and an overview on the complete costs of this system. This data is usually very hard to get but besides getting mere numbers, this process is also an opportunity to get other information. Kauffman Johnson et al. (1999) in their CMS manual advice companies to ask as many “why” questions as possible: “why are we storing these chemicals for so long?”; “Why are we using these chemicals and not less toxic ones, is there an alternative?”, etc.

There are mainly three steps that have to be taken to get results:

1. Mapping the flow of the chemicals and identify the responsible internal departments at each stage of the life cycle;
2. Assigning the costs of chemical use to each life cycle stage;
3. Analysing the nature of the costs and verify them (Kauffman Johnson et al., 1999).

The baseline is the set of data where all savings and costs of the future are referred to. It is also the source on which one can build when searching which savings are achievable when chemicals use is reduced and how the cost structure of the chemical service contract might be designed.

Finally, it is possible and necessary to determine which activities could be transferred to a chemical service provider by considering which costs could be saved. As an example, if a company transfers chemical purchase to a chemical service provider, costs can be saved as the service provider might get chemicals at a lower price but on the other hand, costs could also be saved as the purchasing manager e.g. does not have to spend a certain percentage of his/her time with troubleshooting due to chemical purchase problems.

If companies build up a reliable baseline for their chemical costs this can provide a lot of information. Nevertheless, it is important to keep in mind that this data collection also takes a lot of time which depends largely also on data that is already there and on the number of chemicals used in a company.

The baseline is a good tool for decision support, it helps to

- understand the current system;
- identify potential savings;
- analyse business cases and bids of suppliers;
- design and prioritise performance metrics;
- streamline CMS program implementation (Cole, 2005).

With this baselining it is possible to see all chemical management activities in one place, which makes it easier to analyse and determine where chemicals use can be reduced, waste can be cut and savings maximized.

5.3.3 Cost models

In a CMS project, the cost savings from improved production services are shared between the partners. As such, CMS demonstrates a promising Product-Service-System approach, which brings along sustainability benefits in economic, ecologic and social terms.

In a shared-savings fee structure, the chemical user no longer buys chemicals but pays the supplier a certain fee for meeting certain performance expectations. Bierma and Waterstraat (1999) described three main contract models:

Fixed fees

Under a fixed fee structure, suppliers are usually paid a fixed monthly fee. With the data of historical chemical usage as a basis, the fee and the performance expectations are negotiated between supplier and user. The fee might be higher than historical costs to compensate for additional services provided by the supplier.

This cost model creates a strong incentive for the supplier to reduce chemical usage and waste, as the supplier profits from decreased chemical volumes. Nevertheless, the supplier has to share at least some of the savings with the user to create an incentive also for the user to pursue further cost reductions. One strategy is to reduce the fee after some time to reflect the supplier's lower chemical costs. Another strategy is to rebate some of the savings back to the user and include provisions for periodically adjusting the fixed fees as chemical usage declines (Bierma and Waterstraat, 1999).

Unit prices

Unit prices are similar to fixed prices as they are also independent from the volume of chemicals used. They align the incentives of the chemical user and the chemical supplier to reduce chemical volume. A unit price is the fee that has to be paid to the chemical supplier for every unit of product produced by the chemical user. This can be a fee for every automobile that leaves the plant of an automobile manufacturer but could also be linked to an intermediate step in the production process (e.g. a supplier of paint detackification chemicals might be paid a fee per gallon of paint sprayed in the paint shop). Companies like GM Truck and Bus, as described in the case studies in chapter 5.4 use this model (Bierma and Waterstraat, 1999).

Gain-sharing

Gain-sharing agreements are typically used in combination with unit prices or fixed fees. It is a mechanism where a buyer directly shares cost savings with the supplier. Gain-sharing agreements can also be linked to management fees or dollar-per-pound plus services or to any other savings not even related to chemicals and therefore expands the potential benefits of the supplier relationship. This model is very sophisticated and not easy to implement (Bierma and Waterstraat, 1999).

5.4 Players in CMS

Some institutions have been active in the field of Chemical Management Services for a while. This is a short description of these institutions.

5.4.1 Chemical Strategies Partnership, USA

Chemical Strategies Partnership (CSP) was founded in 1996 in San Francisco, CA[39]. CSP is a non-profit project of the Trust for Conservation Innovation, initiated and staffed by Tellus Institute and California Environmental Associates (CEA) and established with major funding from the Pew Charitable Trusts and the Heinz Endowments (see figure 5-4). CSP was founded because the joint business and environmental potential of CMS was recognized.

"CSP's mission is to reduce life cycle chemical costs, use, waste and risk in the manufacturing sector by promoting a business model based on total chemical cost, in which chemical suppliers are compensated on the basis of services delivered rather than on chemical volume supplied, thus aligning incentives for chemical use efficiency and reduction. CSP engages in hands-on capacity building in manufacturing organizations, working with partner firms to conduct total chemical cost assessments of their manufacturing operations, to assess the business case for a Chemical Management Services (CMS) program, and to develop CMS requests for proposals. CSP also carries out a program of education and communication" (Kauffman Johnson et al., 1999).

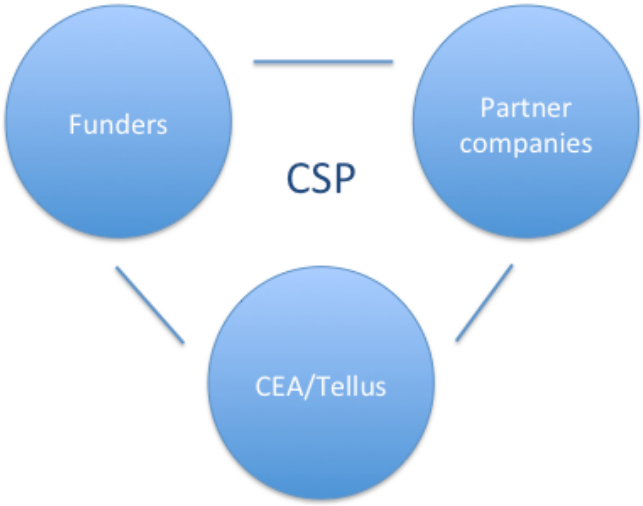

Figure 5-4: Structure of Chemical Strategies Partnership (based on Votta, 2003, amended by the author)

CSP has developed several tools and materials, like a manual for starters, cost models and contract templates. Information is spread through different channels like case studies, industry reports, newsletters and workshops. CSP also provides technical assistance to the manufacturing industry.

Since the beginning, CSP has been involved in the conception, negotiating and documentation of numerous CMS agreements, and has served as an information clearinghouse between providers and customers (Kauffman Johnson, 2007). CSP is acting as a neutral, independent third party and therefore has trust from both sides, customers and providers. CSP has conducted workshops in different sectors like the Pulp and Paper industry and with Silicon Valley companies. A study has been made on exploring whether CMS are a potential mechanism to

[39] http://www.chemicalstrategies.org/about.htm and personal/Skype interviews with director Jill Kauffman Johnson (2004, 2009, 2015)

facilitate the reduction, reuse and recycling of chemicals in educational institutions. This resulted in a case study at the University of New Hampshire and in two pilot projects, one at Dartmouth College and one at the University of California Merced.

In 2000, the CMS Forum was established to give members a platform to exchange on CMS issues[40]. Through this forum, articles were published, it was presented at multiple conferences and workshops, and has launched some pilot projects such as the Silicon Valley Pilot Project, which included working with three Silicon Valley companies on initiating a CMS program. A quarterly newsletter has been published until the end of 2010 to inform CMS Forum members about news.

When one of CSP's masterminds, Tom Votta, died in February 2009, work in this area has not been continued by CSP. "CSP had achieved its mission of mainstreaming CMS" (Kaufmann Johnson, 2014). Industry did not want to fund an "industry association" any longer, and the philanthropic support was tapped out since the model had been proven and penetrated numerous industries. Also, Jill Kaufman Johnson took a new position at another company, and there was not any other person who wanted to step in. Most of the companies that did CMS are still implementing the program, though it may have transformed a bit to incorporate broader management programs like facility management. The only research still on-going is done by the affiliated consultants listed on the website (Jill Kaufman Johnson, 2015).

5.4.2 International E Chem, UK

International E-chem (IeC)[41] was founded by Paul Hodges in 1995, and helps companies to develop strategies to build sustainability along the entire value chain, by changing the relationship between chemicals manufacturers and suppliers.

International E-chem has been active in promoting Chemical Management Services in association with the Chemical Strategies Partnership (see 5.4.1.) in the United States and Green Alliance in the UK (see 5.4.3) for a while. Yorkshire Forward, the UK regional development agency, sponsored some successful work by Tom Votta and Paul Hodges in 2005/2006. This produced a case study by Thames Water/Ciba. They also held a workshop in 2009, but never followed up beyond this (Hodges, 2015).

However, Paul Hodges is now on the World Economic Forum's Industrial Council for chemicals, and has raised the issue there. This has been incorporated into the mandate for 2014 to 2016 as part of a move to encourage chemical companies to move into more of a service orientation and be less fixated on purely product offerings (Hodges, 2015).

5.4.3 Green Alliance, UK

Launched in 1979, "Green Alliance is an influential environmental think tank working to ensure UK political leaders deliver ambitious solutions to global environmental issues[42]". They brought climate change and environmental issues

[40] http://www.chemicalstrategies.org/about_membership.htm
[41] http://internationalechem.com and personal interview with founder Paul Hodges
[42] https://www.charitychoice.co.uk/green-alliance-3594

on the agenda in the UK. Green Alliance, unlike the name would suggest, is not a formal alliance but a charity and company limited by guarantee, governed by a board of trustees. They work closely with partners in the third sector and companies and their activities include research and the organisation of high-profile events and seminars. Green Alliance has permanent staff, part-time voluntary intern positions and associates and is based in London, UK[43] (Green Alliance Website).

Since about 2000, Green Alliance actively promoted the "servicizing" concept. It was supporting the use of service concepts to promote resource use efficiency (Oldham, James and Shaw, 2003). Green Alliance launched a programme in UK called "Service Innovation for Sustainability" in the year 2002 through which it was also promoting CMS (Singhal, 2003). Green Alliance identified the need of CMS to address the concerns related to human health and the environment because of chemicals. The NGO held a major conference in London to advance CMS in February 2003 (Singhal, 2003).

According to Green Alliance (Singhal, 2003), the Chemical Industries Association (CIA) of UK was very interested in CMS. CIA is doing some research on specific sectors to understand what it means to their members and whether they want to promote it among them. A lot of chemical companies who are working towards EMS/EMAS have reported to Green Alliance that CMS helps in obtaining the required data. Some Members of the European Parliament (MEPs) and Department of Environment, Food and Rural Affairs (DEFRA) are also supporting the CMS concept in UK (Oldham, James and Shaw, 2003).

CMS is not as common in Europe as in the US according to Green Alliance, though there are some companies in the UK who are outsourcing water and effluent management (Oldham, James and Shaw, 2003). At the moment no further research on that topic is underway, known to the author.

5.4.4 International Institute for Industrial Environmental Economics, Sweden

"The International Institute for Industrial Environmental Economics (IIEEE) in Lund, Sweden, is an international and multidisciplinary institute at Lund University with the overall ambition to advance and apply knowledge in policy and strategy for sustainable solutions", according to their website[44] and information material. The IIEEE wants to create a bridge between academia and practise in order to meet sustainability challenges. They "conduct interdisciplinary research that explores and advances knowledge in the design, application and evaluation of strategies, policies and tools for a transition towards sustainable solutions" (IIEEE website). In that sense, the institute has for some time also worked in the field of Chemical Management Services. Starting from the year 2000, some publications, master thesis (e.g. Singhal, 2003) and doctoral thesis (e.g. Mont, 2004) have been produced. Meanwhile, the institute is still working on servicizing, especially on circular economy business models and policies, where servicizing is a part, but CMS has not been a topic anymore for quite some time.

[43] http://www.green-alliance.org.uk/
[44] http://www.iiiee.lu.se

5.5 Case studies

In the following, three representative case studies that were accompanied by CSP will be described and analysed shortly. These and more case studies can be found on the website of Chemicals Strategies Partnership[45] and in Bierma and Waterstraat (1999). Some information was also taken from personal interviews by the author and slides that were presented during the CSP Annual Workshop in San Francisco in 2005.

1. General Motors Truck and Bus Plant

Industry: Automotive

Supplier: BetzDearborn

Source: http://www.chemicalstrategies.org/pdf/case_studies/GM_Case%20Study.pdf and Bierma and Waterstraat (1999)

GM was one of the first companies to implement CMS and in 2003 almost 98% of GM plants in North America had implemented a CMS program. “CMS is the cornerstone of the environmental strategy at GM, and the cornerstone of chemical management is process optimization” (Mark Opachak, Program Manager of Chemicals Management, GM, at a workshop in Chicago, 2001). GM plants are staffed with 2-15 personnel per site from their CMS providers and the CMS providers are responsible for major process chemicals and the entire chemical system. It is this close involvement and responsibility that allows the CMS provider to optimize the manufacturing processes and reduce chemical use. For GM this means that, by allowing the CMS provider to control the chemical system, GM plant personnel are now able to focus on the core-business of building automobiles. As the program manager puts it: “they [CMS providers] are making automobiles with us”.

Drivers for initiating the program

In 1987, the management at GM recognized that chemical use throughout the firm was becoming unmanageable. GM had too many vendors per chemical and also paperwork had mounted with each new piece of environmental legislation. Different GM departments were independently ordering identical compounds, missing opportunities to make economies of scale. This was the point where GM managers decided to move from a materials-acquisition mind-set to one of product life cycle and the concept of CMS was born (Bierma and Waterstraat, 1999).

Scope of the services (CSP, n.d., case study description)

- “Acquisition and inventory control
- Monitor and coordinate chemical usage
- Research and improve chemical performance
- Maintain laboratory for chemical and regulatory testing
- On-going reporting and communication
- Product and process engineering development
- EHS compliance and training

[45] http://www.chemicalstrategies.org/resources_casestudies.php

- Continuous waste minimisation"

Contract Structure

The contract is fixed fee-per-vehicle ("unit pricing") based on historical chemical usage and production, with a management fee for selected services.

Main results and benefits (CSP, n.d., case study description)

- "Over $ 1 million in savings;
- 8% decrease in chemical costs per vehicle (first 3 years) with significant expanded services;
- improved inventory control and reduced inventory costs;
- 78% reduction in paint inventory, 50% reduction in paint use;
- training and other programs to improve health and safety protection;
- chemical tracking for easier compliance reporting;
- reduced VOC emissions and sludge disposal;
- reduced downtime and labour costs for sludge cleanout;
- improved paint quality;
- many other improvements which reduce labour overtime, improve process efficiency, improve product quality and reduce rework."

2. Raytheon Company

Industry: Defence/Electronics/Aerospace

Supplier: Haas TCM, Inc.

Source:http://www.chemicalstrategies.org/pdf/case_studies/raytheon_case study_full.pdf

Raytheon Company[46] is a technology and innovation leader specializing in defence, security and civil markets throughout the world. With a history of almost 100 years, Raytheon, according to their website "provides state-of-the-art electronics, mission systems integration and other capabilities in the areas of sensing, effects, and command, control, communications and intelligence systems; as well as a broad range of mission support services". With some funding, the Chemical Strategies Partnership (CSP) engaged in a collaborative effort with Raytheon's Air Force Plant #44 in Tucson, Arizona in 1996. The specific objective was to identify chemicals use reduction opportunities and consider chemical management services (CMS) as a strategy to improve their chemical management system. Following this initial pilot project in Tucson, Raytheon recognized the potential value of a CMS program and launched a company-wide initiative. In 2005, Raytheon's CMS program included more than 45 facilities across the U.S., representing more than 98% of Raytheon's chemical, gas and waste spent.

"In 1999, Raytheon entered into a comprehensive, far-reaching partnership with their service provider, Haas TCM. The contract covered the entire life cycle of chemical management for all chemicals and gases including procurement, inventory, delivery, waste disposal, and data management." (CSP, n.d., case study description)

[46] http://www.raytheon.com/ourcompany/

Drivers for initiating the program

Raytheon primarily wanted to reduce the chemical life cycle cost at each facility and outsource areas that were out of their core competences. Another reason was to seek strategic alliances with the suppliers, reduce purchase and inventory costs by leveraging across the company and reduce waste. The also wanted to improve the data management for environmental reporting.

Scope of the services

Raytheon started to work with CSP and developed a pilot program. They first established a team from all different departments dealing with chemicals, including purchasing, environmental, warehouse and delivery, quality, finance, engineering support and waste management. First thing they decided was to outsource areas that were outside the core competences of the company. Another task was to map the chemicals flow through the facility. To better determine the total costs of chemicals they conducted a chemical management cost analysis for the top 10 chemical using facilities in the company and for a better overview on material emissions and the costs of material loss, a material accounting analysis for one special operation in painting was conducted. Another task was to develop the scope for a new chemical service program and finally, to provide analysis and support for negotiations for a final agreement with their supplier, Haas TCM with specific incentives for cost and chemical use reduction.

A process map was drawn and six different information systems and more than twenty discrete organizational functions supporting chemical management could be identified. The cost analysis revealed chemical management costs of $1 for every dollar of chemicals purchased (CSP, n.d., case study description).

The program covered all chemicals, gases and wastes (CSP, n.d., case study description):

- “Sourcing and procurement of chemicals;
- Supply side management of cylinder, bulk gases, and hazardous waste;
- Inspection;
- Quality certification and product testing;
- “Standardized” custom labelling;
- Inventory management (offsite);
- Just-in-time delivery;
- Data management and EHS reporting (MSDS, use tracking etc.);
- Technical support and process optimization;
- Process efficiency improvement.”

Contract Structure

The contract was negotiated for 6 years, covering more than 45 facilities (renewed in 2005 until 2010/2011). The basis for compensation was a service fee, alongside with incentives for gain sharing or “shared savings” and a bonus for chemical use reduction.

Main results (CSP, n.d., case study description)

- “Commodity cost savings: 15.5%
- Reduction from 1,300 suppliers to 1
- Reduction of warehouse floor space to less than 9,000 sq. ft. (from over

120,000 sq. ft., which is a reduction of about 93%)
- Over 75 of the Raytheon personnel was reprogrammed to other areas (savings in structural costs)"

The work with their supplier is seen as a true partnership. New goals are established every year, based on the previous year's baseline, and ten metrics are tracked to measure performance.

Key challenges

As this was already the third attempt at implementing a CMS program, the scepticism among the team members was huge. Also union labour was opposing the idea. In general, before starting, there was some resentment to outsource a function where people thought that there would know best. Another challenge for the continuity of the program management was the continuous change of key personnel.

With the cost analysis in hand it was not easy to define a vision for what chemical management should be. Lack of involvement and support from the upper management in the beginning did not make it easier. The process-mapping exercise should have been conducted in one of the first meetings. It brought to light the complexity and costs of chemical management (CSP, n.d., case study description).

3. Delta Air Lines
Industry: Air Transport
Supplier: Interface LLC
Source: http://www.chemicalstrategies.org/pdf/case_studies/Delta_Case_Study_2003.pdf

Delta Air Lines is an US Airline, based in Atlanta, Georgia. Delta began its corporate chemical management program in the years 1994 to 1995 to improve its environmental compliance activities. Delta tremendously improved their delivery success rates, inventor practices, environmental reporting, and compliances practices due to their partnership with their CMS provider Interface LLC. A 30% reduction in overall chemical costs and in reduction of overall chemicals use was achieved, which means more than 4.5 million US $.

A pre-program check brought the following facts and data to light (CSP, n.d., case study description):

- "Over $15 million were used for annual chemical purchases (excl. fuel!);
- 350 different chemical suppliers;
- 140 different waste streams;
- A 24/7/365 operational demand with 2-3 hours delivery requirement;
- Over 350,000 transactions per year."

Drivers for initiating the program

Delta wanted to manage chemicals more effectively, which meant to have the right chemicals at the right time at the right place, having a just-in-time delivery in place. Delta also wanted to reduce overhead costs while, at the same time, decrease Delta's liability.

Lowering the total cost of the product and diminishing chemical inventory quantities, thereby reducing hazardous materials usage, air emissions, waste volume, and subsequent compliance costs were some of the aims. Another aim was to redeploy labour from material management, supply chain, and accounting functions to critical core tasks of airline operations, while improving productivity.

Scope of the services (CSP, n.d., case study description)

- "Procurement (e.g. procurement of chemicals, billing, insurance, and liability);
- Logistics (e.g. chemical handling, warehousing, just-in-time delivery, facilities, and equipment);
- Environmental (e.g. environmental fees and information management);
- Information systems (e.g. for compliance, reporting, and inventory management)."

Contract Structure

The Chemical Management Service fee is billed separately and includes fixed and variable components. There are shared savings on process efficiency improvements that result in measurable cost savings.

Main results and benefits (CSP, n.d., case study description)

- "Net savings of about $2.5 million;
- 30% reduction in chemical costs;
- Number of chemical suppliers was reduced from 350 to one;
- 30,000 square feet more of premium floor space;
- Reduced shelf life related losses by 75%;
- Eliminating inventory waste and generating $250,000 annual savings;
- Delivery success rate guaranteed by supplier increased to greater than or equal to 98%;
- Reduced insurance payments due to minimized on-site chemical risk;
- Better compliance with important regulations, improved quality reporting and availability of the complete data for environmental auditing."

5.6 Analysing the cases - Success factors and benefits, barriers and drawbacks

> *"It requires a whole different kind of thinking"*
>
> Bob Conrad, Environmental Specialist, Chrysler Corporation
> (cited in Bierma and Waterstraat, 1999)

The short description of case studies presented in chapter 5.5. reveals that the driver for the implementation of a Chemical Management System in all three companies was the desire to manage chemicals better and more effectively and to reduce costs.

CMS providers are responsible for more or less all process chemicals and the entire chemical system (which they also control), so they take care of the chemicals more or less for the total life cycle. The user hands over control of the chemicals (outsource) in their company and can focus on the core business.

Suppliers also take over the data management and EHS reporting, which takes the burden from the users when it comes to compliance with (new) regulations.

The complexity and costs of chemical management were analysed thoroughly at the beginning in all three cases by Chemical Strategy Partnership as a neutral third party which also provided a tool for that.

In all cases, savings could be obtained throughout the chemicals life cycle: costs for purchases of chemicals could be reduced, as well as costs for storage, inventory, use, emissions, downtimes and labour costs for dealing with all this. It also reduced reworks and shelf-life losses and improved product quality due to better knowledge about the different chemicals and their proper use. Productivity of the company itself could be improved by redeploying all kinds of labour linked to chemicals to other core tasks and operations.

In all three cases, a fixed service fee was the basis of payment.

All contracts run already for a very long time (the earliest started in 1998 at GM).

As these case studies are “second-hand” (no data collection and editing was done by the author herself), the data that is available has to be sufficient to make some conclusions, no further clarifying questions can be asked.

The analysis was put together from

- Case study review from cases at the CSP website (www.chemicalstrategiespartnerhsip.com)
- CMS Industry Reports 2000, 2004, 2005 and 2009 (2000: 15 providers and 15 customers, 2004: 10 providers and 13 customers participated in the survey)
- The book “Chemical Management” (Bierma and Waterstraat, 1999)
- Interviews with Jill Kauffman Johnson, Tom Bierma, Tom Votta and participants of the CSP Annual Workshop in San Francisco in 2005.

Table 5-2 on the next page shows an overview of the three cases in the US.

Table 5-2: Overview on three CMS cases in the US

	GM	Raytheon	Delta Airlines
Drivers for Initiation	Chemicals became unmanageable	Wish to reduce chemical life cycle costs, seek strategic alliances with suppliers	Manage chemicals more effectively, reduce costs and emissions
Scope of Services	Acquisition and inventory control	Sourcing and procurement of chemicals	Procurement of chemicals
	Monitor and coordinate chemical usage	Inventory management	Inventory investment
	Research and improve chemical performance	Quality certification and product testing	Chemicals handling
	Product and process engineering development	Just-in-time delivery	Just-in-time delivery
	EHS compliance and training	Process efficiency improvement	Information system for compliance, reporting and inventory management
	Continuous waste minimisation	Technical support and process optimization	Environmental fee and information management
Contract structure	Fixed fee per vehicle (unit pricing) plus management fees for selected services	Basis is a service fee, with incentives for gain-sharing or “shared savings” plus bonus for chemical use reduction	CMS fee with fixed and variable components plus shared savings on process efficiency
Main results and benefits	Over 1 million USD savings	Commodity cost savings of 15,5%	Net savings of 2.5 million USD
	8% decrease in chemical costs per vehicle	Reduction form 1,300 to 1 supplier	30% reduction in chemical costs
	78% reduction in paint inventory, 50% reduction in paint use	Over 75 people from Raytheon were shifted to other working areas (saving structural costs)	Reduction from 350 to 1 supplier

5.6.1 Success factors and benefits

A look at the case studies shows that the main scope of the chemical services offered by the providers included anything else but application of the chemicals itself. Of all customers that were interviewed in 2004 for the CMS Industry Report (CSP, 2004), 80% indicated that more than two-thirds of their chemical life cycle activities are under a CMS contract. The Industry Report 2004 also shows that CMS programs most commonly include purchasing, inventory, and data management services. 60% or more subscribe to EHS services and value-added activities, while fewer include application-related and disposal-related services. Generally, all companies have reported cost savings, better customer-supplier relationships, better data management and reduced health and safety concerns as their benefits.

Incentives for companies to start a CMS program are:

- Cost savings
- Desire to outsource the information management system
- Reduce the number of suppliers

The benefits customers achieved can be broken down to financial and economic benefits and to "others".

Concerning **financial benefits**, providers estimate, according to the Chemical Management Services Industry Report 2000 (CSP, 2000), that "the net savings in the first year of a CMS contract range from 5 to 25% of the total program. Savings continue to grow at a constant rate through the first 3 years of the contract then savings growth drops slightly by the 5th year." Most of these savings are realized by reducing overall management costs for the customer. CSP has documented the costs of chemical management ranging from USD 1$ to USD 10$ for every dollar of chemical purchased (Kaufmann Johnson et al., 1999; CSP, 2000). It was also reported that the costs ".. were often higher than expected due to the concealed expenses behind chemical use like compliance, safety, and inventory carrying costs." (CSP, 2000). Several providers stated that the reduction of chemical volumes accounted for the majority of the savings realized.

From the customer's point of view, the savings are seen similar, with the difference that they only see the cash savings or reduced annual payments to the provider but not the whole range of hard and soft savings the providers are facing. These "soft savings" could include eliminating the 5-10% of an engineer's time tracking down chemicals or 20% time of a procurement officer dealing with misplaced purchase orders. Though much more difficult to measure, providers estimated that total soft savings can range from 5-40% in any given year of the CMS contract (CSP, 2004).

Customers however start to realize savings in the first year. Suppliers generally do not share that kind of information but it seems that they make more money in years 2-4 since they often have transition costs in the first year that are not covered by the customer. CMS providers claim most of the savings are from manufacturing process improvements over the life of a contract which often result from the value-added and application services. Therefore, it is no surprise that "over 90% of the providers indicated they would like to provide "application

services", which is the most-cited desired activity that providers said they wanted to include in a program" (CSP, 2004).

Environmental benefits are often not tracked in CMS by the providers as these savings are in most cases not part of a CMS contract. CMS focuses on continuous improvement, and the environment as a business issue, but the environment is not the main concern. Nevertheless, it is evident that a CMS program helps to reduce emissions by:

- Chemicals use reduction
- Implementation of recycling or reuse alternatives
- Environmental information management
- Improved MSDS (Material Safety Data Sheet) Management
- Elimination of hazardous materials – chemical substitution
- Waste reduction
- Risk reduction
- Process efficiency

Dematerialisation also has never been an explicit reason that a company would cite for adopting CMS – however the basic notion that CMS could reduce the inputs necessary to produce more outputs is a reason for companies adopting CMS. The dematerialization concept is more of an academic or policy reason for supporting the CMS concept at a macro-level. Also the notion of focusing on function instead of focusing on products is what conceptually interests academics and policy makers, companies would approach this as getting better "value" or better "quality" (Kauffman Johnson, 2005). Nevertheless, CMS can be seen as a "sustainability" concept in a sense that it attempts to reduce chemical use, replace toxic chemicals with more benign substitutes, reduces hazardous waste, and reduces emissions.

The benefits for both, customers and suppliers are summarized in table 5-3:

Table 5-3: Benefits for Customers and suppliers in CMS (based on CSP 2000, 2004, 2005, 2009 and Bierma and Waterstraat, 1999)

Benefits for Customers	Benefits for Suppliers
Improved data management	Earnings from the contracts
Improved inventory management	Better relationships with their customers
Reduced overhead costs	Long-lasting contracts
Reduced chemical purchase costs	Better understanding of customers' needs
More chemical control	Overall strengthened market position
Improved MSDS Management	
Higher product quality	
Better reputation	
Risk reduction, reduced liability	

5.6.2 Barriers and drawbacks

As it is also reported in the Industry Report of 2000 (CSP, 2000), there are some main barriers, which are slowing down the process of adopting CMS across all industry segments:

- Many companies believe that they are already doing the best possible job in managing chemicals and that there is little room for improvement.
- Internal barriers to the customer company driven by the perceived low costs of chemical management, the perceived high costs and risks to implementing CMS and the general resistance to change.
- For many companies there is the question if the up-front investment in developing a CMS program (defining the program, selecting a services provider, etc.) is worth the not yet realized benefits.
- Confusion due to a lack of understanding of the value of CMS, also due to a vague industry definition of CMS.

Another thing customers fear a lot when giving away the management of their chemicals is the loss of control over their processes and gradual depletion of the process knowledge and connected to that, the fear of problems or even a shut down due to quality problems or supply shortages on the provider's side.

From the Industry Reports of 2000 and 2004 (CSP, 2000; CSP, 2004) there is evidence that companies who have outsourced their activities have faced resistance from the workers who found their jobs at risk, which they fear might also happen in the case of CMS. In fact, it is known, that GM, Bell Helicopter and other large corporations have had a "no lay-off" policy where no one lost their job when CMS was started. However, over the years, when chemical management-related employees retired or changed jobs, their positions were not filled – thus through attrition, the overall headcount was reduced. In other cases, the employees of a company were offered jobs at the CMS company. Often it was a better work environment since the core competency of the CMS company is chemical management, where when they were employed by the customer, their job was not core to the business. There is more opportunity for growth at the CMS company for many of the employees (Kauffman Johnson, 2005).

In addition, implementing a CMS program requires a change in the management culture and a significant change in conventional operations. Sales men no longer profit from sold volumes but from helping customers to decrease chemical consumption and by having more work in bringing the CMS model across.

It also requires a change in mind-set, going from thinking in unit purchase costs to thinking in life cycle chemical costs. In addition, a CMS contract requires sharing potentially sensitive business information and thirdly, changing to fewer suppliers changes long-term supplier-customer relations.

Although there are tremendous incentives visible, only few companies are engaging in such strategic partnerships with their suppliers due to logistics, corporate culture, and management reluctance, according to CSP (2000 and 2004). Still, CMS contracts are not standard and the negotiations between customers and providers can be highly complex. Each case is different and needs a tailor-made set of services and a corresponding contract. For customers, often not knowing about their total chemical life cycle costs, it is hard to value a contract.

What makes things even more difficult is the fact that there is (still) very limited information available. According to research from Bierma and Waterstraat (1999), most potential customers learn about CMS from their providers, a small number of customers learn about it through presentations, articles or case studies, which are only available in small numbers. Providers often invest a lot of time and resources in developing a tailor-made service bid and the customer then does not sign the contract.

Another barrier for providers is that they often lack a certain credibility to sell a new, innovative model that can bring additional benefits to the customer. Customers often see their relation to their providers as a seller-buyer relation and not as a cooperation to work together to get best solutions for both sides.

Table 5-4 summarizes some of the key barriers.

Table 5-4: Barriers for the implementation of CMS (based on CSP 2000, 2004, 2005, 2009 and Bierma and Waterstraat, 1999)

Barriers for Customers	Barriers for Suppliers
Belief of already doing the best in managing chemicals, little room for improvement	Suppliers lack the credibility to sell a new, innovative model
Poor data management and cost awareness of current chemical management practices	Reducing chemical throughput poses a possible conflict for a supplier that traditionally profits from volume sales
Chemical management is not a high priority	Skills and resources to manage chemicals are not entirely the same as those required to produce and market chemicals
High perceived transaction costs; companies don't know where to start	CMS requires co-ordination across multiple business units
Lack of understanding and credible information on CMS model	
Fear of loss of control over processes and depletion of the process knowledge	
Fear of quality problems or supply shortages on suppliers side	
Resistance of workers who fear job loss	
Resistance to change	
Reluctance to share potentially sensitive information	

The experience from the work of the Chemical Strategies Partnership suggests that one of the reasons why CMS is not implemented more widely in companies might be that with CMS, as with any new Product-Service-System innovation, there is some hesitation to adopt an unfamiliar business model, especially with something as critical as chemical inputs to a manufacturing process. CMS

adoption is further complicated by the need to change current business relationships from today of the adversarial “buy-sell” mentality towards a more collaborative service orientation.

“Conceptually, companies can understand that it makes good business sense to implement CMS, but they do not understand how to put it into practice. They are simply unaware of the detailed issues that need to be considered and resolved” (Votta, 2003). It is visible that, in the end, benefits significantly outweigh the costs but only after investing lots of time and resources to initiate a chemical service program. The supplier is seen as a strategic resource in this whole process.

CMS is a very challenging business model: for the users, because the chemical management is normally not a priority and there is a lack of credible information and often a poor data management and cost awareness. In addition, there is often no willingness from the supplier’s side to assist in a CMS model implementation, as he would have to change the whole way of making his business.

So at the beginning, to bring a CMS model on track, it has proven to be helpful to have a neutral, third party, working as a centralized source of information and as a mediator, and some financial support as well (CSP, 2004). This role, in the case of CMS in the US, was taken by the Chemical Strategies Partnership.

Chapter 5 summarized the activities around Chemical Management Services, starting from the basic principles to a more detailed analysis of cases studies and success factors and barriers. It also lays the basis for a profound comparison between Chemical Management Services and Chemical Leasing in the next chapter.

6. Chemical Leasing

In chapter 6 the basics of the Chemical Leasing business model of will be described, starting with the concept and main ideas and a short historic overview. The results of the first research activities and first case studies, as well as barriers and success factors and the main players are presented and analysed. The chapter closes with a comparison between Chemical Management Services and Chemical Leasing.

The concept of Chemical Leasing (ChL) is, just like CMS, a service-oriented one in which the customer pays for the benefits obtained by the chemicals and not for the chemicals themselves. In Chemical Leasing the responsibility for the chemical stays with the supplier. Therefore, the economic benefit for the supplier is not linked to the volume sold, the consumption of the chemicals becomes a cost for the supplier. Therefore, it is in the interest of the supplier to optimize and reduce the use of the chemicals and to find solutions for re-use and recycling. Chemicals required for a specific service/production process are not simply sold to the customer, but rather "made available for efficient use". This is in contrast to the traditional business model „supplier sells chemicals to user" and emphasizes the service-oriented business approach. It also makes Chemical Leasing a key element of sustainable chemicals management systems[47].

Although one of the main objectives of Chemical Leasing is emission reduction „as a result of the reduction in chemical consumption, waste load, air and water pollution will decrease, reducing the environmental impact of the production process" (UNIDO, 2011), Chemical Leasing is still primarily a business model.

6.1 Concept and main ideas of Chemical Leasing

The concept of Chemical Leasing was developed in the early 2000er, following the definition of Chemical Management Services by Oksana Mont (Mont, 2000):

> *"The basic idea of Chemical Management Systems is that chemical companies provide the efficiency of the function rather than sale volumes: they provide the same function fulfilled by their chemicals but promise resource reduction and cost reduction for their customers" (Mont, 2000)*

The aim is not to ban or do without chemicals but to optimize the material flows ecologically and to de-couple the use and the consumption of chemicals (Jakl et al., 2003). Resource efficiency and process optimization are the core of Chemical Leasing. Potential for optimization is seen in a complete new model that represents a change in paradigm. Mainly two things characterize this model: a chemical service is the basis for the business and a change in ownership becomes redundant (Jakl et al., 2003).

[47] http://www.chemicalleasing.com/what-chemical-leasing

In a classical (economic) leasing model the user leases a product from a supplier. In a Chemical Leasing model, the user benefits from the service (final result) of the supplier but does not actually apply the product (chemical) himself. The term "Chemical Leasing" is therefore more an umbrella term for service-based business models in the chemicals industry. The actors in the field of Chemical Leasing are fully aware of the fact that the term "leasing" might be misleading possible customers or providers but the term has now been used since more than 10 years.

While in the traditional model the responsibility of the producer ends with the selling of the chemical, in Chemical Leasing business models the producer remains somehow responsible for the chemical during its whole life cycle, including its use and disposal. According to Jakl et al. (2003), the term "Product Stewardship", significantly coined through Chemical Industry, is being implemented in Chemical Leasing for the first time in its full extent: "Product Stewardship is the act of minimizing health, safety, environmental and social impacts, and maximizing economic benefits of a product and its packaging throughout all life cycle stages. The producer of the product has the greatest ability to minimize adverse impacts, but other stakeholders, such as suppliers, retailers, and consumers, also play a role. Stewardship can be either voluntary or required by law"[48]. Principles of Product Stewardship were developed in 2001 by the founding board members of the Product Stewardship Institute.

The chemical supplier in Chemical Leasing is paid for the service rendered by the chemical and not for the amount of chemicals provided. Hence, to reduce his costs, he will try to reduce the amount of chemicals and, if possible, increase the recycling rate. Both, chemical supplier and user, as well as the environment benefit from this approach. The reduced costs are then to be shared among the chemical supplier and the user, both gaining economic advantage applying the Chemical Leasing business model. The idea behind this is that if economic benefits are not linked to sales volumes any more, none of the involved parties is interested in (wasteful) consumption of the chemicals (Jakl et al, 2003). Chemicals are used to a maximum efficiency, which is in the interest of all partners.

In Chemical Leasing, for the first time, two totally different approaches were combined (Nolte, 2003): the first one is the idea of dematerialisation, still a more theoretical and academic concept, by which emissions and environmental burden could be avoided by reducing material throughput. On the other hand, outsourcing, concentration on core competences and customer-cooperation are the new key words. The new concept of Chemical Leasing now combined these two, promising ecologic advantages (e.g. minimizing emissions and chemical use) and increase in process efficiency.

Chemical Leasing is a tool to qualitatively and quantitatively optimize material flows. The different solutions are tailor-made, same as in CMS. The idea is that a supplier, who is the owner of a chemical, knows best how to handle and use this. But it is clear that the handling and use happens on the premises and in the process (e.g. manufacturing of cars, production of metal parts) of the customer. Therefore, a lot of barriers can occur, and a totally new relationship between customers and suppliers is necessary.

The main objective of Chemical Leasing is the environmental and economic

[48] http://www.productstewardship.us

optimisation of a chemical's life cycle. Therefore, before starting a Chemical Leasing project it is necessary to find out *if* there is some potential to optimize a process and hence to reduce the amount of chemicals used and to reduce the impact on the environment while using other, more environmentally friendly chemicals.

6.2 A short history of Chemical Leasing

Chemical Leasing from the beginning had high priority in the Austrian chemical policy. In 2000, Thomas Jakl from the Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) mandated two studies to find out about the potential of new approaches that comply to the concept of Chemical Management Systems as formulated by Oksana Mont in 2000 (Mont, 2000). The studies were partly co-funded by Austria's industry. The aim was to describe and to assess these approaches in detail and to select most promising sectors where these approaches could be followed up. Models and approaches using chemicals that are inacceptable from an environmental and health protection's point of view were not taken into account.

Both studies provided an overview on possible approaches, estimations on possible environmental benefits, a description of possible other business models similar to Chemical Leasing and a description of drivers and barriers. The two consortia conducting the studies were ECOTEC Munich in cooperation with the Institute for Industrial Ecology in St. Pölten and AFC Consult together with BiPRO, Munich. The results of both studies were summarized and published in the report "Chemikalien-Leasing – Modell für eine nachhaltige Stoffwirtschaft" (BMLFUW, 2002) and later-on in a book: "Chemikalien-Leasing – ein intelligentes und integriertes Geschäftsmodell als Perspektive zur nachhaltigen Entwicklung in der Stoffwirtschaft" (Jakl et al., 2003). A first press conference to announce and present the study results was given in November 2002.

In 2003, two events were organised to further promote the Austrian activities: in June 2003, a national conference for interested companies (customers and suppliers) was organised, in cooperation with the Wirtschaftskammer Österreich. There, the two studies were presented to a broader audience, with focus also on success factors and barriers of the new concept. The second event took place in November 2003: an international conference was organised in Vienna in cooperation with OECD on "Experiences and perspectives of service-oriented strategies in the chemicals industry and related areas". The aim of the workshop was to evaluate possibilities to establish service-oriented business models in the chemicals industry and related areas (see OECD, 2003). At the OECD conference, first contacts were made between the Austrian Ministry of Agriculture, Forestry, Environment and Water Management and UNIDO.

The results of the Austrian pilot projects, following the two studies (see also chapter 6.3) qualified Chemical Leasing as a sustainable industrial resource management tool. At that time, follow-up activities like a tailor-made subsidy program, the development of a certification scheme (comparable to the Österreichisches Umweltzeichen), a Chemical Leasing Cluster or a Clearing House were planned and high hopes were set on this new business model.

Several activities followed through the years but Chemical Leasing never reached a real breakthrough in Austria towards a comprehensive implementation. In

October 2008, the project „Workshops und Erfahrungsbericht zu Anbieter – Anwendertandems für Chemikalienmanagement, -leasing und die Umsetzung der REACH-Anforderungen“ was started, conducted by IÖW and JOANNEUM RESEARCH (Jasch and Kaltenegger, 2009). Main aim of this project was the combination of chemical suppliers and users in a workshop series with companies of the BMÖ (Bundesverband Materialwirtschaft, Einkauf und Logistik). In the workshops, the concept of Chemical Leasing should have been presented and together with the companies, processes in their firms should have been calculated and modelled in terms of their material and environmental costs. The experience exchange should have been stimulating and companies should have gotten assistance in elaborating a Chemical Leasing model for their own processes. Due to the economic crises that started in 2008, several big Austrian companies cancelled their participation in the very last minute and the project therefore was only a modest success.

Chemical Leasing won some awards, among them the „Genius 2004“ and in 2005, the company „BEYER Umwelt und Kommunikation - Unternehmensberatung“ was awarded the CONSTANTINUS 2005 in the category „Management Consulting“ for their project „Chemical Leasing in the field of paint stripping”.

In addition to national plans and activities, in 2004 the decision was taken to promote the Austrian experience also through UNIDO’s Cleaner Production Program on an international scale (see Chapter 7) and in 2004, UNIDO formulated the first project document to start Chemical Leasing in developing countries and countries in transition, followed by 2 more “cylces” of projects in 2008 and 2011.

Throughout the last couples of years, additional case studies have been found (mainly through the applications for the Chemical Leasing Awards 2010, 2012 and 2014, see also chapter 11) also in Germany, as well as in the UK and in several other countries. Cases, where NCPC have played an active role, will be described and analysed in more detail in the following chapters.

6.3 Implementing Chemical Leasing

In Chemical Leasing, differently from CMS, *before* the implementation of any case study, an in-depth analysis of possible chances and drawbacks for Chemical Leasing was done within the two studies in 2000 – 2002 in Austria. To see the real benefits of Chemical Leasing, six main questions related to a possible implementation of Chemical Leasing were analysed (BMLFUW, 2002):

1. Which business models are suitable in general?
2. Which markets do exist in Austria?
3. Which applications and which models are already in use internationally?
4. Which are the possible economic and ecological potentials in Austria?
5. What are the drivers and barriers?
6. Which options do suppliers have?

Suitable business models for Chemical Leasing

In total, 6 models in the field of chemicals management were identified (BMLFUW, 2002). It then depends on the use of chemicals which of these models fits best,

but an increase in efficiency is biggest where every partner does what he can do best.

1. Standard Model

This is the traditional model where the customer buys a chemical from the supplier and in doing so, becomes the owner of the chemical and therefore responsible for it. This standard model has great potential for optimization.

2. Responsible Care Model

This model is the first step towards a service-oriented model as the supplier takes back the chemical after use. The Responsible Care model has been used in Chemical industry for several years (see chapter 4.3.1).

3. Supplier Service Model

If the supplier takes over more and more responsibilities, the model is broadened step by step. In the Supplier Service Model, the suppliers remains the owner of the chemical during application, he only “leases out“ the chemical to the customer.

4. Client Operation Modell

In this model, the supplier additionally takes over responsibility for recycling or waste disposal.

5. Supplier Cooperation Model

This is the case when the supplier also operates the machinery at the customer’s premises.

6. Total Care Model

In this last step, the supplier could take over all steps, from delivery to application and disposal of waste, which would be the realisation of a far-ranging model.

Markets in Austria

According to the study report (BMLFUW, 2002), the benefits of Chemical Leasing can only be gained if two main criteria are fulfilled:

- the application can be defined as a service (cleaning, degreasing, painting, etc.) and
- there is no change in ownership, only a change in possession (leasing)

In addition, it can be defined as a criterion that the application is done in a closed application and that a closed loop with take-back, recycling and re-use is possible if the chemical is used as an operation material and not as a component of the product. Based on the experience already achieved, Chemical Leasing models create the largest value added for simple chemical applications, such as cleaning, greasing/degreasing, and cooling/heating. Taking this into account, the criteria are fulfilled mainly in the following 12 sectors:

Table 6-1: Sectors for Chemical Leasing application (based on BMLFUW, 2002)

Sectors for Chemical Leasing applications	
Cleaning/degreasing	Cooling/lubrication
Adsorption/desorption	Textile finishing
Acid cleaning	Water treatment
Synthesis	Cooling of goods
Casting	Heating (oils)
Extraction	Catalysis

On the basis of statistics on raw materials, waste volumes and data taken from environmental statements the range of potential companies for Chemical Leasing in Austria and the volumes of chemicals used could be identified. It was estimated, that around 3,900 companies with around 153,000 tons of used chemicals basically could qualify for the application of Chemical Leasing models back in 2002 (BMLFUW, 2002).

Applications and models already in use

At the time the studies were carried out, only few information on similar projects was communicated among the chemical sector. This does not mean that there weren't more implementations in companies but it shows the reluctance companies have to make their business models public. Due to competitive reasons only little information, especially on economic benefits found its way into the public. More than ten years later, this is still the case, although more case studies are available through the applications for the Global Chemical Leasing Award (see Chapter 7 and following).

Four case studies that were initiated through the study are described in chapter 6.5.

Possible economic and ecological potential

The big expectations were that with the new approach of Chemical Leasing, significant ecological benefits and an increase in efficiency could be gained. So within the study (BMLFUW, 2002), 34 companies were analysed in detail, starting with their status quo, analysing the opportunities towards service oriented models and from that the potential for Austria in terms of Chemical Leasing was deduced. Estimations and extra-polarisations tell that, if only taking companies into account that are possible candidates for service-oriented business model, chemical input could be decreased by a third, which correlates to around 53,000 tons per year. This potential can be assigned to the different environmental media as wastewater (~15%), exhaust air (~10%) and waste (~75%). These numbers give reason to believe that such improvements have their costs. Especially in environmental protection the aspects of additional costs for measures are part of diverse discussions. But in this case, the authors of the studies calculated a possible reduction in costs for users of this new business model of about 10 to 15%. It can be assumed that also suppliers get their share in the long run as they can also sell their know-how (BMLFUW, 2002).

6.3.1 Getting the Status Quo and measuring success

One of the most challenging tasks in Chemical Leasing is to get data and following that, to define the Status Quo from where to start a Chemical Leasing project. As already mentioned in chapter 2, data gathering is essential to detect appropriate measures for Cleaner Production but also for any other process optimisation like in Chemical Leasing. “You can't manage what you don't measure” is a management quote which is also true in Chemical Leasing. Unless something is not measured there is no evidence if things are getting better or worse. In addition, it is also necessary to see *what* (e.g. which part of the process) is getting better or worse.

“It is advisable to have a good data basis for getting an overview on the major material flows in a company” (UNIDO, 2001). Also in Chemical Leasing it is important to ask the following questions before starting to collect data:

- Which data is needed?
- Where can these data come from?
- Which information source already exists in the company? (UNIDO, 2001)

Crucial in this task is to define which sort of data is needed. As Chemical Leasing claims to be a sustainable business model, all three pillars of sustainability have to be covered. This comprises the economic and the ecologic side but also the social side.

Linking the data to the most important waste streams (water, energy, waste and energy) is not an easy task. In most cases this task and its importance is highly underestimated. Data are often unverified and data in the accounting department often differ to quantities consumed in production. When finally, an initial data set is available and Chemical Leasing is being implemented, monitoring and evaluation should start as well. The monitoring of improvements is essential to show the success of Chemical Leasing projects. With only a few data it becomes visible what can be saved in terms of chemicals, water and energy by shifting to the new business model.

In the analysis of the case studies, the indicators used were evaluated and based on this evaluation, a new and extended set of indicator was developed (see chapter 14.1).

6.3.2 Trust and collaboration

One of the main preconditions for a successful implementation of Chemical Leasing is trust between the partners. Trust comes with collaboration. In Chemical Leasing a lot of good will for collaboration is required from the partners, information and know-how has to be shared among the partners.

„Collaboration harvests its benefits from differences in perspectives, knowledge and approaches, and problem solving, while at the same time offering benefits to all those involved in the process” (Lozano, 2013). Among the benefits of collaborations are the ability to optimize both financial and human capital, having access to different markets and knowledge, enriched creativity, avoiding confrontation, decrease the time needed to accomplish objectives and make processes more efficient (Fadeeva, 2004). There is a pay-back for all the players and, in some cases, trans-disciplinary learning is possible (Lozano, 2007).

In Chemical Leasing, the partners share information and share their knowledge in order to obtain economic and ecologic gains from that collaboration from the reduction in the use of chemicals. But there are also difficulties to be aware of: costs for the coordination of the different activities between the partners, there is a risk of jeopardizing important and unique resources (Genefke, 2000) and an increased dependency of the chemical users on their suppliers might be possible, especially if long-term contracts are signed. It is also tricky to define how the economic gains are to be split and there is the possibility of free-riders, who do not really participate but in the end, they still get the benefits (Chilosi, 2003). In addition to that it is not only about the collaboration between a user and a supplier but also about collaboration among the different departments in the user's company which is sometimes an even bigger challenge.

But how can trust be built? Case studies from UNIDO have shown that Chemical Leasing can be based on a good foundation if chemical suppliers and users have been working together for some time before changing the business model into a Chemical Leasing model. Nonetheless, a good contract is necessary to clearly define the tasks of all partners, their responsibilities and their rights but also their shares on the gained benefits. The joint objectives have to be clear for all partners and knowledge transfer and information flow from one partner to the other is a prerequisite. The benefit resp. the "work" the chemical has to perform has to be clearly defined as well as how to identify if the provider has fulfilled his task. Part of the contract needs to be a clear definition of the unit of payment (see Chapter 6.3.3) and also the description of consequences if the provider fails to perform (Jasch et al, 2007).

A neutral third party can assist in the contract design and also in problem solving. In the case of CMS this third party has been the non-profit organisation Chemical Strategies Partnership (CSP), in case of UNIDO's Chemical Leasing program it is the National Cleaner Production Centre (NCPC) in the respective country. NCPCs can help in setting up the contracts, they are able to assist in technical problems and in most cases they know both companies quite well from other (often CP) projects. This "knowing each other" often is also the starting point of a collaboration in Chemical Leasing as NCPCs often know "their" companies for years and can therefore support in matching new teams of chemical suppliers and users and possible other partners. Neutral bodies like the NCPCs are seen as independent information source and consulting institutions and are an important factor in creating trust between the partners and moreover in the whole Chemical Leasing program.

But sometimes the biggest enemies can be found in the companies themselves: lacking comprehension of the Product-Service approach, especially from the upper management and fear from workers to lose their jobs are some of the main internal obstacles.

6.3.3 Developing a new payment basis

As already shown in Chapter 5 for CMS, the total costs of chemicals are often not known by the users of chemicals. If these costs are revealed, this is a chance to re-construct the relationship between user and supplier.

Chemical Leasing is a service-oriented business model and therefore the customer pays for the service provided by the chemical, not for the chemical itself.

In this way, the customer avoids buying more of a chemical than he actually needs for his production, which often happens in traditional business models. In traditional models the customer is responsible for the disposal and recycling of chemicals, within Chemical Leasing business models this responsibility for disposal and recycling remains with the supplier of the chemical. The role of chemical suppliers does also change with the implementation of Chemical Leasing business models. The supplier's economic success is not linked to product turnover anymore, but to the efficiency the chemicals are used with. Therefore, the supplier of chemicals will try to optimise the process in which the chemicals are used and will improve the conditions for recycling in order to reduce the net amount consumed. Instead of being paid for the amount of chemicals supplied, the supplier is actually paid for the expert know-how that is provided. In other words, „under the Chemical Leasing model, the supplier sells the functions performed by the chemical and functional units (number of pieces cleaned, amount of area coated, etc.) become the main basis for payment" (e.g. UNIDO, 2007a). The shift from traditional sales to functional sales (see chapter 3) is implemented. Consumption of chemicals will decline as chemicals sales volume turns from an increasing profit factor ("the more you sell, the more you earn") to an expense factor ("less is more") (UNIDO, n.d)

The challenge now is to make a fair price (win-win) for both parties when consultancy, spare parts, recycling and waste disposal/management shall be integrated. This all asks for major changes in thinking (a paradigm shift). In chapter 5.3.3, some models for CMS were presented. It is known from UNIDO's case studies that companies have different ways of finding a unit of payment. The only precondition this unit has to fulfil is that it has to be a "functional unit" (number of pieces cleaned, amount of area coated, etc.). As the supplier sells the function performed by the chemical, the functional unit becomes the main basis of payment (e.g. UNIDO, 2007a).

Some tools that can be useful to define a fair price are:

- Input/Output analysis
- Cost effective analysis
- A material flow chart to see where the chemicals go

The unit of payment and how it is calculated has to be defined in the contract. Another challenge is how to set a price for the consultancy of the supplier.

It is absolutely necessary to know about the costs to be able to define a payment basis and a price for the service. One tool that can help to learn more about the definite costs of the chemicals is the Environmental Management Accounting (EMA) scheme. EMA, according to the definition of the Tellus Institute can be defined as the "identification, collection, estimation, analysis, internal reporting, and use of materials and energy flow information, environmental cost information, and other cost information for both conventional and environmental decision-making within an organization" (Savage and Jasch, 2005). Its target is to incorporate economic and environmental information and it uses two types of information for internal decision making:

- physical information on the use, flows and destinies of energy, water and materials (including wastes) and

- monetary information on environment-related costs, earnings and savings. (Savage and Jasch, 2005)

Basically, EMA is designed for the user of chemicals. Nevertheless, the supplier could also achieve interesting results, as EMA makes suppliers aware of what should be considered when entering into Chemical Leasing. It provides a good starting point, a good baseline and a calculation basis to get a better and common understanding of costs (Jasch, 2009). It will, however, be necessary to adapt the tool before it can be used reasonably in a Chemical Leasing project. The best field of application is expected to be in data collection.

6.4 Players in Chemical Leasing

6.4.1 Ministry of Agriculture, Forestry, Environment and Water Management

The Federal Ministry of Agriculture, Forestry, Environment and Water Management has supported the idea of Chemical Leasing from the beginning and is still a great supporter (ideally and financially) of the Chemical Leasing program of UNIDO, now together with the Governments of Germany and Switzerland which joined a few years ago. The Ministry laid the foundation for the program by mandating the two studies on possible Chemical Leasing implementations in 2000. The Ministry, personified by Thomas Jakl is still much involved in the development of a strategy for Chemical Leasing and also in the jury for the Global Chemical Leasing Award.

6.4.2 UNIDO

The United Nations Industrial Development Organisation (UNIDO) is a specialised agency of the United Nations "that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability" (UNIDO's website[49]). The mandate of UNIDO is "to promote and accelerate sustainable industrial development (ISID) in developing countries and economies in transition"[50] (UNIDO website).

UNIDO was established in 1966 and became a specialised agency of the United Nations in 1985. As of 1 January 2013, 172 States are Members of UNIDO. Its headquarter is in Vienna but operates worldwide. The Organization focuses on three main thematic areas:

- Poverty reduction through productive activities
- Trade capacity building
- Energy and environment

In the field of energy and environment, UNIDO provides assistance in the following areas:

- Resource-efficient and low-carbon industrial production;
- Clean energy access for productive use; and

[49] http://www.unido.org/en/who-we-are/unido-in-brief.html
[50] http://www.unido.org/en/who-we-are/unido-in-brief.html

- Capacity building for the implementation of multilateral environmental agreements

Cleaner and sustainable production is one of the main areas of resource-efficient and low-carbon industrial production, with one thematic initiative to support cleaner and sustainable production being Chemical Leasing (UNIDO-UNEP, 2015). In 2004, UNIDO took up the idea of Chemical Leasing and has been promoting and further developing it since.

6.4.3 National Cleaner Production Centres (NCPCs)

After the United Nations Conference on Environment and Development (UNCED) in Rio in 1992, the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP) started implementing preventive environmental strategies in key developing countries. For this purpose, UNIDO and UNEP jointly launched a programme to establish National Cleaner Production Centres (NCPCs) and the first batch of eight NCPCs was established during 1994-1995 (UNIDO-UNEP, 2015). Fundamental support has been provided by the Governments of Switzerland and Austria and together with contributions from other donors (including Norway, Italy, Slovenia, Czech Republic, Spain, Denmark and The Netherlands) it was possible to expand the programme to 47 developing and transition countries (UNDIO-UNEP, 2015). “In each of these countries, national experts have been trained, in-plant CP assessments completed and results and experiences disseminated among enterprises, governments, business and professional associations and civil society” (UNIDO-UNEP, 2015 and UNIDO’s Wepage[51])

The services NCPC’s offer are:

- “Raise awareness of the benefits and advantages of Resource Efficient & Cleaner Production
- Demonstrate the environmental, financial and social benefits of RECP through in-plant assessments and demonstration projects
- Help obtain financing for Resource Efficient & Cleaner Production investments
- Provide policy advice to national and local governments
- Disseminate technical information”[52] (UNIDO website).

The National Cleaner Production Centres also played a central role in the set-up of UNIDO’s Chemical Leasing Program. They are the ones that bring together chemical users and suppliers in their countries and support them in the implementation of a Chemical Leasing project. Whenever a representative from a National Cleaner Production Centre was meant throughout this thesis, the abbreviation “NCPC” was used.

6.4.4 National and International Consultants

When Chemical Leasing started in Austria in the early 2000s, national consultants were supporting interested companies in their attempt to test Chemical Leasing as a possible business model for them. They especially supported the first case

[51] http://www.unido.org/ncpc.html
[52] http://www.unido.org/ncpc.html

studies that are described in 6.5.

For carrying out Chemical Leasing projects under the patronage of UNIDO, international consultants were contracted to assist NCPCs and companies in their efforts in Chemical Leasing implementation. Among them was BiPRO[53] (one of the parties that conducted the first study in 2000), which has been part of the program since the beginning, mainly represented by Reinhard Joas. BiPRO has done a lot in developing the principles of Chemical Leasing but also in developing training materials, worksheets, slides and other learning and communication materials. BiPRO supports the NCPCs as well as the companies in the participating countries (as technical advisors) in the implementation of Chemical Leasing projects on-site. Other consultants were also contracted at the beginning of the Chemical Leasing program but throughout time they quit and were replaced by BiPRO.

6.5 Case Studies in Austria

Following the two studies, three pilot projects were implemented in Austria in the early 2000ies with the support of the ministry. The first one was realised in the field of metal cleaning by establishing an Austrian company “Pero Innovative Services” The second pilot project was to implement a Chemical Service business model for the re-procession of heat transfer oils and the third case was Chemical Leasing in the field of paint stripping. A fourth case study was started in petro-chemistry, with two workshops held and the formulation of some ideas on suitable processes and possible solutions for implementing Chemical Leasing in that field.
In Box 4, the successful (and still operating) case of PERO Innovative Services is described.

Box 4: Chemical Leasing Case Study: Pero Innovative Services

This case study was taken from Jakl et Schwager (2008), completed with company data from SAFECHEM (2009).

Pero AG is a manufacturer of high quality metal cleaning machines and always had the goal to reduce the amount of chemicals used by their machines. In the mid 1980ies, PERO AG developed the first encapsulated cleaning machines and in the mid 1990ies, the German Immission Protection Act and its limiting values were based on the low emissions of PERO machines. PERO AG was fascinated by the idea of Chemical Leasing when it entered the scene and started to look for suitable partners with sufficient know-how in chemicals. They found this partner in SAFECHEM Europe GmbH in Düsseldorf (www.safechem-europe.com), a subsidiary of The Dow Chemical Company as they were able to provide the required know-how as well as logistics.

To realise the Chemical Leasing project, a new company was founded: PERO Innovative Services GmbH, based in Weiz (www.pero-teilereinigung.at). The two companies agreed that PERO provides machinery, rooms and material logistics

[53] http://www.bipro.de

and also human resources. Providing rooms, material logistics and human resources is not a pre-requisite for Chemical Leasing but by offering these, the implementation of the Chemical Leasing model for the first time was facilitated immensely. SAFECHEM provides the solvent and stabilisers for the cleaning process, monitors the quality of the solvent and handles the used chemicals.

The first client of the new business model was - and still is – Automobiltechnik Blau, a branch of MAGNA STEYR Fuel Systems Ges.m.b.H. in Weiz (www.blau.co.at). They produce metal parts and their main products are filling systems like caps of fuel and oil tanks for clients all over the world.

It was agreed upon by all partners that the best economic and ecological result could only be achieved if the lessor (in this case PERO) is free in choosing how to solve the task as he has the best know-how on available technologies, high competence of process technologies and the handling of chemicals. So PERO Innovative Services (provider) and Automobiltechnik Blau (user) signed a long-term Chemical Leasing contract. The unit of payment was defined "€/number of cleaned parts". Quality specifications were defined for each individual part. Automobiltechnik Blau can concentrate on its core competences and leaves the cleaning process and all legal requirements to the service provider. PERO, being service provider and manufacturer of equipment in one, provides high-performance machinery, adapted for the specific cleaning processes for the new model, whereas SAFECHEM provides the optimal solvents for the process.

The results were very impressing:

- The lifetime of the solvent is extended to a factor 4-8
- Optimisation of product efficiency through the cooperation between PERO and SAFECHEM
- The client profits from the best solution for his needs
- Adequate risk management as the process is done in a closed loop
- It is economically worthwhile as billing is possible according to cleaning parameters

Advantages in accordance with REACH:

- Easier documentation of chemicals safety, as the know-how of possible risks, as well as the implementation and exposition is in one hand (lessor)
- The user only needs little know-how on REACH as everything is done by the provider

PERO, SAFECHEM and Blau are still working together until today and are still convinced of the idea of Chemical Leasing.

The second pilot project was to implement a Chemical Service business model for the re-procession of heat transfer oils. In this case, the aim was to find a model for the recycling of Isododecane where a supplier or recycling company builds and operates the distillation unit. Until that point in time this has not yet been tried due to difficult legislation. An analysis of company specific data has been done and different models have been designed. The perspectives were promising, nevertheless the project was not implemented to its full extent.

The third case was to explore the potential of Chemical Leasing in the field of paint stripping. In this pilot project, a small company no longer sold solvents for paint stripping but the service of paint stripping itself. The main results were less resource use, complete absence of hazardous wastes and a reduction of waste of about almost 50% (BMLFUW, n.d.).

In another case study the foundation for Chemical Leasing in one of the market leaders in petro-chemistry was laid. Two workshops were held, processes suitable for Chemical Leasing defined and some possible solutions described. Nevertheless, also this case study has never been promoted further.

Other case studies are meanwhile known in Austria but very little details are available. This is due to the fact that many companies don't want to talk about their experiences.

6.6 Analysing the Chemical Leasing model

For the implementation of a Chemical Leasing model, at least two partners are essential:

- the chemical supplier, who might also be the producer of the chemicals and
- the chemical user, who benefits from the chemical being used in his production process, although he does not apply the chemical himself (this is done by the chemical supplier)

But also the following stakeholders can be additional partners (BMLFUW, 2002):

- Equipment suppliers
- Recycling/disposal companies
- Authorities
- Financing

A good cooperation between a chemical producer and suppliers of equipment and machinery seems to be a crucial factor for success in several applications. Closing material flows is a goal within Chemical Leasing concepts. For this purpose, it seems appropriate to include recycling companies as partners as well.

Also authorities and (business) federations can support the process.

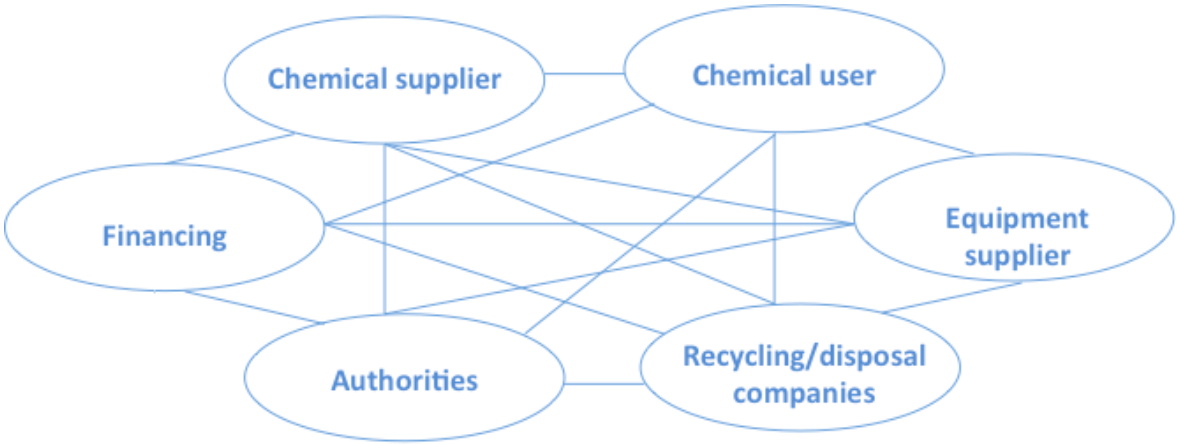

Figure 6-1: Stakeholder map of Chemical Leasing (based on BMLFUW, 2002, translated and amended by the author)

6.6.1 Success factors and benefits

Usually the idea of a Chemical Leasing model gains more interest the more expensive and the more problematic a chemical is. High value chemicals like catalysts, special chemicals and noble metals as well as chemicals that can be found in environmental media to a greater extent are of interest for Chemical Leasing. In addition, chemicals that can be reprocessed after use are also suitable for Chemical Leasing. On the contrary, if a chemical is being consumed during its use, a change in ownership is required and a Chemical Leasing model is not the appropriate tool of choice.

The more important a process is for the production in a company the lower the chance for Chemical Leasing. Reasons are, on the one hand, that if the process is that important, the fear of a know-how drain is quite big and no companies from outside are welcome. On the other hand, for important processes, optimisation potential is often realised during times anyways. Typically, this goes hand in hand with a specialisation of the process or equipment. The more specialised a process is, the more interest is there from the company's side to keep this within the company.

As at the time of the studies, no "real" cases have been reported in Austria, the concept was presented to *potential* user companies and they were asked for their assessments of possible drivers and barriers (BMLFUW, 2002). The possible benefits are summarized in table 6-2 below.

One main challenge in this concept is to get the chemical suppliers on-board as their main source of income is the sales volumes of their chemicals. If chemicals are used inefficiently it is for the profit of the supplier, if chemicals are used efficiently, it's his loss. This is a conflict of interest, which can be solved as the supplier offers his know-how (e.g. best way of application, how to recycle a chemical, etc.) in addition to his chemicals. As this know-how adds to the optimisation of the chemical's benefit, a share on the benefits of an optimised use of chemicals is fair. The options suppliers could have with this new business model were also assessed within the two studies. To survive on the market, there are mainly three options for suppliers according to the studies:

- to produce (more) efficiently
- only do what you can do best
- produce for the user

Every single of these three points is not new but it is new to combine them in one unique package, in Chemical Leasing (BMLFUW, 2002). For example: to produce for the user becomes easier if there is a real cooperation between the supplier and the customer. The user gets the same product but more tailor-made, the user gets a solution not only a chemical and gets advice and support.

For both, suppliers and customers, Chemical Leasing offers chances to find new partners, new clients and to open new markets and to see Chemical Leasing as a strategic tool for that. Furthermore, it can be interesting for all partners involved in Chemical Leasing to use the chances to further develop chemicals, technologies, products and business concepts. Service-oriented business models can better respond to the needs of the fast growing chemical industry, namely constantly changing processes and new chemicals. A more effective use of technology and chemicals are key factors.

Table 6-2 summarizes the benefits for customers and suppliers.

Table 6-2: Possible benefits for customers and suppliers in Chemical Leasing (based on BMLFUW, 2002)

Possible Benefits for Customers	Possible Benefits for Suppliers
Reduced chemical volumes	Income is not linked to amount of sold chemicals anymore
Reduced costs in purchase, handling, storage, waste	Economic benefits, typically increased profits
Reduction of workload	Better understanding of the customers real needs, better relations to customers
Improvement in logistics	Better access to future plans of the customer
Reduction in amounts and costs of waste	Income from services provided (avoiding unpaid services)
Better relationship with suppliers – long-term relationships	Increase in know-how
Reduced emissions	Helps in introducing efficient but more expensive products
Better working conditions and health improvements	Possibility of selling additional services (e.g. disposal of chemicals, storage, etc.)
Reduced risk of accidents	Better Image ("innovative, customer-oriented, environmentally friendly"), business advantage
Availability of an increase in know-how	Advantages on the markets
Concentration on core competences	
Better control and knowledge about chemicals (via the supplier)	

6.6.2 Challenges, barriers and drawbacks

Some of the experiences that were made within the two studies were presented by Reinhard Joas at the OECD conference in November 2003. Among them was the clear statement that "Chemical Leasing is not a self-running process" (OECD, 2003). The intention of Chemical Leasing is to provide economic and ecological advantages, but in a way that asks for a new way of thinking and there are lots of risks and open questions.

An initiator and some "catalysts" (e.g. a neutral third party) might be needed to start the "reaction", people or institutions that are able to promote the process and to find answers to the questions. Entrepreneurs that take the risk and see the chances and talk about their experiences later-on are necessary. Possible know-how drain and communication issues often are relevant topics.

Customers also may have no full awareness of their chemical costs and therefore don't see the potential or the advantages of implementing Chemical Leasing and they might fear a lack of support. In addition to that, some up-front costs until the Chemical Leasing program is set up and for some testing that might be necessary before that, could add up and it is not clear if the promised benefits will ever turn up.

One additional barrier was also the term "Leasing" itself, as companies often defined this term very narrowly and focussed on leasing as one means of financing. A general confusion due to the lack of understanding the value of Chemical Leasing, also due to this vague definition was also visible.

Another obstacle could be that for some time there are two different business models in one company (one where chemicals are sold/purchased and one with Chemical Leasing) which might cause additional confusion. Table 6-3 summarizes the possible barriers for customers and suppliers.

Table 6-3: Possible barriers for customers and suppliers (based on BMLFUW, 2002)

Possible Barriers for Customers	Possible Barriers for Suppliers
Not enough information from suppliers	High demand on personnel
Confusion about the term and the concept	Logistic efforts
Not enough legal certainty	More training efforts
Worse products quality and possibility of incidents	High capital tie-up
Bad experience with outside companies	Liability
Too much administrative work	
Strong dependency on supplier	
Know-how drain	
Decreased flexibility	
Lack of providers that offer Chemical Leasing or are willing to change their mode of operation	
Integrating and negotiation problems	
Resistance from workers	

As a conclusion it can be said that Chemical Leasing is definitely an innovative and future-oriented approach. But this is also exactly the reason why especially customers often need more support to decide whether to try this new business model.

In Chapter 6, the main characteristics of Chemical Leasing and the first case studies have been described. Besides main aspects and challenges as well as success factors and barriers, additional focus was laid on trust and collaboration as well as on the definition of a Status Quo from where to start a Chemical Leasing projects and on the definition of a new unit of payment.

7. Chemical Leasing and other models – a comparison

Chapter 7 is a rather short chapter but all the more important as it shows the similarities but also the differences between some business models that are similar to Chemical Leasing. A special focus is set on the description of similarities and differences between Chemical Management Services and Chemical Leasing.

There are many business models on the market that show certain similarities with Chemical Leasing, so here the most important business models are described briefly.

7.1 Leasing (L) and Chemical Leasing

Whereas in classical leasing the focus is on financing and the producer is the owner of the product, in Chemical Leasing financing is not in the focus. In a classical leasing model, the user leases a product from a supplier/producer. In Chemical Leasing models, the user benefits from the service (final result) from the supplier but does not actually apply the product (chemical) himself. The supplier of the product remains the owner.

7.2 Outsourcing (OS) and Chemical Leasing

When a process is being outsourced, the responsibility for this process is being transferred to a third party, whereas in Chemical Leasing, the responsibility is shared among the user and the supplier. The transferred production mostly takes place outside of the original production site, whereas in Chemical Leasing production takes places at the original production site and the user has no more influence in the chemicals the supplier uses. In most cases, any kind of process optimization is not part of an outsourcing contract. This also makes clear that if a production is transferred outside the plant it cannot be Chemical Leasing anymore.

7.3 Pay-on-Production (PoP) and Chemical Leasing

Pay-on-production is a special form of project financing. In the “pay-on-production” model, the equipment manufacturer finances, plans, builds, runs and maintains the plant on the production site of the user. The machinery equipment and the plant itself remain in the ownership of the equipment manufacturer. The payment is based on the amount of output and process optimisation is provided by the know-how of the equipment manufacturer. In Chemical Leasing, on the other hand, the payment is based on the function of the chemical and the provider of the chemical stays the owner of the chemical. In a Chemical Leasing business model, the equipment manufacturer and the chemical supplier are partners.

7.4 Contracting (C) and Chemical Leasing

Contracting is a model that is often restricted to service areas like heating, cooling, lighting, and ventilation but it is also used for energy supply. The plant operator provides “working materials” (heat, electricity, etc.) and plans, finances and runs the related facility for a fixed period in time, whereas in Chemical Leasing the

chemical user normally runs the facility. The contracting model has a focus set on process optimisation and the financial benefits are shared between the plant operator and the user.

7.5 Cost per Unit (CpU) and Chemical Leasing

In a cost-per-unit model, a cost calculation is made for a single unit of a product. Cost-per-unit models are quite similar to the Chemical Leasing models but normally they don't include any environmental issues. Table 7-1 shows a summary of the different business models and was taken from Joas (2009).

Table 7-1: Characteristics of Chemical Leasing and other business models (Joas, 2009)

Characteristic	Chemical Leasing	L	OS	PoP	C	CpU
Based on the function of the chemical	✔	X	✔/X	✔/X	X	✔
Taking into account environmental issues	✔	X	X	X	X	X
Higher responsibility of the supplier for the application	✔	X	✔	X	X	✔
Higher responsibility of the supplier for waste management and recycling	✔	✔	✔	X	✔	✔
Process optimization	✔	X	✔/X	✔	X	✔
User remains the owner of the products	✔	✔	✔	X	✔	✔
Application takes place at the user's site	✔	✔	X	✔	✔	✔
Shared economic benefits	✔	X	✔	✔	X	✔

7.6 Chemical Management Services and Chemical Leasing

For this short comparison between Chemical Management Services and Chemical Leasing all the characteristics of both models, elaborated in chapters 5 and 6 are summarized, nevertheless, this makes no claim to be complete.

There is no consistent definition of Chemical Managements Services or Systems, the focus of CMS is on services that are somehow linked to chemicals. The supplier offers a series of chemical related services, typical examples are the monitoring of emissions, storage and disposal, risk management or quality control. CMS providers can be the suppliers of all the chemicals but this is not necessarily the case.

Different than that, the services that are offered in Chemical Leasing focus on the optimization of the application process of a certain chemical and the company offering Chemical Leasing also supplies the chemicals it offers the service for.

The desire from the customer to manage chemicals better and more effectively and to reduce costs in the company is in many cases the starting point for looking for a strategic, long-term contract with a supplier that can fulfil this. Payments can consist of a fixed fee or be quantified (like in the Chemical Leasing model) in functional units.

Seen at this background, the main difference between Chemical Leasing and CMS is that Chemical Leasing always raises the efficiency of the chemicals (benefit per volume, further services might be offered in addition to that) whereas CMS offers a number of services where Chemical Leasing could be one but does not need to be. According to the reports that are available, CMS is focusing on all chemicals in a firm that has taken the decision to implement CMS whereas Chemical Leasing is focused on one special process (cleaning, lubrication, etc.) resp. one type of chemicals (water or cleaning chemicals, solvents, paints) in most cases.

In table 7-2 similarities and differences of Chemical Leasing and CMS are listed.

Table 7-2: Similarities and differences of Chemical Leasing and CMS

Chemical Leasing	CMS
Similarities	
A service-based business model	
Aiming at the reduction of chemicals consumption	
Process optimization is a key element	
Transition from selling a product to selling a service	
Change in relationship between customers and suppliers	
strategic, long-term contract	
some hesitation to adopt an unfamiliar business model	
Differences	
Supplier and customers are responsible for application in certain parts of the production process of the customer	*Customer* is responsible for the application of the chemicals in the production
Unit of payment is linked to the service of the chemical	Payment consists in most cases of a service fee and addition elements on gained-sharing or unit prices
Focused on one (non-core) process where chemicals are applied	Focused on all chemicals that are flowing through a company
Suppliers are paid to meet the “performance needs” of the customer.	Process optimization is only an option
Environmental issues are part of the model	Environmental issues are NOT part of the model
(Partial) substitution of a product by a service	Supplementing a product by a service
Chemical Leasing is more use-oriented: the use of products is sold, not the products	CMS is product-oriented, if we follow the definition: “provides additional services to

(e.g. renting, leasing, sharing, pooling), so it is a partial substitution of products by services.	sold products (e.g.: training, consulting, maintenance, disposal, take-back)", it is supplementing a product, as the product (the chemical) is still (mostly) being sold in the old manner, in kg, l, etc.
Chemical Leasing looks at chemicals in combination with the process	CMS looks at chemicals in a company as a whole
Collaboration between providers and users is a key task	Collaboration between providers and users is not necessarily happening
Links to government and authorities are actively followed up	
Additional partners possible	
Chemical Leasing is about managing the *application* of certain chemicals in a special process	**CMS is focused on *services* linked to chemicals**

Nevertheless, both models can be called "Product-Service-Systems" as they are "..a system of products, services, supporting networks and infrastructure that is designed to be competitive, satisfy consumers' needs and have a lower environmental impact than traditional business models" (Mont 2004).

Chapter 7 gave an overview of different business models that are similar to Chemical Leasing, from classical Leasing to Outsourcing and Contracting, from Pay-on-Production to Cost per Unit and Chemical Management Services.

8. UNIDO's Chemical Leasing Model

In chapter 8, the development of UNIDO's Chemical Leasing business model is presented in detail, including a description of the three cycles of Chemical Leasing. Furthermore, the different elements and tools of the model are presented and described.

Proper management of chemicals risks and a reduction of emissions and waste resulting from chemicals use have a high priority on the international agenda and are relevant for policy makers as well as for responsible company managers. Against this background, the Chemical Leasing business model has been developed by the United Nations Industrial Development Organisation (UNIDO) as a new approach that gains its attractiveness in particular by the fact that economic advantages for users and producers of chemicals are the driving force for risk reduction and a more efficient and sustainable use of chemicals (UNIDO, 2007a).

UNIDO has realised the potentials of Chemical Leasing at an early stage and has given strong positive inputs to the further development of the new business model. Developing and promoting innovative services to enhance efficiency and environmental performance of industry represents an important element of UNIDO's Cleaner Production Strategy (UNIDO, 2007a). Cleaner Production was always seen as the basis for the development of the Chemical Leasing concept and therefore, also the National Cleaner Production Centres were chosen as the ones that could build on their experiences with Cleaner Production and could extend their knowledge and portfolio with Chemical Leasing.

In 2004, the Austrian Ministry of Environment with the support of the Austrian Ministry of Foreign Affairs and UNIDO have, decided to promote Chemical Leasing business models jointly. Chemical Leasing is a still on-going project of UNIDO to demonstrate and analyse the applicability and impact of the concept in developing and transition countries. In addition, UNIDO is developing new tools to enable a systematic approach to the implementation of Chemical Leasing business models at company level and seeks to further develop the concept. The results of the individual Chemical Leasing projects in more than 11 countries already will be shared with the entire network of UNIDO's Cleaner Production Programme to facilitate its replication in other countries.

The main elements of the joint project were, at the beginning, national capacity building and Chemical Leasing demonstration projects in selected industries. This strategy has changed over the past 10 years and has been adapted to the circumstances and developments during that time. These changes will also be described in this thesis.

Chemical Leasing has first been implemented in Egypt, Mexico and Russia (St. Petersburg) in close cooperation with the local UNIDO National Cleaner Production Centres (NCPCs) and the United Nations Environment Programme (UNEP) in 2004/2005. The NCPCs play a crucial role in the process of identifying local companies and other relevant stakeholders and facilitating the project's implementation.

Two more cycles of Chemical Leasing projects were started in 2008 (Colombia, Serbia, Sri Lanka and Morocco) and in 2011 (Croatia, Ukraine, Brazil, Uganda, Russia – Volga Region, Nicaragua).

In Box 5 UNIDO's official definition (e.g. UNIDO, 2016 and www.chemicalleasing.com) of Chemical Leasing can be found and the graph in figure 8-1 shows the concept of Chemical Leasing once more.

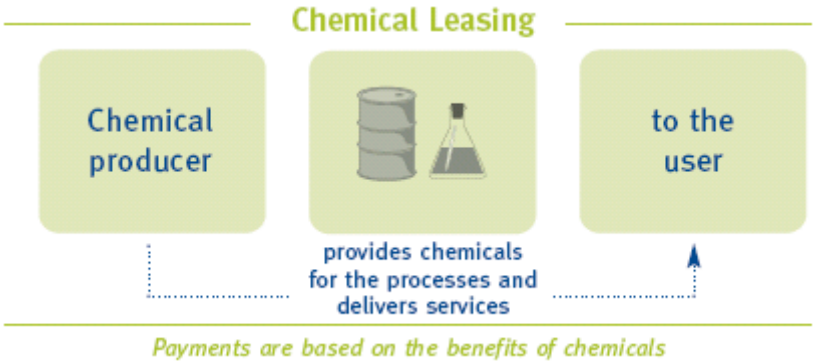

Figure 8-1: Chemical Leasing scheme by UNIDO (source: UNIDO, 2006)

Box 5: UNIDO's official definition of Chemical Leasing

Chemical Leasing is a **service-oriented business model** that shifts the focus from increasing the sales volume of chemicals towards a value-added approach.

The producer mainly **sells the functions performed by the chemical**, and functional units are the main basis for payment[1].

Within Chemical Leasing business models, the responsibility of the producer and service provider is extended and may include the management of the **entire life cycle.**

Chemical Leasing strives for a **win-win situation**. It aims to increase the efficient use of chemicals while reducing the risks of chemicals and protecting human health. It improves the economic and environmental performance of participating companies and enhances their access to new markets.

Key elements of successful Chemical Leasing business models are proper **benefit sharing**, **high quality standards** and **mutual trust** between participating companies.

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[1] Functions performed by a chemical might include: number of pieces cleaned; amount of area coated, etc.

8.1 The development of Chemical Leasing at UNIDO

As already mentioned, the basis for UNIDO's Chemical Leasing program was laid at the OECD conference in Vienna in November 2003 when a staff member of UNIDO approached Dr. Jakl from the Ministry and first talks were made. From

then it took only a few months until the first project proposal in 2004 was formulated by UNIDO.

Chemical Leasing fitted at that time perfectly into UNIDO'S newly developed SIRM concept. SIRM - Sustainable Industrial Resource Management – ".. captures the idea of achieving Sustainable Industrial Development through the implementation of circular material and energy flows in the entire production chain and reduction of the amount of material and energy used with greater efficiency solutions. It focuses on the idea that total material cycles can be optimised and modelled on the self-sustaining cycles of nature." (UNIDO, 2004). One of the basic means to implement the concept of Sustainable Industrial Resource Management is the modification of the supplier/user relationship, shifting from the approach of selling products towards providing services. Within this perspective the first project on Chemical Leasing has been elaborated

UNIDO's National Cleaner Production Centres were foreseen to act as national focal points for the project. Besides offering logistic and administrative support, they should deliver important information on the national chemical sectors and offer their experience in identifying of and working with the national companies to be considered for Chemical Leasing. Based on this knowledge, the NCPCs should play a crucial role in the process of identification and selection of companies and other important stakeholders to participate in the project activities. NCPCs would be responsible for reporting to UNIDO on the implementation activities and the achieved results on a regular basis.

The concept was that one employee of the NCPC (or a newly hired person) should be trained in Chemical Leasing and should be supported by her or his work by an international expert. This international expert was responsible for delivering the training on Chemical Leasing for the national experts and providing technical assistance in the implementation of Chemical Leasing at plant level. The Austrian Ministry financed the international expert and the training and travel costs of the national experts for the first 3 years.

As the implementation of Chemical Leasing aims at reducing the consumption and emission of chemicals, UNIDO saw the high potential of Chemical Leasing to enhance the sound management of chemicals and significantly reduce their emissions. In order to achieve this goal, the main elements of the project were national capacity building, including both the staff of the NCPC and the main national stakeholders, and the implementation of demonstration initiatives at plant level. The demonstration projects were meant to show the applicability of the new business model in the participating countries. „These activities are strongly in line with the services offered by UNIDO's NCPCs" (UNIDO, 2004).

The concept of Chemical Leasing is about sharing of added values from process optimization. A certain potential for optimization has to be there otherwise Chemical Leasing is not useful - this has to be evaluated in the preparatory phase and implemented in the process optimization phase.

When Chemical Leasing is applied to industrial cases, there has to be a reduction in chemicals, otherwise it is not Chemical Leasing. If a provider is paid per output, it can be taken for granted that it is in his interest to use less chemicals.

Successful application of Chemical Leasing business models with tangible environmental and economic benefits requires a systematic and structured

approach. UNIDO in its Chemical Leasing toolkit defines five phases of a Chemical Leasing business model that cover a period of approximately 24 months.

Fig. 8-2 shows the different phases of a Chemical Leasing project in its ideal characteristics:

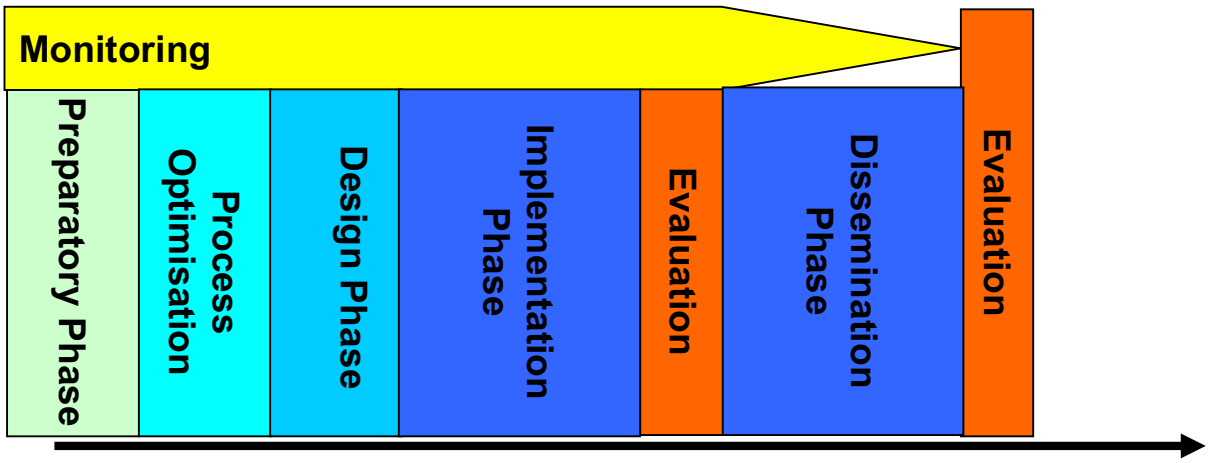

Figure 8-2: Chemical Leasing Project Phases

it is important to stress the fact that besides the five main phases, the whole process is framed and accompanied by constant monitoring and evaluation.

8.2 The three cycles of Chemical Leasing

8.2.1 Mexico, Egypt and Russia

In 2004, first plans for a Chemical Leasing program under the guidance of UNIDO were developed and end of 2004, the project document for the first 3 pilot countries, Egypt, Mexico and Russia (St. Petersburg) was submitted. These countries have been chosen as they already had well established contacts with the chemical sector, had already gained significant experience in the implementation of Cleaner Production in this sector and were well familiar with the problems associated to sustainable industrial development in their countries.

In order to enhance environmental and social responsibility, competitiveness and export potential of national enterprises, the NCPCs offered five closely interrelated core services such as technical assistance and in-plant assessments, training, Cleaner Production (CP), Environmental Sound Technologies (EST) and Investment Promotion (IP), information dissemination and CP Policy Advice. They should provide administrative and organizational support in carrying out the activities related to the implementation of Chemical Leasing and act as a neutral third party, supported by an international Chemical Leasing expert.

Following an internal training on the Chemical Leasing business model for NCPC/NCPP staff and national experts, a training combined with in-plant activities was organized in 2006 to promote and start the implementation of the Chemical Leasing concept in companies and involving other important national stakeholders

like industry associations and research centres. The chemical companies, participating in the demonstration projects, were selected by the NCPCs based on specific criteria and the work at plant level was initiated. A minimum of three companies per country were expected to take part in the demonstration projects and received, on a continuous basis, technical assistance from the national and international Chemical Leasing experts as well as the NCPC staff.

This first project covered a period of 14 months. A mid-term evaluation workshop took place in Vienna to discuss the obtained results and define the plan of action for the remaining months of the project implementation.

In total, 32 companies were involved in Chemical Leasing activities, leading to 15 Chemical Leasing demonstration projects in the three countries. The participating companies came from different sectors, including sugar processing, powder coating and metal finishing. Within the assessment work, the NCPCs played an important role as independent facilitators and quality assurance entities. Based on the experience obtained and in order to facilitate the implementation of Chemical Leasing in companies, a toolkit on Chemical Leasing and Cleaner Production was elaborated in a very first version. This toolkit showed UNIDO's Chemical Leasing methodology and was distributed to the worldwide CP Network to enable a standardized approach to Chemical Leasing.

In late 2006, when the author joined UNIDO to work on Chemical Leasing, the underlying strategy consisted of 2 main parts (Schwager, 2006):

1) Concrete implementation through demonstration projects that had already started in 2004 (planning status, resp. start of implementation in 2005): this is the sector specific approach, resulting in the projects, but also including trainings of Chemical Leasing exerts
   and
2) Global Forum activities, including awareness raising, the Chemical Leasing Award, developing tools and instruments, studies and Public-Private-Partnerships

The demonstration projects mainly covered technical assistance at plant level and in each of the participating NCPCs.

Also from the beginning there was the idea to have Chemical Leasing as a political tool and that it should be in line with REACH that entered into force in June 2007.

For the Global Forum activities, UNIDO organized several international side events and seminars to foster and facilitate the dissemination of Chemical Leasing, e.g. SAICM meetings, meetings in the EU Parliament and many more. From the very beginning the connection to SAICM was very close, Chemical Leasing was always seen as a possible tool to implement SAICM.

Beginning of 2006, UNIDO launched an international high-level working group (IWG) on Chemical Leasing to bring together representatives from industry, government, EU, quality assurance companies, equipment providers, university and consultants. In close cooperation with the members of this group and in order to prepare the ground for a sound understanding of Chemical Leasing, UNIDO developed a clear definition on the concept together with the members of this group (see Box 5).

To inform about UNIDO's Chemical Leasing activities, a website was established, first integrated in the BiPRO website, later-onto be found at: www.chemicalleasing.com. To better demonstrate and promote the results obtained, UNIDO prepared a video on the Chemical Leasing activities undertaken in the three countries[54]. In addition, a brochure on Chemical Leasing success stories was published (UNIDO, 2011c). For UNIDO's future involvement in Chemical Leasing a draft strategy paper was prepared.

Furthermore, negotiations were held in order to establish Public-Private-Partnership with international chemical suppliers to jointly promote the Chemical Leasing worldwide. In this context, UNIDO has developed draft cooperation agreements with two international chemical suppliers, Akzo Nobel (in Egypt) and BASF (in Germany).

Another idea was to create a trademark and a certificate, this was discussed with TÜV Süd in Germany for some time but then given up.

8.2.2 Colombia, Sri Lanka, Serbia and Morocco

In November 2007, preparations started to elaborate a project document to include more countries in the Chemical Leasing program: Colombia, Serbia, Sri Lanka, Morocco and in the first draft also Lithuania. Assessments of the chemical Industry in the respective countries were made to justify the selection of these countries and finally Colombia, Serbia, Sri Lanka and Morocco were selected to be part of the second cycle of Chemical Leasing. This time, the aim was to get at least a minimum of five successful showcases finalized per country within a period of 3 to 5 years. One of the aims firstly formulated was also to get a certification scheme of Chemical Leasing projects ("Certified Chemical Leasing") developed in collaboration with an international certification body, e.g. TÜV Süd. This idea was abandoned later as the need for such a scheme was not really seen.

Already in the first year, projects in Colombia, Sri Lanka and Serbia were very promising: in Colombia, a Chemical Leasing project between Ecopetrol and Nalco on water purification and crude oil dehydration was started. In Serbia, the most successful case was the partnership between Knjaz Milos and Ecolab on lubrication of conveyor belts. At the time this thesis was written, the cooperation between the two companies was still on-going and was even extended to other lines in Knjas Milos throughout the years. In Sri Lanka, the first real Chemical Leasing case was on newspaper printing between Wijeya Newspapers Ltd and General Ink Ltd. Sri Lanka is unique as there are (almost) no producers of chemicals in the country but a lot of distributers who are paid on a commission basis. Throughout the following years, more and more focus in Sri Lanka was laid on the agriculture sector. A first pilot project was started in 2011, which took a while but finally was really successful.

Works on Chemical Leasing in Morocco started quite enthusiastic but were not really successful in the end and Morocco left the Chemical Leasing program in 2011. Unfortunately, no real failure analysis was done to further investigate why this happened.

[54] https://www.youtube.com/watch?v=VhIkvZvy_yM

Projects in Egypt, Mexico and St. Petersburg were still followed up but only played a minor role. Some of the projects from the first cycle have not worked out, like the project with the sugar industry in Mexico, some others were just finished after a year. In Egypt, two Chemical Leasing projects were completed in 2009: the project on Electrostatic Powder Coating between Akzo Nobel and ABB Arab and the project on equipment cleaning with hydrocarbon solvent (Dr. Badawi Chemical Work and General Motors Egypt). One follow-up project was launched in 2009, on an integrated process on pre-treatment and pre-coating of washing machines.

In St. Petersburg special efforts were concentrated on the cooperation with Vodokanal of St. Petersburg. Several meetings and training sessions with managers of Vodokanal and Aquatechservice were organised. As a result of this promotion and cooperation, a new Chemical Leasing contract was signed in December 2009.

In that second cycle of Chemical Leasing, a Workshop in Serbia with participation of Chemical Strategies Partnerships of San Francisco on CMS was held, Chemical Leasing workshops in India and Korea took place, sustainability criteria were developed, the Chemical Leasing toolkit was further developed and Chemical Leasing was presented at several events and conferences. One big event was the first Chemical Leasing Global Award, awarded in March 2010, during the international CHEMCON Conference with the participation of more than 200 representatives from government, industry and consultant companies. In total, 27 companies, consultants and researchers submitted their applications. In addition to that, a brochure "Chemical Leasing – a Global Success Story" (UNIDO, 2011c) was published in 2011.

8.2.3 Brazil, Croatia, Nicaragua, Volga Region, Uganda, Ukraine

The results obtained in the first seven countries were very encouraging for UNIDO and so Chemical Leasing has proven to be a win-win situation for economy and environment and could be applied to different industries of different sizes in developing and transition countries. Several new countries had then expressed interest in participating in future Chemical Leasing projects and so in June 2010, discussions with several NCPCs and the work on the logical framework for future Chemical Leasing projects started. This new project focussed a bit more on regional cooperation, first of all between Serbia, Colombia and Russia and their neighbouring countries and was planned to work for three years.

Contacts have been made previously in Central and Latin America and the NCPCs in Uruguay, Nicaragua and Cost Rica had expressed their interest in Chemical Leasing. Russia contacted Kazakhstan, Belarus, Tadzhikistan, Kirgizstan and the Ukraine. Serbia started an initiative on promote Chemical Leasing in their neighbouring countries and Montenegro and Croatia showed interest.

Finally, Brazil, Croatia, Nicaragua, Volga Region, Uganda and Ukraine started with the Chemical Leasing program in 2011.

In Mexico, Egypt and St. Petersburg, follow-up activities were conducted more or less successfully. In Egypt, three successful Chemical Leasing cases have been carried out until 2014, one in the automotive industry which is still being monitored, one in electrostatic powder coating and one on an integrated process on pre-treatment and pre-coating. The idea was to create a Chemical Leasing cluster and

to work through the supply chain in the future. The long lasting efforts in Chemical Leasing were awarded with Silver in the category Case Studies for the case of General Motors (cleaning of equipment) in 2012. In Mexico, two new cases were initiated on the use of biotechnology in the agriculture sector and on the use of nanotechnology for boilers; negotiations are on-going with some other companies. Meanwhile, the NCPC got a new director and efforts are now increasing to get again more Chemical Leasing cases. In St. Petersburg, the main focus for Chemical Leasing is still on wastewater treatment and hazardous chemicals and the cooperation with Vodokanal is on-going. SUE "Vodokanal of St. Petersburg" and ZAO "KemiraEko" as a supplier of reagent for wastewater treatment process ("Ferix-3") were doing a pilot study for testing a method for wastewater purification from harmful nutrients.

In Colombia, a new case between Grival – Dindep on the treatment of hazardous sludge stored in a security cell in order to recover heavy metals was started. In Serbia, the second Chemical Leasing case was the one on bonding of boxes between Bambi and Henkel. In Serbia and Sri Lanka, Chemical Leasing in agriculture boosted. Chemical Leasing projects on potato, leak, paddy and most promising, on tea in Sri Lanka and on wheat, maize and cucumber in Serbia were conducted; initiatives in Russia, Ukraine, Mexico and Uganda were also started.

Ukraine left the Chemical Leasing program in 2013.

In this period, the second (with 44 applications from 12 countries) and third (more than 50 applications from more than 20 countries) Chemical Leasing Global Award were awarded, a Chemical Leasing Hotline was established, publications and articles were disseminated, global trainings, awareness raising and information events organised and a database on all Chemical Leasing cases studies (not only from UNIDO) was established. Also the Chemical Leasing Toolkit was totally renewed and in 2014, at the end of the third cycle, an intensive discussion on a new strategy on Chemical Leasing started.

In this period, also the first two peer-reviewed scientific articles were published in the scientific journal "Resources, Conservation and Recycling" (Elsevier): Fostering green chemistry through a collaborative business model: A Chemical Leasing case study from Serbia" was jointly published by experts from the CPC Serbia, Utrecht University (Netherlands) and Organisational Sustainability Ltd. (United Kingdom). Another article on „critical reflections on the Chemical Leasing concept" by Rodrigo Lozano, Angela Carpenter and Francisco Lozano, was also published in that period. In addition to that a paper is being prepared on the definition of Chemical Leasing.

A study on the "Potential of Chemical Leasing in Selected Cleaning Operations" was also published in 2015 by Gaia Consulting (Gilbert et al., 2015).

Fig. 8-1 shows the geographical spread of the Chemical Leasing program (UNIDO, 2013):

Figure 8-3: Chemical Leasing geographical spread (source: UNIDO, Annual Report 2013)

Table 8-1 shows the timeline of the development of Chemical Leasing (selection of "highlights" and cornerstones):

Table 8-1: Timeline of Chemical Leasing

2003	
November	First contact between UNIDO and the BMLFUW at the OECD Conference , Vienna
2004	
December	UNIDO joining hands with the Ministry to further promote Chemical Leasing, formulation of the first project document
2005	
	First pilot projects started in Egypt, Mexico and St. Petersburg, (on sugar processing, powder coating and metal finishing)
2006	
	First draft of toolkit
	Website established: www.chemcialleasing.com
	Video produced to better demonstrate and promote results obtained
	First brochure on Chemical Leasing published
	Launch of International Working group (IWG) and first meetings
	Draft strategy paper prepared
	Definition of Chemical Leasing established
	Close connection to SAICM (Dubai and Senegal)
	Presentation of the Chemical Leasing concept at the EU Parliament
	Private Public Partnerships (PPP): first negotiations with Akzo Nobel and BASF
	First discussion about a certification scheme with TÜV SÜD
2007	
	Publication of the book "Chemical Leasing goes Global – Selling Services instead of Barrels"
	Design and development of a toolkit with guidelines and worksheets
	Two "memorandum of understanding" signed with Akzo Nobel and BASF
	Concept note for the monitoring of the first projects in Egypt, Mexico and St. Petersburg (conducted in 2008)
	New project proposal formulated to further promote Chemical Leasing with Colombia, Serbia, Sri Lanka and Morocco
2008	
	International Training Workshop for new countries on Chemical Leasing
	International Workshop in Hungary and meeting of IWG
	Project "Chemikalienleasing als Modell zur nachhaltigen Entwicklung…" being established in Germany
	Side event on Chemical Leasing organised at the Intergovernmental Forum on Chemical Safety, hosted by UNIDO and the governments of Austria and Germany
	First idea of a "Global Chemical Leasing Award"
	Further promotion of PPP (with IKEA Trading India)

	Presentations of Chemical Leasing at different conferences
	First letter of intends from companies in Colombia, Serbia, Sri Lanka and Morocco
	Second version of Chemical Leasing Toolkit launched
2009	
	Sustainability criteria for Chemical Leasing elaborated in the course of the German Chemical Leasing project and further tested in UNIDO cases
	First talks about up scaling of Chemical Leasing to Sustainable Chemicals Management
	Presentation of Chemical Leasing at diverse conferences
	Cross-over of Chemical Leasing and CMS at a Workshop in Serbia
	Chemical Leasing workshop in India
	Chemical Leasing presented at the ICCM2 meeting, side event on Chemical Leasing
	Global Chemical Leasing Award launched by the Austrian Government and UNIDO
	Second evaluation of Chemical Leasing
	First talks of implementing Chemical Leasing in agriculture
2010	
	First Global Chemical Leasing Award awarded in Prague in 3 categories
	Chemical Leasing presented at the 9th Asia Pacific Roundtable on Sustainable Consumption and Production
	Side Event on Chemical Leasing at the ERSCP in Delft
	New project proposal formulated with focus on regional cooperation, between Serbia, Colombia and Russia and their neighbouring countries
	Tool on synergies between Chemical Leasing and Responsible Production developed by UNEP
2011	
	Six new countries participating in the Chemical Leasing Program: Brazil, Croatia, Nicaragua, Russia (Volga Region) Ukraine, Uganda
	Recognition of Chemical Leasing by the European Parliament
	Political Recognition at country level by the Government of Serbia
	Brochure "Chemical Leasing – A Global Success story" on 5 success stories launched
	Announcement of the 2nd edition of the Global Chemical Leasing Award to be awarded in 2012
2012	
	Research Project on Chemical Leasing in hospitals supported by the German government successfully completed
	Chemical Leasing hotline launched
	More publications in different media (Popular and scientific) in different languages
	Database on CHEMICAL LEASING projects developed
	Internationalisation of Chemical Leasing through multinational companies (e.g. Coca Cola, Carlsberg, SAFECHEM)

	Study on Chemical Leasing in selected cleaning operations initiated
	Chemical Leasing recognition by UNEP as a tool to stimulate innovations in firms and support "greening of enterprises and economics"
2013	
	Thematic Sub-group of Chemical Leasing in agriculture established
	Chemical Leasing recommended by CEFIS as an option among several substitution possibilities
	Launch of 3rd Global Chemical Leasing Award
2014	
	Enhanced cooperation with academia
	Several project on Chemical Leasing in agriculture launched in Sri Lanka and Serbia
	Chemical Leasing at the "European Forum Alpbach" (Europäisches Forum Alpbach) with the topic: "Hygiene management in the health sector by way of Chemical Leasing"
	Third evaluation of Chemical Leasing
	3rd Chemical Leasing Award awarded
2015	
	Draft Strategy on further development of Chemical Leasing

Over the last 10 years, lots of improvements in the program itself have been made and the program has been more and more refined. In addition, lots of tools and instruments to spread the idea of Chemical Leasing were developed and case studies put in place. Some of these were described in more detail, especially the most successful ones. In chapters 10 to 12, a description and analysis of the Chemical Leasing program, the instruments and tools and of a selection of five case studies can be found. In chapter 9, the criteria on how to measure these three categories are presented first.

Chapter 8 gave an overview on the development of Chemical Leasing at UNIDO, from its beginning in 2004. It presented the definition of Chemical Leasing, it described the project scheme with its different project phases, and the three cycles of Chemical Leasing that were started in different countries. At the end of the chapter, a timeline showed the corner stones of Chemical Leasing in the different years. This chapter is the basis for the assessment in the following chapters 9 to 12.

PART B – Assessment of Chemical Leasing and Development of a Roadmap

9. Development of a criteria catalogue

In Part B of this thesis, the assessment of Chemical Leasing program, together with its tools and case studies is being done to find answers to the research questions that were formulated. To be able to do so, three evaluations since 2008 have been done and will be presented in Part B.

In chapter 9, first of all, the criteria for the assessment of the Chemical Leasing program, the Chemical Leasing tools and the Chemical Leasing case studies are being developed and described. These criteria are the basis for the assessment but also for the development of a new set of indicators and a roadmap that will be presented later in this thesis.

Chemical Leasing has now been around for more than a decade and has shown some impressing success. Nevertheless, despite the high hopes, it has not really begun to lift off. The question is, if Chemical Leasing as a model or concept is sustainable itself, in the meaning of being long-lasting, enduring, trendsetting and successful and if it is in accordance with other concepts like Sustainable Development, Cleaner Production, Sustainable Chemistry, etc. that stand for sustainability.

The goal of this thesis is to find answers to the following research questions:

1. Does Chemical Leasing contribute to Sustainable Development, the concept of Sustainability? Is Chemical Leasing able to reduce the burden chemicals put on our environment and how can we measure this?
2. What are success factors (economic, ecologic and social benefits) and the difficulties in implementing Chemical Leasing, and how can they be overcome?
3. What are future perspectives of Chemical Leasing (e.g. Chemical Leasing in new sectors), what are recommendations for the program and is there (and in which aspects) a need for further research?

To find answers to these questions, in addition to the results gained from literature research, three evaluations have been undertaken from 2008 to 2014 by the author of this thesis.

To make any kind of assessment, it is necessary to formulate criteria and indicators on how this can be measured. Criteria and indicators can then be applied to the Chemical Leasing program itself, to the tools and to the cases and have to be monitored and evaluated within a certain time-frame to verify improvements, (process) optimization and savings in costs and resources. All three components (program, tools and cases) contribute to this assessment on different levels:

- All three are important to find out about the success factors and the difficulties in implementing Chemical Leasing.

- For the assessment of a contribution to sustainability and sustainable development, the Chemical Leasing program has been measured against the concepts and approaches described in chapters 2 and 3 (Sustainable Development, Cleaner Production, Product Service Systems, Green and Sustainable Chemistry, Circular Economy). They all have special characteristics that link them to sustainability in one way or another. There might be more and other concepts as well but these are the ones that can be clearly linked to Chemical Leasing, be it in their context to chemicals or their underlying notion.
- Tools and cases were analysed and included in the assessment to design a roadmap for the future of the Chemical Leasing program as well.

9.1 Criteria for the Chemical Leasing program

The evaluation of the Chemical Leasing program was done in two different ways:

1. First it was checked if Chemical Leasing is somehow embedded in the approaches described in chapters 2 to 3 or if there is at least some link to them in theory.
2. In a second step, the sustainability and durability of the Chemical Leasing program was evaluated. This is important to find out if Chemical Leasing is a program that will last for longer and help to get chemical industry more sustainable.

For the first step, criteria were defined, according to the concept and approaches towards sustainability that were already mentioned before:

Does the Chemical Leasing program comply with criteria

- for Sustainable Development?
- for Sustainable innovation?
- for Cleaner Production?
- for Circular Economy?
- for Green Chemistry?
- for Sustainable Chemistry?
- for Product-Service-Systems?

In addition to that, also the connections between Chemical Leasing and REACH were evaluated.

The key elements and terms of all these concepts have been summarized in the respective chapters and were a reference for this question.

To find out more about the Chemical Leasing program itself and its impact, the program, together with the cases and with its tools has been assessed in three evaluations over the last 10 years, in 2008, 2009 and 2014 by the author of this thesis. The questionnaires can be found in the Annex (17.1 – 17.3). These evaluations had the purpose to find out about the success factors but even more important, about the obstacles concerning the implementation of Chemical Leasing. It was also the aim to find out if the Chemical Leasing program advances and if the program itself, the tools that are used and the cases studies that are available can push the implementation of the model. The program is the vehicle to bring Chemical Leasing forward and to bring sustainability into the chemical industry.

The measures/questions on the program were qualitative and the NCPCs provided mostly quite extensive answers. The questions as well as the group of respondents changed over the years and will be presented and described at each section separately (see chapters 10.2.1 – 10.2.3).

9.2 Criteria for the Tools

The different tools that have been developed over the last ten years are important to explain and "teach" Chemical Leasing. They should help in a better implementation of the Chemical Leasing program and bring the program further. Some of these tools have changed during the years, some of them have been abandoned after some time and some are still working.

To assess the tools, it is quite hard to find quantitative measures and no real criteria could be found as the one, if they work or if they don't. The tools themselves are described in detail in chapter 10.2, followed by a qualitative analysis. They were subject to the evaluation in 2014 and the assessment was done by the representatives of the NCPCs, the ones that have to work with these tools.

The main criteria and indicators that were used for the different tools were:

- Did you use the tool? Why, why not?
- Was the tool helpful? In which way?
- What is good, what is bad about the tool?
- What could be improved/changed? Any suggestions?
- Would you need more or other tools? Any suggestions?

The aim was to find out, if the existing tools helped to implement and to bring the Chemical Leasing concept further, how they could be amended to fit better and which additional tools would be needed.

9.3 Criteria for the cases studies

Criteria for measuring the success of the Chemical Leasing projects have not been formulated at the beginning of the program in 2004. Nevertheless, sustainability criteria for Chemical Leasing have been elaborated within the course of the German Chemical Leasing project in 2009 and later-on also been used in the UNIDO Chemical Leasing program. These sustainability criteria serve three main purposes:

- Measurable and **concrete ecological improvements** as a key element for sustainability
- Measurable and **concrete economical improvements** as lasting motivation for Chemical Leasing partners to implement Chemical Leasing
- Protection of the **positive image of Chemical Leasing**; prevention of misuse of the term Chemical Leasing e.g. for non-adequate activities related to health or the environment

The sustainability criteria will be further described and analysed in chapter 11. These criteria are only a framework but need indicators on how to quantitatively or qualitatively measure any changes. The case studies therefore were analysed regarding which indicators were actually used to show success of the

implementation of Chemical Leasing. The aim was to come up with a list of indicators that were used in the different cases and afterwards develop a (new) set of Key Performance Indicators (KPI) to make these indicators and the cases themselves more comparable in the future.

When analysing the cases, the following variables were checked:

- Indicators used;
- Technical/organisational changes;
- Economic results/benefits;
- Environmental results/benefits.
- Social results/benefits
- Other results/benefits (e.g. long-term partnerships between users and suppliers, higher working standards, etc.)

Chapter 9 presented the criteria for the assessment of the Chemical Leasing program, the Chemical Leasing tools and the Chemical Leasing case studies. For the Chemical Leasing program itself, criteria were defined, according to the concepts and approaches towards sustainability. To assess the tools, qualitative measures were chosen, primarily if the tools were useful or not. The criteria for the assessment of the case studies are based on the sustainability criteria for Chemical Leasing but in addition to that, cases will be checked according a list of variables that was defined in this chapter.

10. Analysis of the Chemical Leasing program

In Chapter 10, the results from three evaluations that were done since 2008 on Chemical Leasing are presented. In the first section, the compliance of the Chemical Leasing program with other sustainability concepts is being assessed. The following three sections evaluate the Chemical Leasing program itself, each evaluation presented separately. Each of these subsections is concluded with key recommendations. The chapter is closed with the ten most important final conclusions to all three evaluations.

The first part of this chapter focuses on the linkage between sustainability concepts and approaches and Chemical Leasing. A hypothesis was formulated in chapter 1.2, assuming that Chemical Leasing can change the use of chemicals towards more sustainability. This was based on the main assumptions that

- the way how chemicals are handled and used strongly influences the process and its sustainability and
- Chemical Leasing is a program that includes all three dimensions of sustainability.

The analysis of these linkages between Chemical Leasing and sustainability concept were done through a comprehensive literature research first, completed by a cross-check with the results from the three evaluations.

The second part of this chapter is dedicated to the three evaluations conducted by the author of this thesis between 2008 and 2014 with the NCPCs. The representatives of the National Cleaner Production Centres are the ones who are closest linked to the program and to the main protagonists, the companies. Their personal view and assessment and foremost their personal engagement and efforts are vital parts of success or failure of the Chemical Leasing program in a country.

At the end of each evaluation, conclusions were drawn and key recommendations formulated. These recommendations were incorporated later in the roadmap described in chapter 14.2.

10.1 Compliance of the Chemical Leasing program with other sustainability concepts

it is clear that every single of the mentioned sustainability concepts and approaches like Cleaner Production, Product-Service-Systems, Green Chemistry, etc. could not be analysed to its full range within this thesis; the focus was rather to find some key elements of every of these concepts and approaches and put them in comparison to Chemical Leasing to find out if and to which extend Chemical Leasing complies with these concepts and approaches.

The key elements of every concept have been collected and described already in chapters two to four. The comparison showed that Chemical Leasing has a lot of key elements in common with all kinds of concepts and approaches.

In table 10-1, the key elements Chemical Leasing stands for (or at least aims to) were put in correlation to the different sustainability concepts and approaches. This was later-on integrated into the roadmap for Chemical Leasing.

Table 10-1: Key Elements of Chemical Leasing and other sustainability concepts and approaches

Key Elements	ChL	Sustainable Development	Sustainable Innovation	Cleaner Production	Circular Economy	Sustain. Chemistry	Green Chemistry	Product-Service-Systems	REACH
Crucial role of industry for changes	✔	✔	✔	✔	✔	✔		✔	✔
Multi-dimensional illustration of sustainability (social, economic, ecologic)	✔	✔	✔		✔			✔	
On-going process (different social, political cultural and historical contexts)	✔	✔	✔						
Need of radical changes, new ways of thinking	✔	✔			✔			✔	
Decoupling economic success from resource consumption	✔	✔							
Change focus from selling products to selling performances	✔	✔							
Increase efficiency of natural resources (incl. energy)	✔			✔	✔	✔	✔	✔	

Key Elements	ChL	Sustainable Development	Sustainable Innovation	Cleaner Production	Circular Economy	Sustain. Chemistry	Green Chemistry	Product-Service-Systems	REACH
Reduce risk/impact for humans/environment	✔			✔		✔	✔	✔	
Integrated environmental strategy on products, processes and services	✔			✔					
reduce the amount of hazardous chemicals	✔					✔			
Avoid potentially toxic processes and materials	✔			✔		✔	✔		
Reduce material and energy consumption	✔			✔		✔		✔	
Reduce costs on material, energy, waste handling	✔			✔		✔		✔	
Integrated approach, looking at whole life cycle	✔		✔	✔	✔	✔			✔
access to information about emissions, amount, types of chemicals used	✔			✔					✔

Key Elements	ChL	Sustainable Development	Sustainable Innovation	Cleaner Production	Circular Economy	Sustain. Chemistry	Green Chemistry	Product-Service-Systems	REACH
Customer pays for utilisation of product	✔							✔	
Shift from selling products into selling performances – **change in mind set**	✔	✔	✔		✔	✔	✔	✔	
decoupling economic success from resource use	✔	✔							
Profit of supplier and user are not linked to quantity of product sold	✔							✔	
Positive impact on all three dimensions of sustainability required	✔							✔	
New unit of payment (per service unit)	✔							✔	
Closer cooperation between user and supplier	✔							✔	
Design/use of safer chemicals	(✔)					✔	✔		

Key Elements	ChL	Sustainable Development	Sustainable Innovation	Cleaner Production	Circular Economy	Sustain. Chemistry	Green Chemistry	Product-Service-Systems	REACH
Business innovation	✔		✔		✔	✔		✔	
Shift focus to reuse, repair, recycling	✔				✔				
Shift away from traditional ownership towards using and sharing	✔				✔				
Better understanding of need of customers by suppliers	✔							✔	
Preventive approach	✔			✔			✔		
Including all kinds of stakeholders	✔					✔			

10.2 Evaluation of the Chemical Leasing program

According to UNIDO (Schwager, 2006), the Chemical Leasing program is based on two main pillars:

1) Concrete implementation through demonstration projects that had already started in 2004 (planning status, resp. start of implementation in 2005): this is the sector specific approach, resulting in projects, but also including trainings of Chemical Leasing experts
and
2) Global Forum activities, including awareness raising, the Chemical Leasing Award, developing tools and instruments, studies and Public-Private-Partnerships.

Both pillars have been evaluated in this theses.

The Chemical Leasing program, together with the cases and with its tools has been assessed in three evaluations over the last 10 years, in 2008, 2009 and 2014 by the author of this thesis. For this purpose, questionnaires were sent out to the representatives of the NCPCs.

The evaluations had the purpose to find out about the success factors but even more important, about the obstacles concerning the implementation of Chemical Leasing and how they might be overcome. It was also the aim to find out if the Chemical Leasing program advances and if the program itself, the tools that are used and the cases studies that are available can push the implementation of the model. The program is the vehicle to bring Chemical Leasing forward and to bring sustainability into the chemical industry.

The measures/questions on the program were qualitative and the NCPCs provided mostly quite extensive answers to the following questions:

- What is needed to successfully implement Chemical Leasing?
- Does the program fulfil these needs?
- What will the NCPCs need for further successful work (skills, tools, assistance, etc.)?
- What were obstacles faced? What are the main barriers?
- Which opportunities does Chemical Leasing provide? What are the main benefits?
- What are lessons learned?
- Does Chemical Leasing bring in new income?

In addition to that, project documents of UNIDO, as well as different publications, reports, books, periodicals, scientific magazines and journals, online articles, newsletters, background papers, conference proceedings and presentations to cross-check and underpin the answers of the NCPCs were used.

In 2008, the first evaluation was done to provide lessons learned from the first 3 years of Chemical Leasing. After this first period of work in Egypt, Mexico and Russia it was time to evaluate all the activities that have been set and experiences and results that have been achieved so far. Therefore, in 2008 a self-assessment of the Chemical Leasing activities at the three National Cleaner Production Centres in Mexico, Egypt and Russia was done. The self-assessment was intended to capture the main lessons from the NCPC's perspective and all three

NCPCs were encouraged to provide explanations and answers as precisely and detailed as possible and to attach any existing documentation that would support the responses (latest progress reports, annual reports of the last two or three years, any other information, dissemination, training material). The results of the evaluation also aimed at helping to further develop the program and to give (even better) support to the four new countries that started the Chemical Leasing projects in 2008.

A second evaluation was done in 2009, this time already including the four new NCPCs, Colombia, Serbia, Sri Lanka and Morocco. The focus was on improving the (technical) assistance UNIDO is providing together with the international experts to bring Chemical Leasing forward. The questions comprised the training given to the Chemical Leasing experts, the assessment of projects, data collection and reporting.

The third evaluation was done in 2014, trying to get a comprehensive overview not only on the actual situation and status of the Chemical Leasing program and the projects but also to get concrete hints on how to develop and improve the different tools in Chemical Leasing, to get answers on lessons learned so far and a glance at the future of Chemical Leasing. Ten NCPCs participated in that evaluation.

In all three evaluations, the responding NCPCs and countries normally were not named, only if it was important for the context in which they were placed.

10.2.1 First evaluation (2008)

The **first evaluation** was done in 2008 among the three first NCPCs in Egypt, Mexico and St. Petersburg/Russia. The evaluation originally consisted of three pillars: a survey, an analysis of the answers (“lessons learned”) and visits to the NCPCs to verify the data. The visits were cancelled due to time constraints and because the international expert, Reinhard Joas, had spent sufficient time with the NCPCs to be able to verify the data. Instead of that, the results of personal interviews with people involved on the side of the NCPCs were included in the evaluation report.

The survey included open and closed questions and consisted of a “general information chapter” and three main sections:

- General information (contact details, number of employees, start of the Chemical Leasing program, etc.)

1. Chemical Leasing assessments/projects (exact data on the different projects, on the chemicals used and the processes where Chemical Leasing was implemented and on the savings in terms of chemicals, water and energy)
2. Other Chemical Leasing activities (information, training and policy)
3. Results (activities, outcomes, future success)

A concise summary of the first evaluation report (“Lessons learned”) was written at the end of 2008 by the author of this thesis for UNIDO.

It can be stated, that the NCPCs and UNIDO were successful in promoting the idea of Chemical Leasing, to start some demonstration projects and to develop training and promotion materials. However, the NCPCs were less successful in

documenting the concrete impacts and savings at company level, due to different reasons.

For every section of the evaluation, findings and recommendations were formulated. These statements will be used to compare the different outcomes of the program evaluations over the years, as well as to document what have been the results and consequences for UNIDO to change or amend the program to better respond to the needs of the NCPCs. In the following, a summary of the first evaluation is presented.

1. **Chemical Leasing assessments/projects (exact data on the numbers of companies contacted, site visits, etc.)**

In the first evaluation, one focus was set on collecting numbers in different areas like the numbers of first contacts, site visits, first assessments and contracts signed but also number of trainings held for companies and numbers of trainings for the staff. The evaluation clearly showed that collecting numbers without a clear definition of terms (what is a first contact: a telephone call, a first meeting, an awareness raising workshop?) and objectives and desired results (how many trainings held, how many contracts signed?) is not very useful. As an example, for awareness raising activities, for one centre every presentation of the Chemical Leasing concept was seen as an awareness raising activity, for others only presentation at big(ger) events like roundtables, etc. were counted as such. A clear definition does not only make the work on reports etc. easier but also makes numbers comparable. Although the numbers of first contacts, site visits and assessments was quite different in the three centres, all three had two contracts signed in 2008. Nevertheless, an intense follow-up of the first contacts with companies had to be done.

Concerning indicators (e.g. estimated and concrete savings in the companies on water, energy, etc.), it is impossible to compare the three countries, which has two main reasons:

- In the first place, it was hard and not always possible to obtain reliable data for every country;
- Second, the companies, the processes and also the chemicals used are not directly comparable.

So a comparison would be rather far-fetched and not be giving any relevant information. What can be said is that data collection in general was a problem in all three countries. In many cases, companies were not willing or also not able to provide any data. Concrete savings could not be named, often due to technical problems in the companies or because companies have not finished the Chemical Leasing implementation at the date of the first evaluation.

Making estimates on possible savings would have been another option but could not be done in all the cases before starting implementing Chemical Leasing, mainly due to a lack of experience with Chemical Leasing. For example, in Mexico, in one company where the savings for the use of nickel were estimated, instead of expected 30% only 22% of nickel could be saved, the differences occurred because the estimates were done inaccurately. In Russia, in one case, where both

estimates and concrete savings could be named, the estimates on savings were outreached.

2. Other Chemical Leasing activities (information, training and policy)

During the assessment of the Chemical Leasing activities it became clear that also these activities are hard to compare. There are three main topics that were assessed: “awareness raising activities”, “trainings held” and “trainings for staff”. It seemed that the definition of these three terms was not clear enough for the NCPCs; also for the awareness raising activities the term was not clear.

The term “training for staff” was not quite clear for the NCPCs. Whereas in Mexico, not even the yearly workshops of UNIDO were seen as trainings for staff, in Egypt no specific information on the type of training was given. In Russia, trainings with other focus than Chemical Leasing as well as the UNIDO workshop and the participation at the International Working Group on Chemical Leasing were seen as training for staff.

So it would help to clearly define awareness raising, for example as activities set to promote Chemical Leasing (be it information or dissemination events) and training as the building of competences for the own staff or the staff in companies. The suggestion also was that for a training, a minimum of 1 ½ days and maybe also a kind of exam have to be a precondition to be accepted as such. This would also better proof an increase in Chemical Leasing knowledge. There is definitely a need for capacity building and more and more specific trainings, with more success stories and more tools.

3. Results (activities, outcomes, future success)

In general, it was noted that Chemical Leasing is seen as a win-win situation and a tool for raising competitiveness. It is also clear that Chemical Leasing has to be seen as a long-term project and that the commitment of international chemical suppliers was and will be crucial (e.g. BASF, Akzo Nobel). Two of the NCPCs also mentioned that a visons and strategy for the following five to ten years would be needed.

The role of the NCPCs was very much appreciated and mediation and moderation of the NCPCs was often required when companies had meetings. The willingness and a certain culture of cooperation were seen as essential prerequisites for successful Chemical Leasing projects.

The evidence of economic and environmental benefits was the main driving force for Chemical Leasing business models. The identification and quantification of optimization potentials was a strong motivator to do a Chemical Leasing project. But therefore, a baseline and the starting point of a Chemical Leasing project in terms of data collection has to be defined. Therefore, a transparent recording system and cost calculation tool is required.

The monitoring phase of Chemical Leasing projects is a very important phase to adapt the model for day-to-day work at plant level. A standardization of the model with a development of a Chemical Leasing certification scheme would be very supportive for improvement.

The exchange of experiences with colleagues and with other Chemical Management models (e.g. Chemical Management Services) would enhance Chemical Leasing. It was also stated that the integration of Chemical Leasing in the agendas of international initiatives on chemicals management (e.g. SAICM) was needed.

Lessons learned from the three pilot countries would pave the way to go globally with the model in a systematic way. This could be done with a database, collecting success stories and their in-depth description as well as collecting potential processes suitable for Chemical Leasing.

In all three countries, local stakeholders and the regional approach were seen as very important. Also meetings with the government have taken place in every country. Nonetheless, no real involvement from the official side could be detected at the point of the evaluation except from Egypt, where the Ministry of Trade and Industry and the Federation of Egyptian Industries play a very important role in the promotion of Chemical Leasing.

The role of UNIDO and the international experts was seen as very valuable for all three NCPCs, especially the trainings and the support they give in working with the companies. The cooperation between UNIDO, the international experts and the NCPCs so far was very crucial to build trust between companies.

At the end of the questionnaire there was some space left for NCPCs to mention any other thoughts, recommendations, etc.

Conclusions

The Self-Assessment was the first assessment of the Chemical Leasing program after three years. The three pioneer National Cleaner Production centres were the first ones to work with companies on the introduction and implementation of Chemical Leasing. Also for UNIDO it was a challenge: the program has been worked out carefully but had to be tested in practice. As this evaluation could show some unexpected difficulties arose (e.g. data collection) but also risks that UNIDO has been aware before (e.g. chemical industry is not willing to participate in the awareness-raising workshops or is not interested in the concept at all) were proofed (partly) right.

It could be verified that Chemical Leasing is a very innovative model for the future and that there is a need for further development to make the implementation at plant level much easier. More emphasis should be put on high-quality and comprehensive plant assessments to avoid disappointments, failures and dropouts of companies during the pilot project phase.

One of the main results was that in future much more emphasis has to be put on data collection from both sides, UNIDO and the NCPCs: UNIDO has to set clear targets for the different objectives and the NCPCs have to take care of that together with the companies.

The toolkit (or toolbox) which was developed during the first three years proofed to be a very valuable tool but there is still a need for more tools, more success stories and more worksheets for the NCPCs. The staff working with the companies in the three countries realized that putting the concept into practice requires much more effort than expected. More exchange of experiences with other NCPCs but

also other Chemical Management initiatives (e.g. Chemicals Strategies Partnership, San Francisco) would be helpful.

One main task would be more awareness raising activities in all three countries and to present more success stories and "hard" data about Chemical Leasing to companies to be able to better bring across the concept.

In the following, key recommendations which were derived from the analysis and the assessments are summarized:

Key Recommendations

- At first, a **long term strategic thinking**, a **vision** for the Chemical Leasing concept should be formulated and put down for the up-coming 5-10 years which will help in the promotion and the development of the model in systematic steps.
- It became clear that there is a **need for capacity building** of national experts with more concrete trainings programs. Having one seminar at the beginning of the Chemical Leasing program and having the missions of the international experts once a year seems to be not enough. It is highly recommended to **offer (or initiate) more and specific trainings** on Chemical Leasing and related topics by UNIDO and/or the international experts.
- In this regards it is also necessary to ensure that all the NCPC staff that is working with and in companies has a **profound technical knowledge** and it is important to ensure that there are trainings available for that.
- A **clearer definition of terms** (what is staff training (how many hours/days, which content, etc.), awareness raising (what is it?), etc.) and of the **actions** that should be linked to that should be made.
- **Indicate clear targets** the NCPCs should reach during one year of Chemical Leasing (e.g.: two people of the NCPCs should attend (at least) three trainings on Chemical Leasing, CP or Sustainable Chemical Management).
- What is missing in most cases is a **baseline**, meaning the **status quo** from where the Chemical Leasing program is started, data are collected and results are measured upon.
- More emphasis should be put on **data collection**, which includes estimates on savings in the categories of water, energy and chemicals/raw materials but also concrete savings in these categories at the end of an implementation cycle. This is a clear task for the NCPC to claim from the companies but also to assist in data collection.
- Estimates should be done as accurate as possible and be given in **concrete numbers** and not only percentages wherever possible.
- Efforts should be made to obtain **reliable data** on concrete savings at the end of the implementation of Chemical Leasing and on the comparison of the data.
- A high number of first contacts and site visits alone does not guarantee a high number of contracts signed. More emphasis should be put in the **follow-up of first contacts.**
- More information on the **concrete implementation and more tools** (e.g. a Cost-Benefit-Analysis tool, etc.) shall be provided to the NCPCs and included into the Toolbox. NCPCs are also invited to contribute to that with their own experience, tools, etc.

- The **exchange of experience** between the pilot projects in the three pilot countries (and the four new countries) is very important for further development of the concept. In this context, it is recommended to create a system for the exchange of the experiences through certain **training internships for local experts** among the different NCPCs.
- **More detailed reporting** during the years is recommended, especially concerning the data on savings. It seems to be wise to have monthly (but short) reports, including all new contact, plans on what to do concerning Chemical Leasing in this plants, the estimated savings that could be possible, etc.
- The Chemical Leasing program is still in need of a stronger support from the different national stakeholders for promotion. It is necessary to **test the model in different pilot projects** in different sector and processes and enhance the **regional cooperation** on Chemical Leasing.
- It is also recommended to build a **database for all the potential processes,** which are suitable for Chemical Leasing, which will help in capacity building of national experts in planning of Chemical Leasing projects. In this respect, it was recommended to do national surveys to find out, which processes would be suitable for Chemical Leasing.
- Based on that, a database for **success stories** in different countries and sectors can be put up accordingly.
- **Contacts to industry** should be improved by the NCPCs.
- It is also recommended to build **strong contacts with other chemicals management models worldwide** (e.g. Chemicals Strategies Partnership) to get new views and experiences.
- Chemicals should be **integrated urgently in the agendas of all the international initiatives on chemicals management** (e.g. SAICM). This will significantly speed up putting the Chemical Leasing on the national agendas of the participating countries in these initiatives (e.g. Egypt) and will be helpful in the promotion of the concept at national levels.
- Stress the importance of a **certification scheme**, which will set up a concrete framework for recording and calculation of the gained benefits (savings, raw material, waste management, energy savings, etc.).

10.2.2 Second evaluation (2009)

The **second evaluation** was done in 2009 and was meant to be a more technical assessment. As it was done only a few months after the first evaluation and had a slightly different focus, it was too early to find if some recommendation from the first evaluation have already been considered. Nevertheless, the questions were a bit more in-depth and new information could be gathered to help the Chemical Leasing program to be improved and to focus more on areas, where UNIDO and national and international experts could assist more.

The questionnaire was developed (again by the author of this thesis) to find answers on how UNIDO, together with the international experts could improve especially the technical assistance for the NCPCs. The questionnaire was divided into six sections:

1. First training for Chemical Leasing experts (including training materials)
2. Chemical Leasing assessments/projects, site visits, first contacts, assessments and contracts
3. Indicators - estimated and concrete savings on water, energy and resources
4. Chemical Leasing activities - trainings held, staff trainings and awareness raising
5. Reporting
6. Other problems/challenges faced

The questionnaire was distributed among the first NCPCs participating in the Chemical Leasing program in Egypt, Mexico and St. Petersburg, but also among the NCPCs in the second cycle, Colombia, Serbia, Sri Lanka and also Morocco, which was at that time still participating in the program. The questionnaire can be found in Annex 17.2.

1. First trainings for Chemical Leasing experts

All NCPCs stated that the introductory seminar was a good tool to understand the theory behind the model and the basics, but for their practical work, it would need much more practical tools. It was a good start but is definitely not sufficient for the capacity building of national experts. The program of the seminar was good but didn't present strategies to establish a successful contact between users and suppliers, and to see if the companies have the potential for Chemical Leasing or not.

New and unconventional methods of teaching, like webinars, video sessions, training films or games, comics, simulations, business games, etc. should also be introduced and used in the introductory seminar.

If possible, it would also be good to better respond to the special requirements of each of the participating countries, as culture, legislation, etc. are often quite different and might influence the work with Chemical Leasing a lot. Sometimes there is the feeling among the NCPCs, that the tools and methods are too much oriented on the experiences and needs of European and North American countries with highly developed business relations.

An in-depths analysis and discussion of “real” cases in the frame of this seminar for starters could be very helpful besides all the theory. It would also be helpful to describe in more detail the processes, which are (or are not) suitable for Chemical Leasing. Also more interactive tools to enhance the exchange among participants and the trainers, to get to know each other better would be valuable. Comments were that the seminar could last a bit longer (up to one week) and give enough room for more discussion among participants as well as with the experts and also with more focus on the implementation phase of the project (industrial site level). Also a simulation of a case study or a kind of “business game” during the training would be good.

All participants saw the knowledge of the experts as well as the people from UNIDO as very good, with lots of experience in the Chemical Leasing business model (application in other countries). There was a variety of knowledge and experiences of participating experts but it was clear that a strong technical background, needed for the implementation of Chemical Leasing, is still missing among the participants.

The training material is useful to understand the concept of Chemical Leasing and is of good quality (toolbox, video, books, promotional material). The different elements of the toolbox have been widely disseminated to companies and universities as well. One thing missing is a comprehensive explanation why the new business model of Chemical Leasing has advantages over selling and buying chemicals in a traditional way. It would also be helpful to focus a bit more on the terminology (why is the term “leasing” used?) and the differences of Chemical Leasing to other and/or similar business models in the chemical industry. Better economic analysis (calculations) and environmental indicators used for each particular process where Chemical Leasing has been implemented, would be a good addition. Also having more success stories with more details of the implementation at hand would be appreciated. Having the success stories and the whole toolkit in the local language would make it easier for the companies, and the NCPC in their training activities.

It was suggested to include more technical details and more economic data on the success stories in the brochure. Also more details on how savings were calculated were missing. One suggestion was to provide one case as an exercise (this could also be a short training video), which is elaborated and explained in full length and with all details on the methodology, the implementation and all calculations, so it is possible to follow all steps from the very beginning to the successful end of the project, including the monitoring. Therefore, it would be necessary to provide all worksheets, templates, etc., following the Chemical Leasing scheme in the toolkit. One way to do this could be to include all the NCPCs and have a joint effort to re-design the toolkit. It could also be good to have a look at other toolkits dealing with chemical management services implementation (e.g. the handbook of Chemical Strategies Partnership). Concerning the toolkit, it would be appreciated if updates would be made more frequently and changes would be announced via email, newsletters, etc.

Another suggestion was to present a real case in-depth, in order to explain the critical points in the implementation of the Chemical Leasing model. This way, NCPCs could improve the knowledge about the necessary steps (first contact, presentations, letters, process review, payment index, contract agreements, work plan, monitoring, and others). If somehow possible, a site visit (as an on the job

training) of a successful example could be included in one of the seminars or meetings of the NCPCs on Chemical Leasing.

2. Chemical Leasing assessments/projects, site visits, first contacts, assessments and contracts

To get into contact with companies was not so hard, as NCPCs know a lot of companies from their daily work. A lot of companies are also interested at first but then loose interest when it becomes more complicated or they always have some other priorities and problems to solve. To get a first appointment it is necessary to know and get in contact with someone from the top management. From there it sometimes takes a long time to get any decision if they are going to implement Chemical Leasing or not. In some countries, where there are only few or even no producers of chemicals but only distributors (for example in Sri Lanka) it is even more difficult to convince these companies of the advantages of Chemical Leasing. Here, international experts and UNIDO could also be of help.

It was often difficult for companies to understand the Chemical Leasing concept, as it is a new strategy for business. Sometimes it was also the terminology, which was difficult to understand, the term “leasing” was sometimes misunderstood. Another obstacle was to explain and understand that there could be economic advantages for both sides, even if sales are decreasing. This is an obstacle especially for suppliers who fear changes or more often even losses in their business. There is also a certain reluctance to think differently, out of the box. Here, more case studies would make it easier to better explain the concept and its advantages to potential Chemical Leasing partners. Detailed success stories in different sectors on national and international levels and better explanation on the specific benefits that can be achieved would also help to raise awareness and interest companies for Chemical Leasing. Also some examples that were not successful, including a detailed analysis why this was the case could be very useful. In addition to that, if possible, it is good to have company representatives at awareness raising events from companies where Chemical Leasing has been implemented already successfully, to report from their own experiences with Chemical Leasing, the drawbacks as well as the success factors. In general, assistance would also be appreciated in the communication between NCPCs and new companies to win them for Chemical Leasing.

But sometimes, especially in big companies, it takes some time to meet the right people who can make a decision in favour of Chemical Leasing: the initial contact is in most cases to the head of the production departments or sub-divisions. Then, the decision makers within the corporate headquarters (mainly large companies) have to be contacted which often takes 3 or 4 meetings (approximately 1 month) for presenting the model to the right person, without this meaning that it is accepted.

Furthermore, in small enterprises, resources are often just not there to do a complete analysis of all opportunities where Chemical Leasing could be applied. And in some countries the chemical manufacturers are just missing. If in a country there are only companies importing chemicals, it is even harder to give them any motivation to participate in a Chemical Leasing project.

What also became clear is that in different cultures the way to operate business is different and therefore, also the way to present the Chemical Leasing model and the way in which to implement it could be different. For example, also legislation in different countries is important to be aware of (e.g. in Mexico, to take back waste, would mean that companies would have to register as a certified company which would increase its operation costs). Sometimes, "supportive" (environmental) legislation for a new way of doing business is just lacking, as is the support from authorities. It also has to be clearly distinguished between cases in developing countries, countries in transition and developed countries.

For NCPCs in their work with the companies, regular exchange with other NCPCs would be seen as very valuable, as well as a thoroughly analysis and evaluation of projects. NCPCs would see a good possibility to exchange with other colleagues and also with representatives of companies who are implementing Chemical Leasing at the annual Chemical Leasing meetings and trainings to analyse the developments but also drawbacks of the projects, supported by international experts. Training material (presentations, technical reports, etc.) should also contain much more details of the on-going projects and of the method of implementing Chemical Leasing in general. New and more detailed success stories are also seen as a good method to catch attention of industry and show them the manifold opportunities of Chemical Leasing. Technical and financial assistance is needed, especially in the first projects in Chemical Leasing a NCPC implements. To present also technical details of a Chemical Leasing project helps to show the advantages of the Chemical Leasing business model.

Another good thing might be to design two different approaches, one for the users and one for the suppliers.

It is also hard for the NCPC to identify the potential for an application of the Chemical Leasing model for different companies in different sectors.

Another difficulty is always to identify the unit of payment.

For some NCPC in some countries it would be easier if Chemical Leasing cases, if successful, could be awarded with an international certification statement, which would give the companies an extra incentive to implement the model.

3. Indicators – estimated and concrete savings on water, energy and resources

The main problem faced is the transparency in the provision of data by companies, be it data on the production itself or on resources used or other details like information on suppliers/users, etc. In most cases, the companies simply don't have data (e.g. on consumption of chemicals, water, energy, etc.) available as they do not have a proper data recording system or are not willing to provide them to the NCPCs. In some companies, the consumption of water and energy is measured but only at one point in the company, for the whole production site and not separately at different production lines. Sometimes the distrust or competitiveness between the management and certain production departments or even between different departments is too high and people are not willing to exchange data. And in many cases, it is simply not allowed due to confidentially reasons to give data to external experts. This could be dealt with by including confidentiality agreements into the Chemical Leasing contract. It would help if

UNIDO or the external experts could assist in that (also in the comparison of data and as a technical assistance) and be at the site together with the NCPCs, at least when Chemical Leasing just starts in a country.

Support would be needed, especially on how to estimate, calculate and analyse the different data, if one can get hold of some data at least. Suggestion would be to have a special training on Cost-Benefit-Analysis (CBA) and furthermore a specific training on how to use Statistical Process Control (SPC) as an effective method for process monitoring through the use of control charts. These skills should be provided for national experts to enhance their capacities. A valuable criterion could be the ratio of spent efforts vs. achieved result.

The assessment, analysis and comparison of data for a certain case study could be presented as a video (e.g. with Reinhard Joas, BiPRO) involving comments and describing the reasons why certain decisions have been made. Arising questions and unclear aspects could be discussed at certain times or if a mission takes place in a country. Support would also be needed in form of technical assistance (also on site), also by equipment providers and with process data sheets. More tools and work sheets should be provided.

Anyways, data collection always takes a lot of time and does not guarantee project success.

Another important factor is the existing, or better to say non-existing legislative background and support from authorities: in some countries it is just not important to collect any data on environmental effects of chemicals or other problematic substances.

If one is working with (very) small suppliers, it is also difficult as they often, besides a lack of (human) resources also have a lack of experience in the handling and/or application of chemicals and they do not have the technical and production capability to fulfil the requirements that users of medium or large companies require.

The contracts should be checked by UNIDO to guarantee that the philosophy of Chemical Leasing is kept. Also the unit of payment should be checked by UNIDO to be sure to be compliant with Chemical Leasing. And help of UNIDO during implementation would also be very helpful.

A very special problem in some countries is to work with government companies. These companies have their own rules, especially in procurement (not only chemicals) and will not allow any supplier to view the company's processes. Also, the companies normally don't have a free choice to choose their suppliers.

4. Chemical Leasing activities – trainings held, staff trainings, and awareness raising

- **Awareness raising**

To raise awareness is not so easy, as in some countries, regulations do not support a decrease in the consumption of chemicals, so why should companies be interested in a new business model if there is no need for that? In that case it would be useful to indicate the inter-relation between Chemical Leasing, REACH and SAICM to underline the importance of Chemical Leasing.

In some countries, where there are no chemical manufacturers but only distributors, like in Sri Lanka, it is extremely hard to promote the Chemical Leasing business model.

In other countries, the purchase processes are regulated by the government, which makes it complicated for a new model to be implemented. Also if there is more than one provider involved, it seems to be very difficult.

Often, a big obstacle is a lack of appropriate dissemination and awareness raising materials and a low budget for dissemination activities by the NCPCs. It would help to have more elaborated success stories, in different countries, in different sectors and in different companies to have a good variety of different cases. Users and suppliers must find themselves in these cases and see that also they can profit from the new business model. Therefore, also economic calculations could be presented to show the possible economic benefits. The material has to be quite attractive, well designed and appealing, maybe the involvement of media could help.

Sometimes it is also a problem to coordinate and bring together different stakeholders, at least users and providers of chemicals to tell them both about Chemical Leasing. A good way could be to organise such events in cooperation with e.g. the Chamber of Commerce or some other well-known and well-reputed institutions.

- **Staff training**

This capacity building of national experts is one of the major factors that will provide a good basis for further development and adaptation of the Chemical Leasing model. These experts will train companies and need a whole set of tools (more working material, more success stories, etc.) to improve their knowledge and skills. Here, also new ways of teaching (webinars, video sessions, etc.) could be used.

It requires specialized and different training courses, which are related to chemicals management in general (not only to Chemical Leasing) but also on technical and economic aspects and negotiating skills. From the beginning, the differences between Chemical Leasing and all other chemical management business or outsourcing models have to be very clear and understandable.

The technical aspects are sometimes hard to cover, as Chemical Leasing demands good knowledge in all different kinds of processes in companies. The support of international experts but also of other colleagues from other NCPCs with knowledge in that kind of processes would be very welcome. It also needs some experts that can further explain the economic aspects of Chemical Leasing.

For NCPCs, to provide good trainings to potentially interested companies, it is also necessary to have good examples and guidance on processes that have the potential to become a Chemical Leasing case.

Last but not least, the moral support and coordinating role of UNIDO is very much appreciated.

- **Trainings held (for companies, etc.)**

The problems faced here as well, are the limited number of case studies available and the limited in-depth information on the available cases, which induces a lack of interest in companies.

So to give better trainings to companies, a more complete training package with much more (well-designed and well-illustrated) training materials with more case studies, documentation, tools, technical reports, etc. would be needed. Some suggestions are to produce a kind of a comic in which a experienced and "advanced" NCPC expert explains all advantages of a Chemical Leasing business models (the whole scheme of implementation from the very beginning towards the expected profits) to a "sceptical" representative of a potential client from a user company. Another suggestion was to produce 2-3 training films as a supplement to the training materials with simple and clear explanations of the Chemical Leasing definition, the mechanism, on the unit of payment, on the advantages of Chemical Leasing business models over conventional service contract models. These explanations should be supplemented by good and various examples for different industrial branches. Also, a kind of a promotion video of UNIDO experts about the Chemical Leasing principles could be produced. This could start with a general presentation followed by an interview with the expert and ending with answers to "specific" or "unusual" questions (preliminarily prepared according to the experience collected in the countries participating in the project).

In addition, a computer training game ("Create your own Chemical Leasing business model"), could be developed. This game can include two or three scenarios with the evaluation of economic and environmental advantages and profits as well as the assessment of achieved results according to the performance and analysis of successful activities, mistakes and drawbacks.

More technical and financial support through international experts and UNIDO would be needed. It would also be helpful, to have other experts (e.g. from other NCPCs,) and companies (maybe even from other countries) there, who have already implemented Chemical Leasing and can talk about their experiences. Also examples from smaller companies are useful to show that Chemical Leasing cannot only be implemented in big companies. More focus also on the economical side with benefits and risks, should be shown and explained.

There is also a lack of motivated company representatives and sometimes very little incentives to change the way of doing business, as legislation often does not support these changes. For example, in Mexico, the NCPC will continue with the promotion of Chemical Leasing at industrial groups, universities and government on a national and international level, in order to convince business-people of the benefits of the model. So more information (like successful projects from all NCPCs) are needed to prepare new training and promotional material (from UNIDO). The training material also should be much more in detail, like a step-by-step guidance to a successful implementation, starting on how to identify potential companies.

Also for the training of companies, the differences between the Chemical Leasing model and all other outsourcing, leasing, chemical management or similar models have to be clear. It would be good to have some very detailed "show cases" which show what is Chemical Leasing and what is not.

For companies in most cases it is also easier to follow, if training and promotional material is distributed in the local language, as skills are often not sufficient to follow technical explanations in a foreign language.

5. Other problems/challenges faced

Sometimes it is hard to realize, that despite all efforts, only few companies could have won for a Chemical Leasing case study. Even getting intentions letters does not mean to be successful in getting a Chemical Leasing contract at last.

A Chemical Leasing project in a company takes a long time (and causes high costs) in designing, implementing and monitoring the project. NCPCs are also lacking sufficient budget for the implementation, especially for the technical part of the project. More interested and especially assigned people for Chemical Leasing in the companies would be needed, it would also be necessary to form a special Chemical Leasing “task force” or team to efficiently implement Chemical Leasing in a company. But also support from UNIDO or the international experts, especially for the definition of the unit of payment and some other economical calculations would be needed. There is still a lack of links to other Chemical Management models, e.g. the Chemicals Strategies partnership in the US, where one could unite forces and for the sake of the environment, get better results and more companies to join.

One of the basic concepts of Chemical Leasing is Cleaner Production and this should also show and be mentioned in the context of Chemical Leasing. Also links to SAICM, REACH or the Circular Economy approach could be described.

Chemical Leasing often requires new technologies and new methods to find appropriate solutions. Also in this, more support, be it technical, administrative, financial or moral is essential, as well as exchange and discussions with colleagues from other NCPCs. New fields were Chemical Leasing could be applied and which are gaining more importance in the future (at least in developing countries and countries in transition) are seen in drinking water supply and wastewater purification, energy (electricity and heat) supply and food supply (growing vegetables, fruits etc.).

It would be a good idea to develop a kind of reward, like a little statuette with the logos of UNDIO and Chemical Leasing that could be given to companies for their efforts in implementing Chemical Leasing as a stimulus. But also for the involved experts from the centers specially designed certificates could be awarded.

A continuous improvement and development of the Chemical Leasing model is still missing. Also a kind of ensured continuation of the Chemical Leasing business model in the company after completion of the implementation is hard to keep up.

6. Reporting

The main problem here is to get at least some data from companies. The owners of the companies are concerned how the information about their enterprises will be used and whether it could be potentially harmful for the company's image. A certain mistrust might be able to be overcome by more involvement and presence of UNIDO as a “moral authority” with a high credibility. Regular publications from

UNIDO's side in newsletters, on websites, in mass media, etc. could also help to spread the word about Chemical Leasing.

Time constraints are another obstacle: implementation time, and so the time until some data can be gained, often is much longer than expected. This includes technical process reviews, meetings between users and suppliers, in some cases testing of chemicals in certain processes, and then data collection, in the beginning with no security that Chemical Leasing can be successfully implemented. It is not easy to recognize before the beginning, which companies really can implement Chemical Leasing and which can't. This would also decrease the time needed to get some good results and data.

If Chemical Leasing then finally is on its way, it is difficult in many cases to exactly define the process in which Chemical Leasing is now being implemented, concerning the data collection. Sometimes this is simply not possible, as waste and water mostly is only measured company-wide. In this case, new procedures have to be invented and installed. The next step is to inform all responsible people in different departments (especially if the company is a big one), maybe to meet with them and then get the data takes a lot of time. Sometimes difficulties simply arise when company internally use commercial names for chemicals, often not knowing what exactly is in these mixtures.

And then some more time is needed to validate the data. Many companies do not fulfil the requirements of a continuous monitoring procedure concerning their data, which also affects the reliability of the data. A clear definition on a few quantitative indicators would help to better analyse the results of each period. A template for this would be helpful, as well as a kind of data sheet (or questionnaire) to be completed during the visit and to facilitate the collection of data.

A certain training on reporting skills could help to develop a reporting system based on and consistent with the implementation phases indicated in the implementation plan of the toolkit as a reference.

Conclusions

This second evaluation was conducted only shortly after the first one (one year later) and had a slightly different focus: it was more focussed on evaluating the necessary (technical) assistance NCPCs would need from UNIDO or other experts.

It became obvious that the Chemical Leasing approach is still quite new, especially as four new NCPCs were involved but basically, all NCPCs could agree that Chemical Leasing is a very good chance and opportunity to open up new fields of expertise. This is also the reason why in general more assistance – meaning also personal assistance of UNIDO staff and experts - in all phases of a Chemical Leasing implementation, from the first trainings for staff members to the first contacts to the companies until the reporting and monitoring would be needed. NCPCs, after their first trainings feel not confident enough that they know all about Chemical Leasing to convince companies, to identify the potential of Chemical Leasing in a company and the appropriate unit of payment and to be able to answer all kinds of tricky questions and diminish doubts about the concept companies would have. The implementation of Chemical Leasing often resembles

a trial-and-error process, it needs a lot of time from all involved parties and the result is not always positive and convincing.

A step-to-step guidance by an expert through the whole process when a NCPC is implementing Chemical Leasing for the first time would be the best.

It is hard to realize, that despite all efforts, not many companies could have been won for a Chemical Leasing case study. Even getting intention letters does not mean to be successful in getting a Chemical Leasing contract. Although all NCPCs tried to get as many contracts as possible, by using all means they had, like contacting old contacts, include as many different companies from as many different industries, they were often not successful.

UNIDO as the "Patron" of Chemical Leasing plays a very important role in this context, especially as a moral authority but also in its coordinating role. A more frequent feedback from UNIDO would be helpful to support the NCPCs, also morally. An idea that was mentioned several times is to reward the efforts done by the companies to achieve good results when implementing Chemical Leasing with a kind of award or certificate that proofs their innovative attitude. More personal presence of UNIDO and more active promotion of Chemical Leasing through UNIDO would also be desired. In general, UNIDO and the international experts with their positive and well known image and prestige should be better visible at all kind of events, trainings, etc. to underline the importance of the model not only to the companies but also as a contribution to a sustainable chemicals industry.

Besides this moral support and certain technical assistance, also more financial support would be needed.

Support and assistance would be most appreciated of course from UNIDO and the international experts and special experts in some fields but also much more exchange with other NCPCs and the International Working Group (IWG) would be desired.

What NCPCs also would like to see is a continuous improvement and development of the Chemical Leasing model itself. It is also not clear what happens with cases when the implementation of Chemical Leasing is finished – how can the Chemical Leasing model be extended?

One point mentioned a few times is still the terminology and if there could be something done about maybe re-naming it or at least find a better explanation of Chemical Leasing.

Key Recommendations

- A **step-to-step guidance** and **more practical and interactive tools** for NCPCs new in Chemical Leasing should be provided in the introductory seminar. This introductory seminar **should be much longer** (up to five days) and a **more complete training package** should be provided by UNDIO and the international experts. This would have to start already with the questions of how to identify potential case studies.
- One "**model case study"** where all the planning and implementation steps according to the toolkit are shown and explained in detail would be very much appreciated.

- **New and unconventional methods of teaching**, like webinars, video sessions, training films or games, comics, simulations, business games, etc. should also be introduced and used in the introductory seminar.
- In general, more **capacity building** is still very much needed!
- **More success stories, in-depth analysis and a more detailed description** of these case studies should be provided to have good examples to show and to learn from, maybe including also **examples of cases that did not work out**. A good variety of success stories in different countries, in different sectors and in different companies should be available, maybe in a **success story data base**.
- More emphasis from UNIDO and its experts should be put on the **terminology** (why Chemical "Leasing"?) This is what NCPCs often have to explain first to potential Chemical Leasing companies.
- It is essential to make the **advantages of Chemical Leasing towards other business models** in the chemicals industry clear. Also good **descriptions of similarities and differences between Chemical Leasing and other models** are needed.
- **Further support from UNDIO and international experts** – also on site - and practitioners of Chemical Leasing projects will be very important for the adaptation and modification of the concept. Also **assistance** in identifying possible Chemical Leasing cases, adequate selection of cases, checking contracts and calculations, etc. would be highly appreciated. This should also include how to **define the new unit of payment** in a Chemical Leasing case.
- Support from international experts and UNIDO also means **support in the communication with new companies to convince** them of the advantages of Chemical Leasing.
- To put more focus on **country-specific peculiarities** and characteristics that might be important for explaining and implementing Chemical Leasing (legislation, cultural, economic and social differences, etc.).
- Also **more technical and financial support** from UNIDO would be helpful.
- External support should be provided in the **assessment, analysis and comparison of data.**
- To **present more economic analysis and data** is needed in this context and a special training on **Cost-Benefit-Analysis** should be provided.
- More **opportunities to exchange experiences** with NCPCs from other countries and with companies who have already implemented Chemical Leasing should be provided in meetings, trainings, presentations, etc., but also in regular Skype meetings.
- **Better feedback and clear tasks for each partner** (UNIDO and NCPC) have to be formulated.
- A clear definition on a **set of indicators**, valid for all cases, would help to better analyse the results of each period. A template for this would be helpful, as well as a kind of data sheet (or questionnaire) to be completed during the visit and to facilitate the collection of data.
- More **spreading the word by UNIDO** as a well-known authority would be appreciated, this could be by means of the website, newsletters, mass media, etc. More involvement and presence or UNIDO would also be necessary. This should also include more financial support for the NCPCs with the production of **dissemination material in the local language**.

- To give some kind of **international reward/award** to companies and NCPC that were already successful in implementing Chemical Leasing would be advisable to make companies more curious about the Chemical Leasing concept.
- Material on the **interrelations of Chemical Leasing with SAICM, REACH and other international regulations, agreements and approaches** (e.g. Cleaner Production, Green Chemistry, etc.) should be provided by UNIDO to underline the importance of Chemical Leasing.
- A **continuous improvement and development of the Chemical Leasing model** has to be visible for the NCPCs.

10.2.3 Third Evaluation (2014)

The **third evaluation** finally was done in 2014, with a very comprehensive questionnaire, on the occasion of "10 years of Chemical Leasing" and especially for this thesis. That is why a more in-depth analysis of what has happened in the past and of what can still be improved in the future was done. Participants this time were all NCPCs from all three cycles, also including the ones from Brazil, Croatia, Nicaragua, Uganda, Ukraine and Russia/Volga Region which joined in 2012, but not with Morocco anymore which left the Chemical Leasing program in 2011.

The questionnaire was divided into the following sections:

1. Relevance of Chemical Leasing for your NCPC/you personally
2. The Chemical Leasing project itself – problems faced

   [Design and usefulness of tools provided (this part will be examined in chapter 11)]
3. Data - Indicators - estimated and concrete savings on water, energy and resources
4. Monitoring, Reporting, knowledge sharing and exchange of projects and experiences
5. Lessons learned and ways to the future
6. Innovation
7. Additional comments

Many questions in all of these sections have been asked to all representatives of NCPCs participating in the Chemical Leasing program and the answers will be presented in the following sections. In fact, one country was not able to fill in the questionnaire for unknown reasons. All others sent back the completed questionnaire.

1. Relevance of Chemical Leasing for your NCPC/you personally

The issues tackled in this first section are the business model in general, barriers, opportunities and benefits, but also data collection and interpretation and all other issues NCPCs wanted to talk about.

Chemical Leasing is seen as a chance for the NCPCs to create a new income but not in the (near) future. So far it has not been possible to get any income from the activities besides the money the NCPCs get from UNIDO. Only the NCPC in Egypt gets money for their service in Chemical Leasing. "Selling" and implementing Chemical Leasing takes a lot of time and efforts from the NCPCs and the NCPCs still see themselves in the phase of building up competences and know-how, being "apprentices".

The decision to try Chemical Leasing as a new service was taken in most NCPCs because the NCPCs wanted to broaden their portfolio and offer something new to

their clients. Chemical Leasing is seen as a smart business model that can offer some opportunities, especially for a sound chemicals management. It is also seen as a part of the Resource Efficient and Cleaner Production (RECP) services the NCPCs offer and as a holistic and sustainable approach to tackle the overconsumption of chemicals, creating economic, ecologic and social benefits for the companies. The main barriers, from the NCPC's view, were to show these benefits to the companies and to get them to change their mind-sets and try something new. Many companies are not used to working closely together with their users or suppliers and to also reveal sensitive data to achieve better solutions in managing chemicals in a sustainable manner.

All the NCPCs would like to continue with Chemical Leasing although it is often not easy to be a pioneer in a field that takes up a lot of resources. Companies that have seen the economic savings of Chemical Leasing are keen to go ahead with the model. A chance to get new companies involved will be to open up new sectors like agriculture; examples are the tea manufactures in Sri Lanka.

Chemical Leasing is also seen as an important strategy to make the chemical industry and the use of chemicals more efficient and green. Regulations for chemicals, and therefore the need for companies as well as for governments to take some measures is growing and Chemical Leasing could be an appropriate tool, also in combination with SAICM.

The patronage and support by UNIDO helps in promoting but also in financing this model; chances to earn money from Chemical Leasing in the near future are not seen yet.

Although the focus of Chemical Leasing is on the direct savings of chemicals, indirect savings in energy, water and other chemicals that are not part of the process where Chemical Leasing is implemented, could be gained (but not in all cases, as sometimes, for the sake of getting chemicals consumption down, some other resources cannot be reduced or even increase in consumption). On the other side of production, the generation of wastewater and waste could be reduced and, subsequently, a cost reduction in the treatment could be reached. Also savings in personnel costs and even revenues from recovered chemicals could be achieved.

The duration of a Chemical Leasing project is different but in most cases the projects, resp. their implementation last more than one year. Especially for large companies it takes some time to get into the project, to tackle all the issues that occur, and so a longer period for implementation of Chemical Leasing is necessary. The first contracts are normally signed for 1-2 years, also to see how the model works. If benefits are visible and the concept of Chemical Leasing is understood, contracts are often prolonged for up to five years.

In the more successful companies, the benefits of Chemical Leasing are seen as long-lasting and they also try to replicate the model in their daughter companies in other countries or upscale it. It is also easier to get more out of a Chemical Leasing project in a bigger company (even with branches in other countries) then in a small one where the low-hanging fruits – like in Cleaner Production – are harvested in the first year and every other step is getting quite hard.

Concerning the follow-up of a Chemical Leasing project by the NCPCs, efforts are made in all countries to continue with the (successful) cases but this is not always

easy. At least calls from time to time or site visits are done after the end of a Chemical Leasing project and NCPCs try to do at least a kind of monitoring of the Chemical Leasing cases. Sometimes, there is simply no money available at the NCPCs to continue with a kind of monitoring. So the NCPCs try to widen the Chemical Leasing program in the companies that already participate to other lines or to other processes in the same company but sometimes that is simply not possible. If the companies are daughters of a multinational company, efforts are made to implement Chemical Leasing also in other daughter companies, be it in the same or in neighbouring countries.

Within their regular work, NCPCs also try to organise awareness raising activities to get companies informed of and interested in Chemical Leasing. Other means of follow-up are promotion activities on the NCPCs website, also with success stories and approaching companies when the next Chemical Leasing Award is announced.

The scope of support that would be needed or desired by NCPCs from UNIDO is very broad: only few (2) NCPCs think that the support as it is given at the moment is sufficient. In general, more support would be needed for the development of new cases with more relevant and significant impact. Very often, NCPC feel the need to have more specialised technical support when checking different processes in companies for their suitability for Chemical Leasing. For the process optimization phase, the staff resources in the centres are often not sufficient. Experts are needed in very specific fields, e.g. for agrochemicals, petrochemical processes, etc.; just “normal” technical knowledge is not enough. More and continuous trainings are still needed.

On the other side, more financial support would be needed for all kinds of activities like developing success stories or planning awareness raising activities and Chemical Leasing trainings. More (financial) support would also be appreciated for preparing joint projects, writing publications for international journals, or an exchange of Chemical Leasing experts for a longer period (some months). And donors should also promote the concept of Chemical Leasing among their stakeholder groups. Some support would also be needed or better to say *expected* from the (local) government to provide incentives (e.g. favourable policies) and to develop a chemicals management policy and promote this as an implementation strategy in different industrial sectors. Some want UNIDO to come to companies to show the global importance of Chemical Leasing but also more assistance of UNIDO in promotion, information and awareness raising. And finally, a lot of NCPCs also want more knowledge and experience exchange with other colleagues also working on Chemical Leasing.

2. The Chemical Leasing project itself – problems faced

Awareness raising – was it difficult to raise awareness in companies? What did you do to raise awareness?

To raise awareness was quite difficult at the beginning as some aspects of Chemical Leasing are still a new field of activity and quite unclear. Some people in companies are still resistant to any new ideas or are simply afraid of starting something new. It gets a bit easier when success stories can be shown and the

model has a bit more publicity. Also the involvement of UNIDO sometimes helps to convince companies to at least give Chemical Leasing a try. Here it would be important to have much more success stories, that could cover all different kinds of industrial processes to show the potential of Chemical Leasing to companies. Of course, this should be in the local language to avoid misunderstanding.

What really makes it easier is to have the Chemical Leasing supplier on board from the beginning – be it a new one or the already existing one with interest in implementing Chemical Leasing - as this makes users more confident that they will get the expected results. This is important because at first sight, advantages of the Chemical Leasing model are apparently much more on the user's side. Therefore, the interest of suppliers is low in most countries, at least at the beginning. In one country (Mexico) it was easier to get interest in Chemical Leasing when it was offered as a tool within an energy efficient assessment.

The biggest challenge seems to be the change in the mind-set, the way of thinking, as most company representatives, especially sales people are still thinking in the traditional business model of buying and selling chemicals. "The more you sell, the more you earn" is still in their heads. In that sense, users of chemicals are easier to get interested in Chemical Leasing than suppliers, distributors or producers. To get chemical suppliers interested in Chemical Leasing, it takes in most cases much longer than expected and sometimes despite the great effort, the results are modest. It also takes some financial efforts to raise awareness, to organise initial workshops and conduct site visits to different companies. Very different means have been used in different countries, besides site visits and workshops, also TV shows and articles in newspapers as well as on the NCPC websites have been used. Training courses have not only been given to company representatives but also to students at the university for capacity building.

In some of the countries it seemed to have been much easier: NCPC staff used their individual contacts and made visits and workshops. In one country (Volga Region) it was even stated that the awareness raising part was the easiest and 15 minutes was enough to explain the concept of Chemical Leasing, so in a two, three or even six-hours events, the chances for success are even higher. In that country, different events were organised for companies, scientists and for government representatives. Nevertheless, most of the other NCPCs saw this differently, as it seems that Chemical Leasing gets more complex the deeper one digs into it.

And again, the term "Leasing" was a barrier as it is normally understood differently in most countries and businesses. So this has to be clarified for the companies before gaining some interest in the concept.

Was it difficult to contact companies and have first meetings?

For the NCPCs it was not very difficult to make first contacts. Due to their work in Cleaner Production they all have their contacts. This proofed to be a good way, as trust is not only needed between the user and the supplier but also to the NCPC as the mediator in a Chemical Leasing project. Good personal relationships to people or recommendations from colleagues are also a good way to get first contacts. Sometimes, contacts were also made at a first presentation of the

Chemical Leasing model to a broader audience, e.g. at scientific or industrial conferences. And in some cases it was good luck to get the right person or company who wants to be a pioneer and is very open minded.

The tricky thing is to make them interested in the Chemical Leasing model by showing them the benefits and savings and to address the right people in the companies who are taking the decisions and are convinced by the idea. The need for testing or implementing a model like Chemical Leasing is often not seen, as there is no incentive to change the way on how to do business. In that case it needs some persistence to convince the companies to at least give Chemical Leasing a chance.

When it comes to work with the model it is the hardest bit to develop a first case in a sector or a country. Often the concept is misunderstood at first and from the worker's side, the need to change their way of working is not understood.

How hard was it to interest companies for Chemical Leasing and to find companies wanting to do a Chemical Leasing project?

For some countries, when there is a lack of chemical regulations and therefore a lack of control of chemical safety or also if there is no or hardly any chemical production in a country, it was hard to get companies interested. Nevertheless, it has to be clear that companies can gain something by implementing Chemical Leasing, so an assessment should be made to show the potential for some optimization. A big obstacle was the "sales thinking": supplier's main concerns were still the volumes they sell and they were understandably not interested in any (suspected) decline in their business.

But even if the idea appealed to the people, implementation was another big step, as this normally requires a lot of process modification, which causes fear of quality loss or high initial investments.

For daughter companies of international firms, the concepts itself was often interesting but they are in some way depending on the decision of their headquarters to go for it.

In general, there seemed to be interest from the user companies, however suppliers were not highly motivated, since their main concern was that their sales volumes will be reduced. Users seemed to be more interested as they are almost always interested in some kind of process optimization and in improving their image.

How did you win companies for Chemical Leasing?

There were different approaches to win companies for Chemical Leasing: in one country it was the possibility to participate in a program under the UNIDO flag and with international recognition and to participate in the Chemical Leasing Award. It was also easier, when some success stories could be shown or if Chemical Leasing was presented as part of an energy efficiency assessment. The chance to optimize costs and the consumption of chemicals, so to present the benefits that can be achieved with Chemical Leasing, was also a good start to convince companies. A first assessment could also show the potential for optimization. It

was easier to get a foot in the door, if one already knew a company, be it from personal contact or former (CP) projects.

In all cases, a certain persistence was needed and a constant follow-up and support of companies to keep them at it. One of the main findings, as in the two other evaluations, was that a high number of first contacts and site visits alone does not guarantee a high number of contracts signed in the end. So more emphasis should be put in the follow-up of first contacts.

In which phases of the project did you face the most problems?

Preparatory phase

At the preparatory phase the problems are at first mainly in getting support from the top management: it is not easy to decide to try a very complex, new concept which might perhaps also require new technologies, a new way of thinking and where the management is not always confident about the real benefits. Besides fully understanding the concept of Chemical Leasing, finding the right partners was also a major challenge, as normally the relationships between users and suppliers are only on an economic basis, which could also change if a better (meaning: cheaper) supplier appears. This could also be a problem if there were more than one supplier.

Another challenge was to understand the definition and the whole concept of Chemical Leasing and the definition of the unit of payment.

Agreeing and setting the baseline, so to determine the status Quo and the starting point of a Chemical Leasing project in terms of data collection was another important point. There, the measurements and negotiations took some time, sometimes several months, as data is in most cases not ready at hand. In some cases, a profound Status Quo has never really been established and documented.

Do companies sign a cooperation agreement or only a Chemical Leasing contract?

In most cases, the companies that are willing to cooperate also signed the cooperation agreement before the contract. Sometimes, they didn't want to make any obligations until the mutual economic interest was clear.

However, concluding the contracts was complicated in view of the lack of the corresponding legislation in some of the countries. It was noticed that especially in the agriculture sector, companies did not want to sign any cooperation agreement.

In Mexico, for example, Chemical Leasing contracts were normally only signed if they were embedded in an overall project contract.

Process optimisation in the company – which problems were faced and why?

Most important was to have good experts in the country who were familiar with the concept of Chemical Leasing and who really could show the possible process optimization potential beforehand. Nevertheless, it is never guaranteed that Chemical Leasing will be a success in terms of process optimization. The decision

for a process optimization depended on the CEO or head manager, he/she had to be convinced first. Unfortunately, no legislation stimuli existed to convince company authorities to change something in a process.

If the processes required new technology, substitution of chemicals or changes in the infrastructure, the optimisation could take long, and execution depended heavily on company decisions.

Sometimes, the user was not really interested in changing the process, which often also means to invest in new technologies. If that investment was not done, process optimization was often hard to achieve. Sometimes there was also no money for any kind of process optimization measures and then, in most cases, Chemical Leasing was bound to not be successful.

There was also the fear that the quality would go down when something in the process is being changed. Especially for companies in the food industry and in the cleaning and sanitation sector, this is of high concern and has to be tackled.

Designing the business model, contracts – which problems were faced and why?

In the phase of designing the model and putting up the contract, one of the main issues was the identification of proper benefit sharing and the definition of the unit of payment, followed by the agreement on penalties in case the contract would not be fulfilled. Here the change in thinking had to take place as well, as chemicals are not bought and sold per kg or litres anymore.

It is a good advice to discuss all different issues with experts and all partners in detail before signing the contract to avoid problems and troubles afterwards. In addition to that, a proper quantitative assessment should be done, which is often difficult due to absence of data.

Three countries out of eleven had no problems at all in this phase.

Implementation and monitoring/ evaluation – which problems were faced and why?

The biggest challenge in this phase was to convince the partners to implement Chemical Leasing. Sometimes the willingness and ability to do so either came from the chemical supplier or the chemical user, but normally not from both! Convincing the other part to implement the project at this stage was quite a challenge. The implementation phase also required some financial support in some cases and even more continuous technical support from the chemical suppliers and the NCPCs.

The biggest problem with the monitoring was that some companies were not willing to disclose the information about their processes and did not work completely transparently, or, also very common, didn’t have proper data management. Sometimes, staff was also not trained to measure properly or it was simply not possible with the equipment in place. A monitoring process is always time-consuming, which has to be seen and approved by the management.

Especially indirect costs, like for energy, water, waste and wastewater were quite hard to quantify and to include in the monitoring as they were often only monitored and measured for the whole company.

Dissemination phase – which problems were faced and why?

The dissemination phase was successful if the company was interested in sharing achievements and effective solutions. Precondition was that there were successful cases to be presented! But even a successful case was no guarantee for successful dissemination.

Although there was often a limited budget and time for dissemination, there were certain things that made this phase easier, especially for the companies which were part of UNIDO's Chemical Leasing program: there was the chance to apply for the Global Chemical Leasing Award but also to be part of the success stories that are published by UNIDO, either in brochures, books or on the website.

Another successful channel of dissemination was the one via the NCPCs, which often organised special events to present what was also their success and to get new companies interested for Chemical Leasing. Important was, that also companies were participating and presenting their own success and revealing also some of their data to make the case reproducible. To present sensitive data from others than the companies itself was not possible.

Successful implementation was especially interesting for companies in the same country as they would have the same preconditions and therefore results are more likely to be reproducible.

How hard is it to find/define the unit of payment? Which problems did you face here?

For simple processes it was rather easy to find the unit of payment, in the case of more complicated processes this was a bigger challenge. It was clear that a certain technical capability, know-how and experience was needed to be able to define a good unit of payment; the NCPCs have knowledge and expertise in many different processes. Some additional know-how within the companies about costs, environmental awareness and socio-economic effects of the management of chemical substances is still needed. In multinational firms this is quite common, but in SMEs this might cause difficulties.

Existing cases gave good examples how a unit of payment could be defined but also shows the difficulties that might occur: in the very special sector of agriculture it was very difficult to define the unit of payment due to the influence of environmental factors and weather conditions.

Another example showed that in the dyeing process in the textile industry, different type of auxiliary chemicals to accelerate the dyeing process were used, which were often purchased from more than one supplier and which made the definition of a good unit of payment rather impossible. Here, advice from experts in that special field would be needed.

How did you define the process where Chemical Leasing is to be implemented in the company?

The definition of the process where Chemical Leasing was being implemented was different from case to case: if a company had long-term partners, some ideas for the process selection already exist. In such a case, the process was analysed by the NCPC and the way on how to implement Chemical Leasing was suggested. In some cases, a technical team of Chemical Leasing experts visited the company and helped to select the appropriate processes. After an in-depth analysis, the engineers defined which processes were most likely to benefit from Chemical Leasing. In other cases, the process appropriate for a Chemical Leasing project has been defined by the user of the chemicals or related to the chemicals that are being used. Sometimes it was simply a decision of the expert who did the company visit, based on his/her experiences in the field and from other cases. And in some other cases, testing showed that Chemical Leasing was not the appropriate method to achieve process optimization and could not fulfil the sustainability criteria.

Is a Chemical Leasing team formed in the company? Who is in that team?

In most cases, a team was formed in the participating companies to deal with Chemical Leasing: it was agreed that this team should ideally represent all levels, from the top management (whose approval is absolutely necessary) down to the workers in production. At least, the head of production, (technical) representatives of the environmental and energy department, and in some cases purchasing staff, people from quality control and procurement, environment and management should be in that team. This was not possible in some companies.

Is sustainability covered by Chemical Leasing projects?

Most NCPCs agreed that Chemical Leasing could contribute to a more sustainable handling and a sound use of chemicals, even if a Chemical Leasing project normally only covers specific (and not all) processes linked to chemicals in a company. In the framework of Chemical Leasing, the companies changed their business concepts to a more responsible model, where both partners change their consumption patterns, resulting in a lower consumption in general. Chemicals are used in a more efficient way when they are not bought and sold per volume or tons. Chemical Leasing also provides incentives to especially reduce the amount of hazardous chemicals and/or perhaps substitute them by more environmentally benign alternatives. In some countries, national legislation is still not supporting that a lot.

In general, NCPCs would state that the consumption of chemicals is optimized and reduced and therefore the environmental impact is lower. Other resources, like waste or energy use are usually also decreased. Occupational health and safety is normally improved and an increased profit for both partners can be achieved as a result of a Chemical Leasing implementation. Another benefit is the better management of chemicals.

Referring to the three pillars of sustainability, all three areas were met in all the cases: there was increased profit for all partners, use of recourses (not only

chemicals) was reduced and social benefits (e.g. occupational health and safety or working conditions) were achieved. A closer look will be given to the topic of sustainability when analysing the case studies in more detail (see chapter 12).

The overall sustainability criteria that were developed for Chemical Leasing have to be met if the companies were implementing Chemical Leasing within the UNIDO program and especially if companies would like to apply for the Chemical Leasing Award.

Use of chemicals and other resources decreased?

The focus clearly was on the reduction in chemicals consumption, especially of hazardous ones (in some cases a reduction of 30 to 40% was possible). But also other resources, mainly water and energy could be saved. As a side effect, in some cases also the generation of wastewater and sludge could be reduced and revenues could be gained by the recovering of resources. Nevertheless, it was not always possible to reduce other resources besides chemicals.

Substitution of chemicals

Substitution of hazardous chemicals by more environmentally friendly options has been discussed in all Chemical Leasing cases. However, not in all cases it was possible or feasible: in some cases, the best option simply was to optimize the consumption of the chemical and/or the process and to stick to the chemicals already used. Sometimes it was also not easy to find a more environmentally friendly option on the market and in some cases, the supplier came up with a totally different option (e.g. dry lubrication instead of wet lubrication). If economic benefits could be achieved, substitution was a very welcome option.

In all the cases, as they applied for the Global Chemical Leasing Award, the sustainability criteria were applied and fulfilled. The substitution of chemicals will be a continuous task for the NCPCs in the future to follow this aspect and to insist on complete material balances (there is a tendency by some companies to hide additional chemicals under confidentiality requirements).

Other side effects?

Better chemicals management (e.g. better handling and storage) was one of the main side effects, gained through more efficient processes, which brought more savings in the purchase of raw materials. The suppliers created more business for themselves.

Besides that, especially working conditions (health and safety issues (protection cloths, less evaporation of chemicals, reduced risk of slipping on wet floors, etc.) were improved and also positive effects to the neighbouring environment (cleaner rivers and woods) could be achieved; this could also be used for PR activities.

Very important were the long-term business relationships among the different partners that develop through the close cooperation.

How sustainable are Chemical Leasing projects in terms of being long-lasting? Follow-ups of Chemical Leasing projects

The implementation of the first Chemical Leasing project in a company normally took about 18-24 months and the first contracts were signed for 1 to 2 years, which could be prolonged if the cases were successful (up to 5 years usually).

During the last years in several countries, successful Chemical Leasing cases have been prolonged and even been up-scaled (e.g. extended to other process lines). Nevertheless, it became clear that still not enough effort is put on the follow-up of cases studies.

To initiate follow-up projects was never an easy task: in Mexico, after the first projects, no new cases could be generated so far. In St. Petersburg, the strategy is to go on with the big companies where Chemical Leasing projects have already been done, like Vodokanal. In Egypt, from the beginning the NCPC got paid for the service they provide so they could also afford to provide monitoring beyond the first project phases.

In most countries (except Egypt) it was quite difficult to monitor and accompany the projects after finalisation of the first implementation, as there was no further financial support by UNIDO.

NCPCs tried to offer monitoring as a neutral third party and in general, tried to keep in touch with the companies that once participated in a Chemical Leasing project. Very important was to show presence, meaning calling companies, sending emails, maintain contacts and keep Chemical Leasing in the minds of the companies. This also included to support companies in their application of the Chemical Leasing Award which was often seen as an incentive to continue with Chemical Leasing.

A good strategy seemed to be to promote Chemical Leasing for processes similar to the once that have already been proven successful, e.g. lubrication in the food and beverage sector and to develop similar (Chemical Leasing) projects for other processes in the same company.

Is more support needed?

In general, more support would be needed from UNIDO in the promotion and awareness raising of Chemical Leasing and in producing more success stories for showing the benefits of Chemical Leasing to the companies. Also more direct contact between UNIDO and the companies would be appreciated to show the companies that their efforts in Chemical Leasing are of great importance and that UNIDO cares about what they do. More support in the dissemination of Chemical Leasing cases, more contacts of UNIDO with governments and other relevant stakeholders would be appreciated as well.

More technical specialists in different fields, like in exploitation, transport and refinery of petrochemical processes or specialists in agriculture to introduce Chemical Leasing there would be needed. More training on different (other) topics of Chemical Leasing for the NCPC staff would also be helpful.

More exchange between NCPCs would be appreciated, like joint projects or joint publications in journals, inviting colleagues to talk about their experiences in their countries or “short term scientific missions” for staff members for some weeks.

On the other side, more support through national governments would be helpful. Their task would be, at least in some countries, to create the necessary legislative basis for a sound chemicals management.

More financial support for the project implementations would always be needed, too.

Additional problems faced

In general, in most countries there was low interest of authorities in the promotion of Chemical Leasing due to the lack of the corresponding legislation and regulations.

Resistance to change and maybe a “lost in translation” kind of problem was also evident: people heard the word “leasing” and thought that they have to pay more.

Chemical Leasing is a complex strategy: maybe new technologies or changes in the process are needed and trust and confidence between the partners is a key factor.

Any other suggestions?

One of the points that were suggested additionally was that the Chemical Leasing model should include not only cases in which there had been changes in the unit of payment, but also cases in which sustainable management of chemicals objectives were achieved and innovation in the relationship of user-supplier was developed, for example, cases of outsourcing to see alternative models and the differences to Chemical Leasing projects.

Another suggestion was to present also cases that were not successful and explain in detail the reasons why this happened.

4. Data – indicators – estimated and concrete savings on water, energy and resources

The main problems that occurred in data collection on estimated or concrete savings were caused by a poor monitoring system. Often, companies were not used to monitor their data, be it consumption on chemicals, water or energy or the production of waste and wastewater. In addition to that, there was often no incentive to save resources, no legislation and no punishment if consumption was too high.

In many companies the information on different data was widespread throughout different departments in the company and it was hard to get this information. Data were often monitored for the whole enterprise, not for specific production lines or processes, which was especially the case for water and energy.

If data were available, it was not always sure that these data were really reliable or if they were only rough estimates. Nevertheless, good estimates were better than no data at all, it was OK, if it was too hard to get exact data but estimations should be as accurate as possible.

In some cases, the fear to give away sensible data which can provide good information to competitors, was big. Making data public on chemicals consumption might cause problems as it also reveals information on good or bad environmental performance of a company.

When companies finally decided to implement Chemical Leasing, the situation changed: a baseline was set, a lot of data was collected, the optimization potential was identified and data before and after Chemical Leasing implementation was collected. At least, that is how it should have been! To collect the initial data sometimes took more than one assessment.

In most cases, the Excel spreadsheet from the toolkit has been used, in some companies, also specific, tailor-made excel sheets were used for data collection.

Monitoring is an essential part of a Chemical Leasing project. Monitoring plans were developed but sometimes could not be fulfilled due to a lack of funds for the monitoring process. Sometimes, the Chemical Leasing team of the companies did the monitoring, sometimes together with the NCPCs. Another possibility was that companies did the data collection but the analysis and verification was done by the NCPCs. Especially the monitoring after the first Chemical Leasing project in a company often could be done without further funds.

More support, also in data collection is being expected from UNIDO experts. This support should be in the collection and estimation of data to understand the needs of potential clients. Also more training on how to do this monitoring would be appreciated, including the provision of data sheets, technical assistance on site with the companies but also in analyzing the data and defining the unit of payment.

Special support is needed in the agro sector, as this field is relatively new for Chemical Leasing.

Only one NCPC said that no further support is needed.

5. Monitoring, Reporting, knowledge sharing and exchange of projects and experiences

The necessary reporting twice a year (Half-Year Report and Annual Report) to UNIDO was seen as a good source of information. On the one hand, the reports offered a good opportunity to learn about obstacles, opportunities, failures and successes of the other NCPCs and to get new ideas for one's own work. On the other hand, especially writing the Half-Year Report was seen as a burden by many NCPCs and most of them would like to only have to write an Annual Report. This report could then be more extensive and give more detailed information on the cases.

The templates for the reports, reworked several times during the last 10 years, were seen useful and easy to understand, but according to one centre, nonetheless not covering all the different "variants and specific features" of the NCPC concerning Chemical Leasing. For most NCPCs, the templates were also helpful for collecting the relevant data and to guide through the monitoring system.

All NCPCs were willing to share their knowledge, if asked for. In some cases, it was easier or more convenient to share knowledge, e.g. among the countries in Latin America or among South-East Europe due to the same culture and language. In most cases, information and knowledge was exchanged during the

Annual Chemical Leasing meetings or through Skype meetings, that were organised by UNIDO on several occasions.

Some people from the NCPCs also shared information (e.g. by email) if they found something that could also be of interest to other colleagues.

Most NCPCs would like to have more convenient ways to communicate, maybe in a forum on the website with easy access and where companies could also participate. Also the Annual Meetings were seen as a place for more exchange and so several NCPCs would like to extend the duration of these meetings and have more time with colleagues from other NCPCs.

If funded by UNIDO, also exchange visits between countries would be very appreciated.

6. Lessons learned and ways to the future

The main challenges

The main challenges for many NCPCs was to find companies and to convince them to start with the Chemical Leasing implementation. When the projects then started, there were always technical problems that needed to be solved, but that was not a real big thing.

A certain resistance to changes could also be detected in most countries. Especially convincing suppliers of the benefits of Chemical Leasing was difficult. Much more (detailed!) success stories would be needed to demonstrate this. Also the calculation of the unit of payment was not always really clear.

Chemical Leasing is about building trust and partnerships between companies. This way companies can work as a “user-provider tandem” and share their knowledge to manage chemicals in a sustainable way. Many companies don’t trust each other but this is a precondition for a functioning Chemical Leasing model.

Other challenges were the commitment of the top management, the fair sharing of costs (not only of benefits) for new equipment to gain process optimization, which is especially a problem for small companies. A lot of information and knowledge is needed to be able to successfully implement a Chemical Leasing project. Well educated and responsible staff in the companies and enough time for proper testing and developing a good case is also needed.

Appropriate legislation and governments that support the idea of Chemical Leasing (e.g. by including it into policy frameworks) would also help a lot in its dissemination.

In general, NCPCs stated a huge potential for Chemical Leasing. Companies were well interested in “green” projects and ideas if there were some financial benefits to achieve. NCPC staff, during their work with the Chemical Leasing model learned how to introduce the concept to enterprises and how to identify opportunities for the implementation in different sectors.

Some NCPCs mentioned that a lot more information and tools (e.g. the whole toolkit) needs to be translated into the local language as especially small

companies are not willing or able to work in English. The question who should do that and pay for that remained unanswered.

Projects in your countries – what will happen?

Almost all NCPCs were optimistic that the cases that were promising and showing good first results would go on even after the first year(s). For example, in Serbia, the companies were so convinced after their first successful results that the new contract were signed for three resp. five years. For Sri Lanka, there were funds available to continue with the Chemical Leasing projects, even in difficult sectors like agriculture. Some cases will be extended to other process lines and others will be replicated in other plants and companies.

It is also clear that some cases will stop due to changes in the chemical provider or due to other problems in the implementation, but all the NCPCs were sure that other cases will develop, despite all difficulties.

Will Chemical Leasing have a future in your country?

All NCPCs agreed that Chemical Leasing will have a future in their countries, if some difficulties could be overcome: in some countries, legislations will have to change to a more supportive one, favoring the reduction of chemical impact on the environment and punishing a non-responsible consumption of chemicals.

It will also need some stamina to bring Chemical Leasing to different kinds of sectors and processes, others then the ones where Chemical Leasing already was successfully implemented. This was the case in agriculture where it was for a long time taken for granted that Chemical Leasing will not succeed and now (in 2014) there were pilot applications in at least three different countries and with different kinds of plants (vegetables and crops).

The link from Chemical Leasing to sustainable management of chemicals and international agreements (e.g. SAICM) in this field should help to achieve a better implementation rate. There is a lot of potential in companies for process optimization, so if success stories could be presented and promoted better, more companies would be interested in the model.

How do you follow up your projects after the first year?

At the time of the third evaluation, not all the NCPCs had projects that were lasting for more than a year. The NCPCs tried to keep in touch with the companies, be it through visits, through telephone calls and emails or by providing technical assistance for further improvements of the already on-going projects and free-of-charge service as a neutral monitoring body. NCPCs also suggested companies to apply for the Chemical Leasing Award and supported their applications. Normally the NCPCs carried out various projects with these companies, not only limited to Chemical Leasing which made it easier to stay in contact.

Some NCPCs had to develop a better follow-up strategy. They also did their best to strengthen the contacts with companies' authorities and persistently promote the UNIDO platform in order to change the existing paradigm of the consumption society suffering from a tremendous chemical impact on natural ecosystems.

Where do you see Chemical Leasing in the next 5-10 years?

The following answers were given to that questions:

- Chemical Leasing will be implemented in other sectors than now, like in water protection, agriculture and the automotive industry;
- Chemical Leasing will be a tool to comply with the law;
- Chemical Leasing will be a future model in chemical industry for big companies (producers and users);
- Chemical Leasing will hopefully be implemented on a larger scale;
- Chemical Leasing will be a more structured and strong business model, where companies use the new concept of doing business in benefit of all;
- Chemical Leasing will be a good part of an advanced chemicals management approach;
- Chemical Leasing will be implemented in more multinational companies and in SMEs as well;
- Chemical Leasing will be implemented in most of the potential sectors of Uganda.

What new sectors will be appropriate for Chemical Leasing?

The selection of potentially interesting sectors for Chemical Leasing differ from country to country but here is a list of sectors that were mentioned:

- Protection of the regional and international aqueous systems;
- Agricultural sector, including plant protection and fertilizers;
- “Greening” the automotive transportation system;
- Various cleaning/degreasing processes – this also includes cleaning operation in hotels;
- Coating and Painting;
- Tanneries;
- Mining;
- Dairy sector;
- Sugar sectors.

One NCPC mentioned that sometimes it’s hard to think beyond the own field of expertise and there might be much more options for Chemical Leasing as one might think of right now.

Which new countries could be involved?

This is a list of possible interesting countries:

- India
- Ecuador
- Hungary
- Bosnia and Herzegovina
- Costa Rica
- Ecuador
- El Salvador

- Kenya - given the fact that many of the chemical suppliers are from Kenya, it has a very high potential for Chemical Leasing implementation

Which new chemicals/processes would be appropriate?

The NCPCs came up with this list of possible, not always new chemicals and processes where Chemical Leasing could be implemented:

- Hydro-wave technologies using water as a reagent instead of special chemicals;
- Bio-based fertilizers;
- Construction chemicals;
- Solvent based building paints;
- Oil refining and petrochemicals;
- Agriculture processes;
- Fertiliser application in tea sector;
- Cleaning in Place (CIP) in the dairy sector;
- Printing in the newspaper industry.

7. Can you think of any radical innovation in Chemical Leasing?

For several NCPCs Chemical Leasing itself is still an innovation, in many countries new ways to apply chemicals were found by implementing Chemical Leasing (e.g. reagent-free desalination/purification of water using only water as a reactant).

An APP on the Chemical Leasing methodology could be developed, and a software that helps with the calculations.

One centre could also think of combining Chemical Leasing with outsourcing models.

For Mexico it would be already a radical innovation to sell Chemical Leasing there. It would be important to find ways to let much more companies try out Chemical Leasing.

8. Additional comments

It would be helpful and important to produce a data base about new technologies which can be used to support Chemical Leasing contracts. Then each participant of Chemical Leasing network could offer solutions for chemicals supplier in their countries.

Other ideas that could be thought of is to have more cooperations between universities and with academia in general.

There is a need for exchange missions among the different implementing countries.

Conclusions

The third evaluation in 2014 was the by far most comprehensive one. Even after ten years, the concept was still seen as quite new and much more support, be it with case studies or technical or financial support would be needed. The NCPCs somehow felt not well prepared to be able to handle a difficult program like Chemical Leasing optimally. The biggest challenge is still seen in the change of mind-set the companies would have to perform.

NCPCs so far were not able to get money from their work in Chemical Leasing, in the contrary, implementing Chemical Leasing takes a lot of time and resources from the NCPCs. They are still dependent on the money from UNIDO. Nevertheless, they see it as a new part of their portfolio and a good link to their work in Resource Efficient and Cleaner Production.

The term “Leasing” is still a problem as the connotation in the business world is a different one from what is meant in Chemical Leasing.

Data availability has always been a problem in the companies. More data is needed from the companies to be able to proper monitor and evaluate the cases and also to proof success of the Chemical Leasing program as well as to compare the cases.

But NCPCs also see the opportunities that Chemical Leasing can offer for companies: an optimization in chemicals consumption, a better process performance, reduction also in other resources, like water and energy, better occupational health and safety and better working conditions. For many NCPCs, Chemical Leasing is an important instrument and part of a strategy to make the chemical industry and the use of chemicals more efficient and green. All NCPCs stated that they see a chance in the future for Chemical Leasing and they mentioned some sectors and countries were Chemical Leasing could be transferred to.

Key Recommendations

- More information on the procedure of selecting and implementing Chemical Leasing is still needed. Therefore, **more and continuous trainings**, also for more experienced NCPCs which have been working with Chemical Leasing for a while would help. It is especially important to make sure that all experts at the NCPCs working with Chemical Leasing **fully understand the concept, can show process optimization potential** and **are able to define a new unit of payment** according to the definition.
- **More and new case studies, with much more details** on the implementation, on barriers, etc. to show different implementations in **different sectors** and **different companies** is urgently needed, if possible, also in **different languages,** so it could be better guaranteed that companies can see themselves in the stories and can imagine to implement Chemical Leasing also in their companies. Also better promotion linked to the cases will help.
- **Cases** that **show the difference between Chemical Leasing and other models** (e.g. outsourcing) and **cases that show when Chemical Leasing was not successfully implemented** should be available.

- A **database on sectors and industrial processes that are (most) suitable for Chemical Leasing** would be needed to have an orientation where Chemical Leasing could be applied successfully.
- The **term "Leasing**" is still an obstacle in promoting Chemical Leasing. Maybe to extend the definition of Chemical Leasing would be an option, as the term is still an obstacle for many companies.
- Focus should clearly be on how to **set the status quo** and on **continuous data collection, monitoring and evaluation.**
- It would be good to **embed Chemical Leasing in or link to other concepts**, be it Cleaner Production, Green Chemistry, SAICM but also energy and resource efficiency programs.
- A more **thorough analysis of the different sectors** in a country should be made before starting implementing Chemical Leasing to know if there is enough potential for such a model.
- A **continuation in the Global Chemical Leasing Award** would be highly appreciated as it is a reason for many companies to try or continue with Chemical Leasing.
- **More support from UNIDO** would be needed: first, international consultants should be with the NCPCs more often to provide **technical support**, especially in very special fields like agrochemicals or petrochemical processes. On the other hand, also more **financial support** is still needed, to produce information material, success stories, etc.
- But also **more knowledge or assistance in terms of Cost-Benefit-Analysis and socio-economic effects** should be available.
- **More knowledge and experience exchange** with other colleagues in Chemical Leasing is urgently wanted. At least one Annual Meeting should be organised by UNIDO but also other ways to easily communicate should be provided, be it a special section on the website, where also companies could participate.
- A lot **more material has to be translated into the local language**.
- More emphasis should be put on the **follow-up of first contacts** and also of first Chemical Leasing projects in a country.
- Data availability is often still weak, a good but simple **tool to make data collection and monitoring** easier would be needed. Also more **training on how to get data (or calculate accurate estimates) and how to monitor and evaluate them** should be provided by the international experts.
- Therefore, **criteria and indicators** for sustainability have to be defined and monitored.
- The **support of the government** to provide incentives (e.g. favourable policies) and to develop a chemicals management policy and promote this as an implementation strategy in different industrial sectors should, be gained.
- UNDIO should also assist more in the **contact with governments and other relevant stakeholder** (e.g. guilds, chambers, etc.) to raise awareness on the Chemical Leasing program.
- UNDIO, in general, **should be better visible** in the companies as the "brand owner" of Chemical Leasing.

Final conclusions to all three evaluations

Having a close look at all three evaluations, it became clear that there are many recommendations that were mentioned in all three evaluations. Two of them have already been realized: to create a certification scheme, which was done with the launch of the Global Chemical Leasing Award in 2010, and that Chemical Leasing should be integrated into SAICM, which has also been realized.

Among the top recommendations, that were mentioned by the centres and have not been realized so far, the following seem to be the ten most important:

- **More success stories**, with more details, in as many different countries, sectors and processes as possible. An idea that always came up was to collect the case studies in a **data base** which is accessible by all NCPCs.
- There is still the need for **capacity building** among the staff of the NCPCs, they would need more and longer trainings, especially at the beginning but ideally also once a year to refresh the knowledge, ask questions to international experts and **exchange their experiences** with colleagues.
- **Data collection,** setting the **baseline** and **monitoring and evaluation** are always a task where the NCPCs feel that they would need more support.
- The **term "Leasing"** is still a problem for many NCPCs, especially when they explain the Chemical Leasing model to companies.
- A kind of **data base for sectors and processes that are (most) suitable** for a Chemical Leasing implementation would be appreciated by the NCPCs as kind of orientation.
- More support in economic issues, e.g. to develop a **Cost-Benefit Analysis tool** and provide some training on that.
- More **technical and financial support** is also one point mentioned in all three evaluations.
- A **continuous improvement and further development** of the Chemical Leasing concept should be visible for the NCPCs.
- To have the linkages of Chemical Leasing to **other concepts** like Green or Sustainable Chemistry, SAICM, Cleaner Production, etc. and to have a clear listing of similarities and differences of Chemical Leasing and other, **similar models** (e.g. Outsourcing, Pay-on-Production or Contracting) would be needed.
- And last but not least, more **"moral support**" by UNIDO, meaning more visibility at events with companies, etc. would be very much appreciated.

On the basis of this summary, a roadmap will be developed to help UNIDO as well as the NCPCs to overcome these shortcomings.

Chapter 10 first compared the Chemical Leasing concept with other concepts and approaches linked to sustainability and could proof that they have lots of key elements in common. The chapter also summarized the results of the three evaluations of Chemical Leasing that were done from 2008 to 2014. The outcome was a shortlist of the 10 most important recommendations for improvement of the program that will be followed up in chapter 14.

11. Analysis of Chemical Leasing Tools

Chapter 11 analyses the tools that have been developed for Chemical Leasing over the past ten years. These tools were identified from the different reports and from practical experience the author had during her work with UNIDO. The tools are all described and analysed. From the evaluations, especially the one in 2014, possible amendments and further developments for these tools are gained.

During the past ten years, a big range of different tools and instruments were elaborated by UNIDO, together with national and international experts, to educate and train people in Chemical Leasing, to further develop the Chemical Leasing business model and to support the NCPC representatives with the implementation of Chemical Leasing in companies. Tools are also important to support communication between Chemical Leasing practitioners and to show the success of Chemical Leasing projects. Some of these tools have been newly developed or changed during the last years, some of them have been abandoned after some time and some have been working well since the beginning.

11.1 Description and Analysis of the Tools

All the tools were evaluated in 2014 by the representatives of the NCPCs participating in Chemical Leasing projects for this thesis. In the following, every tool is described in short, followed by an analysis. As already mentioned in chapter 9.2, the main criteria and indicators that were used for the different tools were:

- Did you use the tool? Why, why not?
- Was the tool helpful? In which way?
- What is good, what is bad about the tool?
- What could be improved/changed? Please provide suggestions!
- Would you need more or other tools? Please describe!

∗ Chemical Leasing definition

The formulation of a definition for Chemical Leasing was one of the first activities of the International Working Group in 2006 (UNIDO, 2007b). The aim was to find a clear but short explanation of the principle of Chemical Leasing for companies, as well as for policy. The definition has not changed since:

> ***Chemical Leasing** is a service-oriented business model that shifts the focus from increasing the sales volume of chemicals towards a value-added approach.*
>
> *The producer mainly sells the functions performed by the chemical, and functional units are the main basis for payment[1].*

Within Chemical Leasing business models, the responsibility of the producer and service provider is extended and may include the management of the entire life cycle.

Chemical Leasing strives for a win-win situation. It aims to increase the efficient use of chemicals while reducing the risks of chemicals and protecting human health. It improves the economic and environmental performance of participating companies and enhances their access to new markets.

Key elements of successful Chemical Leasing business models are proper benefit sharing, high quality standards and mutual trust between participating companies.

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[1] *Functions performed by a chemical might include: number of pieces cleaned; amount of area coated, etc.*

In 2015, a Delphi survey was done by the author of this thesis together with Rodrigo Lozano from Organisational Sustainability and Angela Carpenter, University of Leeds, concerning the definition of Chemical Leasing. One of the main outcomes was that there has to be a definition which is official and also proven by UNIDO as people working in Chemical Leasing rely on the opinion of UNIDO as the founder and patron of Chemical Leasing (Kaltenegger, Lozano and Carpenter, not yet published).

Nevertheless, it became clear that the definition needs to be ‚translated' into the ‚language' of each of the target audiences: for practitioners it could be a short one, very precise, and for academics a longer, extended one. There is an alternative suggestion for a new definition, but so far, UNIDO does not want to change a definition that has been in place for such a long time.

- **Sector Studies**

The first sector studies were done in 2004 before the start of the Chemical Leasing program, when Egypt, St. Petersburg and Mexico provided data on the chemical sector in their countries. Sector studies have also been produced in the second cycle of Chemical Leasing, where the mineral water sector in Serbia and the oil and gas sector in Colombia have been surveyed.

In 2013 a "global" sector study on cleaning was elaborated by BiPRO to depict potential around the world. This study was extended by Gaia Consulting and made available in 2015 (Gilbert et al., 2015).

Sector studies were meant to provide information on specific sectors that were promising for the implementation of Chemical Leasing projects. They were mainly done to find out about the potential in a country before starting with Chemical Leasing. Nevertheless, not all the NCPCs provided such a sector study. The idea now came up that every country should elaborate a sector study, making some investigations in which sectors Chemical Leasing could be implemented in their country. Sector studies could also help other NCPCs to find potential sectors and

processes for a Chemical Leasing implementation in their own country, so these studies shall be made available for all NCPCs in the Chemical Leasing program.

Writing sector studies is not an easy task. To write the comprehensive one on cleaning, it took more than a year to get all the relevant data. For NCPCs, as it was expressed, it would be helpful to have a workshop on how to write proper and useful sector studies and how to find and select relevant data.

Nevertheless, some sectors where it would be interesting to have sector studies done are the following:

- Agriculture
- Energy sector
- Chemical industry
- Food and beverage
- Hospital industry (cleaning chemicals)
- Industrial wastewater purification
- Pollution in potable water supply systems
- Waste water treatment
- Metalworking industry
- Printing/painting
- Dairy sector
- Tea plantations
- Textile sector
- Sugar sector

One suggestion was also to include site visits while writing a sector study or to visit other countries where the resp. sectors have been explored already and to organise joint Chemical Leasing demo projects.

* **Seminar for "starters"**

At the beginning of a new cycle of Chemical Leasing projects, participants (representatives of the NCPC who were chosen to be responsible for the implementation of Chemical Leasing projects in their countries, so called "national experts") were invited to UNIDO's headquarter in Vienna, to get a first insight into the topic of Chemical Leasing. In a two-to-three days training, provided by UNIDO and its international experts, they got all information and tools necessary for a successful start of a Chemical Leasing program in their countries: the concept of Chemical Leasing was presented, success stories were shown, an introduction to the toolkit was provided. The theoretical part was supplemented by work sessions on how to identify potential Chemical Leasing partners and how to approach them, how to prepare first meetings and company visits and a short training on how to overcome obstacles etc.

The training was completed by a development of a first work plan by the NCPCs. This work plan included the tasks that have to be fulfilled, the time frame, responsibilities, expected outcomes and support from other people or organisations. A certain budget was allocated to the NCPCs for specific tasks.

The seminar for starters was conducted at the beginning of the first and the second cycle in a joint meeting in Vienna, in UNIDOs headquarter. For the third cycle, the seminar was done individually in each of the newly participating NCPCs.

Therefore, also the assessment of the seminar was different. NCPCs of the first cycle were again participating in the starter's seminar of the second cycle, having the opportunity to refresh their knowledge but also to provide their experiences to the newcomers.

For the first cycle of NCPCs, the beginning was unclear: explanations were not sufficient as also the experts had only little experience with putting Chemical Leasing into practice. Therefore, it was a more theoretical seminar.

In the second cycle, much more demonstration material was already there, the promotion video already existed and the training was enriched with role-plays, and other interactive tools. It was an advantage to do this first training together with already experienced Chemical Leasing experts from the first cycle of Chemical Leasing who could provide their first-hand experience in implementing Chemical Leasing. This was liked a lot by the "new" NCPCs in the second cycle.

NCPCs from the third cycle said that for most of them their first seminar was helpful.

Basically, almost all NCPCs expressed the need for more and more intensive trainings. Suggestions were that these trainings should best take place in the course of the Annual Meetings of the Chemical Leasing group but could also be done independently from that (but still once a year). Methodological issues should be addressed, technical experts should be present and visits should be made in companies where successful cases already had been implemented. In general, more trainings would be needed in specific aspects of the processes where Chemical Leasing could be implemented but also in general to refresh the knowledge on Chemical Leasing and to get new inputs and updates.

Elements that should be more focussed on or included in that seminar are:

- Success stories with a very in-depth explanation of problems and issues to pay attention to;
- Sales training;
- Exploration of sectors where Chemical Leasing has not been implemented so far to get new ideas where to promote Chemical Leasing;
- Training on Cost-Benefit-Analysis;
- Visits to companies (in different countries);
- More practice then theory;
- Examples and calculation of the unit of payment;
- Include more examples for indirect cost savings calculation.

Some NCPCs also expressed the wish to have training materials in their local languages. Some of the NCPCs have already developed and adapted information and training material in their local languages to better reach and train companies.

∗ The UNIDO Toolkit

In 2006, first steps to develop a toolkit for a systematic approach to the implementation of Chemical Leasing at company level were done. This toolkit is the basic tool for all NCPCs and experts who are interested in Chemical Leasing. The toolkit covers the main steps to ensure smooth and efficient application of Chemical Leasing to industries from different sectors and countries by means of

guidelines, presentations and worksheets. Based on the experiences of the NCPCs in applying the toolkit and in cooperation with the national and international experts, the toolkit has been further developed and revised throughout the years.

The toolkit has been distributed among NCPCs and the initial training of the four new NCPCs in the second cycle, Sri Lanka, Serbia, Colombia and Morocco was already based on this toolkit.

A second version of the toolkit, the "Chemical Leasing Toolbox", has been released in 2011 as a CD-ROM, and included the guidelines, even more worksheets and presentations, the Chemical Leasing video and the Chemical Leasing book. The worksheets comprised templates for letters of intent, cooperation agreements, sustainability criteria, Chemical Leasing contracts as well as training and reporting guidelines for national experts.

The elements of the toolbox were provided on the Chemical Leasing website in the members-only area and also as CD-ROM upon request for everybody who was interested, so also for other than Chemical Leasing consultants, for companies, authorities, etc. During the work on this thesis, a fundamental update and renewal of the toolkit was planned and started in 2014/2015, including tailor-made features for managers, technicians and policy-makers. Some of the results of the third evaluation already were included in that new toolkit. The toolkit is now also integrated in the IOMC Toolbox for decision-making in Chemicals management. Since 2016, the toolkit is also available online: http://www.chemicalleasing-toolkit.org. Since then, no further evaluation was done and no information was collected on how the online toolkit is being accepted.

NCPCs said that they often consult the toolkit to look up things they want to read again and that might help in their daily business with Chemical Leasing.

- **Missions of UNIDO experts and assistance for NCPCs**

For every NCPC there is the possibility to ask for assistance not only in the first time but also for difficult meetings with companies, presentations, etc. International experts, under contract with UNIDO, are assisting NCPCs in their work with the Chemical Leasing model but are also monitoring the work of the NCPCs with their clients in these so-called missions. International experts often stay for a few days to assist and are obliged to report back to UNIDO what has been done during the time of their mission.

In addition to that, the program officer of UNIDO, Petra Schwager, visits the NCPCs from time to time to undermine the importance of Chemical Leasing to UNIDO and to participate in important meetings or conferences on the topic of Chemical Leasing.

The missions and assistance of international experts in Chemical Leasing were in all cases seen as very helpful. They did a great job in supporting the NCPCs in many tasks, e.g. building up knowledge among the staff of the NCPCs and create awareness when they accompany NCPC representatives at company visits, help building national expert networks and working groups, in talks with potential Chemical Leasing companies, providing technical input to identify process optimization potential, providing international benchmarks, experiences and

examples and even in monitoring the Chemical Leasing implementation. They brought new ideas and tools. Sometimes there is still a need for international sectorial experts for very specific issues (e.g. in the new field of Chemical Leasing in agriculture) or when companies send technical staff to the meetings with the NCPCs.

But at least some NCPCs would favour (at least at the beginning of the work with Chemical Leasing) more than one mission per year to provide the technical support that is needed. When NCPCs have implemented Chemical Leasing for some time, missions are not financed anymore by UNIDO and NCPCs miss the support of the experts. At least more Skype conferences and/or regular consultations via email, hotlines, etc. would be very much appreciated, especially when new fields and sectors like agriculture shall be explored for an implementation of Chemical Leasing.

- **Chemical Leasing Annual Meetings**

Once a year the Annual Meeting on Chemical Leasing takes place where all the representatives of the NCPCs meet and exchange their experiences. If possible, these Annual Meetings take place in combination with other events related to the Chemical Leasing program like the meeting of the International Working Group, the Chemical Leasing Award ceremony or other topic-related meetings and conferences of UNIDO, e.g. the RECP meetings. Usually, two days are reserved for these yearly events. It is more than just exchanging ideas and experiences, it is also an important factor to reassure motivation and get new ideas for one's own work.

The Annual Meetings are seen as a great chance to meet other colleagues and exchange experiences. The meetings have always been enjoyable but nevertheless were too general and did not bring a lot for the practical work. The meetings should be more practical, with sales examples or a training session on how to obtain the unit of payment.

There is a strong wish to improve these meetings with in-depths trainings that last for at least two to three days and with site visits (could also replace missions, if these visits could be organised in the country where the meeting is taking place). A real chance for deeper discussions and exchange shall be provided, maybe in working groups or something similar. Working groups could also be formed to discuss efforts for joint projects like in the field of agriculture or wastewater purification.

The meetings should be closely connected to the International Working Group so that also academia and governmental experience on the policy framework that could foster the implementation on the concept, can be included.

- **Annual and Half Year Reports**

NCPCs have to deliver a half-year and a more detailed Annual Report every year to document their work, their success and the difficulties in implementing Chemical Leasing. In 2007, the first Annual Report was published to provide an overview of the Chemical Leasing activities performed in 2006. In June 2007, also the first

half-year report was published to provide an interim overview of activities that took place in the first half of 2007.

Annual and half-year reports have been produced every year since until 2014. For these reports, data on the projects at plant level (savings, benefits, etc.) and data on the Global Forum Activities (e.g. presentations at conferences, etc.) were collected. A template has been developed for collecting the data by the author of this thesis already back in 2007. The reports are an instrument for UNIDO to present the results of the Chemical Leasing projects within UNIDO and also outside.

During the years the reports became more and more a marketing instrument for UNIDO to strengthen the public image in certain matters. This became mainly visible in the way the reports were written and where they were distributed. The highlights were presented quite well but with no in-depth analysis of the cases. In early 2016, a "10 Years Report" was published, summarizing the results and achievements of the years 2004 to 2014 (UNIDO, 2016).

Since the launch of the Chemical Leasing program it was necessary that UNIDO could proof the progress and success of it. Therefore, inputs for annual and half-year reports had to be provided by the NCPCs. In general, the reports were seen as useful, most of the NCPCs also took them as a source of information on cases in other countries and sectors and for motivation as they summarize quite well the international experience during the year, evidenced obstacles, opportunities, failures and successes. However, the process of writing the reports could be less formal. Their preparation required a lot of efforts, however it was sometimes difficult to use them later-on for getting enough information of other cases since they were described too briefly and needed more clarification and comments from the authors.

The templates however were seen as good and useful and easy to fill in, although it was not sure that they asked for the information that was needed for different stakeholders (UNIDO, companies, NCPCs).

- **Monthly Reports**

From April 2009 to November 2011, also monthly reports were collected from the NCPCs. Data were collected on

1) Awareness raising activities;
2) Training with staff;
3) Training with companies;
4) Other Chemical Leasing activities;
5) Companies contacted by Phone/Mail or very first visit;
6) Company Quick Scans;
7) Companies who signed a LoI or Chemical Leasing agreement;
8) Chemical Leasing Contracts;
9) Projects cancelled/postponed.

The original idea was to make it easier for NCPCs to collect data they had to provide every six months in a more detailed report and also to make it easier for UNIDO to have current data available if needed. As these reports seemed to be

too much of a burden for the NCPCs, at the end of 2011, these reports were dismissed.

- **Success Stories**

The first success stories in Chemical Leasing have been published in the book "Chemical Leasing goes global" by Jakl and Schwager (2008) where, besides other topics of Chemical Leasing, the first case studies in Russia, Mexico and Egypt were described. A small booklet followed in 2011, where five new success stories from Russia, Egypt, Colombia, Serbia and Sri Lanka were presented in brief (UNIDO, 2011c). These case studies were also available in the Toolbox. Since 2015, five new case studies have been available on the Chemical Leasing Toolkit website[55].

The importance of success stories (or at least case studies) has been mentioned several times before. On the one hand, these case studies were seen as a good source for new ideas and new cases for the NCPCs themselves. On the other hand, the booklet on the success stories has also been given to interested companies to show the potential of Chemical Leasing.

A reason why NCPCs didn't use the booklet for their own work so much (anymore) was that meanwhile the cases are quite old – the booklet has been already published back in 2011, with project results from 2009, and not updated or extended since - and new ones are missing, especially cases in new sectors like in agriculture or about cleaning chemicals. So an update is really needed. For using it in the centres, NCPCs would like to have much more details on the cases (including e.g. the calculation of the unit of payment, exact savings, etc.) in a new booklet. NCPCs are willing to provide as much data as possible, but companies could be more reluctant to reveal their results and data.

All these case studies should be included in a new book to be written that also provides a methodological update. Cases could be, instead of a booklet, provided as kind of fact or data sheets that can easily be provided to interested parties but also easily exchanged when necessary. These fact sheets could also be easily translated into local languages if needed.

All the cases should be collected additionally in a database (not only facts and data but very extended). This could also be linked to some scientific database like SCOPUS or Web of Science. One idea was also to issue a special UNIDO periodical journal on Chemical Leasing cases.

- **Chemical Leasing books**

In 2003, the first book on Chemical Leasing was published. It was a summary and in-depth analysis of the two Austrian case studies that were conducted from 2000 to 2002: "Chemikalien-Leasing – eine intelligentes und integriertes Geschäftsmodell als Perspektive zur nachhaltigen Entwicklung in der Stoffwirtschaft" (Jakl et al., 2003). This book was only available in German but parts of it and the further development of Chemical Leasing under UNIDO was summarized in the book "Chemical Leasing goes global", published in 2008, edited

[55] http://chemicalleasing-toolkit.org/node/8

by Thomas Jakl, BMLFUW and Petra Schwager, UNIDO (Jakl and Schwager, 2008). Especially this book is still a reference for all NCPCs in their work with companies on Chemical Leasing. All interviewees have read the book “Chemical Leasing goes global”, it was given to them as soon as they decided to work with UNIDO on the Chemical Leasing program.

Most NCPCs said that it was good to have a picture at the beginning about the concept and the methods of Chemical Leasing. Some of them also still take this book with them on their first visits to new companies. After starting to work with the companies, NCPCs read the book resp. specific chapters from time to time, to refresh their knowledge. This book was also seen very useful to train the companies and also for the work with students it was regarded as a good tool.

However, an update of the book would be very appreciated, especially if it includes the following tasks:

- It should be translated into several other languages, as especially for companies it is often not self-evident to be able to read a whole book in English.
- A new edition should also include the latest developments in Chemical Leasing, and especially include new success stories, if possible from all involved countries, also in other sectors (especially agriculture).
- The description of the unit of payment (especially for agriculture) and a more in-depth Cost-Benefit-Analysis method would also be very welcome.
- The relation to the sound chemicals management and RECP should be added.
- A sector approach could be chosen.
- The definition of the unit of payment as well as the Cost-Benefit-Analysis should be given more room and be explained in more detail.
- Barriers and opportunities of the Chemical Leasing model should be explained in more detail.
- An implementation guide, introducing the cases, giving a detailed case study description for examples of step-by-step Chemical Leasing implementation at certain companies should be added.
- A better description/guidance how to sell the model to potential clients (How to offer it? How to “lure” the client? Do they work with companies that already have the model and just change its name to Chemical Leasing? How do they convince the client to do it?) is needed.

∗ Participation in International Program Schemes

To promote Chemical Leasing around the world, at least two international project proposals were elaborated during the last 7 years: one for EU’s FP 7 program and one for SWITCH Asia. The project proposal for SWITCH Asia was evaluated positively but nevertheless cancelled by the program management at last minute due to financial constraints. In 2015, another attempt was started to place Chemical Leasing in international project funding schemes: the project aimed at promoting new business models towards a more resource efficient chemical industry and was led by Rodrigo Lozano from Utrecht University. A decision if this project will be funded has not been made at the time this thesis was written.

In the first years, getting money from other sources was not so important but now, as also success stories can be presented, a participation in international program schemes becomes more and more important and if there is an opportunity, it is taken. Being part of international program schemes is also connected to more links to academia which is definitely becoming more and more important for Chemical Leasing and UNIDO.

- **Scientific papers on Chemical Leasing**

UNIDO always was interested to place articles and presentations about Chemical Leasing in scientific journals and at conferences. At least from 2007 onwards, articles on Chemical Leasing were placed in different scientific journals: abstracts, for example, have been sent to the African Journal of Pure and Applied Chemistry, to ERSCP 2008 (Berlin) and SCORE 2008 so to get also scientific reputation for Chemical Leasing.

Scientific papers now are also a category for the Global Chemical Leasing Award and they have to be peer-reviewed. In the future the efforts to intensify linkages with academia will be further increased.

- **Contact to other institutions**

During the last years, contacts to different organisations, institutions, etc. have been fostered: intensive contacts have been built up with the Chemical Strategies Partnership (CSP) from 2008 onwards until the activities at CSP were stopped, mutual visits at different occasions have been conducted.

Another institution where contacts have been fostered was Gaia Consulting, a consulting company situated in Finland. Ylva Gilbert was and still is the main contact person and has been working with UNIDO on the global sector study on “Chemical Leasing in cleaning applications” (Gilbert et al., 2015).

Contacts to other institutions are more and more fostered by UNIDO to have a livelier exchange on the Chemical Leasing program.

- **Promotion activities**

In each country it was necessary to provide material to further promote Chemical Leasing, be it a promotion video of the first success stories in Mexico, Egypt and St. Petersburg, leaflets, posters, CD-ROMs, etc. Many of these tools were provided in the local language to lower the entry barrier for the new topic within industry. Also presentations were given in the local language. To raise the quality of the material, UNIDO has opened a category for PR material within the Global Chemical Leasing Award already in 2010. One of the most innovative PR materials was a comic on Chemical Leasing produced in Sri Lanka, but also coffee mugs or caps were produced to promote Chemical Leasing (e.g. in Serbia).

Other activities included announcements on the NCPCs own websites, on a Facebook page (e.g. in Uganda), emails to companies, skype conferences, announcement in local business journals, on local radio and TV shows (e.g. in Serbia) or a regular newsletter to interested parties and several other information

activities. Also presentations for industry (companies, guilds, etc.), students and professors, the public sector and other stakeholders were among the activities, sometimes as a part of their awareness raising activities, sometimes also as a special event.

In addition to that, promotion material in English is always being provided by UNIDO on the website, in addition to leaflets, CD-ROMs, books, videos, etc.

Most NCPC representatives said that they feel quite well informed about UNIDO's own promotion activities. They get emails from UNIDO on a more or less regular basis about what's going on in Chemical Leasing, and they get information on the website and at the Annual Meetings. Nevertheless, several NCPCs would like to have more information and more activities set by UNIDO to further promote Chemical Leasing.

- **Articles in journals, presentations at conferences**

UNIDO also promotes Chemical Leasing at different events, conferences, meetings, etc. Papers (not peer-reviewed) were presented at international conferences (e.g. the European Roundtable on Cleaner Production, the SCORE conference series, etc.) but also at more UNIDO/UNO specific conferences, like the RECP Annual Meetings. Interviews and articles are given to industry journals upon request.

To present papers and articles in journals and at conferences is becoming more and more important to raise the visibility of Chemical Leasing.

- **Website and Newsletter**

A website has been in place since 2006[56] with a "members only" area and is being updated more or less regularly. The website provides information on Chemical Leasing in general, has a download area for papers and information material, information on the case studies, and much more.

The website was seen as a valuable source of information but could, in the opinion of the NCPCs, be designed a bit more illustrative and be updated more frequently. Also more specific topics should be addressed and more and new tools provided (e.g. a Cost-Benefit-Analysis Tool was mentioned). The website was seen more as a tool for NCPCs then for companies. It should also be available in other languages, especially for the companies interested in Chemical Leasing in other countries. There is a "members only" area on the website but it was rarely used, as people forgot their password, etc. The website should be more actively promoted by UNIDO.

Nearly all NCPCs would very much appreciate a (at least) quarterly newsletter with the latest news, issued by UNIDO, to inform about updates on the website, the methodology and toolkit and to get news on on-going cases in the other participating countries. In 2012 there was the attempt to establish such a newsletter but not many were willing at the end to contribute at that time. In addition to that, it was not welcomed by UNIDO (due to internal reasons) so this initiative was stopped. News are now placed on the website and distributed to

[56] www.chemicalleasing.com

Chemical Leasing “members” whenever appropriated, also via Skype conferences or via email.

Most of the NCPCs find that the information flow in general is sufficient, there are many ways to contact UNIDO, the experts and the colleagues in other NCPCs. Nevertheless, there is some potential to improve, as not all NCPCs feel well enough informed about the cases in the other countries. Regular emails on different topics would be very much appreciated by most NCPCs. In addition, it also seems useful to exchange experiences, case studies and data via scientific databases.

What some NCPCs mentioned is that they would like to visit other NCPCs and accompany colleagues at their work to have an insight view on other Chemical Leasing cases (“exchange missions”).

* **Telephone and Skype Conferences**

Telephone conferences were established quite early to get updates on Chemical Leasing cases in the participating countries quickly. Skype conferences replaced telephone conferences when the number of participants exceeded a certain manageable number. For topics as the bi-annual launch of the Global Chemical Leasing Award or for the preparation of the Annual Meeting, all NCPC representatives are always invited to participate. In 2014, a thematic Skype group especially on agriculture was started, which was useful for the selected and interested participants and not wasting somebody else’s time who was not really involved in that topic. These meetings were seen as very useful but were not done on a regular basis.

Minutes were always taken in all telephone and Skype meetings and sent out. Recently, documents were also shared via Dropbox to allow the exchange of larger documents as well.

When six new NCPCs joined the Chemical Leasing network in 2012, Skype conferences became more demanding, due to time differences and also due to the capacity and decreasing quality of Skype as more people participated. Best would be to have more face-to-face meetings but this is definitely not an option. Suggestions within the evaluation were that it does not need to be a Skype conference, also other means should be used (no suggestions were given on which). Besides all the NCPC representatives, the international experts should also be available for technical or specific questions. In addition, information on new cases could be prepared before the virtual meeting, bringing details and prepare information, following a certain template so that similar information is provided from all NCPCs before the conference. At the conference only questions for clarification and problems should be addressed, that could interest most of the participants.

In general, it was stated that the number of information exchange opportunities should be increased but how to do this in practice is not really clear yet.

∗ Chemical Leasing Hotline

In autumn 2012, in order to support the implementation and promotion of national and international activities, the Chemical Leasing Hotline was established and can (still) be reached via email. The main tasks of the Hotline team included (UNIDO, Annual Report, 2012):

- to screen preliminary Chemical Leasing ideas and project proposals and check if the projects are in line with UNIDO requirements for Chemical Leasing;
- to assist in further development of your on-going projects (analysing the technical data, situation in companies, assisting in identification of unit of payment, helping in solving different kind of problems);
- to organize expert's exchange/missions to support the projects implementation in the countries, where UNIDO Chemical Leasing activities are on-going;
- to collect the news related on Chemical Leasing and Sound Chemicals Management and prepare the news mails for the Chemical Leasing community;
- to assist in preparing different reports (including annual report) and updating the web-site;
- to develop the guidelines for the Annual Chemical Leasing Award (only for the NCPCs);
- to revise and update a database on Chemical Leasing cases and develop the library of supportive documents and tools;
- to review national PR materials and articles and to provide feedback.

The team consisted (and still does) of one representative of UNIDO, representatives of the NCPCs of Colombia and Serbia and the author of this thesis. In case of difficult matters and questions concerning Chemical Leasing, other experts could be consulted as well.

The hotline is promoted on the website[57] (but still people find the address and contact the Hotline team. Questions are mostly about how to join the network and how to apply for the next Global Chemical Leasing Award.

∗ International Working Group (IWG)

In most cases, at the Annual Meetings also the International Working Group (IWG) meets. The IWG was established as an international multi-stakeholder working group already at the end of 2005 to globally promote Chemical Leasing and develop ways of implementation (UNIDO, 2007b). The aim of the group is to bring together representatives from industry, government, EU, quality assurance companies, equipment providers, university and consultants. For the first time this group met in January 2006. In close cooperation with the members of this group and in order to prepare the ground for a sound understanding of Chemical Leasing, UNIDO developed a clear definition on Chemical Leasing already at the beginning.

[57] http://www.chemicalleasing.com/contact

Basically, the existence of an International Working group on Chemical Leasing is seen as a useful thing, although the work of this group is not really visible to the NCPCs. This also resulted in the fact that Chemical Leasing experts often don't even know the members of the IWG and so have no direct use of the IWG. Nevertheless, it would be good to have a medium like the IWG to share ideas, exchange knowledge but also include academia, scientist, public authorities and policy makers.

What the IWG seems *not* to be is a real working group. To be useful, the IWG should have a clear working schedule or plan and at least clear tasks to work on, also between meetings. The work on the strategy of Chemical Leasing that has been started in 2015 with the IWG is something that might come near to that idea.

What NCPCs could think of is that the IWG should be consulted when trying to open up new sectors and processes for Chemical Leasing (from the experience of their members) and for a better dissemination of success stories. A strong participation of companies seems strongly advisable.

- **National working groups (NWG)**

The first National Working Groups (NWG) were established in 2010 in Colombia and Serbia, followed one year later by Sri Lanka and Brazil as well as Germany. They consist of members of different governmental departments, industries and academia and meet more or less on a regular basis. It is an information platform for the members.

The National Working Groups on Chemical Leasing, as far as there exists one, are organised and seen quite differently in different countries. In one NCPC, the NWG is only seen as a good promotion tool but no real help in developing Chemical Leasing any further, whereas in another country, the NWG supports the NCPC in identifying potential projects, conducts research on Chemical Leasing (especially on process optimization), helps to promote the concept among interested parties, assists in getting governmental and other institutional support to include the concept in policy level and some members voluntarily support the NCPCs as consultants. Nevertheless, no further information on the work of these NWG was available.

At least in two other NCPCs, the establishment of a NWG was planned, in the other NCPCs, the need for such a group was not big enough at that time.

- **Global Chemical Leasing Award**

At the beginning, the Global Chemical Leasing Award was a joint initiative of UNIDO and the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. In summer of 2008, the award criteria have been drafted and the award was announced for the first time on the 13th of May 2009 during the ICCM-2 meeting in Geneva. The Chemical Leasing Award is the first award of this kind and recognizes successful Chemical Leasing implementation at company level and publication and promotion activities through four categories: (1) case studies (companies), (2) consulting services, (3) scientific publications, and (4) public relations (reports, media, brochures, websites). “It aims at globally enhancing the visibility of Chemical Leasing, at encouraging innovative

applications of the concept and at acknowledging contributions to disseminate the business model" (UNIDO, 2009b). Organizations, companies and individuals worldwide were encouraged to apply, not only companies joining the UNIDO Chemical Leasing program. For each category an entry form was provided which was available for download at the Chemical Leasing website.

For the four categories, specific selection criteria and weighting factors were defined. With these selection criteria a high quality of applications shall be achieved. The status quo before Chemical Leasing consultancy and implementation would serve as the baseline for comparison.

For companies applying (category 1, case studies), criteria taken into account are

- the implementation status (Chemical Leasing contracts have to be signed already and the project should be in its initial implementation phase or beyond),
- the impact (on economic and ecologic aspects of the companies involved) and
- innovation/novelty (innovation in the way chemicals are used during the production process as a result of the Chemical Leasing arrangement, and novelty of application with regard to chemicals and industry sectors.

For category 2 – consulting services - the same three criteria are valid, in addition to that, feedback from companies and the multiplication potential (if the proposed Chemical Leasing project could also be replicated at other companies and organizations) are taken into account.

For scientific publication, category 3, it is important to show the novelty (e.g. novel experiences on Chemical Leasing in the context of innovative implementation approaches, new application fields and trans-disciplinary strategies) but also the relevance (impact) for the specific industrial sector but also be significant for the Chemical Leasing landscape in general. In 2012, it became mandatory that scientific publication should be peer-reviewed and applications should include information on the peer-review.

For category 4, public relations, newspaper articles, documentaries, interviews, brochures, web pages and pioneering PR activities are considered for nomination. Criteria are impact (contribution to dissemination of Chemical Leasing and raising awareness), novelty (conveying new experiences or findings on Chemical Leasing or be in itself a new dissemination activity) and quality of applications.

The award jury consisted in its beginning of six members, nominated by UNIDO and BMLFUW, in 2014, ten people were members of the jury. All jury members had a profound understanding of Chemical Leasing strategies and had first-hand experience of implementation and promotion practices.

In **2010**, the Award was awarded for the first time. The first place was worth USD 5,000. As no contribution obtained the minimum of 2.5 points to qualify as successful submission in scientific publications, no award was given in this category. The winners in category 1 – case studies – were Ecopetrol and its partner Nalco from Colombia, second place was awarded to Ecolab and Knjaz Milos from Serbia and the third place was awarded to SAFECHEM Europe, Germany and to Cabot, UK. A special award for "Outstanding Efforts in Implementing Chemical Leasing in the Supply Chain" was given to IKEA India.

In **2012**, the award was jointly sponsored by UNIDO, the Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW) and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). This time, five companies were ranked on first place and shared the prize money, four companies from Serbia and SAFECHEM from Germany were the winners. Silver was given to General Motors, Egypt and Bronze to two companies in Sri Lanka, Mr. Manjula S K Jayasena and Mr. C A K Jayasena.

In **2014**, in addition to the established sponsors, the Swiss State Secretariat for Economic Affairs (SECO) and the Swiss Federal Office for the Environment (FOEN) joined the board. Two, resp. four companies won Gold, a hotel and its supplier for cleaning agents from Brazil (Windsor Hotel and Ecolab) and an automotive company and its supplier of anti-corrosion from Colombia (Polikem and Sofasa), Bronze went to Uganda to a brewery and its supplier of lubricants for conveyors (Crown Brewery and Diversey). Special Acknowledgement was awarded to five companies of the new initiative “Chemical Leasing goes Agro” and to two very advanced cases from Colombia (Ecopetrol and Colceramica). For the first time in 2014, “conformity declaration certificates” were given to all the companies that passed a certain threshold defined in the award criteria.

In general, the Chemical Leasing Award was and still is seen as a useful promotion tool which provides international recognition for the participating companies: companies in many countries look for “ways to shine” and the award is a good opportunity for publicity. The Global Chemical Leasing award is an effective mechanism to motivate companies in the development of Chemical Leasing cases. Most of the large industries (especially export oriented companies) are interested to implement Chemical Leasing because of this award.

Except for one country (Volga Region), the award was an incentive for companies to make their work visible and get some promotion. Companies who got the award in the past presented their success in the media. Getting an award meant a better image and a chance to open up new markets and win new customers.

The evaluation criteria were clear and companies got help from the Chemical Leasing experts in filling in the applications, if necessary.

From the jury’s point of view, some observations and suggestions for improvement were made: it would be good to improve and simplify the format of the application form and to make it easier to see the “before” and “after” of a Chemical Leasing implementation more clearly. It was also suggested to review the rating system in general but no further discussion among the jury was held on that topic.

The category “scientific papers” has always been hard to evaluate as for the first two awards no paper could fulfil the requirements. This will probably change in the future when more academics get interested in the topic.

- **Cost-Benefit-Analysis and EMA**

Cost-Benefit-Analysis tools have always been one of the most required tools for Chemical Leasing. The experience after the first two years of Chemical Leasing implementation showed that it was rather difficult to get accurate economic information related to the performance of specific industrial process.

In 2007, Rudolf Schott, an international expert for the first 3 years, elaborated a first draft of a Cost-Benefit-Analysis (CBA). This draft was part of the toolkit and the book “Chemical Leasing goes Global” (Jakl and Schwager, 2008). Rudolf Schott presented a simplified model, only taking into account the business relations of two partners and one product. This draft aimed at giving the reader an idea what kind of costs may be considered before implementing Chemical Leasing. The main purpose was to “.. show how fair sharing of added-value can be realised and what kind of factors have major impacts” (Schott, 2007).

It became clear that having a kind of Cost-Benefit-Analysis when talking to companies about starting a Chemical Leasing case is absolutely necessary. It is one main point to show that a company will have some economic benefit out of it and the point top management is interested most. Many NCPCs, as long as they didn’t have their own method of doing a CBA, used the method that is presented and explained in the toolkit. For a first assessment it was easy to use and understand. Companies want to have a clear picture of numbers and possible savings but also of ecological benefits and added value. In some cases, the companies (especially big ones) did their own analysis.

In 2009 there was an attempt to implement Environmental Management Accounting (EMA) in Chemical Leasing, developed by Deborah Savage and Christine Jasch (Savage and Jasch, 2005). This scheme was presented by Christine Jasch at a Workshop in April 2009 and first data were collected in companies in Serbia in June 2009 (Jasch, 2009).

EMA is a tool to improve the transparency of costs related to material flows. In particular, the real costs of waste and emissions become clearer. The EMA scheme would be a very valuable instrument, as companies are normally unaware of the real costs of the chemicals, related to storing, handling, recycling, etc. This is because these costs are normally bundled in “overhead accounts” and are not visible. The perceived costs of purchasing and managing chemicals are often (wrongly) calculated as less than 1% of operating costs (Kortman et al, 2006). However, studies estimate that the cost of chemical management can range from one to ten times the purchase cost of chemicals (CSP, 2004).

Basically, EMA is designed for the user of chemicals. Nevertheless, the supplier could also achieve interesting results. EMA makes suppliers aware of what he should consider when entering into Chemical Leasing (Jasch, 2009). EMA provides a good data baseline, a calculation basis and a better and common understanding of costs.

During the seminar and also during the phase of data collection in the companies it became clear that this tool is by far too sophisticated for most companies.

Nevertheless, it is clear that there is a need to have a reliable and comparable (among the different Chemical Leasing cases) tool at hand to be able at the end of a Chemical Leasing project to clearly show the savings that could be realised. How deep a Cost-Benefit-Analysis could go, depends mainly on the transparency of the cost structure and the mutual trust of the partners and has to be more or less tailor-made for each case.

∗ Baselining and Monitoring – Key Performance Indicators

Baselining and monitoring and having at least some Key Performance Indicators (KPI) have always been an issue in Chemical Leasing. The evaluation revealed that there is a certain dilemma in collecting data: data and numbers show the quantity but that does not need to say anything about the quality of data. And still, in many cases it is not even easy to get data. Several attempts have been started to monitor the Chemical Leasing projects on a regular basis. The simplest way was to collect data in the diverse reports. As the data in these reports were, in most cases, neither complete nor significant enough to give evidence of the benefits of Chemical Leasing, another attempt was to collect at least some Key Performance Indicators, which failed as it was not really pushed by UNIDO.

The monitoring of improvements is essential to show the success of Chemical Leasing projects. With only a few data it is visible what could be saved in terms of chemicals, water and energy by shifting to the new business model. It became clear that this is one point where more efforts should be put in and in chapter 14.1, a concept for a set of initial data and indicators to be collected was developed.

∗ Sustainability criteria

Five quality criteria for sustainability of Chemical Leasing have been developed in the scope of the German Chemical Leasing project in 2009. These sustainability criteria serve three main purposes (UNIDO, 2009a):

- Measurable and concrete ecological improvements as a key element for sustainability
- Measurable and concrete economical improvements as lasting motivation for Chemical Leasing partners to implement Chemical Leasing
- Protection of the positive image of Chemical Leasing; prevention of misuse of the term Chemical Leasing e.g. for non-adequate activities related to health or the environment

The criteria are as follows (UNIDO, 2009a):

1. **"Reduction of energy and resource consumption** and minimization of adverse impacts on the environment and health caused by chemicals, their application and production processes (e.g. reduced environmental impact measurable by reduced material flows (including waste and emissions generated and energy savings) and compared to the situation before Chemical Leasing. For the overall balance, the manufacture of chemicals and the impact of equipment and machinery also need to be considered; reduced impact on health (reduced exposure to chemicals and/or reduced hazardousness of chemicals used) measurable by material flow analyses and hazardousness classification (GHS).
2. **Improved handling and storage of chemicals to prevent and minimize risks** (e.g. reduced risks due to improved handling and storage as a consequence of the increased collaboration between user and supplier. Since measurements are difficult to perform, a qualitative description is necessary for actions regarding the prevention and/or reduction of risks. This can be carried out by means of classical risk assessment, i.e. describing the probability of accidents and their potential impacts; Apart

from improvements of the environmental situation and health issues, economic impacts (change of liability for Chemical Leasing partners) might also be relevant.

3. **No substitution of chemicals by substances with a higher risk** (contradictions in terms of sustainability can occur if chemicals are substituted by substances that pose a higher risk for the environment and health. Experience has shown that this criterion does not apply to many pilot projects (no substitution intended). In cases where chemicals are substituted, it needs to be determined at which level higher risks occur for the environment and health (references might be REACH/GHS classifications and exposure data). For the risk assessment, the exposure (real and potential) as well as the hazardousness of the substance need to be considered.
4. Generation of **economic and social benefits**, **continuous improvement** and **fair sharing of the benefits** between the partners (Economic benefits for both partners are essential if the contract is to continue and for the success of Chemical Leasing as a business model. Economic improvements are relatively easy to quantify. Typical social benefits include better working conditions. It is not the aim of Chemical Leasing to increase the efficiency of processes by reducing the number of jobs involved. The objective of continuous improvement as well as the fair and transparent sharing of benefits between the partners should be included in the Chemical Leasing contract.
5. Providing for the **possibility to monitor improvements** (highly relevant for most pilot cases; easy to check whether the data corresponds to that fixed in the contract; important to check whether fully implemented). Challenges: Agreeing on specific monitoring measures with sufficient transparency and acceptable levels of work involved; Preservation of confidentiality when monitoring sensitive data.“

The sustainability criteria are binding and need to be fulfilled in case a company applies for the Chemical Leasing Award. They have also been tested in more detail in the following cases (Joas, 2010):

- Sri Lanka: General ink – Wijeya Newspaper;
- Russia: Vodokanal – Aquatechservice;
- Egypt: Union Coating – Link Misr;
- Columbia: Nalco - Ecopetrol (cleaning of water);
- Serbia: Ecolab – Knjasz Milos (lubrication for transport of bottles on a conveyer); United Kingdom: Cabot – various customers of the mineral oil industry;
- Germany: 3M;
- Austria: SAFECHEM – Blau

The application of the quality criteria on these case studies showed that in general, the criteria fit well and that the projects could fulfil them in most cases:

A continuous improvement of environmental and health impacts caused by chemicals and machines/equipment for their application was always possible in the starting phase but has to be followed up during the years of a Chemical Leasing contract. Here, a necessary pre-condition is that a quantification and thus baseline data are available.

An improved handling of chemicals was fulfilled in all cases.

The transparent share of risk and economic improvement has also to be checked again then the full Chemical Leasing contract is in place.

The criterion on substitution of chemicals is of particular importance and has to be checked very careful, e.g. by complete material balances, as hints could be found that some companies might hide additional chemicals under confidentiality requirements.

Improved energy efficiency concerning chemical use was the most difficult criterion to fulfil as energy balances are not always available.

Monitoring and measurement of the modifications and improvements was fulfilled in all cases, due to the fact that Chemical Leasing companies have to report the results of a Chemical Leasing project on a regular basis (reports) to UNIDO.

Nevertheless, these criteria are more a rough guidance but would need more refinement to give a better picture of the sustainability performance of the companies.

- **Public Private Partnerships**

Public Private Partnerships (PPP) have always been in the focus of UNIDO to strengthen links to industry. First PPPs were achieved with Akzo Nobel and BASF in 2007 and with IKEA in 2008, where a “Memorandum of Understanding” was signed. In the following years, other partnerships, e.g. with SAFECHEM were established although not really sealed with a contract.

In 2014, the UNIDO Evaluation Group conducted an evaluation of Public Private Partnerships within UNIDO (UNIDO, 2014). The subject of this evaluation was the overall UNIDO business partnership programme. In this document, the term ‘business partnership’ is used throughout the report as equivalent to ‘Public Private Partnerships’. Among the selected, ongoing partnerships was also Chemical Leasing as an example for a multi-stakeholder partnership. One of the recommendations that were given from the authors was that UNIDO should “…give priority to multi-stakeholder platforms like the Chemical Leasing approach as they offer significant leverage and scaling-up potential. The Chemical Leasing approach should be brought to a higher level and UNIDO should establish partnerships with big chemical companies at the corporate level.“ (UNIDO, 2014).

- **Evaluation of Chemical Leasing**

The three evaluations that were conducted from 2008 to 2014 on the Chemical Leasing program could also be seen as a tool. For this analysis of tools, the representatives of the NPCs were asked if they think that the whole Chemical Leasing program should be evaluated from time to time or on a regular basis, if they find the questionnaires and evaluations useful and which outcome/changes they expect/wish to have from evaluations like this.

All NCPCs found the evaluations useful and even necessary, in order to improve the Chemical Leasing programme in general. It would also be a good opportunity to identify and report about problems, issues and barriers faced in the

implementation of the Chemical Leasing programme. Most of them also said that an annual evaluation would be appreciated. This would also result in less work and less extensive questionnaires for the evaluation.

But it is also important for the NCPCs that after such an evaluation, the results should be discussed, maybe at the Annual Meetings or in any other form that seems to be suitable. And, it is even more important for the NCPCs to see that their suggestions, remarks and wishes are taken seriously and to see real changes taking place after such evaluations.

- **Overall Strategy for Chemical Leasing**

As can be seen from table 7-3, activities on Chemical Leasing were planned and done in a logical order from the beginning, one step following the other, nevertheless it seems that a real strategy behind the model was at least partly missing as these steps sometimes were not linked to each other or not followed up after some time.

In the project document of 2007 (UNIDO, 2007b), a logical framework was mentioned in the annex but this was more a roadmap only for the projects in the participating countries. More or less all NCPCs mentioned in the evaluations that they were missing an overall strategy and that they were sometimes not seeing any development in the program.

But in 2015, for the first time, a real strategy document which also was named as such started to be developed. A vision was defined and the strong links to the UN Sustainability Agenda 2030 and the corresponding Sustainable Development Goals were highlighted.

- **Chemical Leasing as a political instrument**

Throughout the years, Chemical Leasing has become a political instrument in some countries as well as for the European Parliament. Chemical Leasing is now seen as an efficient policy instrument for sustainable chemicals management

The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management fosters best-practice models like Chemical Leasing as part of its chemicals policy[58]. The importance of Chemical Leasing to the Austrian Ministry is visible in the workshops, events, publications and support activities (e.g. financial support and assistance in pilot projects) done since the beginning of Chemical Leasing. The argument for Chemical Leasing also being a political instrument are (BMLFUW, 2006):

- Emission reduction without economic burden but with economic benefits
- Increased responsibility of the producers reduces risks
- Know-how and technology transfer to developing countries

In the European Parliament resolution of 13 September 2011 on an effective raw materials strategy for Europe (2011/2056(INI)), Chemical Leasing was explicitly mentioned: „.. remarks that social innovation, lifestyle changes and new concepts such as eco-leasing, Chemical Leasing and sharing should be supported by the

[58] https://www.bmlfuw.gv.at/greentec/chemikalien/chemikalien-leasing-und-gruene-chemie.html

Commission.“ [59]

In Germany, financial support for companies interested in the implementation of Chemical Leasing business models is offered by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through the „Umweltinnovationsprogramm“.

It is known from at least two governmental authorities who explicitly mentioned Chemical Leasing as a political tool: the Government of the Republic of Serbia recognized the importance of Chemical Leasing and its close relation with provisions of REACH and principles of SAICM in 2009, manifested in an official statement from the Chemicals Agency of the Republic of Serbia. The Ministry of Environment of Colombia is also strongly committed to include Chemical Leasing in its national strategy as an innovative tool to minimize hazardous waste in industry (UNIDO, Annual Report 2011).

Chemical Leasing is also in line with international treaties like Basel, Rotterdam and the Stockholm Convention as well as with IOMC and SAICM, as it provides practical solutions to enhance the efficiency of industry while at the same time reducing consumption and/or substituting hazardous chemicals by less or non-hazardous, thus protecting human health and the environment.

Chemical Leasing and SAICM

Chemical Leasing is part of SAICM, the Strategic Approach to International Chemicals Management. SAICM is a global policy framework to support efforts to achieve the goal of the Johannesburg Plan of implementation. “SAICM overall objective is the achievement of the sound management of chemicals throughout their life cycle so that by the year 2020, chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health“[60]. SAICM aims to coordinate, catalyse and facilitate all efforts for better international chemicals management systems. SAICM is neither a new organisation nor a legal binding instrument and does not replace existing institutions and mechanisms.

In 2006, participants of the UNIDO-Austria side event on Cleaner Production and Chemical Leasing that took place in parallel to the International Conference on Chemical Management in Dubai, on 6th of February 2006 concluded that „the Global Action Plan of the SAICM process and the Quick Start Programme should support the international dissemination of Cleaner Production and Chemical Leasing projects“[61] (BMLFUW, 2006). Applying Chemical Leasing helps to achieve some of the global SAICM objectives on the level of the individual business or production plant:

- To minimize risks to human health, including that of workers and to the environment throughout the life cycle of chemicals;
- To minimize risks from unintended releases of chemicals;
- To ensure that knowledge and information on chemicals and chemicals management are sufficient to manage them safely.

[59] http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2011-0364+0+DOC+XML+V0//EN
[60] http://www.saicm.org/About/SAICMOverview/tabid/5522/language/en-US/Default.aspx
[61] http://www.chemicalleasing.com/concept/policy-background/saicm

Chemical Leasing and REACH

Already back in 2003, high hopes were set on Chemical Leasing being pushed forward by the start of REACH, the Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals which streamlines and improves the former legislative framework on chemicals of the European Union (EU)[62]. „REACH is based on the principle of documentation, evaluation and minimisation of risks resulting from chemicals – which is above all to be implemented by the industry itself“ (Jakl et Schwager, 2008). One of the main elements for REACH is the „no data – no market“ concept, where producers or importers of chemicals are obliged to deliver a certain amount of documentation regarding properties of chemicals and possible risks during their applications as a precondition for market access. It was also ensured that the “precautionary principle” is a cornerstone of the new legislation if a chemical is suspect of being of very high concern for human health or the environment.

REACH has been devised specifically to meet the challenges of Europe’s future chemicals policy. The key targets are summarized in the “Sixth Community Environment Action Program “[63], which stipulates the following requirements: “(25) Chemicals that are dangerous should be replaced by safer chemicals or safer alternative technologies not entailing the use of chemicals, with the aim of reducing risks to man and the environment”.

The Action program also demands to „...place the responsibility on manufacturers, importers and downstream users for generating knowledge about all chemicals (duty of care) and assessing risks of their use, including in products, as well as recovery and disposal“ (Doutlik, 2003). The Action program finally commits the Union to „..aim at achieving within one generation (2020) that chemicals are only produced and used in ways that do not lead to a significant negative impact on health and the environment“ (Doutlik, 2003).

One outcome of the already mentioned conference in November 2003 was the following conclusion (Jakl, 2008, in BMLFUW, 2008): “All these new service-oriented chemical business models require a close cooperation between the provider and the user of the chemicals. Therefore, the potential of these business models has also to be seen in connection with the new EU Chemicals Policy (REACH) which will require a new relationship between provider and user and the conventional paradigm “supplier here – customer there “will hardly be crowned with commercial success. On the one hand, the supplier will have to document potential hazards of chemicals as well as risks occurring during their use and application. On the other hand, also the user will be challenged to make available new experiences, gained during the handling and use of the chemicals, to its partners and to the system itself. This will also require a new culture in terms of information exchange, communication and cooperation.” (Jakl, 2008, in BMLFUW, 2008). These commonalities suggested that REACH could also boost Chemical Leasing models for several reasons.

In fact, Chemical Leasing business models and REACH have some common objectives:

[62] http://ec.europa.eu/environment/chemicals/reach/reach_en.htm
[63] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32002D1600

- both intend to reduce the risks resulting from the use of chemicals
- both intend to improve the industry's competitiveness through responsible manufacture and application of chemicals
- both intend to create benefits from an intensified sharing of know-how and information (UNIDO, 2011b).

So the assumption was that REACH would be able to boost Chemical Leasing for different reasons (e.g. UNIDO, 2011b):

- *Promotion of information exchange*

  Aspects of REACH concerning the transfer of information along the supply chain are also addressed by the Chemical Leasing model. Both concepts promote an increased cross-linking of know-how between the producer/supplier and the user of chemicals.

- *Higher recognised value of solutions for risk management*

  Due to the complexity of the REACH regulation, the value of integrated management services for consumers is expected to rise, especially in the fields of legal compliance and risk management. The need to share costs and benefits becomes more obvious as a result of the REACH requirements.

- *Need for new rules for confidentiality*

  Solutions and developments under REACH regarding confidentiality will require new rules to ensure mutual trust and confidence. Increased transparency of chemical processes entails the risk of imitation; service oriented business models are therefore protected by an imitation barrier.

- *Better environmental record of production processes*

  The perception of ecologically sustainable process solutions is expected to increase along the supply chain due to REACH. This should increase the market value of service solutions that promote closed loop systems.

REACH is going to mandate along the supply chain (information exchange, monitoring procedures, patterns for sharing and co-operation, documentation and assessment procedures) and Chemical Leasing is supportive to the REACH implementation as it involves different stages of the supply chain: Chemical Leasing businesses are life-cycle oriented, and chemicals and applications are monitored.

Continuous optimisation in economic and ecologic terms is an inherent and integrated element of the Chemical Leasing concept. One of the results of these optimisation processes is resources efficiency and the substitution of chemicals of very high concern, where their use within the European Union is subject to authorisation under the REACH regulation. The application of Chemical Leasing might thus be a precondition for the use of such a substance to be authorized as it has already happened in one case of metal cleaning in Serbia.

Table 11-1 summarizes all the tools and instruments used in Chemical Leasing, listing their main aims, the usefulness and some recommendations to further improvement, if applicable.

Table 11-1: Instruments of Chemical Leasing and their purposes

Instrument	Assist implementation (NCPCs and companies) – internal tool	Support dissemination of Chemical Leasing (UNIDO) – external tool	Useful tool	Recommendations for improvements	Comments
Chemical Leasing Definition	✔	(✔)	(✔)	Make it more tailor-made for practitioners and academics	Delphi survey in 2015
Sector studies	✔	(✔)	✔	Should be done for every new sector where a Chemical Leasing case study is going to be implemented.	A tool to explore new fields for Chemical Leasing
Seminar for starters	✔		✔	Should be longer, with more innovative learning tools, etc.	Urgently needed
UNIDO Toolkit	✔	(✔)	✔	Should be updated on a regular basis	Now this is also a tool for dissemination as it is available online
Missions of UNIDO experts/assistance for NCPCs	✔		✔	Sometimes sectorial experts would be needed (e.g. for agriculture)	Is a very helpful tool and should be available more often
Chemical Leasing Annual Meetings	✔		✔	Should be more practical, longer, more in-depth trainings, should be connected to IWG	Should be held in the future as well
Annual and Half-Year Reports	✔	✔	✔	Should include much more details on the case studies so that NCPCs can learn from each other, maybe some parts should not be published	The reports have, over the years, become more and more a marketing instrument to also show results to the public
Monthly Reports	✔		-	Not in use anymore	Were only in place from April 2009 to November 2011
Success Stories	✔	✔	✔	Much more success stories	Motivation for NCPCs

Instrument	Assist implementation (NCPCs and companies) – internal tool	Support dissemination of Chemical Leasing (UNIDO) – external tool	Useful tool	Recommendations for improvements	Comments
				needed, development of a database with more details is highly recommended	and companies as well as a marketing instrument
Chemical Leasing Books	✔	✔	✔	Update on books, or even a new book is needed	A valuable tool for the NCPCs
Participation in international program schemes	✔		✔	Whenever there is an opportunity it should be taken	Is a good starting point to link with academia
Scientific papers	✔	✔	✔	Should be done by more NCPCs in the future	Will be pushed by UNIDO
Contact to other institutions	✔	(✔)	✔	Should also be actively initiated by NCPCs	Will be pushed by UNIDO
Promotion activities (like leaflets, etc.)		✔	✔	Support is needed (financially) to produce promotion material in the local language	Mainly to interest new companies
Articles in journals, presentations at conferences, etc.		✔	✔	Would be needed more to raise visibility of Chemical Leasing	Necessary to show results of Chemical Leasing to the public
Website and Newsletter	✔	✔	✔	Should be updated more frequently and news should be send out more often	Information source for NCPCs, companies and interested parties
Telephone and Skype conferences	✔		✔	Should be more focused on thematic groups (ie. cleaning, agriculture), more regularly	Should be done also in the future to exchange experiences
Chemical Leasing Hotline	✔		(✔)	Not used very often, should be promoted more (e.g. on the website more prominently)	Should be kept alive

Instrument	Assist implementation (NCPCs and companies) – internal tool	Support dissemination of Chemical Leasing (UNIDO) – external tool	Useful tool	Recommendations for improvements	Comments
IWG/NWG/other working groups	✔	(✔)	✔	Should be enhanced and become a real working group to assist in further development of the Chemical Leasing concept	Could be very helpful to bring Chemical Leasing further
Global Chemical Leasing Award	✔	✔	✔	Should be done on a regular basis	Motivation for companies and NCPCs and a marketing instrument
Cost-Benefit-Analysis and EMA	(✔)		✔	Urgently needed!	UNIDO could maybe provide an expert to elaborate a CBA
Baselining and Monitoring - KPIs	✔	(✔)	✔	Urgently needed! See chapter 14.2. of this thesis	Proof of success
Sustainability criteria	✔	(✔)	✔	Should be supported by indicators (see KPIs)	Support the Chemical Leasing strategy
Public Private Partnerships (PPP)		✔	✔	UNIDO should establish partnerships with big chemical companies	Will be forced
Evaluation of Chemical Leasing	✔		✔	Should be done on a more frequent basis	Can help to identify gaps and further potential
Overall strategy on Chemical Leasing	✔	✔	✔	Under development in 2015	NCPCs would appreciate this very much
Chemical Leasing as political instrument		✔	✔	Continuous development by UNIDO	A tool to bring Chemical Leasing forward

11.2 Summary of and recommendations for the Tools

As already mentioned in the beginning, the Chemical Leasing tools were developed to

- educate and train people in Chemical Leasing,
- support the NCPC representatives with the implementation of Chemical Leasing in companies,
- further develop the Chemical Leasing business model,
- to support communication between Chemical Leasing practitioners and
- to show the success of Chemical Leasing projects.

In general, the NCPCs have the feeling that most tools they need for their work in Chemical Leasing are already in place and that they are useful. However, some of them could be amended to better fit for their needs and some new/other tools were suggested:

- More possibilities for **regular communication** of representatives of political and business authorities with the leaders of the Chemical Leasing program should be available;
- A **new book**, summarizing all new developments in Chemical Leasing, including case studies, should be published;
- Implementation of an **international research institution** on Chemical Leasing should be built up;
- A fund where money for Chemical Leasing projects for companies is available, e.g. a "**Green Fund on Chemical Leasing**" should be established;
- A tool how to (better) **reach potential new companies** and how to (better) sell Chemical Leasing would be helpful;
- **(a more) regular updated information** on new cases, new dissemination tools, figures, statistics, publications should be provided;
- A tool on how to **calculate the unit of payment** is needed;
- **More case studies** about successful Chemical Leasing implementation in different sectors are urgently needed;
- A **Cost-Benefit-Analysis (in-depth assessments)** of the implementation of the project in different sectors should be provided;
- More **policy framework support** is needed;
- An expansion of the **working groups should be done**: geographical working groups (e.g. Latin America, Eastern Europe) and thematic working groups (e.g. on agriculture, cleaning chemicals) – and to make better use of the potential of already existing working groups, be it the national ones or the International Working Group.

Chapter 11 gave an exhausting overview on the different Chemical Leasing tools that are or were in place during the last ten years. Based on a thorough description and analysis, some recommendations were derived which went into the draft roadmap for Chemical Leasing in chapter 14.2. The need for a tool for data collection and monitoring was followed up in the development of a new set of indicators, described in chapter 14.1.

12. Analysis of Chemical Leasing Case Studies

In this chapter, five Chemical Leasing case studies are described and analysed. They represent a cross section of the different sectors and processes and of different countries where Chemical Leasing has been implemented until 2014.

When the Chemical Leasing program started back in 2004/2005, no clear (key performance) indicators on how to measure success of the implementation were defined (UNIDO, 2014). In the material available (reports of UNIDO, Chemical Leasing toolkit, Chemical Leasing success stories brochure), the cases are briefly described at the beginning (sector, process, partners,), the situation before and after the Chemical Leasing implementation is presented (including calculations or estimations of savings), and the unit of payment is given.

For this work, five Chemical Leasing case studies were chosen out of 55 case studies that were available at the time of the 3rd Global Chemical Leasing Award at the end of 2014 for a more in-depth analysis. The information was taken from the Half-Year and the Annual Reports, from the case studies that were published in a brochure and on the Chemical Leasing Toolkit website and from talks and other documents collected throughout the years of work with UNIDO and the NCPCs.

To be able to assess the quantity and quality of data available through these reports as good as possible, especially cases that were well documented were chosen.

For this assessment, the cases' background is described at the beginning, presenting the sector and the reason why this case was suitable or chosen for the implementation of Chemical Leasing. This section is followed by a description of the involved partners and the situation before Chemical Leasing. The implementation of Chemical Leasing with all available information on chemicals used and process changes is described in detail. The unit of payment is given before and after Chemical Leasing. A table shows the benefits and achievements due to Chemical Leasing, listing all the economic, ecologic, social and other benefits that could be gained through the reports, including numbers where available. The description of the cases always concludes with an analysis of the case. For confidentially reasons, no names of companies were mentioned.

When analysing the cases, the following variables were checked:

- Indicators used;
- Technical/organisational changes;
- Economic results/benefits;
- Environmental results/benefits;
- Social results/benefits;
- Other results/benefits (e.g. long-term partnerships between users and suppliers, higher working standards, etc.).

12.1 Case studies in Colombia, Egypt and Serbia

Case Study 1: Waste water treatment, oil dehydration and corrosion inhibition in the Colombian oil sector

This first case is one of the best-documented ones and is presented here in detail. The data was taken from the different Annual Reports (UNIDO 2008 – 2014), the description on the Chemical Leasing Toolkit website[64], UNIDO's Success Stories brochure (UNIDO, 2011c), from the companies' websites and from different emails and interviews undertaken with the NCPC representatives Yuan Kuan and Gladis Sierra throughout the years 2008 to 2014.

Background

Water clarification and treatment after the extraction and dehydration of oil needs a huge amount of physical and chemical processes, which are very complex and use products that can cause adverse effects to the environment. Two oilfields in Colombia have become the main operation area for the user company in this case. To maintain the high level of production, the operations in these fields require careful and highly efficient treatment because the fields contain large volumes of fluids (oil, water and gas) to be treated, around 136,000 barrels of oil and 649,000 barrels of water. The treatment processes are managed efficiently, if the water content in crude oil and the oil contend and the suspended solids in wastewater are low.

The largest Colombian oil company was looking for new strategies to decrease their costs and identified the Chemical Leasing business model as the most suitable strategy, which also fitted their ecologic visions.

Involved partners

The **user of chemicals** is Colombia's largest oil company. In 2012 it was ranked 14th among the best performing energy companies in the world and it is one of the four largest oil companies in Latin America. Besides Colombia, where it accounts for 60% of total production, the company is involved in exploration and production activities in Brazil, Peru and the United States (Gulf of Mexico). The company is also considerably increasing its engagement with biofuels.

The **supplier of chemicals** is one of the world leaders in water treatment and process improvement applications, providing services, chemicals and equipment to industrial and institutional customers. The company serves over 160 countries with its extensive network of specialists and more than 40,000 employees. The company also has an Energy Services Division, which provides on-site chemical and service solutions to the global natural gas, petroleum and petrochemical industries. They also deliver a wide range of water treatment services to these companies, along with recovery, production and process enhancement services.

At the beginning of the project the partners clearly defined the roles of each partner: in the two oil fields, the provider is responsible for the chemical treatments of the fluids (oil and water) produced by the oil company. They are responsible to

[64] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_colombia2.pdf

deliver the fluids with the quality contractually established; additionally, they must ensure the reliability of the equipment and the pipelines and of the two oil fields.

The **NCPC**, represented by Yuan Kuan (and later-on by Gladis Sierra) supported the companies through continuos evaluation of the Chemical Leasing implementation and by encouraging and supporting the team with knowledge and practical support but also by doing extensive calculations for a cost benefit ratio.

Situation before Chemical Leasing

For this case there is a very good description available from the success stories brochure that was published by UNIDO in 2011 (UNIDO, 2011c) as well as the online Chemical Leasing Toolkit[65] and which was taken (partly) for this thesis as the author worked on that documents together with UNIDO:

In 2006, the oil company's purchasing strategy was based on the lowest costs, and savings could only be achieved by reducing the volume of the chemicals used. The company recognised that this model did not correspond to the global vision of their activities and started to look for new strategies in order to not only work at the lowest possible costs but also to consider the total economic balance of the crude oil drilling and water treatment operations. They then started their first project, which focused on the dosage of the chemicals applied. In 2008, they recognised the potential environmental and economic benefits that can be achieved by implementing best practices in the chemical process. In this respect, Chemical Leasing appeared to be the most comprehensive and global strategy and therefore a cooperation with the NCPC Colombia was started.

A comprehensive baseline evaluation was done and the exact numbers of how many different chemicals (e.g. emulsion breakers, antifoam, etc.) were used for which amount of oil and water to be extracted and treated, were documented. Also the list of chemicals that were applied, with a description of their function in the process was provided.

Implementation of Chemical Leasing

The oil company wanted to sell "clean barrels", meaning they wanted to avoid accidents on their premises that would harm their employees and the environment and they wanted to "produce in harmony with the communities and other stakeholders" (UNIDO Annual Report, 2011). To achieve these goals, they already had implemented a number of measures aimed at reducing chemical consumption and product substitution by green products throughout the years. In addition to that, the company decided to start a new alliance with a partner who could manage the processes and chemicals efficiently and responsibly, ensuring the delivery of fluids with the qualities required and without environmental impact.

The Chemical Leasing business model was applied to the following processes:

- Oil dehydration, where the water/oil emulsion gets separated;
- Water purification, where the oil and solid contents are eliminated from the water;

[65] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_colombia2.pdf

- Corrosion inhibition, where the facilities which come into contact with crude oil are prevented from corrosion, as the crude oil contains water.

The aim of the project was the continuous improvement and development of alternative chemical treatments to optimize the costs, to reduce the consumption of chemicals and to protect the environment. An important part of the project was the monitoring of the project, where software was purchased to manage all the information streams and to control the consumption. Another part was the development of technological innovation projects like the destruction of phenols and chlorophenols, microfiltration, biological treatments, reinjection of disposal water, scale inhibition and the design of green chemicals for replacing conventional chemicals.

The following measures were implemented in a first step:

- Avoiding chemical waste;
- Simplifying operations and logistics by injecting just one emulsion breaker in two oil fields;
- Diluting the purifier, thus cutting costs by approximately 20%, and reducing the oil and grease deposited in the cooling;
- Measuring the water quality parameters in real time by installing flow-metres and introducing mobile laboratories.

Through improved measurement techniques and constant evaluation of the dosage and points of application, the use of chemicals could be optimized to a maximum. The dosage controlling equipment, installed in the fields, helped to better control the dilution and saturation of products injected into the fluids. Optimum laboratory equipment enabled the chemical supplier to simulate the operating conditions of the equipment in the field.

The results have been a substantial increase in the production and treatment of oil and the treatment of water with only a minor increase in the quantity of chemicals used and solid waste produced. Due to the tremendous results obtained with that contract, both companies decided to sign another Chemical Leasing contract in April 2011 for another five years. The contract is based on three pillars: the optimization of the application of chemicals, development of technological innovation projects and on the substitution of hazardous chemicals.

As data show, due to Chemical Leasing implementation, more oil and water can be treated with less chemicals (emulsion breaker, water clarifier), just an increase of the inverse breaker and antifoam products was needed to fulfil the required water quality standards. In addition to that, also less solid waste was generated. Linked to Chemical Leasing, already back in 2012 a so called “scale inhibition project” was developed. With the application of chemicals for scale inhibition, the replacement time of pumps now exceeds 560 days, whereas in former times the pumps had to be replaced nearly every 150 days.

Pilot projects to improve the post-treatment of the water generated in the field were also developed, for example to improve the reduction of phenols and chlorophenols, microfiltration to reduce the suspended solids or biological treatments using species of plants to reduce the use of chemicals in the treatments. In total, 27 new green chemicals (e.g. non-toxic, biodegradable and non-bioaccumulative products) have been designed for oil dehydration, water clarification, corrosion inhibition, scale inhibition, oxygen scavenger and biocides

so far. One of the most important projects was the replacement of Naphta by a viscosity reducer, which has been tested and will be used in one oil field in the future. It was estimated that the consumption of Naphta will be reduced by 15% and that the energy consumption will be reduced by 20%.

In 2013 a Total System Analysis (TSA) was made, consisting of a review of all production systems of the oil company (stations, wells, gathering lines, HSE), by the provider, and as a result a portfolio of 47 projects was generated with estimated cost savings in production of about 127 million US $ for the oil company. The 47 projects then entered the review and planning process for further development.

The oil company has then decided to include the Chemical Leasing model in every contract for chemical purchases starting from 2011, including their new provider, which is starting the implementation of Chemical Leasing in catalyst processes. In 2011, the oil company also produced a video to show their achievements in Chemical Leasing[66].

The development of a memorandum of understanding with UNIDO was also discussed in 2013, the scope of which has not yet been agreed upon. A possible joint activity could be the organization of Chemical Leasing training courses for suppliers of the oil company.

Two people from the oil company are also part of the National Working Group in Colombia to promote the concept among interested parties.

Unit of payment

Before Chemical Leasing	US$ per gallons or kilos of chemical purchased
After Chemical Leasing	US$ per kilo barrels of oil with a specified quality

Benefits/Achievements

Table 12-1 shows the comparison before and after the implementation of Chemical Leasing and shows the indicators that have been used to describe the benefits.

[66] https://www.youtube.com/watch?v=nYiUkiIwHlo (in Spanish)

Table 12-1: Before and after Chemical Leasing, case 1

Before Chemical Leasing	After Chemical Leasing
• Operations with a high consumption of chemicals • Low efficiency and potential risks at the oil fields • High operational costs due to chemicals • Operative costs related to the price of chemicals • Only a few possibilities for improvement • Commercial relationship only based on price	**Economic benefits:** • Reduction of oil and grease in the cooling towers, cost reduction due to the recovery of oil in pools, the prolongation of cleaning and the maintenance of the pools and cooling towers • Reduction of the costs of the treatment process by almost 20% • Adjustment of the yield of the equipment • Reduction of drums used for the transport and storage of the chemicals from 4,900 to 3,500 pieces • Cost savings due to the recovery of oil in the stabilization pools and lower costs for maintenance of the pools and cooling towers • Total savings for the oil company - 1.8 million US$ (in the first year: 2008 - 2009) • Savings for the chemical supplier – 165,000 US$ (in the first year; 2008) • Long-term commercial relationship encouraging continuous process improvement **Environmental benefits:** • Reduction in polymer consumption • Reduction in chemicals consumption and less residues in the stabilization pools and treated water of 20% in the first year • Reduction of the polymer residues in the stabilisation pools and the treated water • Reduction of the environmental impact of the treated water due to less content of oil • Installation of flow-metres and laboratory tests to achieve an even higher degree of optimisation • No sub-products in the chemicals production process due to the

	methodology used by the provider (machination process) **Social benefits:** • Creation of jobs (in laboratories) • Long-term commercial relationship • Risks reduction and better working conditions **Other benefits:** • 100% of staff are local people • long-time job security • other services like the rental of vehicles were done in the region

Analysis of the case

This case is very well documented, running for more than five years now and it won the first Global Annual Leasing Award in Gold in 2010. The case also got a special acknowledgement in 2014 for being already a very advanced case study. In 2012, the NCPC Colombia (Yuan Kuan) was awarded Bronze for the efforts in implementing Chemical Leasing in Colombia, amongst others in the analysed cases study. A success story in the Chemical Leasing case study brochure of 2011 (UNIDO, 2011) as well as one of the case studies in the online toolkit[67] is also dedicated to this case.

The company has detailed records on the contract from 2011 to 2015. These data were included in the application for the Global Chemical Leasing Award in 2014 but cannot be displayed here for confidential reasons.

Chemicals applied in the fields were permanently assessed in order to improve their yield by redistributing the points of the application of chemicals or new formulations or new technologies of treatment. With the redistribution of the points of application of chemicals and a new formulation, an important consumption reduction of the inverse breaker in the water clarification process was achieved.

This case is also very inspiring for the whole oil-processing sector and could probably be reproduced in many other countries and companies. As the oil company also follows an “open book” approach, there is the possibility to get more data and make it available for others, at least among the NCPCs to better be able to give valuable support to their companies.

A comprehensive baseline evaluation was done and the exact numbers of how many different chemicals (e.g. emulsion breakers, antifoam, etc.) were used for which amount of oil and water to be extracted and treated, are documented. A suggestion is, that the form that was used for these analysis could be provided to all other NCPC or companies as a template and to have *one* identical and

[67] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_colombia2.pdf

standardized table for all the cases no matter in which country or company so that cases can be compared and numbers are calculated and/or measured the same way in every case. This would also help UNIDO or any other official institution (e.g. ministries) to see the results of a case. A baseline data set is also needed to see the changes over time. Goals of what companies want to achieve during one year or a certain period have to be set at the beginning. These achievements can be based on calculations (e.g. with a CBA tool) or can also be estimated if there is no other way. If no goals are set at the beginning, it is hard after a certain time to verify what has been achieved.

Data on energy consumptions and savings could be collected, documented and published as well.

What is missing in this case is a description of challenges and barriers (if there were any) and how they have been overcome, so that others can learn from that. These could be collected for all cases in a database, available for all NCPCs and companies already working in the Chemical Leasing program but also for future project partners.

Case Study 2: Integrated Process of Washing Machine Painting in the Engineering (Electrical Domestic Appliances) and Chemical Sectors

The information on this case was taken from several Annual Reports (UNIDO 2008 – 2014), presentations, the companies' websites and personal talks to the (now) director of the ENCPC, Ali Abo Sena and the Chemical Leasing toolkit success stories[68].

Background

Surface protection of electrical appliances is essential to ensure their high quality and durability. This protection includes the processes of metal pre-treatment (degreasing and phosphating), cathodic deposition (e-coating) and electrostatic powder coating of the appliances' surface. The chemicals for these processes may have a considerable impact on the environment and on human beings, which requires an efficient and safe application of the chemicals. However, this process is categorized as a non-core business process for the producer of washing machines, which is mainly focusing its business on electrical technology of domestic appliances and not on the metal surface pre-treatment processes or on coating technologies.

A large Egyptian producer of electrical appliances, refrigerators and washing machines faced high costs per washing machine and high annual losses in coating due to non-optimized processes and high amounts of waste. In addition, the workers did not have great knowledge about chemicals, as they only had very limited access to relevant information and also risk management was not a priority.

To solve these problems, a large and well-known powder coating company in Egypt as supplier for coating chemicals, a company as supplier of surface pre-treatment chemicals (represented in Egypt by an authorized agent) and the producer of the electrical appliances, in close cooperation with the Egypt National Cleaner Production Centre have agreed to join hands in implementing the Chemical Leasing concept on the integrated painting process.

Involved partners

The user of chemicals is the largest and leading Egyptian company in the field of electrical equipment manufacturing. The company is mainly producing electrical appliances, refrigerators, and washing machines.

The **leading supplier** is a leading company in powder coating and covers around 60% of the Egyptian powder coating market. Its main end user sectors in Egypt are domestic appliances, electric equipment and air-conditioners.

There is also a **sub-contracting supplier & co-partner** involved, which is a global company committed to specialty chemistry. Its activities focus on products and processes for the chemical treatment of metal surfaces and plastics, as well as selected fields of fine chemistry, e.g. lithium and caesium compounds. The company is actively working in Egypt with a wide range of industrial sectors (e.g.

[68] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_egypt_metal-final.pdf

automotive industry, domestic electrical appliance, and aluminium and galvanization sectors)

The Egypt National Cleaner Production Centre (ENCPC) as the implementing agency is also a partner. The ENCPC was established by the United Nations Industrial Development Organization (UNIDO) in close cooperation with the Ministry of Trade and Industry (MTI) as a service provider to the Egyptian industry in the field of Cleaner Production. It is an integral part of the program for "Egypt's Technology Transfer and Innovation Centres (ETTIC)" for Modernization of the Egyptian Industry. The ENCPC, as the only NCPC so far, is paid for its services to industry, also for supporting companies in implementing Chemical Leasing.

Situation before Chemical Leasing

The high thickness of coating and non-optimized processes led to a high consumption of chemicals per unit (washing machine). This fact resulted in high costs per washing machine but also in a high amount of re-work and rejects (up to 9%). The amount of sludge wastes from the phosphating process before implementing Chemical Leasing was 0.021 per unit (about 6 tons in 2008), which went to the nearby dumpsite. The amount of wastewater was 30m^3 per day and the amount of fine powder, which was wasted every day and went into dumping, was 10%. Only limited information on chemicals management and risk management was available for workers; there was also no full compliance with REACH or RoHs.

The chemicals used in this integrated process are as follows:

- Surface pre-treatment chemicals (degreasing chemicals, conditioning and activation chemicals, Zinc-Phosphate)
- Electro-deposition chemicals
- Electrostatic powder coating

Implementation of Chemical Leasing

The objectives of the project could be summarized as follows:

- Reduction in consumption of the chemicals by efficient use in the surface pre-treatment processes and electrostatic powder coating in the electrical equipment manufacturing;
- Optimization of production processes in general;
- Reduction of costs in the production processes (cost reduction per produced unit);
- Closing the loop of chemical waste by minimization and recycling;
- Reduction of the risks of chemicals and enhancement of worker's health and safety.

At the beginning, a comprehensive technical audit and cost analysis was done to be able to identify the possible benefits of a Chemical Leasing implementation. This was followed by an On-the-Job Training on Chemical Leasing and other supportive Chemicals Management tools. Benchmarks were identified and an optimization plan was developed.

Numerous measures to optimize the pre-treatment and the electrostatic powder coating application were then implemented in the user company. This was combined with a training programme for workers on the correct and efficient application of chemicals. Both measures brought about significant reductions in chemicals and cost per unit produced and also lowered the amount of chemical waste.

Several measures were implemented to optimize the use of chemicals: hazardous chemicals used in pre-treatment were replaced by non-hazardous chemicals without cyanides and nickel content. The application process for powder coating was improved and the thickness of the powder coating was reduced to an optimum. Wastewater from the pre-treatment process was also reused.

Unit of payment

Before Chemical Leasing	Egyptian Pound per kilos of chemical purchased
After Chemical Leasing	Egyptian Pound per produced washing machine

Benefits/Achievements

Table 12-2 below shows the comparison before and after the implementation of Chemical Leasing.

Table 12-2: Before and after Chemical Leasing, case 2

Before Chemical Leasing	After Chemical Leasing
• High chemicals consumption due to high thickness of coating and non-optimized processes • High costs per washing machine • Re-work percentage and rejects of up to 9% • Annual losses of 2.5% • Amount of sludge waste from the phosphating process at 0.021t per unit,, wastewater of 30 m^3 per day, fine powder waste of 10 • No full compliance with REACH or RoHS • Limited information on chemicals management and its risk management available for workers	**Economic Benefits:** • Total reduction of costs per washing machine of 15-20% under Chemical Leasing • Re-work percentage and rejects reduced to 1.5% (benchmark) • Reduction of costs of production processes (cost reduction per produced unit) **Ecologic benefits:** • Reduction of 15- 20% for pre-treatment chemicals and 50% for powder coating • Reduction of losses down to 1% • Elimination of sludge waste by using environmentally friendly pre-treatment

	process (e.g. non-cyanide and nickel-free phosphating technologies) and re-use of wastewater, recycling of waste) **Social Benefits:** • Compliance with the requirements of REACH and RoHS for the supplier • On Job Training and capacity building for workers on chemicals management including Chemicals Risk.

Analysis of the case

From the description, it seemed that the implementation of Chemical Leasing followed the steps described in the toolkit.

At the beginning, a comprehensive technical audit and cost analysis was done which might have included at thorough data collection at the beginning to set a baseline, but that is not documented. It was indicated that benchmarks were identified and an optimization plan was developed, as well as measures for process optimizations were implemented but there is little information which benchmarks and measures these are.

Numbers on benefits and savings were mostly given in percentages and do not indicate any consumption of chemicals, energy or water in absolute numbers. It was not clear if exact numbers before and after have been collected or if these are only estimations on the savings.

The training program for workers was an effective measure to lower the amount of chemicals used and wasted.

The case ended after the optimization was implemented and was not followed up, neither by the ENCPC nor by UNIDO.

Case study 3: Metal parts cleaning in the Serbian automotive supply industry

Case number three is also a very well documented one and the information was taken from different Annual Reports (UNIDO 2008 – 2014), the success stories from the Chemical Leasing toolkit website[69], from the companies' websites and from presentations and talks with the supplier of chemicals and the Serbian NCPC.

Background

This case is about a manufacturer of bearings and cardan shafts. Cardan shafts are needed in a huge variety of industries and everyday objects, like washing machines, tumble driers, photocopiers and printers. Bearings constrain motion and reduce friction, cardan shafts - which themselves contain bearings - connect components of the drive train, delivering power to wheels.

These metal parts have to be cleaned after production, as organic oils, greases or loose material is accumulated on the metal surfaces. To remove these, chemicals like detergents, solvents or other cleaning agents and compounds are needed. In the case presented here, big amounts of tetrachloroethylene (also known as perchloroethylene) - a chlorinated solvent – were traditionally used to clean the parts.

The user company in this case was consuming 30 tons of solvent and producing 25 tons of hazardous waste per year, the solvent was emitted to the natural environment and the working environment, resulting in potential damages to the workers' health. The company wanted to make the metal cleaning processes more efficient and safe and after being contacted by the Serbian NCPC they got interested in the Chemical Leasing model.

Involved partners

The **user of chemicals** is a local Serbian manufacturer which produces bearings and cardan shafts for agriculture machines, business vehicles, mining and transportation equipment and the global car industry.

The **supplier of chemicals** is a subsidiary of a large US Chemical Company and is producing chlorinated solvents. In Serbia, they are represented by a local distributor.

Additional partners in the Chemical Leasing projects are a **supplier of the distillation equipment** (a manufacturer of high quality metal cleaning machines) which is also responsible for maintenance and the **Serbian National Cleaner Production Centre** as an independent body for the implementation of the agreement and supervising the implementation of Chemical Leasing.

[69] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_serbia_auto2.pdf

Situation before Chemical Leasing

As already mentioned, the producer of metal parts used a lot of tetrachloroethylene and produced a lot of hazardous waste, linked to these other facts:

- High consumption of solvent (30 t per year);
- The solvent was emitted to the environment and the working environment;
- The solvent was fed into the machines manually;
- The waste contained 95% of the solvent;
- Large quantities of hazardous waste were produced (25 tons per year);
- The solvent used in the cleaning machines had to be changed weekly (2 machines/ 300 litres) which caused shortages due to maintenance work;
- The two cleaning machines were heavily corroded; metal parts (iron and copper) had to be substituted very often;
- Cleaning was a bottleneck in the production;
- By the end of the working week the quality of cleaning was decreasing;
- Costs for waste export was about 70,000 EUR per year.

In 2011, after the first testing was finished, the chemical suppliers came up with the following expected benefits that could be achieved through a Chemical Leasing business model:

- Consumption of perchloroethylene should be reduced by 25 tons (only a max. of 5 tons will be consumed instead of 30 tons that were consumed at that time);
- A longer life time of the solvent in the machine should be achieved with this;
- Less production of the waste and less solvent in the waste: after the implementation this should not exceed 5%;
- Improved waste management, as the waste will be taken back and exported for recycling;
- Cleaning quality results would stay at the same level during the whole week;
- Increased capacity due to an increased number of metal parts per basket and shorter cleaning cycles (very important for the producer, as they planned to increase capacities);
- Reduced air emissions (both canalized and diffused) due to a lower distillation temperature;
- Improved occupational health and safety. Due to a special system, provided by the chemical supplier, it will not be possible for the workers to get into contact with the solvent anymore. There should be no emissions of chlorinated solvent to the working environment anymore, due to (improper) handling;
- Improved risk management.

Implementation of Chemical Leasing

After an UNDIO mission in December 2009, when the producer company expressed interest in a Chemical Leasing model implementation on metal parts cleaning, the NCPC in Serbia contacted the later supplier of chemicals. Two specialists visited the producer shortly afterwards and both companies agreed to

start a Chemical Leasing project. Samples of oils for testing were sent to the chemical suppliers. It took some time until finally in February 2012, the partners signed a Letter of Intent and agreed upon the Chemical Leasing model, using the closed system the supplier provides. In late 2012 the Chemical Leasing contract was signed between the partners for 5 years.

The producer company is running the cleaning process and equipment following the supplier's recommendations delivered to them by the local distributor.

To make the chemicals application more efficient, the perchloroethylene dry-cleaning was replaced by a perchloroethylene metal cleaning, which is stabilized against acidification. Continuous monitoring of the solvent's parameters was successfully implemented and the acidity of perchloroethylene could be adjusted and controlled. In addition, a distillation unit for the recovery of wasted solvents on site was installed. Due to these measures, the solvent had a much longer lifetime and consumption could be reduced from 30 tons to 5 tons per year. Additionally, the amount of hazardous waste due to the cleaning process could be reduced from 25 tons to 1.5 tons per year, decreasing the amount of solvent in the waste to less than 5% (before: 95%). This is linked to savings of about 100,000 EUR per year. Not included in these savings are the costs for maintenance and the costs for downtimes (exchange of solvent on two machines every week was necessary), which are now significantly lower.

The employees have been trained in the proper and safe use of the distillation unit and the safe use of solvents, the proper determination of parameters of the solvent in the machines and the optimum adjustment of additives. Now, closed containers which are compliant with Responsible Care® principles are in use to store and transport the solvent during the entire cleaning and recycling process. Process modifications accompanied this innovation and the solvent transfer is now managed by pumping and the workers are protected from solvent vapours. Containers with drums are equipped with wheels and much easier to handle.

Due to the modified storage and handling of the solvent and the installation of carbon black based filters in the cleaning machines, there are no emissions to the environment anymore.

In 2014, the producer applied for the Global Chemical Leasing Award and was recognized with a Conformity Declaration Certificate for its efforts.

Unit of payment

Before Chemical Leasing	EUR per litre of solvent
After Chemical Leasing	EUR per number of working hours

"Number of working hours" was taken as the new unit of payment because it can be easily measured and monitored and because it correlates with the number or surface area of parts cleaned. It was agreed to pay a monthly fee for the whole package that includes the solvent, the distillation unit, the waste management, the solvent stabilization, the process management (solvent stabilization managed by the supplier's lab) and the staff training. It was not possible to base the unit of

payment on the surface area of the cleaned parts due to the high variety of sizes and shapes of metal parts and the high variation of impurities that can occur during the process (e.g. depending on the type of oils used).

Benefits/Achievements

Table 12-3 shows the comparison before and after the implementation of Chemical Leasing:

Table 12-3: Before and after Chemical Leasing, case 3

Before Chemical Leasing	After Chemical Leasing
• Use of standard perchloroethylene grade • Short life-time of the solvent (baths changed every week – 300 l of used solvent) • Use of 30 tonnes of the solvent • 25 t of hazardous waste • Content of the chlorinated solvent in the waste: over 90% • Manual dosing and emptying of the solvent	**Economic Benefits:** • Savings of about 100,000 EUR per year • Overall costs reduction by approx. 18% (without savings of maintenance costs and downtime costs) • Increased productivity due to shorter cleaning cycles • Consistent quality and significantly lower maintenance costs (no corrosion of machine parts) • Less frequent changes of the solvent resulted in less shortages due to maintenance work • The costs of cleaning are predictable due to better costs transparency • Avoidance of financial penalties due to quality issues **Ecologic benefits:** • The consumption of perchloroethylene was reduced to 5 tons per year (six times lower than before) • Generation of hazardous waste declined to 1.5 tons per year (20 times lower than before) • Content of the solvent in the waste was reduced to less than 5% • No emission of the solvent to the environment • Use of stabilized, metal cleaning grade of perchloroethylene • Longer life-time of the solvent

	Social Benefits: • Effective risk management in accordance to Responsible Care • Improved occupational health and safety • No emissions of the solvent to the working environment • Containers (hermetically closed) with drums were equipped with wheels and are much easier and safer to handle now **Other benefits:** • Better and consistent quality of cleaning • higher cleaning standards • Reliable long-term business partnership was established

Analysis of the case

Also this case is very well documented and is a good example for an overall process optimization with short-term economic benefits, e.g. cost savings through solvent reduction and energy reduction through technical optimization and an enhanced cleaning capacity. The implementation of Chemical Leasing not only brought significant economic, but also environmental and occupational health and safety benefits. The training of workers is essential for the success, not only for their own safety but also for an optimum use of chemicals.

This case is special as the use of perchloroethylene is only allowed as no other substitute is available that fulfils the quality criteria and because it is used under a Chemical Leasing contract.

Data on the case are available in detail, as the supplier as well as the local distributor both applied for the Chemical Leasing Award. Also due to the accuracy with which the Serbian NCPC wrote the reports, lot of data are available through the Annual Reports also for other NCPCs.

12.2 Reaching out to new sectors and industries

Case study 4: Chemical Leasing in the service sector – example of cleaning processes in a five-star hotel in Brazil

Cleaning operations are important in many service sectors, especially in food and accommodation services but also in the health sector, as in hospitals. Clinical hygiene in medical care is a highly complex issue; nevertheless, there were some investigations if Chemical Leasing was also suitable for that sector.

Other areas where cleaning operations might be supported by Chemical Leasing are the cleaning of vessels, bottles and pipes and industrial wastewater treatment processes. For all these sectors, a certain potential for the implementation of Chemical Leasing and therefor process optimization potential could be detected. Further information can be found in the study of Gilbert et al. (2015): “Chemical Leasing within industrial and service sector cleaning operations”.

In the case study presented here, the focus is on the accommodation services and the implementation of Chemical Leasing in a five-star hotel in Rio de Janeiro, Brazil.

The data and description of the case from Brazil was taken from the Chemical Leasing Toolkit website[70], the companies websites, from diverse Annual Reports (UNIDO 2011 – 2014), and personal talks with the NCPC of Brazil and the manager of the hotel.

Background

Hotels are big consumers of chemicals, energy and water and their activities may cause negative environmental impacts around the area where they operate. Services include cleaning operations, laundry and restaurant services and chemicals are used for the cleaning of rooms and sanitary areas, for washing of bed linen and towels as well as for dishwashing and the cleaning of surfaces in general. In consequence, hotels are responsible for a huge amount of chemicals consumed, waste related to packaging, wastewater and other emissions to the environment.

The use of chemicals for cleaning operations in hotels and its possible decrease through Chemical Leasing is the subject of this case study, motivated by the high demand due to the mega events that took place in Brazil, especially in Rio de Janeiro (FIFA World Cup in 2014 and Olympia in 2016), one of the most visited tourist destinations in the country. These cleaning chemicals differ from the products that are used in private households, as they have to meet higher sanitation standards to keep large areas clean and safe. Overall, the costs of chemicals and cleansing agents can represent between five and 15 % of the total operational cost of a hotel (Gilbert et al., 2015).

[70] http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_BRAZIL.pdf

Involved partners

The **user of chemicals** is a five-star hotel with 545 rooms and 32 meeting rooms located in Copacabana, Rio de Janeiro, Brazil. It opened in 2010, already starting with a holistic concept of sustainability and Chemical Leasing being a part of it. In 2012, the hotel already received an award for sustainable services in tourism, the Travellife Certification in Gold. Many sustainability actions were already implemented at that time to get this certification and to improve the hotel's Sustainable Management System, aiming at reducing the consumption of water, energy, chemicals and wastes.

The **supplier of chemicals** has been a reliable and engaged partner of the hotel since it has started its operations in 2010. The company has received international certifications and recognitions, is a signatory of the United Nations Global Compact and the CEO Water Mandate, an active member of the Corporate Eco Forum and a founding partner of the Alliance for Water Stewardship through partnerships with the World Wildlife Fund. It is actively involved in sustainability-related working groups within industry associations such as National Restaurant Association, Grocery Manufacturers Association, American Cleaning Institute, Global Food Safety Initiative, World Travel and Tourism Council, among others, and operates in more than 200 countries worldwide. In this case, they were responsible for providing efficient chemicals services, to calculate chemicals dosages, to control the hotel's chemicals storage and for the training of the hotel staff.

Centros de Tecnologia SENAI (CTS Ambiental) as an independent party provided the technical support and developed an evaluation scheme of benefits and analysis of Chemical Leasing compared to the conventional purchase of chemicals in this sector.

A Chemical Leasing-like contract was already signed in 2010, when the cooperation between the hotel and the supplier started.

Situation before Chemical Leasing

The hotel opened in 2010, already with a Chemical Leasing-like concept in use so it was not possible to describe a situation without Chemical Leasing in this very same hotel. As the consumption could not be compared to previous years, the hotel chose to compare its consumption to that of a hotel with similar functions, but much smaller with only 50 rooms. Hence, the economics of scale cannot be taken into account.

Implementation of Chemical Leasing

The driver for implementing Chemical Leasing was to minimise the use of chemicals in the hotel's cleaning operations. An additional driver was that the supplier offered a smart billing method when the new hotel was started. Chemical Leasing was applied to the chemicals used in the cleaning of rooms, common areas, dishes and laundry.

The cleaning agents that were analysed in an environmental impact analysis right at the beginning included three types of detergents used in the laundry and one

dish machine detergent. Together these accounted for 96% of all cleaning agents used at the hotel.

Together with the supplier of the chemicals, the hotel established cleaning standards and defined different chemical kits for various purposes. New technologies have been implemented in the dishwashers to be able to use industrial solid detergent and industrial washing machines, equipped with automatic chemical dosage to avoid worker's exposure to highly concentrated chemicals were installed. These high technology washing devices also now need far less amounts of water, energy and chemicals. The use of concentrated chemicals is much more efficient and the chemicals are prepared on the spot in a special device.

With the support of Senai/CTS Ambiental, new solutions for waste were evaluated. The leasing costs were lower than the direct purchase of chemicals and the size of the hotel (545 rooms, 70% of annual occupation) allowed a leasing with an even lower price.

All chemicals were identified by tags and all MSDS were available in Portuguese. Furthermore, every week the supplier visited all the areas of the hotel and supervised the use and management of chemicals, in order to avoid leakages and wasting. The supplier also controlled the chemical's storage and quantities consumed and ensured safe handling of chemicals and that no direct exposure of chemicals to employees was posisble. The company provided the chemicals with an automatic dosage system so employees never got in direct contact with the chemicals.

The partners then started to work on minimizing packaging and transportation; therefore, recyclable containers have been introduced to reduce the costs of disposing of the packages. A future focus will be on minimising water usage, as Brazil is suffering from fresh water availability and water prices are increasing.

As a consequence of all these measures, the hotel reported a total decrease in chemicals consumption of 80% and could reduce the costs for cleaning chemicals per occupied unit. Due to the Chemical Leasing model, the economic and environmental outputs of the hotel are much better than those of other hotels in the chain.

Unit of payment

Before Chemical Leasing:	Reais (R$) per gallon or kg of products
After Chemical Leasing:	Reais (R$) per occupied room per day

Benefits/Achievements

Table 12-4 below shows the comparison before and after the implementation of Chemical Leasing:

Table 12-4: Before and after Chemical Leasing, case 4

Situation in other hotels of the same chain	After Chemical Leasing
• The purchase of chemicals in other hotels of the hotel chain was conventional (per litre, kg or gallon) • Chemical consumption was higher and more waste (wastewater, packaging) was being produced • The supplier's average chemical consumption was 0,46 kg of chemicals per occupied room per day • The costs of chemicals per occupied room per day were R$ 4,16	**Economic benefits:** • The hotel only pays R$ 2,00 per occupied room per day for chemicals • New machines with an automatic dosage system help to reduce water and energy consumption • Better budget planning for users and suppliers **Environmental benefits:** • The consumption of the supplier's cleaning is 0,28 kg per occupied room per day (40% less) • Less water is used than in other hotels of the same chain • Greywater is being totally recycled in the hotel's toilets and garden • Packaging waste has been eliminated **Social benefits:** • employees are not in direct contact with chemicals due to the introduction of an automatic dosage system • employees are trained by the supplier on hazard analysis and proper cleaning, on health protection and on environmental and economic issues • less accidents occur **Other benefits:** • Long-term partnerships between users and suppliers have been established

Analysis of the case

This case could show that Chemical Leasing is also applicable in the service sector. The potential for hotels is big and the implementation of Chemical Leasing in that hotel could bring along many other optimization opportunities, like the recycling of greywater or the reduction in packaging waste. Tourism is a big global

business and sustainable tourism is getting more and more important, which offers a great chance for Chemical Leasing.

The hotel in this case study was already very active in searching for sustainable solutions in the service area. Together with the supplier of the chemicals, the hotel implemented new technologies that made it possible to use less chemicals, water and energy.

What is missing in this case, due to the start of the new hotel already with the Chemical Leasing concept is the status before Chemical Leasing. So no real baseline could be set from where to start the Chemical Leasing project and the measurements on chemicals and other resources' savings.

On the other hand, this case shows the differences between conventional cleaning services in hotels compared to Chemical Leasing in this sector.

Case study 5: Chemical Leasing goes agro

In this section, attempts to implement Chemical Leasing in a totally new and promising sector, agriculture, are presented. Some of the main actions in different countries will be described. The structure in this section does not exactly follow the one that has been used in the previous cases.

Background

A sector which is very interesting for a Chemical Leasing implementation is the agricultural sector with its fertilizers and pesticides. Globally, more than one million tonnes of pesticides and 50 million tonnes of fertilizers are consumed every year (UNIDO, 2016). The application of these agrochemicals on the field is a very complex issue and depends on many variables (e.g. weather, soil, pest infestations, etc.) that can hardly be influenced by the farmers.

A few attempts have been started during the last decade to implement a Product-Service-approach like Chemical Leasing in agriculture (e.g. Karner et al., 2004; Vorbach et al, 2007; Reisinger et al., 2009) but have not been followed up after the initial stage. Nevertheless, Chemical Leasing, with its incentives to prevent over-consumption of agrochemicals and the promotion of knowledge transfer between stakeholders can offer ways to apply these chemicals in a more environmentally friendly and efficient way.

Implementation of Chemical Leasing in different countries

In 2009, first discussions started among the NCPCs participating in the Chemical Leasing program of UNIDO and Sri Lanka, Serbia, Ukraine and Morocco showed interest. In 2012, first pilot cases started in Sri Lanka, Serbia and Ukraine. A thematic group to connect the different cases and to exchange knowledge was started in 2013, followed by the first award applications by Sri Lanka and Serbia in 2014. These cases in potato, wheat, corn and tea cultivation all received a „special acknowledgement“, as they paved the way for Chemical Leasing in this sector. In Sri Lanka, also academia is very interested in this topic and some academic papers were already written back in 2012, developing a complex formula to define the unit of payment.

Sri Lanka

In Sri Lanka, socio-economy has always been based on agriculture. Along with the global trend, the use of chemicals in agriculture has been steadily growing. The use of agrochemicals is highly subsidized by the government and so, considering the high potential for adverse health and environmental effects associated with the use of pesticides, it was recognized that there was a need for building national capabilities and capacities for the “Sound Management of Chemicals in Sri Lanka” as an important aspect of sustainable development (Premachandra, 2007).

Already back in 2009, the idea to implement Chemical Leasing in the agro sector in Sri Lanka came up and in 2012, the first pilot project at a potato farm started. In that case, a field was divided in two halves, one cultivated using the Chemical Leasing approach and one without, to see the differences. Partners in that case

were farmers, a service provider, a consultant and the NCPC as facilitator. One of the results was that up to 40% of chemicals could be saved by implementing Chemical Leasing in agriculture in that specific case (UNIDO, Annual Report 2011). In the second case, a larger area was chosen (15 ha) in paddy cultivation where 55% in pesticides could be saved during one growing period. The model was also implemented for leak and carrots and in 2013, a Chemical Leasing agreement was signed between a big tea planation and the NCPC, going for 4 years to cover one crop cycle. The process was accompanied by the National Tea Research Institute. The pilot project is done on a 7-hectres field and the expected reduction is 10% of the present consumption of agrochemicals and fertilizers. To monitor the project, it was agreed to collect data on weather conditions, crop volumes, etc. for a certain period of time for both fields.

The task of the supplier is to introduce appropriate chemical application equipment and the technical know-how. The supplier also provides trainings for proper chemicals and fertilizers applications. The task of the user is the application of chemicals according to the supplier's recommendation, after the consultation of the National Tea Research Institute. This institution has to be informed of any changes of application practices in the country. The user also takes care of the monitoring and data recording.

The expected ecologic benefits are manifold, amongst them are

- a reduction of chemicals consumption;
- a reduction of leaching into water bodies;
- the development of a mechanism to return the empty containers to the supplier or a suitable government approved hazardous waste disposal method;
- the provision of cleaning places for the sprayers and shower rooms for the workers;
- a better calibration of the sprayer nozzles;
- a reduction of the carbon foot print/the emission through a reduction of Nitrogen release.

Among the expected economic benefits are

- a reduction of working hours for the application of chemicals;
- a reduction of pests;
- a higher yield at a lower cost;
- achievement of savings of 60 to 70$ per hectare of tea (UNIDO, Annual Report 2011) compared to the conventional business model.

Once the pilot project is successfully completed, Chemical Leasing could be applied in all 26 plantations of the tea company, which is about 19,273 Ha.

Unit of Payment

A major challenge was to develop a fair benefit-sharing model for the agrochemicals sector. For the cases of potatoes, carrots and leak, the unit of payment was calculated following a very complicated formula.

In 2013, when the Chemical Leasing model was implemented at the tea plantation, it was agreed that the savings from Chemical Leasing implementation will be shared between the supplier and the user and an amount of 50 % of the resulted cost reduction, compared with the conventional approach, will be paid to the service supplier at the end of the production cycle (four years).

The main objective of the projects was to apply fewer chemicals on the soil but gaining the same or more yields and to maintain or even improve productivity. It also aimed at changing the existing industry practise, where the supplier is only a "material provider", to become a "service provider" and to obtain a win-win situation for the supplier as well as for the user.

Serbia

Also in Serbia, there is a big potential to implement Chemical Leasing in agriculture. In 2013, two case studies were started on the cultivation of maize and wheat with the same partners, a farmer and a chemical distributor, the NCPC supported the implementation. In both cases, the main tasks were:

- to fertilize the soil according to the results of the soil testing;
- to sow the right quantity of seeds;
- to choose the right time for the application of pesticides to avoid an unnecessary contamination of the soil.

Contracts were signed in 2013 for wheat and in 2014 for maize, in each case for the upcoming growing season.

The idea for both project was to make use of the best knowledge on how to grow wheat and maize, which means that the chemical distributor, who has the knowledge, gives advice on soil fertilizing after testing the soil by an authorized laboratory, soil preparation before sowing, seed selection, type and quantity of chemical(s) that should be used, time for soil (N-min) or plant testing related to nitrogen management, additional fertilizing in accordance to results of N-min testing, regularly monitoring of the field in order to apply proper pesticide(s) on time.

In the case of **wheat**, the consumption of fertilizers was reduced and the consumption of pesticides was optimized, targeting on exactly the pests and weeds that were on the fields at that moment. State-of-the-art agricultural measures were implemented.

The property was divided in two parts (4.35 ha each), one treated in the traditional way, one by implementing Chemical Leasing.

The following **environmental benefits** could be achieved:

- Farmers normally use more seeds for planting than necessary. By using the proper amount of seeds, soil pollution by pesticides from treating more seeds than necessary was lower;
- Less air pollution due to less consumption of fossil fuel (74l used instead of 90l, due to reduced tillage on the field);

- Soil testing showed that only nitrogen fertilizer would be needed, so 400 kg/ha less fertilizer was used;
- Soils and leafs were tested and the result was that even less nitrogen fertilizer was needed then expected (45% less on the "Chemical Leasing field");
- Pesticides targeted for specific fungi, pests and weeds were used.

Economic benefits

The yield on the Chemical Leasing field was 6,808 kg/ha on the Chemical Leasing part (total 29,7t) with 16 EUR/t spent on fertilization, whereas the yield on the conventional treated field was 6,675 kg/ha (total 29,1t) with 47 EUR/t spent on fertilization, meaning that the yield was 2% higher at the Chemical Leasing part of the field (about 100 EUR of income more) and the plants were even healthier. There were also some savings on pesticides and seeds costs, but not that significant.

Also in the case of **maize**, the soil was tested at the beginning of the project and the fertilizers were chosen according to the testing results. The **environmental benefits** here were:

- Choosing the right type and quantity of fertilizer, based on the soil tests, so future contamination of soil and ground water by an overdose of fertilizers is avoided;
- The "right type" of herbicides in an optimum quantity was applied.

For the **economic benefits**, measurements and calculations showed that agrochemicals for the "traditional" part costed 200 EUR/ha whereas the agrochemicals for the Chemical Leasing part costed 178 EUR/ha. At the time this works was written, this case study was not finished and the final benefits were calculated after harvesting.

An overview of the Serbian project was presented by the National Cleaner of Serbia in the local television[71].

Unit of Payment

The unit of payment is the same in both cases and is related to savings and the yield: price of chemicals (that is paid in advance) + difference in profit

Difference in profit = [Yield (t) on "Chemical Leasing" field x price of maize/wheat (din/t) - [yield (t) on "our" field x price of maize/wheat (din/t)] + [costs of agrochemical on "Chemical Leasing" field (din) - costs of agrochemical on "other" field (din)]

The profit is to be shared 50%:50% (positive or negative).

Analysis of the cases

The cases in Sri Lanka and Serbia could show the enormous potential in the application of Chemical Leasing in agriculture and that it is possible to transfer the

[71] https://www.youtube.com/watch?v=OAQUqio8drM&feature=youtu.be

model of Chemical Leasing from industry to agriculture. The optimised use of fertilizers and pesticides equals a reduced amount of chemicals brought onto the fields. In a second step, the chemicals in use could be substituted by more environmentally friendly ones.

A fair sharing of risks and benefits in the field of agriculture is maybe even more important than in any other Chemical Leasing case, as a lot of factors associated with crop cultivation like weather conditions, pests and diseases cannot be fully controlled or predicted.

In most of the agriculture cases so far, there have been “shared fields” in use, meaning having the field divided in one half with traditional treatment and one half, where Chemical Leasing was implemented. This is a perfect way to have a “baseline” right at hand to be able to compare “with” and “without” Chemical Leasing.

To make a distinction between fertilizers and pesticide is useful and also the unit of payment has to be defined differently: in the case of pesticides, the unit of payment cannot be defined as “pest free area but “pest controlled” as it is not possible to define “pest-free”. For fertilizers, the classical unit of payment is money/t of fertilizer, whereas in Chemical Leasing it is calculated as money/t of yield.

Less pesticides on the product means a better quality and reduced risk for the applicants and the consumer. For fertilizers, the focus is more on the right mixture and/or method of applying then on the amount used.

The knowledge of farmers depends on the size of the farm and the country they live in, in different countries different approaches are needed. A capacity build-up is needed as well as an appropriate testing of the soil at the beginning and continuous control to optimize the use of fertilizers as well as the use of pesticides. The expertise of an agro specialists could be helpful.

In addition, also appropriate sustainability criteria are needed for the future, which should be based on the already existing general Chemical Leasing Sustainability Criteria (UNIDO, 2009a).

A lot of different crops have already been tested for an implementation of Chemical Leasing, like maize, wheat, tea but also cucumber or leek and could be extended to even other crops, e.g. wine. Also other countries like Uganda, Ukraine and Russia became interested.

The main benefits of applying Chemical Leasing in agriculture are (UNIDO, 2016):

- less pollution of soil and water, lower air emissions, increased resource efficiency (environmental);
- less exposure of field workers to hazardous chemicals; less contaminated foodstuff for consumers; reduced risks (health);
- reduced consumption of chemicals; cost savings (economic, farmers);
- compensation for know-how transfer; generation of innovative solutions; higher profit based on delivery of product-service solutions (economic, suppliers/distributors).

In third world countries or countries in transition, fertilizers are often heavily subsidised and there is only little or no motivation to reduce the amount as it is not a matter of costs. Here it would be necessary to address governments to include

Chemical Leasing in their environmental policy programmes as best practice example for sustainable business in agriculture.

12.3 Summary and discussion of case studies analysis

The five cases/sectors presented in the last chapter were all well documented cases. These cases were chosen to show the broad spectrum of Chemical Leasing implementations. The cases are quite diverse concerning the data they present and the details they contain. Data were collected in the Half-Year and the Annual Reports, a template was provided almost from the beginning, developed by the author of this works, but still the data received was quite different from country to country.

These cases especially, but also the other 50 cases known to UNIDO at the deadline for applications for the 3rd Global Chemical Leasing Award were checked with regards to the indicators that were used to measure the savings and the benefits. The list of all the cases can be found in the Annex (17.4), also including cases that were not finished or stopped after some time.

The list also shows some interesting cases, on the edge of being Chemical Leasing as well:

- In one case in Colombia, wastewater was used again and again in the process and the supplier supports the user to make the whole process chemical free (“Zero Discharge”). This case was intensively discussed in the Chemical Leasing Jury in 2014, if this is still Chemical Leasing or not. On the other hand, it presents an optimum result in process optimization, there is no product anymore, only a service offered from the supplier’s side. A great amount of chemicals was reduced; the supplier earns by providing a service, not a product.
- In another case, in Russia, Chemical Leasing was implemented in lighting, a viable process in all industries. By implementing Chemical, mercury could be saved by up to 66%. The company, producing refrigerators did not buy lamps anymore but leased them from a service provider. This is a classical Product-Service-System, but the question is, if that is Chemical Leasing, although the consumption of the chemical mercury is reduced.

In addition to the five examples in this chapter, all the other cases have been scanned to make an assessment of the different indicators in use. It has shown that the data records are often very poor and robust and reliable data often were not available.

The following indicators were the most used in the different cases:

Economic:

- Direct cost savings - reduction of the total cost per product output
- Reduced costs for chemicals (due to process optimization)
- Reduced costs for waste water treatment
- Reduced costs for waste treatment
- Reduced costs for transport and storage
- Reduced percentage of re-works and rejects
- Reduced losses

Ecologic:

- Reduction in the amount of chemicals used (due to process optimization)
- Substitution or elimination of certain chemicals, but only by more environmentally friendly ones
- Safer handling and storage of chemicals
- Improved environmental management system
- Compliance with environmental regulations on waste management and workplace environment
- Elimination of waste by using environmentally friendly pre-treatment process
- Re-use of waste water
- Recycling of waste
- Compliance with REACH
- Reduction of the environmental impact of treated water
- No sub-products in the chemicals production process due to a new methodology

Social:

- Improved health and safety of workers
- Better working environment
- Reduced risk of injuries
- Employee motivation improved
- Long-term business relationship between the partners leading to process improvement and innovation
- Training and capacity-building for workers on chemicals management and chemical risks
- Creation of jobs

This assessment clearly showed the limitations of data management in Chemical Leasing: although a lot of indicators were collected, not the identical indicators were collected in all the cases and they have not been described and measured to the same extent, which made a comparison between cases difficult. The definition of a set of Key Performance Indicators(KPIs) that is valid more or less for all the processes where Chemical Leasing can be implemented, is crucial to be able to define improvements and success.

So, through a more in-depth look it became clear that

- there is no clear definition of a set of indicators that have to be assessed;
- often there is no defined baseline from where companies started their work with Chemical Leasing and so the changes in a certain period of time cannot really be determined;
- there is no clear target which savings have to be gained within a certain time when implementing Chemical Leasing; questions to be asked are: where is potential for improvement, in which range could that be possible, and what was agreed in the beginning?
- it has to be clear in which timeframe the collection of data was done;
- concrete and reliable data are often missing;
- the reporting on savings is not unified (sometimes done in numbers, sometimes in percentage), although a template existed;

- a clear monitoring plan and an evaluation scheme is missing in many cases or at least not indicated in the different reports. This would also be helpful to underline the sustainability and long-lasting of cases over some years.
- a more detailed reporting on the changes due to the implementation of Chemical Leasing, also in a qualitative way, is missing;
- cases that faced problems are not described at all or only to the point where they were abandoned.

To sum it up, in many cases, exact data on the implementation of Chemical Leasing is not available. A common tool that is used by all companies and would allow comparison of cases, also among different sectors, could help here. It became clear that a very sophisticated tool is not appropriate and too complex for many, especially small companies, but a simple tool should be made available for all companies.

Following all this, a simple template for data collection and a monitoring plan was elaborated which can easily be used to get a more unified data base on Chemical Leasing case studies and which makes a comparison of data possible and can be used to assess the sustainability of Chemical Leasing cases (see chapter 14.1). Such a template also helps to remind people which data are essential and have to be followed up on a regular basis.

Connected to the issue of data collection is the analysis of these data. Throughout the past ten years, “cases have never been analysed in depth” (citation of one NCPC at one of the meetings) to see where the weaknesses are. If UNIDO wants to have successful cases and NCPC, resp. companies to imitate successful Chemical Leasing implementations, the cases and their descriptions have to be available for companies and NCPCs. It is clear that some secrecy requirements are in place in some companies, but if they decide on participating in Chemical Leasing they also have to agree to a certain monitoring and evaluation as only this way, success can be verified and the brand “Chemical Leasing” be protected. An overall better and more detailed descriptions of the cases, with all the difficulties and obstacles and an analysis would be very helpful. However, this should not mean, as it was done until now, that only successful cases should be described. Sometimes, learning effects are bigger when cases that failed for certain reasons are analysed. So a certain failure analysis should be done for these cases and be included in the database.

There can still be a form of “marketing reports”, to show the success of Chemical Leasing cases in brief, but this kind of publication does not help the NCPCs nor the companies with Chemical Leasing.

And finally, a kind of plan for a follow-up of the cases shall be developed. It is a pity if a case was finished successfully and then just ceases. Efforts should be made by the NCPCs to encourage companies to follow up the process, to upscale it, to implement it also in other processes or production lines in the company.

Chapter 12 provided insight in five case studies that were developed in five different industry sectors. The background was described, as well as the partners, the situation before and after the Chemical Leasing implementation and the unit of payment. A list of indicators of commonly used indicators was compiled and are the basis for the development of a new list of Key Performance Indicators in chapter 14.

13. Summary and discussion of findings

This chapter summarizes in brief the findings from the literature review, the evaluations of the Chemical Leasing program, the tools and the case studies and provides answers to the research questions.

Chemicals are an integral part of today's life. They are the basis of many industry sectors, they cure diseases, they protect plants but are also a possible source of risk to human health and the environment if not managed properly. Industry plays an important role as they produce these chemicals, they use them in their processes and it's in their hands to use them in a sound way.

The comprehensive literature research in the first part of this thesis showed that lots of initiatives and regulations have been put in place to get chemicals under control from governmental as well as from industry's side, including the different Conventions (Basel, Rotterdam, Stockholm). The Inter-Organisational Program for the Sound Management of Chemicals (IOMC) followed by its policy framework SAICM (Strategic Approach to International Chemicals Management) in 1995 resp. 2006. All these, together with voluntary initiatives like Responsible Care and more scientific and academic approaches like Sustainable and Green Chemistry, had great success in regulating hazardous chemicals and wastes and fostering the sound management of chemicals.

REACH, the European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals, put into force in 2007, explicitly shifts the responsibility to industry in terms of assessing and managing the risks of the chemicals they produce and distribute and providing appropriate safety information to the users. New forms of cooperation among the companies are required, especially much more communication along the supply chain.

Also in terms of a sustainable development, industry plays a crucial role in solving the problems caused by chemicals production and consumption. Different approaches to take industry into account have been initiated, one of them the Cleaner Production approach, which aimed at finding measures to fight adverse impacts on health and environment at the source, also including modifications in the production process and in the products themselves. This approach is also characterized by being an integrated approach, looking at the whole life cycle.

Setting measures at the source is the first step but there has to be a change in focus from (only) looking at the processes to rather looking at production and consumption patterns. Material flows in production as well as in consumption have to be decreased by creating a system of products and services that can still satisfy customer's needs but promising a reduction in resource use and costs for the customers. Decoupling economic success from resource consumption is the goal, which means radical changes and a new way of thinking in changing the focus from selling products into selling performances.

Product-Service-Systems imply more or less the radical change in thinking and a new way of doing business that is required for a sustainable development. The customer or user pays for the utilisation of a product, and the function of the products satisfies the user's needs, not the product itself. But these systems also ask for a much more intense interaction and cooperation between all stakeholders,

especially the user and the supplier of chemicals. Change also takes place in the way of payment, products or chemicals are paid per service unit. But even these Product-Service-Systems do not always have environmental goals and criteria. Economic reasons are the main drivers, a reduction in environmental impact is only a side effect.

The literature review at the beginning of this thesis revealed that Chemical Management Services (CMS) in a way combine for the first time the need for a sounder management of chemicals with a new business model. In this model, the user and the service provider engage in a long-term contract where the supplier manages the user's chemicals and provides related services. Chemical Management Services are also characterized by the need to change current business relationships, based on a "buy-sell" mentality, towards a more collaborative service orientation. Research proofed that in all CMS cases that were analysed, reduced consumption of chemicals and improvements in health and safety issues could be gained besides significant cost savings but environmental issues were not explicitly part of the contracts. Due to the reduced consumption of chemicals, environmental benefits are inevitable though.

This model had to fight against some barriers, as it also incorporates a change in mind-set, going from thinking in unit purchase costs to thinking in life cycle costs. Additionally, there was some confusion as the value of Chemical Management Services was not easy to understand also due to a vague definition of the term itself which led to some hesitation in companies to adopt an unfamiliar business model.

Around 2002, Chemical Leasing slowly started to evolve. From the beginning, resource efficiency and process optimization were the core of Chemical Leasing. It is a tool to qualitatively and quantitatively optimize material flows. Chemical Leasing is still primarily a business model but it has in mind the economic and environmental optimization for a chemical's life cycle and over the years, also more and more social issues came into focus. An intensive comparison between Chemical Management Services and Chemical Leasing showed that also the latter was (and still is) facing the same or similar barriers as Product-Service-Systems and Chemical Management Services specifically: the difficulties to understand the term itself, the concept behind it and the added value for a company. What Chemical Management Services and Chemical Leasing have in common is that they both are service-based, that they aim at a reduction of chemicals and that they fundamentally change the relationship between users and suppliers into long-term, strategic relations.

What distinguishes the models is that Chemical Leasing is normally focused on just one specific process (and not on all chemicals in a company), that in Chemical Leasing the unit of payment is linked to the service of the chemical and has to be re-defined, and therefore the use of products is sold, not the products themselves.

Referring to the ***first research question***, the literature research revealed that Chemical Leasing had a lot in common with all the before mentioned approaches and could therefore, at least in theory, contribute to main corner posts that are said to stand for (more) sustainability: resource efficiency, life-cycle thinking, including all three dimensions of sustainability and a radical change in thinking and the way of doing business. Being based at the National Cleaner Production Centres, the Chemical Leasing model is rooted in Cleaner Production but going beyond.

An intense practical evaluation of the Chemical Leasing program, the tools that are and have been used so far and of the case studies that are available indicated that also in practice, a lot of main tasks for sustainability are fulfilled but not to the whole possible range. This was also the case as data, especially for a comprehensive evaluation and monitoring, and therefore the possibility to reveal all savings and benefits and identify gaps, were only partly there. There is not one consistent set of data that is being collected and monitored over the years by all companies to profoundly proof that.

This leads to the ***second research question*** which was dealing with identifying the success factors and the barriers and difficulties that hinders Chemical Leasing to really brake through. Some of the positive and negative factors have been identified in the literature review, including the reduced costs in the management of chemicals, a better relationship between suppliers and users of chemicals and environmental (e.g. reduced emissions) and social (reduced risks and better working conditions) benefits on the positive side. As for barriers, the confusion about the term “Leasing” and the concept as a whole, as well as the strong dependency of a user from the supplier and a higher demand on personnel and on training efforts on the supplier’s side were identified. The practical evaluation that was done three times within eight years could more or less verify these factors but also some others and more important factors were identified.

Although the exact amount of savings was not always reproducible due to a lack of data, a reduction and optimization in chemicals’ consumption, combined with a reduction of chemical impact to the environment and a reduction in costs could always be gained. In many cases, an additional reduction in water and energy consumption could also be achieved. On the social side, a decrease of chemicals risks, better working conditions and better occupational health and safety could be gained. In addition, the management of chemicals and the process performances were definitely improved. What could also be stated was that knowledge increased on the supplier’s side and that Chemical Leasing definitely led to a better cooperation between users and suppliers of chemicals and to long-term relationships, where the implementation was successful.

On the other hand, also barriers and difficulties could be verified in the evaluations: except the already mentioned confusion about the term “Leasing”, there are still too few case studies there, which are thoroughly elaborated and documented to be able to serve as good models on how the implementation of Chemical Leasing could work. Besides that, also tools, like a Cost-Benefit-Analysis or a data collection and monitoring tool that would support the work in Chemical Leasing to a great extent, are missing. For NCPCs there is still not enough information available on how to select the industrial processes suitable for Chemical Leasing. The implementation of Chemical Leasing turned out to be much more time-consuming than expected and time but also financial resources are rather limited. There is still a lack of knowledge and capacity building in the National Cleaner Production Centres, qualified Chemical Leasing experts are still rare and much more in-depth training for the staff would be required. A lack of trust between companies was reported in the questionnaires, reflecting the fear of users to become too dependent from the supplier.

The main obstacle that was located was the lack of data: data on the process and the consumption of chemicals, energy and water in the companies is not there at all or not reliable, so in most cases it is not possible to definitely define the savings

and benefits from a Chemical Leasing implementation. This also leads to the effect, that Chemical Leasing cannot be promoted as successfully as it could be if there was more proof of all the benefits, underpinned by data, to push the program.

Another point was that NCPCs want to have a long-term vision and strategy on how the Chemical Leasing model will develop and they also want to see that their recommendations and answers from the evaluations are taken seriously by UNIDO and are somehow tackled with.

And last but not least, besides all success and benefits, it is difficult and takes a long time to change traditional ways of thinking and doing business that have been in place for decades. But paradigm shift in companies is also a matter of age. The younger generation is mostly more open to new ideas and sometimes, time is working for an idea. To quote Albert Einstein: *problems cannot be solved at the same level of awareness that created them.*

This leads us straight to the ***third research question*** about the future perspectives of Chemical Leasing, what would be recommendations for the program and if there is a need for further research.

To solve the problem with data collection, monitoring and evaluation, the author developed a new tool for that which will be presented in chapter 14.1. The recommendations that were collected in and deduced from the questionnaires were summarized in a blueprint of a roadmap for the future of Chemical Leasing (see chapter 14.2).

Chapter 13 contrasted the results from the research with the research questions and it could be proofed that Chemical Leasing is linked to other sustainability concepts and approaches and based on that, has big potential to contribute to a more sustainable development. It has revealed a lack of tools especially in data collection and management and a need for a long-term strategy. This will be tackled in the next chapter.

14. Towards a sustainable chemicals management through Chemical Leasing

In chapter 14 a new set of indicators and a road map is being developed on the basis of the results from chapters 10 to 12. This new set of indicators as well as the roadmap should support in paving the path towards a (more) sustainable chemical management by using Chemical Leasing.

The evaluations of the Chemical Leasing program, the tools and the case studies revealed the main success factors and barriers. The following chapter now presents two tools that have been developed in the course of this thesis to better support the work in Chemical Leasing: a new set of indicators, combined with a simple tool for data collection and a roadmap on how to reach more sustainability in Chemical Leasing.

14.1 Data collection and indicators

It became quite clear during all the work with the Chemical Leasing program, that data collection, data management and the monitoring and evaluation seems to be a big issue, if not the biggest one in Chemical Leasing. The monitoring of improvements is essential to show the success of Chemical Leasing projects. With only a few data it would be visible what can be saved in terms of chemicals, water and energy by shifting to the new business model.

The sustainability criteria that were developed in 2009 (UNIDO, 2009a) are a good framework but these criteria have to be supported by a set of (key performance) indicators, that are rather easy to get and are also significant in terms of sustainability.

All NCPCs of course use some kind of tables and instruments to collect data but they are not really comparable. And it is easier just to take numbers and data that are there and not necessarily the numbers and data that are useful and needed. And some companies simply don't measure.

So within the work on the thesis, the author decided to come up with a new set of indicators and a new tool for data collection. The new tool was developed on the basis of Excel, which is available in most companies and also makes calculations possible. The sheet developed aimed at being so simple that it can easily be used in field while doing a quick scan survey with a company interested in implementing Chemical Leasing. The aim of this tool is to make comparison possible through a standardised program every NCPC and company uses, to make savings and benefits through the implementation of Chemical Leasing visible and to see if sustainability criteria are fulfilled.

Before starting data collection some general facts should be mentioned and described: who is the user, who the supplier and which other partners are involved (e.g. equipment provider), and in which sector and in which process Chemical Leasing is implemented. It is important to set clear boundaries in which process(es) Chemical Leasing is to be applied. Then, a baseline is needed from where to start to measure improvements, meaning e.g. savings in resources and outputs like wastewater and waste. It would be ideal to use a fiscal or calendar

year as the reference time but in practice, Chemical Leasing cases often start during the year so it would be advisable to use one year from the start of a projects as a first reference point.

As mentioned in the Chemical Leasing toolkit (UNIDO, 2008) at one of the first meetings with an interested company also people from other departments than production should be present and these are the people you also might get data from: people in charge for accounting, sales, purchasing, maintenance, human resources, environment, etc. Other sources for data, outside the company might be industry sector organisations, local authorities and government. Also the international experts could assist in identifying where to find the necessary data in the companies. For some reasons some indicators might not be trackable. If not possible otherwise, in this case it is possible to make some estimations or base the data on empirical values but this has to be clearly documented. It is important that always the same methods for measurements or calculation are used to make data comparable.

Data to be collected with this Excel sheet was chosen from different sources: first, referring back to the analysis of case studies, all data was included that were already collected by NCPCs, resp. companies as it was clear that these data are available in companies. Then data were chosen that should be easy to collect and should be able to evaluate the sustainability of the Chemical Leasing program, but where nobody so far has thought of collecting these data. Basis for the selection of these indicators were the GRI-Guidelines[72], the guidelines for the sLCA (social Life Cycle Analysis) (UNEP-SETAC, 2009), and the EMA scheme (Environmental Management Accounting) (Savage and Jasch, 2005).

The following indicators have finally been chosen to form the maximum set of indicators. It is clear that not all the indicators are applicable in all the cases but if that is the case, it has to be clearly described why.

1. Data collection on resource use

Baseline (before the implementation of Chemical Leasing):

- Amount of chemicals (in tons or litres), with a description of which type of chemical (harmful, flammable, etc.), link to MSDS, description of storage
- Amount of water (in cubic metres): water consumption in the referred process, plus total water consumption in the company
- Amount of energy data collected (in kWh): energy use in the part of the process and/or in the whole company (define the area), stating which type of energy (fossil, renewable) is used.

After implementation of Chemical Leasing:

- Reduction in the amount of chemical used (in tons or litres/in%/per unit of product output)
- Reduction in the amount of water used (in cubic metres/in%/per unit of product output)
- Reduction in the amount of energy used (in kWh/in%/per unit of product output)

[72] https://www.globalreporting.org/information/g4/Pages/default.aspx

Sometimes the above also has to be an average of savings per unit, if there are different types of products included.

- Substitution or elimination of certain chemicals, but only by more environmentally friendly ones (in tons or litres plus qualitative description)
- Safer handling and storage of chemicals (qualitative description)
- Improved environmental management system (qualitative description)
- Compliance with environmental regulations on waste management and workplace environment (qualitative description)
- Compliance with REACH (qualitative description)
- New technology used (qualitative description)

2. Data on pollution/waste

Baseline (before the implementation of Chemical Leasing):

- Amount of wastewater (in cubic metres): total volume of used water that is leaving the process and/or the whole company
- Amount of waste (in tons or cubic metres): total volume or waste that stems from the process or otherwise (definition of area) is transported from the site, measured in tons or litres, hazardous waste should be measured and described separately, with the measures that have to be taken (and the costs)
- Amount of air pollution (in tons of equivalent emission of the primary greenhouse gas: NOx, NH_3, SO_2, POPs, heavy metals, others)

After implementation of Chemical Leasing:

- Reduction and/or reuse of waste water (quantitative and qualitative description)
- Reduction of waste (in tons or cubic metres)
- Elimination of waste by using environmentally friendly pre-treatment process (qualitative description)
- Recycling of waste (qualitative description on which kind of waste and amount)
- Reduced air pollution

3. Economic indicators

Baseline (before the implementation of Chemical Leasing):

- Costs for chemicals
- Costs for energy
- Costs for water
- Costs for waste treatment
- Costs for waste water treatment

After implementation of Chemical Leasing:

- Economic benefits for the supplier (direct cost savings (material costs, in US $) and indirect cost savings (e.g. savings on energy, water, other related chemicals)

- Economic benefits for the user (direct cost savings (material costs, in US $) and indirect cost savings (e.g. savings on energy, water, other related chemicals)
- Economic benefits for other partners (e.g. equipment provider, etc.,) user (direct cost savings (material costs, in US $) and indirect cost savings (e.g. savings on energy, water, other related chemicals), if applicable
- Reduced costs for chemicals (in US $ and/or %)
- Reduced costs for waste water treatment (in US $ and/or %)
- Reduced costs for waste treatment (in US $ and/or %)

Social indicators:

Baseline: problems faced before the implementation of Chemical Leasing (working conditions, dangerous working environment, exposure to hazardous chemicals, etc. - qualitative description.

After implementation of Chemical Leasing:

- Improvements in working conditions (qualitative description, brief description of measures that were taken: e.g. special protection equipment for workers, closed containers, etc.)
- Training and capacity-building for workers on chemicals management and chemical risks (qualitative description) Improved health and safety of workers (qualitative description)
- Reduced risk of injuries (qualitative description)
- work accidents (please add number and type of accident)
- number of jobs at present/newly created
- gender balance, ratio men/women in the process where Chemical Leasing is applied
- Long-term business relationship between the partners leading to process
- improvement and innovation (qualitative description)

Social indicators are the hardest to define as most of them are only qualitative. Nevertheless, it is the declared aim of Chemical Leasing also take into account the social part of sustainability when talking about the benefits of Chemical Leasing.

Based on the data collected in the Excel sheet, it is also easy to check if the sustainability criteria are all fulfilled:

- Reduced adverse effects
- Improved handling
- Substitution
- Economic and social benefits
- Monitoring

All these indicators should be seen as a common set where the indicators are interrelated to each other: if productivity is not optimized, consumption of materials and water will increase which will lead to more waste and more waste water. If more material is used as needed, generally more energy will be needed as well and maybe also more water to process these materials. If more water is used, probably more energy will also be necessary, whereas an increased used of

energy may also lead to an increased consumption of materials, increased use of energy may also effect the consumption of materials and water as one might need more water to contain or discharge waste heat and so on. But these correlations can also be used to the company's benefit: by targeting improvements at one part of the system, one will generally be able to simultaneously improve the performance in regard to other parts of the system, e. g.: fewer chemicals need less water and energy and create less waste and wastewater.

When finally, an initial data set (the baseline) is available and Chemical Leasing is being started, monitoring and evaluations should start as well. The monitoring of improvements is essential to show the success of Chemical Leasing projects and the Excel sheet should support the work of the NCPCs or the companies in that task.

The first draft of the Excel Tool has been tested with NCPCs in Sri Lanka, Serbia and Colombia. The feedbacks were positive, although the tool has only been filled in by the NCPCs themselves with data from different companies, but its use on-site has not been tested. Some amendments have been done afterwards but UNIDO never decided to use this tool to gather detailed information.

It is clear that the Excel sheet as it is now, is only a first attempt and much work has to be put into that, which also includes testing the new criteria with companies in real cases and to monitor and document where the difficulties are and where it is simply not possible for most companies to get data from (e.g. to collect data for air pollution and the different gases). It might also be good to have a kind of a summary sheet that gets automatically created after filling in all data, to have the most important information at first view.

Table 14-1 shows a screenshot of parts of the Excel sheet, the full data collection sheet can be found in Annex 17-5.

Table 14-1: Screenshot of parts of the Excel Sheet for data collection

	COUNTRY											
	User											
	Provider											
	Sector											
	Process											
	Other companies involved (e.g. equipment supplier)											
	Letter of Intent signed:											
	ChL contract signed											
	ChL case (short description)											
		Baseline	Description and comments	Estimated savings - goals to achive	achived savings (1st year) in tons, litres, etc.	achived savings (1st year) in %	achived savings (1st year) per unit of product output	comments	achived savings (2nd year) in tons, litres, etc.	achived savings (2nd year) in %	achived savings (2nd year) per unit of product output	comments
	Date											
	Resource Use											
Before Chemical Leasing	Amount of chemicals/raw materials (in tons or litres, please specify)		*please add a description of the type of chemicals (flammable, etc.), a link to MSDS, and how it is stored*					*Redcution in the amount of chemicals*				
Before Chemical Leasing	Amount of water (in cubic metres)		*water consumption in the referred process, plus total water consumption in the company*					*Reduction in the amount of water used*				
Before Chemical Leasing	Energy (in kWh)		*energy use in the part of the process and/or in the whole company (define the area), stating which type of energy (fossil, renewable) is used.*					*Reduction in the amount of energy used*				
After Chemical Leasing	Substitution or elimination of certain chemicals, but only by more environmentally friendly ones (in tons or litres plus qualitative description)											
After Chemical Leasing	Safer handling and storage of chemicals (qualitative description)											
After Chemical Leasing	Improved environmental management system (qualitative description)											
After Chemical Leasing	Compliance with environmental regulations on waste management and workplace environment (qualitative description)											
After Chemical Leasing	Compliance with REACH (qualitative description)											
After Chemical Leasing	New technology used (qualitative description)											
After Chemical Leasing	Any other changes											
	Pollution											
Before Chemical Leasing	Wastewater (in cubic metres)		*total volume of used water that is leaving the process and/or the whole company*					*Reduction and/or reuse of waste water (quantitative and qualitative description)*				
Before Chemical Leasing	Amount of waste (in tons or litres, please specify!)		*total volume or waste that stems from the process or otherwise (definition of area) is transported from the site, measured in tons or litres, hazardous waste should be measured and described separately, with the measures that have to be taken (and the costs)*					*Reduction of waste (in tons or cubic metres)*				
Before Chemical Leasing	Air pollution (in tons of equivalent emission of the primary greenhouse gases)		*primary greenhouse gases are NOx, N_2, SO_2, POPs, heavy metals, others)*					*Reduced air pollution*				

14.2 A roadmap

Following up the results of the evaluations (key lessons and key recommendations) and the development of a new indicator set, it also seemed useful to draft a sort of roadmap for the next few years of Chemical Leasing. To start with, some explanations at the beginning: it was not at all the authors intention to develop a strategy for the future of Chemical Leasing. This is the task of UNIDO and UNIDO started this strategy process in 2015, developing ".. a post-2015 strategy for the wider adaptation of Chemical Leasing that is aligned with national and regional activities. It provides a narrative for the future path of the Global Chemical Leasing Programme" (UNIDO, 2016).

In this work, a roadmap, meaning a „detailed plan to guide progress toward a goal", according to the Merriam Webster online dictionary[73] was designed. It consists of practical and simple instructions for actions in the short-, medium-, and long-term future of Chemical Leasing. It will deal with tools and preconditions that have to be provided to support the way of Chemical Leasing from the more or less sustainable use of chemicals (Chemical Leasing) to a real sustainable business model. The goal is to get Chemical Leasing widely spread and ultimately reach more sustainability in the chemical industry.

The elements of this roadmap were taken from the three evaluations, but also from reports, from articles, from talks and interviews. The aim was to translate experiences and key lessons from the evaluations into key recommendations for a roadmap and also correspond to the need for more target-oriented tools and materials. Nevertheless, not every recommendation and hint that was ever given in one of the evaluations could be included, there had to be a certain selection. This roadmap is also an attempt to rank the tasks that in the opinion of the NCPCs are still open, according to their importance and urgency, some of them had to be left out.

This roadmap is addressed the main stakeholder groups in Chemical Leasing: UNIDO, as the implementing institution and the NCPCs, as the executing institutions. Most of the tasks are in the responsibility of UNIDO, but a lot of them have to be strongly supported by the NCPCs.

First, a comprehensive list was compiled with recommendations for UNIDO and the NCPCs. Then this was transferred into a matrix where the time frame was added. At best, UNIDO could take up these more practical recommendations and include them in their strategy.

[73] https://www.merriam-webster.com/dictionary/roadmap

Recommendations for the Chemical Leasing program

UNIDO

A long-term strategy and vision and further development of Chemical Leasing

- There is a need for long-term objectives, to have a clear strategy where Chemical Leasing will be in the next 5-10 years. This was clearly expressed by the NCPCs. A continuous improvement and further development of the Chemical Leasing concept should be visible for the NCPCs.
- The International Working Group as well as the National Working Groups could be better used for further development of the Chemical Leasing program, for getting new ideas, etc. The meetings should be more interactive, the group could be seen as a "source of knowledge and experience". Guest speakers from industry, unions, chambers, etc. could be invited for an exchange of ideas. These working groups should be as diverse as possible and should be informed on a regular basis on further developments in Chemical Leasing.
- Of course, also the NCPCs should be involved more in the further development of the Chemical Leasing program. It became clear that they also want to be included and contribute to the program. Especially the Annual Meetings could be used for that purpose. Everyone is there and the group has its own dynamic.
- A clear listing of similarities and differences of Chemical Leasing and other, similar models (e.g. Outsourcing, Pay-on-Production or Contracting) would be needed.
- The principles of Cleaner Production, Green and Sustainable Chemistry, Product-Service-Systems, etc. should be included in the program and communicated among all stakeholders. A clear connection to Resource Efficiency and Circular Economy should be made, and information provided on what exactly is meant by that and in which connection to Chemical Leasing this has to be seen. This would be very helpful especially for NCPCs.
- Also the links between policies, initiatives and regulations like REACH, SAICM, the different Conventions (Rotterdam, Basel, Stockholm) and their relevance for Chemical Leasing, should be elaborated and provided to the NCPCs as well as to companies (not only links to the resp. websites).
- It could be worth an attempt to have a second look at the official UNIDO Chemical Leasing definition. It was clearly mentioned that the term "Leasing" and the corresponding definition still cause confusion. It might not be necessary to change it completely but maybe explain a bit more around the five main lines. The suggestions from the Delphi survey (Kaltenegger, Lozano and Carpenter, not yet published) on the Chemical Leasing definition could be considered for that: to make the definition more tailor-made for different stakeholder groups and maybe to define what Chemical Leasing is NOT.
- Further effort should be put in getting strategic alliances (Public-Private-Partnerships, PPP) with a few bigger companies (e.g. Ecopetrol, SAFECHEM, etc.) as supporters of Chemical Leasing.

- For a constant development of Chemical Leasing, the opening of new sectors and new countries is a must. This could be supported by more sector studies. A lot of ideas for new sectors and countries were given by the NCPCs and should be followed up. Also new players should be considered, like for example to have a closer look at Eco Industrial Parks (EIP), which are according to the definition of Lowe (2001) "...communities of manufacturing and service businesses located together on a common property. Member businesses seek enhanced environmental, economic, and social performance through collaboration in managing environmental and resource issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of individual benefits each company would realize by only optimizing its individual performance."
- Research revealed that cultural differences, differences in legislation and regulations but also different political situations should never be underestimated when introducing a new model like Chemical Leasing. The possibility of failure should be kept in mind and enough time should be scheduled for a successful implementation.
- The social side is still underrepresented, although several new indicators have been added with the new set of indicators and the new excel tool for data collection.

Benefits of Chemical Leasing, data collection and monitoring, documentation

- There is also the need to better explain the benefits of Chemical Leasing, underpinned by hard facts and data. This directly leads to the next task:
- A comprehensive data collection is needed to proof success of Chemical Leasing.
- Firstly, a new and more comprehensive set of data that has to be collected to proof sustainability of the Chemical Leasing model and perfectly complement the already existing sustainability criteria is needed.
- This is closely connected with the development of a tool to collect the data, to set the baseline and to be able to monitor and evaluate the data is needed. This tool has already been developed during the course of this thesis (see 14.1).
- Further, with the data collected and some additional and comprehensive information on case studies in as many different countries, sectors and processes as possible, a database could be filled and made available to all NCPCs. It would also be an asset to include non-successful cases into this, with a failure analysis as another source of knowledge and a learning possibility. It is necessary to keep this database always up-to-date.
- In a next step, that database could be extended by adding sectors and processes that are (most) suitable for a Chemical Leasing implementation. So in the end, a good database could be a main source of information for all kinds of questions by the NCPCs. It would be worth to invest from UNIDO's side to have this database be professionally designed and set up.
- Documentation of the implementation of a Chemical Leasing project should be re-considered: this is concerning the program itself, but even more the case studies. Monitoring and evaluation have to be integrated as a vital part from the beginning (baseline!) and also the reporting and the follow-up after the implementation has been done is important. A decision is needed if

reports are more an internal tool or a marketing tool that should be visible to the world outside.

Cases

- The cases on the online toolkit are nice but a bit too PR oriented. There is not enough data for NCPCs or companies to really understand and reconstruct the case with all its difficulties and stumbling blocks but also with its opportunities and successes. As already suggested above, all this information can be collected in a database for NCPCs but in addition to that, also some material that is more PR oriented to catch attention and summarize briefly all the results and can be provided. This could be for example done in form of a loose-leaf collection where one can add new cases as soon as they are documented and no new brochures etc. have to be published.

Practical work and tools needed

- It seems that NCPCs and companies would need more support in the work with the cases by appropriate tools. Some tools would need an update as indicated in chapter 11.
- One of the most needed tools is a Cost-Benefit-Analysis tool to help with economic calculations. A simple one should be developed (arranged by UNIDO) and some training on it provided as well.
- More emphasis should be put on the description and the definition of the unit of payment, as this new, performance-based unit of payment is a big change and challenge within the implementation of Chemical Leasing. More examples would be useful.
- The guidelines and criteria for the Global Chemical Leasing Award might need some amendments.
- New tools like LCA should be considered and maybe a second attempt should be started to included EMA. CMS experiences have shown that such analysis are remarkably illuminating for companies. Often companies have no idea about the costs of chemicals in their firm, to see the flow of chemicals through the facility may help. UNIDO could take over the CMS tool and adapt it.
- One idea that was mentioned quite often was to publish a new book. In this book, new developments within Chemical Leasing could be described, new case studies could be presented, but also the link to academia could be done and scientific articles be included.

Capacity building and training

- There is still the need for capacity building among the staff of the NCPCs, they would need more and longer trainings, especially at the beginning but ideally also once a year to refresh the knowledge, to be able to ask questions to international experts and exchange their experiences with colleagues.
- It is necessary to adopt new ways of teaching, be it learning videos on YouTube, a special e-learning platform on the Chemical Leasing website or

the use of webinars for trainings. A lot more suggestion came from the NCPCs and should be considered more carefully.

Information and exchange

- More connection with other institutions and cases that were developed in Chemical Leasing outside of UNIDO should be established.
- It is important to have a dialogue with science, and academia should be included more in the discourse. They have a different approach to Chemical Leasing which could bring in fresh and controversial ideas. Concepts like Product-Service-Systems, Sustainable Chemistry and Green Chemistry came from academia but have lots of linkages with the business model.
- This should be combined with including Chemical Leasing more in scientific programs and funding schemes.
- More information within the Chemical Leasing community is still requested: be it news of the week or news of the months, via Skype, GoToMeeting or the website, a more regular update is needed. This is necessary to keep Chemical Leasing in the minds of the NCPCs.
- The website could also be used better: the internal area would be perfect for a discussion forum, to place blogs, to renew information more often, maybe also instead of a newsletter. It seems important to the NCPCs, that information is exchanged on a more or less regular basis.
- New media like Facebook and Twitter should be analysed if they could be useful for a better dissemination. In many EU project the use of these new media is already claimed.
- As Chemical Leasing is a business model it should also be taught at business schools.
- The Annual Reports have become more and more a PR tool and a short summary for internal administration of UNIDO. A decision should be made if that should also be the case in the future or if the reports should become again more an information tool for the NCPCs.

Financial and moral support

- If possible, more financial and moral support should be provided to the NCPCs, this was clearly expressed in all three evaluations. Moral support means more visibility of UNIDO at events, with companies, etc. and would be very much appreciated.
- Some money should be provided for translation activities as these seem to be very important for most of the NCPCs. If information and material is not available in the local language this is an additional obstacle for most companies. Also a translations of the Chemical Leasing website of UNIDO in the most used languages in Chemical Leasing should be provided.

UNIDO and NCPCs together

- Strengthen the role of NCPCs: NCPCs are the change agents in Chemical Leasing, meaning that NCPCs have to be equipped with all necessary tools, instruments, knowledge, etc.

- NCPCs are the “brokers”, the mediators and the third (neutral) party in the implementation of Chemical Leasing, which is a very important role and often decides if a Chemical Leasing project is being done or not. The NCPCs are also technical advisors, but there might be a need to have additional technical support, especially if it concerns specific industrial processes.
- It would also be wise to include NCPCs more to get their support and their advice in developing the Chemical Leasing model further as they are the ones who work in the field.
- NCPCs should be included more in the training of new NCPCs, as they already have some experience. This has already partly been done among Latin American NCPCs, but this approach should be enhanced more.

NCPCs

- A better linkage and cooperation with other NCPCs should be established, besides the opportunities UNIDO already provides.
- NCPCs should actively share their experiences, their concerns, their comments on the program with UNIDO.
- A good work with and in the companies is essential: to start with good quick scans in companies to get information on the potential of a Chemical Leasing implementation, to collect data, to monitor and evaluate it and to have a good documentation. To have outstanding case studies in one sector to be multiplied in other countries (e.g. oil sector) would be a great asset. But also a good failure analysis if something goes wrong is important to learn from.
- NCPCs and companies have to 100% understand Chemical Leasing. Therefore, it is necessary to be up-to-date with all training materials that are there already.
- New ways of financing Chemical Leasing in the countries are needed. Maybe crowdfunding could be an option?
- Opening up new sectors and new areas (e.g. EIPs) is essential.
- Material often needs to be in the local language. Translation should be provided, maybe with financial support of UNIDO.
- If good tools are already available in the NCPCs, they could be shared with UNIDO and other NCPCs.

The following table 14-2 outlines the recommendations for a roadmap on Chemical Leasing on a short-, medium- and long-term basis. In the table only the most important tasks are listed to not overload the matrix.

Table 14-2: Recommendations for a roadmap on Chemical Leasing

	Short-term (within one year)	Medium-term (2 to 3 years)	Long-term (4 to 6 years)
UNIDO	**Involve NCPC** in the further development of the Chemical Leasing program	**Restructure the IWG and NWG** and make it more supportive	**Strategy** for continuous improvement and development
	Provide a document on **similarities and differences** to other similar models (contracting, etc.)	Reconsider the **definition of Chemical Leasing**	**Strategic alliances** with big companies
	Provide a document on **CP, PSS, Green and Sustainable Chemistry**	Have a closer look at **cultural, political and other differences**	
	Link to policies initiatives and regulations and point out their relevance for Chemical Leasing	Include the **social side better** into Chemical Leasing	
	News sectors and new countries – elaborate sector studies	Develop a **loose-leaf collection of case studies** that can easily be extended	
	Provide a **comprehensive data base** that can be filled with data on case studies	**Extend database** with all kind of information that could be useful for NCPCs (e.g. sectors that qualify for Chemical Leasing)	
	Provide a **set of indicators that have to be collected** by NCPCs in the case studies	Develop **more PR oriented case studies** for catching first attention of companies	
	Provide a **tool for data collection** to the NCPCs	Think of **including new tools like LCA, s-LCA or EMA**	
	Stress the **importance of monitoring and evaluation**	Enhance the **links to academia**	
	Develop a **simple Cost-Benefit-Analysis tool** for economic calculations	Enhance **contact to other institution**s that are doing similar business as Chemical Leasing (CSP, etc.)	

	Short-term (within one year)	Medium-term (2 to 3 years)	Long-term (4 to 6 years)
	Provide more description and more examples on the **development of the unit of payment**	Publish a **new book** on Chemical Leasing, including the description of the similarities and differences of Chemical Leasing and other similar models, the linkages to Cleaner Production, Green and Sustainable Chemistry, etc., new case studies and contributions from academia	
	Rework the **guidelines and criteria for the Global Chemical Leasing Award** before the next Award	Strengthen and values the role of NCPCs as mediators and a neutral third party	
	Rework trainings and consider **new ways and methods of teaching**		
	More information should be provided on a regular basis via different media (website, newsletter, blogs, etc.)		
NCPCs	Engage better and **link with other NCPCs**	Opening up **new sectors**, new areas and new ways of **financing**	
	Engage more in collection and monitoring of data and provide good cases		
	(Support) **translation of material** into own language		
	Train own personnel and keep **knowledge** on Chemical Leasing up-to-date		
	Share good tools and experiences with other NCPCs and UNIDO		

To sum up, the table clearly shows that most of the issues that can bring Chemical Leasing forward are urgent matters, meaning that they should be initiated very soon. Establishing a comprehensive database, collecting the data and evaluate it, better elaborate cases studies, etc. needs some time and should be started as soon as possible.

Chapter 14 presented a new (maximum) set of indicators that should be used in all future Chemical Leasing cases to make them comparable. In the second part of the chapter, a road map was developed, providing practical and simple instructions for actions in the short-, medium-, and long-term future of Chemical Leasing. Both new instruments can help to bring Chemical Leasing forward towards a more sustainable management of chemicals.

15. Conclusions

The research done within this thesis on Chemical Leasing explored the Chemical Leasing program with its tools and case studies and it analysed its links to other sustainability concepts.

Can a new business model like Chemical Leasing now provide more sustainability to chemicals industry? Yes, to a certain extent. This research demonstrated that Chemical Leasing seems to be a promising concept with the potential to contribute to more sustainability. Nevertheless, it is still a challenging task for all stakeholders involved, be it the companies, the NCPCs as the executing institutions or UNIDO as the implementing institution. UNIDO has done an amazing job in the last ten years to bring Chemical Leasing forward, however, some tasks have not been considered thoroughly over the whole time. This research indicated that there are still gaps in data collection that have to be bridged to better be able to proof success of the Chemical Leasing model. Furthermore, a long-term strategy is needed to show companies and NCPCs, as well as UNIDO a possible path how to proceed. A roadmap to support this was developed within this research.

15.1 Main research contributions

This research contributes to a better understanding of Chemical Leasing, its success factors and barriers and its possibilities to contribute to a more sustainable chemical industry and gives recommendations for the near future.

Firstly, the research systematically explored the links between Chemical Leasing and several concepts and approaches that are linked to sustainability in order to find out if Chemical Leasing theoretically fulfils the requirements to contribute to sustainability.

Secondly, it clearly distinguished Chemical Leasing from other, similar concepts, especially from Chemical Management Services, and clearly pointed out the advantages of Chemical Leasing.

Thirdly, a thorough analysis of the Chemical Leasing concept, the program, the tools and the case studies was done. This took most of the space in this work and enabled the author to identify gaps and tasks that have to be fulfilled to better shape Chemical Leasing towards more sustainability.

Fourthly, based on this, a new set of indicators for a better data management and a roadmap for the future of Chemical Leasing were developed.

Finally, this work proposes some tasks that should be included into further research.

15.2 Further research

During the last years, although Chemical Leasing is a practical implementation in companies, it became more and more interesting for academics and science. The following section proposes some parts of Chemical Leasing where research but also practical implementation could be enhanced further.

If the new set of data is used in future cases of Chemical Leasing, it should be possible to better analyse the savings and benefits, which could also be interesting for academia. The availability of much more data will also increase the validity of further studies in Chemical Leasing, be it on ecologic or social issues.

The excel sheet for data collection should be tested with companies, including an evaluation how these data are being assessed and collected and where there are difficulties. Based on this, and maybe after some amendments, a comprehensive database should be build up, including all different kinds of indicators and description of current and past Chemical Leasing case studies to define the status quo. Also a list of sectors qualifying for Chemical Leasing and a list of chemicals already covered by Chemical Leasing should be part of that database.

There is a need to further develop the roadmap drafted in 14.2. and to fill it with life. This is partly based on research but also on the experience of practical implications.

There is still a need to further enhance the social side of Chemical Leasing. The new set of data, designed within this thesis has included more social indicators as has been in use so far, but it could be tried to maybe introduce parts of a social Life Cycle Analysis (sLCA) into the Chemical Leasing concept. This could be done from the scientific side first and then be aligned with the practical implementation.

The true costs of chemicals are still not known to companies in most of the cases. It would be worth to think again of starting with Environmental Management Accounting (EMA) in Chemical Leasing companies. This could relate to the development of a simple but comprehensive Cost-Benefit-Analysis tool that is still missing.

In the research, it also became evident that there is a different perception of innovation and how to deal with it in different cultures and it would be worth to have a more in-depth look into that.

It could be useful to further look for cases that are being implemented outside of UNIDO and include them into the community as well as in the data base for a more comprehensive exchange.

A new book on Chemical Leasing could summarize all these suggestions, including new developments in the practical implementation but also in the scientific field.

15.3 Final Remarks

The data collection for the thesis was finished in December 2014, after the 3rd Global Chemical Leasing Award ceremony. The author is aware of the fact that an UNIDO strategy for Chemical Leasing has been developed throughout the years 2015 and beginning of 2016. The roadmap developed in this thesis is solely based on the experiences the NCPCs reported during the three evaluations and on the literature research that linked Chemical Leasing to sustainability. Nevertheless, it would be interesting to connect the roadmap of this thesis with the new Chemical Leasing strategy of UNIDO.

The author is also aware of the fact that within the German Chemical Leasing project some indicators have been developed during 2016 but the indicators presented in this thesis were developed independently by the author starting already back in 2012, out of the need to have better data available at the end of each year and for the Chemical Leasing Award.

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http://europa.eu/rapid/press-release_IP-11-1547_en.htm

http://www.chemicalleasing.com

http://www.chemicalleasing.com/concept/policy-background/saicm

http://www.chemicalleasing.com/concept/sustainability-criteria

http://www.chemicalleasing-toolkit.org

http://chemicalleasing-toolkit.org/node/8

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http://internationalechem.com

http://web.unep.org/greeneconomy/what-inclusive-green-economy

http://www.abc.net.au/science/moon/earthrise.htm

https://www.bmlfuw.gv.at/greentec/chemikalien/chemikalien-leasing-und-gruene-chemie.html

https://www.charitychoice.co.uk/green-alliance-3594

http://www.chemicalleasing.com/what-chemical-leasing

www.chemicalstrategies.org

http://www.chemicalstrategies.org/about.php

http://www.chemicalstrategies.org/implement.php

http://www.chemicalstrategies.org/resources_casestudies.php

http://www.cornell.edu/video/the-first-ecologist-john-ruskin-and-the-futures-of-landscape

http://www.epa.gov/sustainability/basicinfo.htm

http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2011-0364+0+DOC+XML+V0//EN

https://www.globalreporting.org/information/g4/Pages/default.aspx

http://www.green-alliance.org.uk/

http://www.greenpeace.org/international/en/about/our-core-values/

http://www.hohlwelt.com/en/interact/context/sbrand.html

http://www.merriam-webster.com/dictionary/triangulation

https://www.merriam-webster.com/dictionary/roadmap

https://www.nachhaltigkeit.info/artikel/nachhaltigkeitsdreieck_1395.htm

http://www.nasa.gov/centers/johnson/home/earthrise.html#.VPacPBb_7Ic

http://www.productstewardship.us

http://www.saicm.org/About/SAICMOverview/tabid/5522/language/en-US/Default.aspx

http://www.score-network.org/score/score_module/index.php?cat_name=cat_t_sco_home

http://www.unep.fr/scp/cp/

http://www.unido.org/who-we-are/unido-in-brief.html

http://www.unido.org/ncpc.html

http://www.unido.org/greenindustry/green-industry-initiative.html

www.bmlfuw.gv.at%2Fdam%2Fjcr%3Ae4ef6bea-04d3-44f8-bc3c-83c981ceb1dc%2FBest%2520Practice_final%2520231211.pdf&usg=AFQjCNF1TnFj4RB5CID2bDCwC82UTdjrkg&sig2=3NXrMb7Q_SmF-0BUF901Rg

https://www.youtube.com/watch?v=VhIkvZvy_yM

Companies

http://www.bipro.de

http://www.dow.com/safechem/eu/en/

https://www.pero-teilereinigung.at

http://www.raytheon.com/ourcompany/

http://www.warnerbabcock.com

www.blau.co.at

www.safechem-europe.com

Case studies

http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_BRAZIL.pdf

http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_colombia2.pdf

https://www.youtube.com/watch?v=nYiUkiIwHlo

http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_egypt_metal-final.pdf

http://chemicalleasing-toolkit.org/sites/default/files/chl_casestudy_serbia_auto2.pdf

https://www.youtube.com/watch?v=OAQUqio8drM&feature=youtu.be

Conventions, regulations and initiatives

Basel Convention
http://excops.unep.ch/index.php?option=com_content&view=article&id=71%3Athe-basel-convention&catid=42%3Athe-conventions&Itemid=27&lang=en

Globally Harmonized System
http://www.cefic.org/Regulatory-Framework/Governmental-Initiatives-and-Regulations1/Globally-Harmonized-System-of-Classification-and-Labeling-of-Chemicals-GHS/

Green Chemistry
https://www.acs.org/content/acs/en/greenchemistry/what-is-green-chemistry.html?_ga=1.179270244.1950909121.1489399434

IOMC
http://www.who.int/iomc/en/

Marrakesh Process
http://www.unep.fr/scp/marrakech/pdf/MP%20Flyer%2019.02.10%20Final.pdf

POPs
http://chm.pops.int/TheConvention/ThePOPs/The12InitialPOPs/tabid/296/Default.aspx

REACH
http://ec.europa.eu/environment/chemicals/reach/reach_en.htm
http://www.cefic.org/Industry-support/Implementing-reach/

Responsible Care
http://www.cefic.org/Responsible-Care/

Rotterdam Convention
http://www.cefic.org/Regulatory-Framework/Governmental-Initiatives-and-Regulations1/The-Rotterdam-Convention/
http://www.pic.int/TheConvention/Overview/tabid/1044/language/en-US/Default.aspx

SAICM
http://www.saicm.org
http://www.chem.unep.ch/unepsaicm/mainstreaming/

Seveso Directives
http://ec.europa.eu/environment/seveso/
Seveso Directive: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31996L0082
Seveso-II (Directive 96/82/EC: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:01996L0082-20120813
Seveso-III (Directive 2012/18/EU: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012L0018

Stockholm, Convention
http://www.unido.org/en/what-we-do/environment/capacity-building-for-the-implementation-of-multilateral-environmental-agreements/the-stockholm-convention.html

SusChem
http://www.suschem.org

Sustainable Chemistry
http://www.oecd.org/env_sustainablechemistry_platform/
http://www.oecd.org/chemicalsafety/risk-management/sustainablechemistry.htm
http://www.suschem.org/about-suschem/vision-and-mission-sustainable-chemistry.aspx
http://www.umweltbundesamt.de/en/topics/chemicals/chemicals-management/sustainable-chemistry#textpart-1
https://isc3.org

Sustainable Consumption and Production
http://www.cefic.org/Regulatory-Framework/Governmental-Initiatives-and-Regulations1/Sustainable-Consumption-and-Production-SCP/
http://ec.europa.eu/environment/eussd/escp_en.htm

17. Annexes

17.1 First evaluation questionnaire

Evaluation of Chemical Leasing activities in Egypt, Mexico and the Russian Federation

Background

Developing and promoting innovative services to enhance efficiency and environmental performance of industry represents an important element of UNIDO's Cleaner Production strategy. In 2004, the Austrian Ministry of Environment with the support of the Austrian Ministry of Foreign Affairs and UNIDO have, thus, decided to join hands to promote Chemical Leasing business models. The on-going project is to demonstrate and analyse the applicability and impact of the concept in developing and transition countries.

The main elements of the joint project are national capacity building and Chemical Leasing demonstration projects in selected industries. The project is being implemented in Egypt, Mexico and the Russian Federation in close cooperation with the local UNIDO National Cleaner Production Centres (NCPCs) and the United Nations Environment Programme (UNEP). The selected Centres have already well-established cooperation with the chemical industry in their countries. The NCPCs play a crucial role in the process of identifying local companies and other relevant stakeholders and facilitating the project implementation.

After 3 years it is time to have a look at all the activities that have been set and experiences and results that have been achieved during this period of time. This will be done in form of a survey, which will also provide an opportunity for key staff of the Centres to reflect on past activities and achievements, and provide input to the future direction of the programme.

Evaluation

The evaluation consists of three pillars:

- a survey attached to this information, to be filled in by the Centres;
- an analysis of the survey;
- visits to the NCPCs (starting from August 2008) to verify the data.

The complete evaluation will take place between April and December 2008. The survey will be coordinated by Ingrid Kaltenegger, JOANNEUM RESEARCH, under the supervision of UNIDO.

Reference date for the evaluation is April 1st which means that any data that refers to activities or results *before* that date should be included in the statements.

This survey is intended to capture the main learnings from the Centre's perspective. The survey includes open and closed questions, and you are encouraged to provide explanations and answers as *precisely* and *detailed* as possible. If questions are not clear to you, do not hesitate to contact the coordinator.

You are invited to attach any existing documentation that would support your responses. This could include:

- Information, dissemination, training material
- Latest progress report
- Annual reports of last 2 or 3 years
- Any strategy documents for the Centre, for example on vision, mission, service areas
- etc.

The survey is organised in four main sections:

1. General information
2. Chemical Leasing assessments/projects
3. Other Chemical Leasing activities (information, training and policy)
4. Results

The survey is formatted as a Word-table; please provide your answers in the white cells.

Kindly return your responses no later than **Friday, 16th of May 2008** by email

Please feel free to contact me for any queries you may have with regard to this survey.

Thank you for your cooperation!

CHEMICAL LEASING SURVEY

SECTION 1: GENERAL INFORMATION

Name of Centre	*(insert full name)*
Contact person	*(insert full name and position)*
Contact information	*(insert full address, phone, fax, email)*
Year of establishment	*(year national centre was established)*
Number of employees	*(male/female)*
Number of employees dedicated to Chemical Leasing activities	*(male/female)*
Is Chemical Leasing a key service of the NCPC?	
Starting point of Chemical Leasing activities	*(month/year)*
Annual budget for Chemical Leasing activities	*(if different, please name budget year by year)*

SECTION 2: CHEMICAL LEASING ASSESSMENTS/PROJECTS

Number of companies contacted (first contacts):

2005	
2006	
2007	
2008	
Total	

Chemicals/processes of all companies ever contacted

company	sector	chemicals *(please describe in detail which chemical is used)*	processes

Total number of site visits:

2005	
2006	
2007	
2008	
Total	

Total number of couples of suppliers-users identified/ChL agreements signed

year	company 1	company 2	sector	chemicals	processes

Chemical Leasing contracts signed

year	company 1	company 2	sector	chemicals	processes

Please describe briefly the Chemical Leasing Assessments undertaken (refer to Chemical Leasing agreements and contracts signed)

Chemical Leasing Assessment 1:

year	company	sector	chemicals	processes

Brief description:

Chemical Leasing Assessment 2:

year	company	sector	chemicals	processes

Brief description:

Chemical Leasing Assessment 3:

year	company	sector	chemicals	processes

Brief description:

Chemical Leasing Assessment 4:

year	company	sector	chemicals	processes

Brief description:

Chemical Leasing Assessment 5:

year	company	sector	chemicals	processes

Brief description:

Chemical Leasing Assessment 6:

year	company	sector	chemicals	processes

Brief description:

Please copy the table if you have had more assessments!

INDICATORS 1:

Estimated savings in the companies participating in a Chemical Leasing project (per year)

Year	Company	Water [m^3]	Energy [kWh]	Chemicals/raw materials [t] or [l]	Others *(please indicate)*

Concrete savings in the companies participating in a Chemical Leasing project (per year)

Year	Company	Water [m^3]	Energy [kWh]	Chemicals/raw materials [t] or [l]	Others *(please indicate)*

SECTION 3: OTHER CHEMICAL LEASING ACTIVITIES (INFORMATION, TRAINING AND POLICY)

Areas	
1. Information/Dissemination	*(Briefly describe, for example success stories, video, popular brochures, assessment manual, technical guidelines, fact sheets, website that have been produced for advertising Chemical Leasing)*
2. Chemical Leasing awareness raising activities	*(Briefly describe the ChL awareness raising activities that have been undertaken)*
3. Trainings held for companies, etc.	*(For each main training activity undertaken (min. half a day in duration), briefly summarize learning objective, target group, type of training materials and total number of participants)*
4. Trainings where NCPC staff has participated	*(For each main training activity undertaken (min. half a day in duration), briefly summarize learning objective, type of training materials and total number of participants from the NCPC)*

5. Policy advice	*(Briefly describe which – if any – activities the Centre has undertaken to influence government policy, for example: membership of government task forces, submissions to governments, policy studies, etc.)*
6. Others, i.e…..	*(Please explain)*

INDICATORS 2:

Total number of awareness raising activities:

2005	
2006	
2007	
2008	
Total	

Total number of trainings (more than half a day in duration) held:

2005	
2006	
2007	
2008	
Total	

Total number of trainings where NCPC staff has participated:

2005	
2006	
2007	
2008	
Total	

Income from and costs of Chemical Leasing projects

	Income	Costs
2005		
2006		
2007		
2008		
Total		

SECTION 4: RESULTS

Activities (products, services or else the Centre has produced)	*Which activities of the Centre have resulted in tangible increase in the uptake of Chemical Leasing? Trainings, awareness raising activities, etc. Please give a short description of the different activities and a short explanation why they were useful!*
Outcomes *(evidence of uptake of Chemical Leasing e.g. by companies, in government policy, in professional education etc)*	*What changes have companies, industry and government organisations and/or other stakeholders made as a result of Chemical Leasing? Better tracking of chemicals, etc. Please give a short description!*
	What have been the estimated benefits (environmental, economic and/or social) achieved from implementation of Chemical Leasing? Have these been systematically tracked and/or quantified on a regular basis?
Future Success (how the Centre can continue the Chemical Leasing activities in the country)	*What will the Centre have to do to be an effective platform or catalyst for Chemical Leasing in the country? Please explain briefly!*

	What are the future plans of the Centre concerning Chemical Leasing? Please briefly describe planned and already started future activities!
	Are the services offered by the Centre and through the UNIDO programme useful for the implementation of Chemical Leasing? Please explain briefly!
	Is the competence in the Centre high enough for successful Chemical Leasing projects? Please explain briefly!
	What will the Centre need (know how, skills, resources, commitment, assistance, etc.) to achieve future success? Please explain briefly.
	Is it likely that the benefits from the Chemical Leasing programme will continue into the future? Please explain briefly!

	Would you expect continuation of the current institutional set-up, or would the Centre have to change, for example ownership structure, host organisation and/or legal form? Please explain briefly!
Additional Questions	*To what extent are local stakeholders (industry, government, etc) contributing resources to the implementation of Chemical Leasing? Please explain briefly!*
	How important is the role of UNIDO? What is helpful/good, what could be improved? Please explain briefly!
	How important is the role of international experts within the programme? What is helpful/good, what could be improved? Please explain briefly!
	What were the problems faced during the last 3 years (organisational (not enough personnel, etc.), not enough support from government, etc.) Please explain briefly!

	What are the lessons learned? *Please explain briefly!*

*

Please provide any other thoughts or comments you have in regard to the survey/evaluation of the Chemical Leasing programme here:

Thank you for your cooperation!

Please return by May 16th 2008

17.2 Second evaluation questionnaire

Questionnaire
Chemical Leasing
(Technical) Assistance

In the following you will find some questions, which should help in improving especially the (technical) assistance UNIDO together with the international experts is providing. Please take the time to answer to the questions as detailed as possible.

The questionnaire is divided into six sections:

1. First training for Chemical Leasing experts
2. Chemical Leasing assessments/projects, site visits, first contacts, assessments and contracts
3. Indicators - estimated and concrete savings on water, energy and resources
4. Chemical Leasing activities - trainings held, staff trainings and awareness raising
5. Other problems/challenges faced
6. Reporting

The survey is formatted as a Word-table; please provide your answers in the white cells.

Kindly return your responses no later than **Friday, 9 January 2009,** by email.

Please feel free to contact me for any queries you may have with regard to this questionnaire.

Thank you for your cooperation!

1. First training for Chemical Leasing experts

How was your first training in Chemical Leasing? What was good? - What could be improved?	*(please describe in brief)*
How was the knowledge of experts?	
What do you think about training materials, the ChL Toolbox? What could be improved?	
Others?	

2. Chemical Leasing assessments/projects, site visits, first contacts, assessments and contracts

What were the problems faced when having first contacts to companies?	*(please describe in brief)*
Where would you need more support? (presentations, success stories, etc.)	
Which kind of support?	

From whom (UNIDO, international experts, etc.)	

3. Indicators - estimated and concrete savings on water, energy and resources

What were the problems faced when collecting the data? Which data were hard to get? Why?	*(please describe in brief)*
Where would you need more support? (estimating and collecting the data, analysing and comparing the data, etc.)	
Which kind of support? (data sheets, technical assistance on site, etc.)	
From whom (UNIDO, international experts, etc.)	

4. Chemical Leasing activities like trainings held, staff trainings and awareness raising

4a) Trainings held

What were the problems faced?	*(please describe in brief)*
Where would you need more support? (preparing material, etc.)	
Which kind of support?	
From whom (UNIDO, international experts, etc.)	

4b) Staff trainings

What were the problems faced? (not enough trainings, etc.)	*(please describe in brief)*
Where would you need more support? (more trainings, other trainings, technical trainings, more materials, etc.)	

From whom (UNIDO, international experts, etc.)	

4c) Awareness raising

What were the problems faced?	*(please describe in brief)*
Where would you need more support? (success stories to present, attendance of UNIDO, international experts, etc.	

5. Other problems faced

What other problems were faced?	*(please describe in brief)*
Where would you need more support?	

6. Reporting

What were the problems faced? (time constraints, data collection, etc.)	*(please describe in brief)*

Where would you need more support?	
What could be changed?	

*

Please provide any other thoughts or comments you have in regard to the questions here:

Thank you for your cooperation!

17.3 Third evaluation questionnaire

Questionnaire on Chemical Leasing
2014
NCPCs

Dear friends of Chemical Leasing,

This year we are facings 10 years of Chemical Leasing. That's why we thought it is time to have a more in-depth look into the last ten years, first to see what has happened in the past and second, to find out what can still be improved in the future.

In the following you will find some questions, which should help to picture Chemical Leasing in the year 2014. Please take your time to answer the questions as detailed as possible. The results will be handled strictly confidentially, so please be quite frank with your answers, it is also in your interest, as we always try to improve things. Please also do not only answer "yes" or "no" but please provide more details so we can work on specific issues that arise.

The questionnaire is divided into the following sections:

1. Relevance of ChL for your NCPC/you personally
2. The ChL project itself – problems faced
3. Design and usefulness of tools provided
4. Data - Indicators - estimated and concrete savings on water, energy and resources
5. Monitoring, Reporting, knowledge sharing and evaluation of projects and experiences
6. Lessons learned and ways to the future
7. Innovation
8. Additional comments

We also strongly appreciate any additional suggestions to any of the topics you might rise!!

The survey is formatted as a Word-table; please provide your answers in the white cells. You can also widen them if you have more input to give!

Kindly return your responses until **Tuesday, September 9, 2014** by email. Please feel free to contact me for any queries you may have with regard to this questionnaire.

Thank you for your cooperation!

1. Which relevance does ChL Leasing have for your NCPC/for you personally?

Did ChL help your centre to get a new income?	*(please describe in brief)*
Did it cause any "problems" (more work, hard to get it to companies, etc.)? Is it a burden?	*(please describe in brief)*
What are barriers and opportunities for ChL? What exactly were the problems?	*(please describe in brief)*
What positive effect did you get from ChL? (e.g. process optimisation, chemical reduction, energy reduction, etc.)	*(please describe in brief)*
Why did your NCPC/you chose ChL as one of the services to offer? Who decided this?	*(please describe in brief)*
Is ChL special and if, why/in which way – please explain! For you personally, what do you think about ChL?	*(please describe in brief)*
In your opinion, does ChL contribute to a more sustainable handling of chemicals, to a sounder use of chemicals? Please explain why/why not!	*(please describe in brief)*
What is in your personal opinion the most important task of ChL (substitution of chemicals, process optimisation, etc.)?	*(please describe in brief)*
Will you also continue with the ChL program in the future? Why/why not?	*(please describe in brief)*

***

2. The ChL project itself – problems faced

Which problems did you face in your contacts to the companies you wanted to have for a ChL project? Why did it often take so much longer as expected? ***(please describe in brief in the cells below)***	
Awareness raising – was it difficult to raise awareness in companies? What did you do to raise awareness?	*(please describe in brief)*
How did you decide which companies to contact? Did you have contact to them from other projects before (e.g. CP projects)?	*(please describe in brief)*
How hard was it to interest companies for ChL and to find companies wanting to do a ChL project?	*(please describe in brief)*
How did you win them for ChL?	*(please describe in brief)*
Was it difficult to **contact** companies and have first meetings?	*(please describe in brief)*
Do companies sign a cooperation agreement or only a ChL contract?	*(please describe in brief)*
In which phases of the project did you face the most problems? ***(please describe in brief in the cells below)***	
preparatory phase – which problems and why?	*(please describe in brief)*
Process optimisation in the company – which problems and why?	*(please describe in brief)*

Designing the **business model, contracts** – which problems and why?	*(please describe in brief)*
Implementation and monitoring/ evaluation – which problems and why?	*(please describe in brief)*
Dissemination phase – which problems and why?	*(please describe in brief)*
How hard is it to define/find the **unit of payment?** Which problems did you face here?	*(please describe in brief)*
How did you define the process where ChL is to be implemented in the company?	*(please describe in brief)*
Is a ChL team formed in the company? Who is in that team?	*(please describe in brief)*
Is sustainability covered by ChL projects? In which respect?	*(please describe in brief)*
Is the use of chemicals or other resource really decreased? Which other resources (water, energy)?	*(please describe in brief)*
What about substitution of chemicals ? Is that discussed in your ChL projects?	*(please describe in brief)*
Which other side effects can be gained through ChL? (health issues, working conditions, etc.) – please refer only to your own project(s) not to what could be gained in general!!	*(please describe in brief)*

Which additional problems did you face in addition to the ones mentioned above?	*(please describe in brief)*
Would you need more support? Which kind of support? From whom?	*(please describe in brief)*
How long-lasting are ChL projects? Do they go beyond the first project/the first year(s)?	*(please describe in brief)* *s*
How do you follow up the ChL projects after the successful implementation? Do you monitor them further? Do you try to get other ChL projects with different processes in the same company, in similar companies?	*(please describe in brief)*
Would you need more support in doing so? Which kind of support and by whom? To whom do you turn to when you have questions? Colleagues, other NCPCs, UNIDO, international experts, etc.?	*(please describe in brief)*
Any other **suggestions**?	*(please describe in brief)*

****

3. Design and usefulness of tools provided

* First training for Chemical Leasing experts – Seminar for starters

Can you remember your first training for ChL when you started the program? Was it helpful – in which way?	*(please describe in brief)*
What could be improved? – any suggestions?	*(please describe in brief)*

Would you need more trainings and workshops over the years to re-fresh and deepen your knowledge on ChL?	*(please describe in brief)*

* Missions of UNIDO experts and Assistance for NCPCs

The **missions** of the UNIDO experts and UNIDO itself – do they help? In which respect? What could be changed	*(please describe in brief)*
Is the **assistance** you get from UNIDO/experts during the year (*except* the missions) enough? What else would you like to have, what kind of assistance?	*(please describe in brief)*

* ChL Annual Meetings

Do the ChL Annual Meetings help you with your work? How? (Knowledge-exchange, experience exchange, meeting nice people, etc.)	*(please describe in brief)*
Would you like to have any changes in the meetings (other content, more days, etc.)	*(please describe in brief)*

* Sector Studies

Did you ever do a sector study for your country? Which one? Was this difficult to research and write it?	*(please describe in b rief)*
Did you get and read sector studies from other countries/Sectors? Were they useful? Why/why not?	*(please describe in brief)*

Studies on which sector would be useful?	*(please describe in brief)*

* Book: "Chemical Leasing goes global

Did you read the book "ChL goes global "for your work with ChL? Did it help?	*(please describe in brief)*
What helped and why?	*(please describe in brief)*
Do you read it from time to time again?	*(please describe in brief)*
Do you see the need for another book/a sequel? What would you like to have as a content of another book?	*(please describe in brief)*

* Case studies brochure

Did/Do you use this brochure to get new ideas?	*(please describe in brief)*
Do you see the need for another brochure/a sequel? What would you like to have as a content of another book? Which cases?	*(please describe in brief)*
Would you like to contribute with a case study?	*(please describe in brief)*

* Promotion activities

Do you get informed about promotion activities by UNIDO?	*(please describe in brief)*
Do you set promotion activities yourself in your country/region? Which ones (videos, poster, etc.) and to which group of people?	*(please describe in brief)*

* Global Chemical Leasing Award

Is the Global chemical Leasing award helpful for your work with the companies? How? (motivation, etc.)	*(please describe in brief)*
Is it hard for you/the companies you work with to fill in the templates? Why? What could be changed?	*(please describe in brief)*
Are the evaluation criteria clear?	*(please describe in brief)*

* Cost-Benefit-Analysis

Do you use any kind of Cost-Benefit-Analysis in the work with ChL companies? The one in the toolkit? Anything else? Which one?	*(please describe in brief)*
Do companies ask for any kind of Cost-Benefit-Analysis before they start a ChL project?	*please describe in brief)*
How do you present the benefits to the companies interested in ChL?	*please describe in brief)*

* Information Flow - Newsletter, Homepage, Skype conferences

Is there (in general) enough means to get in contact with UNIDO, national experts, other NCPCs? And do you use them? Which?	*(please describe in brief)*
Do you think that the **information flow** is enough within the ChL community? Do you get enough information on ChL news/news from other countries?	*(please describe in brief)*
Would you like to have a regular ChL **newsletter** and would you like to contribute to that? How could that look like? (regular emails once a month, a "professional" newsletter, etc.?)	*(please describe in brief)*
Do you visit the ChL **homepage** regularly? Why, why not?	*(please describe in brief)*
Is the **homepage** a useful source of information for you? Do you inform the companies about it? What could be changed?	*(please describe in brief)*
What about the **skype** conferences? Do you find them useful or a waste of time?	*(please describe in brief)*
What could be changed about the **skype** conferences?	*(please describe in brief)*
Any other **suggestions**?	*(please describe in brief)*

* National and International working groups (NWG, IWG)

Do you find the **international working group** helpful? In which way?	*(please describe in brief)*
What do you like about it? What would you change? Would you like to have any other activities in the working group?	*(please describe in brief)*
Does your country have a **national working group**? Why not?	*(please describe in brief)*
Does this group help with your work with the ChL projects? How?	*(please describe in brief)*

* Questionnaires and evaluations like this

Do you think the whole ChL program should be evaluated from time to time/on a regular basis?	*(please describe in brief)*
Do you find questionnaires and evaluations like this useful?	*(please describe in brief)*
What outcome/changes do you expect/wish to have from evaluations like this?	*(please describe in brief)*

* Any other tools you would like to have/need for your work?

Please tell us!	*(please describe in brief)*
	(please describe in brief)
	(please describe in brief)
	(please describe in brief)

****

4. Data - Indicators - estimated and concrete savings on water, energy and resources

What are/were the problems faced when collecting the data? Which data were hard to get (water, energy, chemicals, others? Why, what were the problems?	*(please describe in brief)*
Why is it so hard to get data from companies?	*(please describe in brief)*
Did you do a baselining at the first assessment?	*(please describe in brief)*
Do you use a data sheet? Which one – could you please attach it, if there is some in use, thanks!	*(please describe in brief)*
Do you monitor the data on a regular basis or do the companies do that? How?	*(please describe in brief)*
Where would you need more support? (estimating and collecting the data, analysing and comparing the data, etc.)	*(please describe in brief)*
Which kind of support? (data sheets, technical assistance on site, etc.)	*(please describe in brief)*

From whom (UNIDO, international experts, etc.)?	*(please describe in brief)*

5. Monitoring, Reporting, knowledge sharing and evaluation of projects and experiences

What do you think about the reporting an monitoring of the ChL program by UNIDO (half year reports, Annual reports, etc.)? Do you think it is necessary? Do you think it is a lot of work? Do you use the reports (to get information, to get inspiration, etc.)	*(please describe in brief)*
What about the templates for that, do you find them useful, not so good? In which respect?	*(please describe in brief)*
Do you share knowledge with your colleagues in other countries? When and how?	*(please describe in brief)*
Would you like to have a regular forum to exchange knowledge and experiences with colleagues? How should that be?	*(please describe in brief)*

****

6. Lessons learned and ways to the future

What are the main lessons learned/main challenges you faced while working with ChL?	*(please describe in brief)*

What do you think will happen to the projects you already started in your country? Will the go on, be extended, stopped after a while, etc.?	*(please describe in brief)*
Do you think that ChL will have a future in your country? Do you think that more companies will be interested in ChL in the future?	*(please describe in brief)*
How do you follow up your projects after the end of the first year(s)?	*(please describe in brief)*
Where do you see ChL in the next 5 to 10 years?	*(please describe in brief)*
Which new sectors do you think would be appropriate for ChL projects? (e.g. agriculture, cleaning,e tc.)	*(please describe in brief)*
Which new countries do you think could start with a ChL project (one of your neighbour conutries, etc.)?	*(please describe in brief)*
Which new chemicals/processes would be appropriate for ChL too?	*(please describe in brief)*
Any additional comments?	*(please describe in brief)*

****

7. Innovations

Can you think of any radical innovation, something totally new in ChL you would like to suggest?	*(please describe in brief)*

8. Additional comments

Please provide any other thoughts or comments you have with regards to the questions above:

Thank you for your cooperation!

Please return by September 9th, 2014

17.4 List of Chemical Leasing case studies

Country	Sector	Process
Austria	Metal working industry	Paint Stripping
Austria	Metal working industry	Metal Cleaning
Colombia	Oil industry	Waste Water Treatment
Colombia	Metal Working Industry	Galvanization and Degreasing
Colombia	Metal Working Industry	Waste Water Treatment
Colombia	Galvanic Sector	Waste Water Treatment
Colombia	Construction/Ceramic Industry	Waste Water Treatment
Egypt	Engineering industry	Electrostatic Powder Coating
Egypt	Galvanization Industry	Hot Dip Galvanization
Egypt	Automotive industry	Cleaning Equipment with Hydrocarbon Solvents
Egypt	Automotive Maintenance Industry	Metal parts washing and cleaning with Hydro-carbon solvent
Egypt	Engineering industry	Washing Machine Painting
England	Metal Working Industry	Metal Cleaning
Germany	Metal working industry	Cleaning and degreasing
Germany	Metal Working Industry	Metal Cleaning
Germany	Health Service	Disinfection in Hospitals
India	Textile industry	Dying
Mexico	Metal working industry	Electroplating
Mexico	Food Processing	Lubrication of Equipment
Mexico	Agriculture	Fertilization
Russia, St. Petersburg	Water Supply	Waste Water Treatment
Russia, St. Petersburg	Water Supply	Disinfection
Serbia	Metal Working Industry	Metal Cleaning
Serbia	Food Processing	Bonding of Boxes
Serbia	Food processing	Lubrication of Equipment
Slovenia	Paper Industry	Lubrication
Slovenia	Metal Working Industry	Dye Casting of Aluminium
Sri Lanka	Printing Industry	Printing of Newspapers
Sri Lanka	Printing Industry	Packages Printing
Sri Lanka	Paint industry	Building painting, binder and paint handling
Sri Lanka	Agriculture	Plant Cultivation
UK	Oil Industry	Oil Drilling
Ukraine	Agriculture	Plant Cultivation
Brazil	Cleaning of super-markets, hospitals, shopping centres	Disinfection
Brazil	Metal mechanical, civil construction.	Insecticides and Pest control
Brazil	Tourism and hospitality	Disinfection, cleaning
Colombia	Automotive industry	Surface treatment

Country	Sector	Process
Costa Rica	Metalworking	Degreasing
Costa Rica	Food production	Cleaning and disinfection
Croatia	Food industry	Lubrication
Ecuador	Beveridge industry	Cleaning, disinfection, lubrication
Egypt	Petrochemical industries	Water treatment
Egypt	Air Conditioning, Cooling	Water treatment
Nicaragua	Slaughterhouses	Cleaning and disinfecting
Peru	Agriculture	Insecticides, fertilizers, pest control,
Russia, Volga	Car washing	Washing
Russia, Volga	Printing industry	Glue
Russia, Volga	Industrial utility system	Lighting of production facility
Serbia	Agriculture (maize)	Agrochemicals
Serbia	Agriculture (wheat)	Agrochemicals
Sri Lanka	Plantation (tea) &	Agrochemicals
Sri Lanka	Textile dyeing process	Treatment of water from
Sri Lanka	Agriculture sector	Agro chemicals sector
Uganda	Beverage industry	Lubrication
Uganda	Beverage industry	Lubrication

17.5 Data collection sheet

	COUNTRY	
	User	
	Provider	
	Sector	
	Process	
	Other companies involved (e.g. equipment supplier)	
	Letter of Intent signed:	
	ChL contract signed	
	ChL case (short description)	

		Baseline	**Description and comments**	**Estimated savings - goals to achive**	**achived savings (1st year) in tons, litres, etc.**	**achived savings (1st year) in %**	**achived savings (1st year) per unit of product output**	**comments**	**achived savings (2nd year) in tons, litres, etc.**	**achived savings (2nd year) in %**	**achived savings (2nd year) per unit of product output**	**comments**
	Date											
	Resource Use											
Before Chemical Leasing	Amount of chemicals/raw materials (in tons or litres, please specify)		*please add a description of the type of chemicals (flammable, etc.), a link to MSDS, and how it is stored*					*Redcution in the amount of chemicals*				
	Amount of water (in cubic metres)		*water consumption in the referred process, plus total water consumption in the company*					*Reduction in the amount of water used*				
	Energy (in kWh)		*energy use in the part of the process and/or in the whole company (define the area), stating which type of energy (fossil, renewable) is used.*					*Reduction in the amount of energy used*				
After Chemical Leasing	Substitution or elimination of certain chemicals, but only by more environmentally friendly ones (in tons or litres plus qualitative description)											
	Safer handling and storage of chemicals (qualitative description)											
	Improved environmental management system (qualitative description)											
	Compliance with environmental regulations on waste management and workplace environment (qualitative description)											
	Compliance with REACH (qualitative description)											
	New technology used (qualitative description)											
	Any other changes											
	Pollution											
ng	Wastewater (in cubic metres)		*total volume of used water that is leaving the process and/or the whole company*					*Reduction and/or reuse of waste water (quantitative and qualitative description)*				

Before Chemical Leasi	Amount of waste (in tons or litres, please specify!)		*total volume or waste that stems from the process or otherwise (definition of area) is transported from the site, measured in tons or litres, hazardous waste should be measured and described separately, with the measures that have to be taken (and the costs)*					*Reduction of waste (in tons or cubic metres)*				
	Air pollution (in tons of equivalent emission of the primary greenhouse gases)		*primary greenhouse gases are NOx, N_3, SO_2, POPs, heavy metals, others)*					*Reduced air pollution*				
After Chemical Leasin	Elimination of waste by using environmentally friendly pre-treatment process (qualitative description)											
	Recycling of waste (qualitative description on which kind of waste and amount)											
	Economic Data											
Before Chemical Leasing	Costs for chemicals							*Reduced costs for chemicals (in US $ and/or %)*				
	Costs for energy							*Reduced costs for energy (in US $ and/or %)*				
	Costs for water							*Reduced costs for water (in US $ and/or %)*				
	Costs for waste treatment							*Reduced costs for waste treatment (in US $ and/or %)*				
	Costs for waste water treatment							*Reduced costs for waste water treatment (in US $ and/or %)*				
After Chemical Leasing	Sum of economic benefits (direct cost savings (material costs, in US $) and indirect cost savings (i.e. savings on energy, water, other related chemicals)											
	Social Indicators											
Before Chemical Leasing	Please descibe problems faced before the implementation of Chemical Leasing (working conditions, dangerous working environment, exposure to hazardous chemicals, etc. - n.		*qualitative description*									
Leasing	Improvements in working conditions (qualitative description, brief description of measures that were taken: e.g. special protection equipment for workers, closed containers, etc.)											
	Training and capacity-building for workers on chemicals management and chemical risks (qualitative description) Improved health and safety of workers (qualitative description)											

After Chemical L	Reduced risk of injuries (qualitative description)											
	number of work accidents (please add number and type of accident)											
	social benefits/changes											
	number of jobs at present/newly created		*please indicate number of jobs only in the defined process for monitoring*									
	gender balance, ratio men/women in the process where Chemical Leasing is applied											
	improvement and innovation (qualitative description)											
	Long-term business relationship between the partners leading to process											
	Quality criteria						**please indicate if fulfilled or not fulfilled**	**comment, e.g.:**			**please indicate if fulfilled or not fulfilled**	**comment, e.g.:**
After Chemical Leasing	Reduced adverse effects							*mainly reduced emission to water and reduced energy consumption*				*mainly reduced emission to water and reduced energy*
	Improved handling							*mainly due to improved training of workers and better equipment*				*mainly due to improved training of workers and better*
	Substitution							*substitution took place, but only by non hazardous chemicals*				*substitution took place, but only by non hazardous*
	Economic and social benefits							*benefits for both partners*				*benefits for both partners*
	Monitoring							*monitoring system established*				*monitoring system established*

Person in charge of monitoring: (company, name of person)	....

“The more I study, the more I realise how much I don’t know”

Albert Einstein