Market analysis in the field of drive technology for the introduction of a new transmission

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Abstract

Starting a new business is a challenging task that requires having sufficient knowledge, not just about the product or the service that the business is offering, but also about the market situation and the competitors. In some cases, the later might be even trickier to gain than the former.

Smart Gearing GmbH is a new company that has been founded this year and is offering a modified technology in the industrial gearbox industry. The product it is offering is a state-of-the-art coaxial gearbox that is called Smart Gear. It has many advantages that makes it outvalues the existing gearboxes by a margin.

Despite the technical advantages however, the small knowledge of the target markets is still a barrier to Smart Gearing GmbH. Therefore, it intends to know the situation of the markets it wants to penetrate with its new product. This will be the main target of this research.

This research will briefly explore the coaxial gearboxes to gain information about the product in hand and will highlight the product itself afterwards, while giving information about Smart Gearing GmbH.

This research will analyze the target markets that Smart Gearing GmbH are aiming for. It will discuss the current state of each market and their forecasted state as well. Afterwards, this research will present a market plan on each market based on the planned target of Smart Gearing GmbH and the sales profit from that plan. The research will make a total market plan based on the accumulate information from all the target markets.

This research will conduct the market analysis of the target markets based on methods advised and used by market analytics experts throughout the years. These methods will be discussed in detail in this research.

Contents

1. Introduction

In market analysis and in marketing the primary target is to gain information about the marketplace and the customer, as it is an advantage in business to build a profitable customer relationship[1].

A certain market could be large and growing, however, this is not a certainty that customers are going to buy whatever product is offered in a particular opportunity. The vast majority of new products, including the ones targeted at growing and large markets, do not find enough buyers and eventually they fail. Therefore, one should look individually at costumers in assessing market opportunities, in order to have a clear idea of the attractiveness of the target segment itself. Which their offering resolves known issues in the segment, provides customer benefit, the segment is more likely to grow and if it opens the door for other subsegment entries.[2]

Entering a market without a sustainable source of competitive advantage is not a very good idea and obtaining a competitive advantage in a market is not a standard procedure to follow. However, there are things a company could do to gain competitive advantage. One way is to gain resources that are rare, valuable and the others cannot imitate it. Another way is to focus on getting to know one's competitors and costumers and generally sharing the results of that research's information within the organization itself[3]. The latter is basically the main focus of this research.

The information gathered in market analysis is used to detect and identify marketing opportunities and issues, to modify, develop and verify marketing measures, to improve the understanding of the marketing process and to evaluate marketing success.[4]

There are a series of planned steps that must be followed while conducting market analysis. The first of which should be the planning step, the next step is to formulate hypotheses and goals. Afterwards, data collection and data evaluation must be done[5]. In a qualitative empirical research, it is required to segment the gathered information to evaluate it before making the final assessment. By doing so, it is possible to obtain temporary knowledge and test it once again in the proceeding analysis[6]. Market analysis is basically done by primary research and secondary research. Primary research represents a new type of data that the researcher acquires using a variation of different methods. While secondary research represents the data that the researcher acquires through past researches made by others.

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[1] Cf. Kotler,Armstrong, 2008. P. 4 et seq.
[2] Mullins, Walker, Jr, Jamieson, 2016. P. 126-127
[3] Mullins, Walker, Jr, Jamieson, 2016. P. 127-128
[4] Cf. Kuss, 2012. P. 2
[5] Cf. Olbrich,Battenfeld,Buhr, 2012. P. 45
[6] Cf. Buber,Holzmüller, 2007. P. 34

1.1 About the Company Smart Gearing GmbH

Smart Gearing GmbH is a newly established small sized company. The company is currently in the founding process. It is planned to be based in Graz, Austria. The company has invented, designed and produced a new kind of coaxial gearbox that can be used in a wide range of industries. This new patent that the company made is a state of the art that tops what is currently used in the industries by a margin. Therefore, Smart Gearing GmbH plans to enter the market of the industrial gearboxes and wants to know the situation of the industries it wants to compete in.

1.1.1 Current Situation

Smart Gearing has now successfully produced its first prototype that is totally functioning as expected. The prototype is undergoing various tests to assure its liability and functionality in the targeted operations and industries. This is done by a collaboration between the mechanical, electrical and software developing teams in the company.

1.2 Research Issue

The market of industrial gearboxes is unknown to the company. Also, because the usage of industrial gearboxes is not only adopted in one or two industries but rather a wide variety of industries. Therefore, it is not an easy thing to gather information about all the industries using industrial gearboxes. Research organization claim that they have accurate information about the industry. However, the reports they are offering are highly expensive with no guarantee of the quality of the information inside these reports.

1.3 Thesis Objectives

As mentioned earlier, gathering information about each industry that uses industrial gearboxes is not something that can be done in a single report. Therefore, this research will be concerned about gathering information about four industries that are believed to be highly demanding for industrial gearboxes and are expected to have the most sales share of Smart Gearing GmbH new gearbox. These industries are as follow:

1- Robotics industry
2- Construction machinery industry
3- Wind turbine industry
4- Solar panels industry

The main resource of information would be a detailed secondary research about the market situation of each industry, and a survey will be made in each market as a primary research to validate the information gathered in the secondary research.

The thesis objective can be categorized into the following points:

1- Defining market analysis and its methodologies.
2- Exploring the industrial gearbox and its types.
3- Presenting the company and naming the competitors.
4- Investigating and analyzing the target industries using primary and secondary research methods.
5- Setting a market plan in each industry.
6- Setting a total market plan for all the industries combined.
7- Concluding the analysis and setting future research points.

Investigating and analyzing the target industries will be done as follow:

- A brief explanation about the industry.
- Explaining the use of gearboxes in the industry.
- Collecting and presenting information about the current market status.
- Collecting and representing the forecasted market status in the upcoming years.
- Representing the survey that has been sent out to companies in the industry with the results that came out of it.
- Analyzing the results of the survey.
- Formulating a market plan based on the analysis of the gathered data.

1.4 Structure of the Thesis

This research is divided into three parts.

Part one (chapters 2-4) will contain the theoretical part of the thesis. It will start by discussing the market analysis definition and methodology, why is it important and what is it used for? How to conduct one? And what are the used method? It will then continue to discuss the product in hand which is the industrial gearbox, exploring the product and its functionality and its different types. Afterwards, a brief information about Smart Gearing GmbH will be made, analyzing it by a SWOT analysis and Porter's 5 forces. Also, a brief naming of the major competitors will be done.

Part two (chapters 5-8) will contain the practical part of the thesis. Investigating the target industries by collecting data using secondary and primary research methods. Analyzing the collected data and conducting a market plan for each industry separately and for all of them combined.

Part three (chapter 9) will contain the conclusion of the data gathered in the thesis.

2. Theoretical Background of Market Analysis

This chapter will discuss market analysis in terms of its theoretical background. The definition of market analysis, what is it used for? How to conduct one? What are the various methods and how to analyze the gathered data? This chapter will also discuss the competitive analysis between companies in an industry and the tools to do so.

2.1 Market Analysis

The term marketing and market analysis may be easily confused, but they refer to different activities. Marketing can be described as all the actions that support the promotion of a given product in the market. On the other hand, a market analysis may be described as the activities that seek to assess critical factors in the market environment through a variety of techniques or methodologies. Market analysis involves gathering information on the conditions that may affect a marketplace[7]. The analysis is mostly used within business plans. A business plan provides a guide/roadmap of the goals and objectives of a company. The business plan also outlines how the company plans to achieve specific goals and objectives[8]. Within the business plan, the market analysis demonstrates a business's expertise in handling matters within the market. The market analysis also outlines how the market favors the business from a financial perspective.

A market analysis encompasses multiple activities that can be categorized as[9]:

- Defining and expounding on the market problem.
- A complete analysis of the existing market situation.
- Selecting instruments for data collection.
- Analyzing the data and interpreting the findings.
- Relating the findings to the existing literature to fill in the knowledge gap and generate new ideas about the issue.
- Designing a plan or the most appropriate recommendation for overcoming the existing marketing problem.

[7] Filistrucchi, 2018. P. 45
[8] Sahadeo,2018. P. 200
[9] Filistrucchi, 2018. P. 45

Conducting a market analysis can be inspired by a variety of reasons. One of the reasons is to examine the size of the target market when introducing a new product or venturing into other markets. Secondly, an organization or an individual conducts a market analysis with the intention of evaluating the brand or product competitiveness hence influence the decision to innovate or adjust to the dynamic needs of the market[10]. Thirdly, market analysis is critical in providing insight into the most effective strategies for improving a brand competitive edge[11]. This research paper discusses the steps taken while making market analysis and the methodologies therein.

2.1.1 Defining the Problem

The success of a market analysis largely depends on having a clear definition of the problem. The rationale for having a clear definition of the problem is that the different solutions offered may differ with the nature of a problem[12]. Defining the market analysis problem helps in formulating an approach to solve the problem.

This is, therefore, the most important step of the market analysis. It is only in the presence of a problem that a solution can be made. The research process is also conducted effectively if the problem has been well defined. The market analysis problem may be wrongly identified. The wrong definition of a problem results in inappropriate results for the market analysis[13]. Business leaders, therefore, need to be careful while defining the research problem for the success of the market analysis. No matter how well the research team is equipped, an inappropriate definition of the problem leads to misleading results. Misleading market analysis results are dangerous to a business. Problem definition involves various steps and factors to be considered. The process involves stating the general problem and outlining the various components of the problem. This can then be recorded and then passed on to the decision-makers and researchers. The problem defining process is a communal task that involves everyone within a business, the decision-makers, and the researchers. These teams communicate back to the main team what additional parts of the problem they think may be left out. Formulating the problem as a team helps identify the issues each of the members faces while in the business[14].

[10] Zameer, Wang, Yasmeen & Mubarak, 2020. P. 50
[11] Franck, & Peitz, 2019. P. 20
[12] Lane, 2018. P. 22
[13] Barroga, 2020, P. 1
[14] Avdiji, Elikan, Missonier & Pigneur, 2018. P. 400-407

The business team also present ideas on what support they may require for a successful business. The problem is compiled in a research brief. The research brief includes the problem, the required research support, and proposals on possible solutions. The researchers then take over and apply different methodologies to arrive at a conclusion. Defining a problem is a sketchy description of the market analysis. The solutions and proposals given within the problem may not be accurate. They are just a vision of what the team thinks should be done. It is the researcher's task to confirm the accuracy of the solutions and come up with more accurate recommendations.[15]

2.1.2 Situational Analysis

The situational analysis provides a detailed description of the relevant information that may be related to the problem. The situational analysis provides an in-depth understanding and also shines a light on the missing information that may be relevant in developing knowledge toward solving the problem[16]. At this stage, information about the past performance, current trends, and interviewing the relevant stakeholders are highly valued resources. On the other hand, for existing brands, information about the market mix, external environment, marketing trend, and competition may be valuable in helping build a better understanding of the problem under investigation. A situational analysis helps in making a decision. The analysis gathers observations that make the market analysis more effective. With effective situational analysis, researchers and decision-makers can make corrections amidst the research process. The making of changes can be made when the research process starts producing unexpected results. A situational analysis identifies potential customers to a business[17]. The analysis also identifies the business' competitors and assesses their strengths and weaknesses. A projected growth graph is also included within the situational analysis. The projected growth maybe for the next five or ten years. The team may also choose to include short-term projected growths. This may be for a few months or within two years. A situational analysis also includes a detailed SWOT (strengths, weaknesses, opportunities, and threats) analysis. The SWOT analysis investigates and identifies the factors that support or may challenge the business objectives. This requires an internal assessment of the business. The internal assessment identifies the strengths of the business. An external review of the business competitors and market players helps derive the opportunities and threats the business has within the market[18].

[15] Avdiji, Elikan, Missonier & Pigneur, 2018. P. 400-407
[16] Hicks, 2017. P. 30
[17] Sousa, Rocha, 2019. P. 150
[18] Namugenyi, Nimmagadda & Reiners, 2019. P. 1145-1154

The SWOT analysis within the situational analysis is presented in table form with respective lists for each category. The company's strengths are identified by looking at the advantages of the company's culture, organizational structure, financial resources, staff, and operational efficiency. The advantages are the positive attributes of the various factors hence making up the strengths of the business. A team formulating the strengths and weaknesses may settle on the tangible and intangible aspects of the organization. However, these aspects must be within the control of the organization.[19]

Weaknesses, on the other hand, constitute the negative attributes of the organization. Weaknesses hinder the achievement of the business's desired goals. An analysis of the organization's external environment helps formulate the organization's opportunities and threats. Factors within the external environment that affect the business's returns are identified. The external factors investigated include the market trends, suppliers within the market, customer flows, competition, technology, and the economic patterns of the market. Opportunities are attractive factors present in the external environment. Opportunities can increase the organization's returns and positively influence the business operations of a company[20]. Threats, on the other hand, are elements within the external environment that may put the organization's goals at risk. A proper SWOT analysis within a situational analysis classifies the threats according to their levels of severity. A situational analysis is therefore important in identifying the strengths, weaknesses, opportunities, and threats of an organization both from its internal environment and external environment. The situational analysis investigates all the factors and aspects within and without the business.

2.1.3 Collecting Relevant Data

The collection of data for developing market analysis is influenced by the nature problem under investigation[21]. Therefore, the data collection strategy should the best fit for the development of market research. However, it is worth noting that the researcher needs to consider the suitability, feasibility, and ethical concerns before making a decision to rely on a given research strategy. How the data is collected depends on the type of study the research team settles on: the research plan and design help in identifying the methods and types of data to collect. There is a wide variety of methods and relevant data to collect for effective market analysis. To identify the most relevant data for the market analysis, a business team ought to consider the following:

[19] Hollensen & Opresnik, 2019. P. 30
[20] Nisar, Prabhakar & Strakova, 2019. P. 21
[21] Clark & Vealé, 2018. P. 30

1. The form in which the information exists. There are two most common forms data could take; these include secondary and primary data[22]. Identifying the form and nature of the data helps in identifying how the data will be collected. Primary data has to be collected from scratch, unlike secondary data, which may require simple summarization.

2. The relevance of the data. Relevant data to a market analysis meet the research objectives. A researcher is able to gauge whether the data is related to the research objective in any way. Close relations show more relevance to the data. Research objectives also help in identifying whether the data to be collected requires to be facts and figures or opinions and feelings[23]. At times the research objectives require both types of data. Facts and figures make up the quantitative data of the market analysis, while opinions and feelings make up the qualitative data of the market analysis.

3. The nature of the research: Research can either be exploratory, descriptive or causal. Exploratory research seeks to gain more insight and reactions to a problem. Descriptive research gives more information on something that is already known. Casual research identifies the cause and effect relationship between various elements. Most market analysis problems require exploratory research. The kind of data required for each type of research varies with each type. Identifying the type of research to be carried out, therefore, helps in identifying the data to be used.[24]

4. The available data sources: Identifying the potential data sources helps in understanding the available data. The internal factors within the organization may not be difficult to collect the data. However, for external factors, the collection of data may be difficult to get primary data. Most of the time, teams end up using secondary data to access the external environment of the business. Having identified the relevant data for the research, researchers can now come up with the respective research methodologies for the project. Identifying the relevant data for the research also helps in making a realistic budget for the research[25]. This process also determines the timeline of the research process. It also gauges the research objectives on whether they are achievable or not.

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[22] Bishop & Kuula-Luumi, 2017. P. 23
[23] Mohajan, 2018. P. 32
[24] Cf. Olbrich/Battenfeld/Buhr (2012), P. 50
[25] Grover, Chiang, Liang & Zhang, 2018. P. 15

Data can be collected using primary methods or secondary methods. Secondary methods of collecting data involve obtaining the data from existing reports and literature books and journals. Internal data on a company can be collected from previous records, the company's website, and newspapers and journals on the company. External data for the company can also be collected secondarily. Collecting the data depends on whether the method answers the research objectives. Primary research answers the research objective specifically. Primary research involves the use of questionnaires, interviews, and surveys. Secondary research is, however, the most preferred form of data collection. It is the most preferred because it is faster, easier, and less costly compared to primary research. Primary research requires the formulation of time-consuming data collection tools, while secondary research can be done by exploring existing data like the data on the internet.[26]

2.2 Methodology and Data Collection Methods

Methodology refers to the processes and techniques adopted in ensuring that the research conducted is accurate[27]. Aligned to the objective of the market analysis methodology involves determining the size of the sample, choosing data collection and techniques to be used in data analysis, analyzing and developing a conclusion. Methodologies used in the market analysis gather information on the various factors affecting the company. The methodology is also the various techniques used to collect the data. The information collected using the different methodologies is used to improve the business.

There are two main types of research, primary research and secondary research[28]. The two are further divided into research methods[29]. There are four common research methods used for market analysis. The methods include surveys, customer observation, interviews, and focus groups. Surveys involve the use of short questions. Surveys are the most efficient methodologies used for market research. The questions could be open or closed-ended. Surveys are the most efficient methodologies because they are easy to conduct and less costly. They can be rolled out in interviews or questionnaires. A business can receive thousands of responses from a simple survey. The responses carry useful data that helps the research significantly. Open-ended questions, however, take more time to analyze. They are, however, efficient in understanding the customer experience or staff's opinion on the business operations.

[26] Mkandawire, 2019. P. 1
[27] Queirós, Faria & Almeida, 2017. P. 12
[28] Aguinis, Ramani & Cascio, 2020. P. 22
[29] Harrison, Birks, Franklin & Mills, 2017. P. 12

Interviews are the most insightful methodologies used in market research. They are one-to-one conversations with staff or external members of a businesses' environment. Interviews are advantageous because the interviewer can read beyond the information given. The interviewer can read the non-verbal cues given by the interviewee. Non-verbal cues help confirm the legibility of the information given by the interviewee. With modern technology, video conferences can be organized when it is not possible to carry out a physical interview. Interviews help the business understand their customers and the target market.[30]

Focus groups bring the entities of a business together and give them the allowance to share their insights on the business and its progress. Focus groups are useful in collecting customer preferences and preferred products. These groups help the business understand the market better. A business can also learn more about the user experience through focus groups. For this methodology, the research team needs to appoint a moderator. The moderator directs the flow of the discussions between the focus group members. The moderator also records the data received from the sharing of the focus group members. The moderator also has to be part of the business. This is because he/she has a better understanding of the business's products and market requirements. Focus groups are, however, dangerous because biased members could provide false information and influence the other members hence providing inaccurate information for the analysis. Focus groups are, therefore, not efficient for startups or non-established companies that do not have prior information concerning their products and services.[31]

Observation is an efficient methodology when collecting information on user experience. A staff member observes a customer use the product and note down their reactions. The observation could also be used to capture customers' reactions to competitor products. This gives the business information on what to include their products and what not to include for the customer's satisfaction. Observation is not only inexpensive but also gives "natural" results. The customer's reaction cannot be influenced by focus groups. However, observation is not as efficient because the observer cannot process why the customer made the reaction. The observer can only note down the respondent's reaction. The discussed common methodologies help a business in conducting research for their market analysis.[32]

[30] Harrison, Birks, Franklin & Mills, 2017. P. 12
[31] Jang & Kim, 2018. P. 22
[32] Won & Lee, 2016. P. 33

The **data collection process** is one of the most important steps that determine the success of a market analysis project. It is worth noting that there exist various data collection strategies that may be used depending on the project needs[33].The two main types of data collection methods are discussed broadly in the sections below.

2.2.1 Primary Data

The primary data collection method can be described as the act of gathering information with the intention of solving a specific problem. Primary data is considered more valuable as they are specifically collected for the intended research. Although the collection of primary data is considered time-consuming, costly, and cumbersome, the researcher maintains control over the information collected. The results obtained through the primary data collection are considered more reliable as the researcher retains control over budget and can also tailor the instruments to be able to capture the desired information.[34]

The primary collection of data is done individually by the business. Raw data is collected directly from respondents. The business team members go directly to the source and gather information by asking questions or using another direct methodology. There are various forms of primary data collection. These include interviews, surveys, questionnaires, focus groups, and reconnaissance visits to competitor offices. Primary research enables a business to collect either of two kinds of information. The two kinds of information include exploratory information and specific information. Exploratory information is whereby the respondent provides opinions and feelings on a given matter[35]. Exploratory information is collected through an open-ended survey or questionnaire questions. Lengthy interviews also help in collecting exploratory information. This mode of collecting data is time-consuming and cumbersome. However, the data collected is adequate to provide enough information towards the rolling out of a product or new operation. Specific information, on the other hand, is brief and straight to the point. Specific information is collected from short-ended questions. Short-ended questions require yes or no answers. Specific questions are used to answer a problem identified while carrying out exploratory research. The answers given help confirm the theories given by the customers and staff. Formal interviews and multiple-choice surveys and questionnaires are used to collect specific information.

[33] Won & Lee, 2016. P. 33
[34] Lee, Chou & Chen, 2020. P. 24
[35] Lee, Chou & Chen, 2020. P. 24

Primary research is costly and is time-consuming[36]. The research methods involved require a lot of time to collect and analyze the data collected. It is also worth noting that primary data in one research may be considered as a source of secondary information in another research. Different approaches may be used to collect primary information, which includes the use of surveys, observation, and experimentation.

Interview and Survey

Conducting interviews is one of the popular techniques for collecting primary data. Interviews involve the researcher taking notes of the different views shared by the target population[37]. Despite the evolution of the technological era, face to face interviews remains a popular research method used to collect market analysis data. This is because these interviews are advantageous over collecting data over the internet or through questionnaires sent back by the respondents. Interviews provide more accurate data. Individuals can rarely provide false information on interviews. Issues such as gender and age are hard to hide within an interview. However, in an online survey or questionnaire, the respondent can easily get around and provide false information. Interviewing ensures that the business receives accurate data for appropriate data analysis. Within the interview, it is also easy to capture body language that translates into non-verbal cues. A well-trained interviewee can tell when the respondent is lying. With non-verbal cues, the interviewee can also get more information from the non-verbal cues. With online surveys and questionnaires, it is hard to note the non-verbal cues. Interviews also ensure fast reception of data from the respondent. With surveys, the business has to wait for the respondent to find the time and answer the questions provided. However, with interviews, the interviewer is in control of the interview. The interviewer makes sure that the interviewee stays focused and works on completing the interview on time. During interviews, there are rarely any distractions such as calls, texts, or work[38]. The interview is within the moment, and the data is collected within the moment. Interviews can also be used to capture both quantitative data and qualitative data. Qualitative data can be captured in the form of the emotions and behaviors displayed by the interviewee in response to questions. Quantitative data, on the other hand, can be collected in the form of facts and figures provided during the interview.

[36] Lee, Chou & Chen, 2020. P. 24
[37] Phillippi & Lauderdale, 2018. P. 300
[38] Phillippi & Lauderdale, 2018. P. 315

Interviews, however, have undesirable traits that contribute to their disadvantages. Interviews are costly as they require organizing venues for face-to-face interactions[39]. The staff to conduct the interviews also needs to be paid. This reflects additional costs for the business. The quality of the data collected also varies. Some interviewees may provide low-quality information. The information may be shallow and useless to the research. Interviews also require manual entry of data. The staff has to enter the data manually into the system for analysis. The manual entry also increases the cost of the data collection. With interviews, the sample size is also limited. The sample size is limited to the number of interviewers available within the staff and the number of interviewees the company manages to reach.

Surveys, on the other hand, are presented as questions to the respondent. They are able to choose from a variety of choices, their most appropriate option. Worth noting, when considering the use of a survey as a technique to collect the relevant information, the researcher should ensure that some standards are met to minimize the risk of harm[40]. Some of the consideration involves maintaining anonymous, treating data with confidentiality, making sure that the participants understand the nature of the research and its objective, and seeking the consent for data collection. A survey provides information with a breadth view through the wide coverage. Some of the information that may be obtained through the research includes demographic characteristics, psychological awareness, and people behavior. Using a survey approach to collect primary data may include conducting groups or individualized interviews through telephone or reaching the target population for the survey through emails.
It is worth noting that the value of the survey results also depends on the factor that some criteria are reasonably satisfied[41]:

- Having defined the target population correctly.
- Ensuring that the sample used is representative of the target population.
- The selected participants are willing to corporate and share relevant information.
- Ensuring that the questions used in collecting the information are clearly understood by the respondent.
- That the interviewer or the respondent records the response information correctly.

Conducting an interview may take different forms, either as structure or unstructured interview techniques. Survey as a technique of gathering primary information ensures that the researcher obtains a clear and more current view of the issue under observation.

[39] Phillippi & Lauderdale, 2018. P. 312
[40] Sovacool, Axsen & Sorrell, 2018. P. 32
[41] Sovacool, Axsen & Sorrell, 2018. P. 35

2.2.2 Secondary Data

Data considered as primary in one study may be a source of secondary data in another project. The fact that the secondary research may involve examining and integrating information from different sources yields valuable knowledge that answers questions that may not be practically answered through the primary research approach.[42]

In deciding whether to use either the secondary or primary source of data, the researcher considers the nature of the information sought. Issues regarding the objectivity of the information sought, future orientation, degree of validity, and reliability are other important issues worth consideration.
Some of the sources of secondary research include company historical performance, related scientific research, and official statistics from government and other organizations[43]. The information gathered from different sources helps to bridge the knowledge gap needed in developing a solution to the problem under examination.

In recent years, the use of explanatory research is majorly relying on qualitative research on secondary resources with the aim of gaining a preliminary insight into the problem under examination. Most of the qualitative research relies on prior surveys with open-ended questions. Qualitative research tends to rely on relatively low samples with a focus on capturing relevant information through answers provided to the questions. Some of the advantages of relying on qualitative data include; it is economical, get the timely result, and provide broad in explaining the problem[44]. On the other hand, some of the drawbacks associated with the use of qualitative data include lack of validity, reliability curtailing its potential to be generalized to the entire population.

On the other hand, the use of quantitative research design typically relies on empirical findings to draw conclusions. Quantitative research tends to rely on a formalized standard of selecting a representative sample when collecting information[45].

[42] Rosinger & Ice 2019. P. 129
[43] Ruggiano & Perry, 2019. P. 38
[44] Silverman, 2020. P. 35
[45] Sovacool, Axsen & Sorrell, 2018. P. 33

2.3 Quantitative, Qualitative, and Mixed Method

The fact that data analysis is the most important part of conducting research, the right method and approach should be considered to ensure that the information obtained is the most reliable in developing the desired research. It is a problem under research that guides the appropriate research methodology. Depending on the subject under analysis, the researcher can rely on either qualitative, quantitative, or combine both approaches while conducting the research. The quantitative approach refers to drawing knowledge by drawing from connections from numerical and statistical information.

The quantitative approach is mainly considered when a deductive design is considered in developing a solution to the market problem. The quantitative approach assists the researcher to confirm or disconfirm an existing knowledge on the problem. Quantitative research collects facts and figures concerning a research problem[46]. Facts and figures are quantitative data. The quantitative data is mainly collected through surveys, questionnaires, and interviews. The data collected is useful in coming up with marketing strategies and product details from the market analysis. During quantitative research, exact short-ended questions are asked. These include questions on a customer's preference for the company's goods and the reasons why a customer would not purchase the company's products. With quantitative research, data analysis is easier and more efficiently done. This is because the amount of data is not as large as compared to qualitative research.

On the other hand, qualitative research refers to the approach of exploring the meaning and interpretation of various social issues. Mostly, the approach relies on questions that seek answers to complex issues. The questions require more detailed answers. The researcher seeks explanation on various issues with the intention of getting an in-depth understanding of the critical issues at hand. In the process of gathering qualitative information, data is collected from a broad range and later put into categories[47]. Categorical information is compared with the existing knowledge on the topic under study.

In a mixed approach, the research combines both qualitative and quantitative approaches towards understanding the problem under investigation. Using a mixed-method approach enables the researcher to integrate both philosophical and numerical information in developing a solution to the problem under consideration. The integration of both qualitative and quantitative research gives the researcher a complete data set[48].

[46] Sovacool, Axsen & Sorrell, 2018. P. 32
[47] Smith & Albaum, 2012. P. 22
[48] Smith & Albaum, 2012. P. 22

Using the mixed method approach is common within the health industry. This is because this industry relies on both the facts and figures received from a patient as well as their emotions and feelings. The method is also efficient within a market analysis as it helps in understanding the figures and their relationship with the customer's experience. The customer's experience is captured through a qualitative approach. The facts and figures concerning the total sales are collected through a quantitative approach.[49]

2.4 Methods of Data Analysis in Market Analysis

Data analysis involves the separation of information gathered into component parts. It entails the action of separating the complex information gathered into fine and more valuable components. The fine components from the information gathered to enable the researcher to have a deep understanding of the phenomenon under observation. The data analysis process involves cleaning, transformation, and the modeling of data into analytical models[50]. The analytical models help extract important information that is useful for the success of the business. Data analysis is a critical step toward effective decision-making. The information extracted from the data analysis is useful in making decisions. Both the data and the processes within a business can be processed. The data analysis can be carried out to map out the company's trends and predict the future performance of the company. There are various data analysis tools that make it easier for analysts to collect and analyze the data. The analysis tools establish the relationship between data sets and various environmental factors[51]. The tools also produce respective reports on the patterns and trends of a business. The patterns and trends given are easy to interpret and draw conclusions from.

Data analysis comes in different types. The types are dependent on the type of business/company and the technology available. The various types of data analysis include[52]:

1. Prescriptive analysis
2. Text analysis
3. Predictive analysis
4. Statistical analysis
5. Diagnostic analysis

[49] Tariq, Woodman, 2013. P.1-8
[50] Lechevalier, Narayanan, Rachuri & Foufou, 2018. P. 54-67
[51] Lechevalier, Narayanan, Rachuri & Foufou, 2018. P. 54-67
[52] Lechevalier, Narayanan, Rachuri & Foufou, 2018. P. 54-67

There are different methods used for data analysis. These methods include:

1. Regression Analysis
2. Factor Analysis
3. Monte Carlo Simulation
4. Cluster Analysis
5. Cohort Analysis
6. Time Series Analysis
7. Sentiment Analysis

Most of the methods are used to analyze quantitative data. Sentiment analysis is, however, used to analyze qualitative data. Regression analysis estimates the relationship between a set of variables. In a regression analysis, there are two types of variables; the dependent variable and the independent variable. Regression analysis measures how much the independent variables affect the dependent variables. Time series analysis identifies the trends and variations within a data set. The data analyst looks out for the three time series patterns within the data. These include; trends, seasonality, and cyclic patterns. The type of data analysis method depends on the nature of the research data collected and the expected results from the data analysis.[53]

2.5 Competitive Analysis

Competitive analysis helps a business to understand their competition. The competitive analysis outlines how the competition works, their strengths, weaknesses, and the potential threats they pose to the business. With this understanding, the business is now able to formulate ways in which it can outdo the competition. When doing a competitive analysis, the business team members first identify their competitors[54]. The competitor's products and market strategies are then analyzed. Businesses use this information to ensure that their products stay up to date with the current trends in the market. The product is compared to the competitor's products and brought to the standards of the industry.

[53] Lechevalier, Narayanan, Rachuri & Foufou, 2018. P. 54-67
[54] Ko, Jeong, Yoon & Son, 2020. P. 200

A competitive analysis also helps a business in identifying their product's strengths and weaknesses. A product's strengths and weaknesses outline its propositional value. If the product's propositional value is low according to the competitive analysis, the business works on improving the product. The competitive analysis also helps a business in gauging their marketing strategies. The business analyzes the competitor's marketing strategies. The effectiveness of the marketing strategies helps the leaders in understanding whether they are undertaking the right marketing strategies. The competitive analysis also involves going through a competitor's customer review. This helps the business in identifying what their competitor is doing right or wrong. Customer reviews also tell what is missing in the competitor's products. The business can then use this information in making their own products fit for the market ahead of the competitor. The competitive analysis also provides information concerning competitors in the market that help the business in measuring their own growth. The competitive analysis also identifies gaps within the market. The business takes advantage of this information to make additional revenue. A competitive analysis, therefore, involves studying the business operations of a competitor and using the information to build market-efficient products.[55]

2.5.1 Competition Within an Industry and Competitive Strategy

Competition within an industry constitutes of the additional sellers selling a similar product within the market. Every industry has competition. Competition is healthy as it promotes standardized operations within an industry. Healthy competition pushes businesses to improve their products so as to attract potential customers. Identifying the company's competition is important in formulating a competitive strategy. A competitive strategy is a long-term plan that defines how a company plans to encounter competition within the market. The competitive strategy includes plans on how to achieve a competitive advantage over competitors in the market. This is done by identifying the industry's competition, its strengths and weaknesses, and comparing them with those of the company. An effective competitive strategy helps the company in withstanding the competition within the market, attracting more customers, and laying a strong foundation for the company within the market. There are different types of competitive strategies. The strategies include cost focus, differentiation, differentiation focus, and cost leadership. Differentiation comes up with unique products that are totally different from what is already in the market. Producing different products builds the brand and promotes loyalty among customers.[56]

[55] Ko, Jeong, Yoon & Son, 2020. P. 200
[56] Huang, 2019. P. 31-82

Formulating this type of competitive strategy is, however, expensive as it requires lengthy research. Cost leadership seeks to create products at a lower cost so that they are sold at a lower cost than what the competition is giving[57]. The strategy sets out a plan on how to get quality raw materials at relatively low prices. This way, the company is able to sell the product at a lower price within the market. By doing so, the business can have a competitive advantage in the market. The focus strategy reduces overall costs only for its target market. The business identifies its target market and lowers the price to a point they can easily afford. However, the company is not the lowest cost provider within the market. With these strategies, the business is able to identify its competitive advantage and exploit it.

[57] Ko, Jeong, Yoon & Son, 2020. P. 200

3. Strain Wave, Planetary and Cyclo Gearboxes

Strain wave, planetary and cyclo are all some of the different types of gearboxes that is widely used in almost every industry. Gearboxes are also defined as enclosed speed reducers or gear reducers. They are typically used in a variety of electromechanical drive systems[58]. Perhaps the most well-known usage of gearboxes is the transmission system found in vehicles.

Gearboxes are available in a variety of speed ratios and load capacities. The main function of the gearbox is to reduce or increase speed, and as a result of this operation, the output torque will become the inverse of the speed function. If the gearbox is used as a speed reducer, this means the speed input is higher than the speed output, then the output torque will be higher than the input torque. If the gearbox increases speed, then the output torque will decrease.[59]

In this section, the research will briefly explain three of the most used industrial gearboxes, which are the strain wave, planetary and cyclo gearboxes. They are also part of the coaxial gearbox family.

3.1 Strain Wave Gearbox

The strain wave gearbox was originally invented in 1955 by Musser and has been used in a wide variety of application in the 70's, initially in aerospace. The most famous space application that strain wave has been used in is in the lunar rover vehicle in 1971 on the Apollo Mission. It was used as the mechanical transmission element. Its named after the deformation characteristic of its flexspline, a thin cylindrical cup that is non-rigid and with teeth that serves as output. The strain wave gearbox is broadly known as Harmonic Drive gearbox, which is the most famous manufacturer of the gearbox.[60]

The strain wave gearbox has advantages over the other coaxial gearboxes, some of these advantages are zero backlash, high gear ratio-ranging from 30:1 to 320:1-and high precision. Making the strain wave gearbox a best fit in a low load robotic arm[61].

The strain wave gearbox is also used in a variety of applications, like semiconductor equipment, printing machines and machine tools.

[58] Daniel, Paulus, 2019. P. 705-784
[59] Daniel, Paulus, 2019. P. 705-784
[60] García, Crispel, Saerens, Verstraten, Lefeber. 2020. P. 8
[61] Yu, Gong, 2014. P. 1

3.1.1 Types of Strain Wave Gearbox

Strain wave gearbox has two types that are commercially available[62]:

1- Cup style strain wave gear

This type has three main components. The wave generator, which is basically a ball bearing that has an elliptical cam insert. The flexspline, which is a cupped shaped thin shell. And the circular spline which is a rigid ring gear (Figure 1).

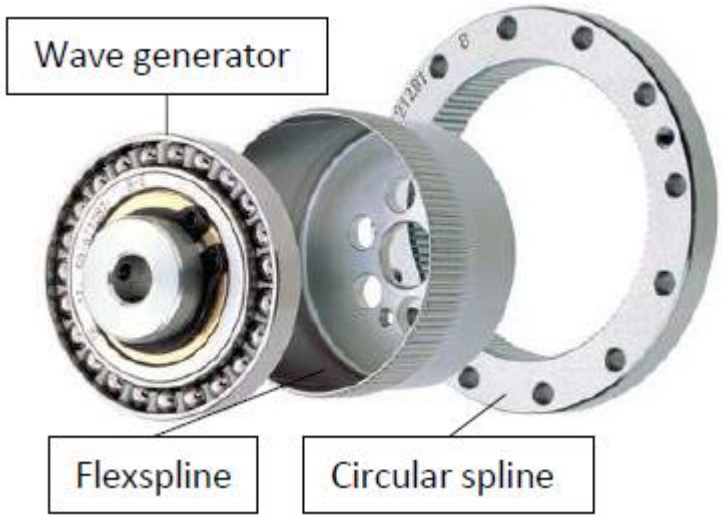

Figure 1: Cup style strain wave gear[63]

[62] Yu, Gong, 2014. P. 1
[63] Yu, Gong, 2014. P. 2

2- Pancake style strain wave gear

This type has the same three components as the cup style type, although it has an extra component which is the dynamic spline (Figure 2). The dynamic spline is added to reduce the lengthwise dimension of the pancake style strain wave gear.

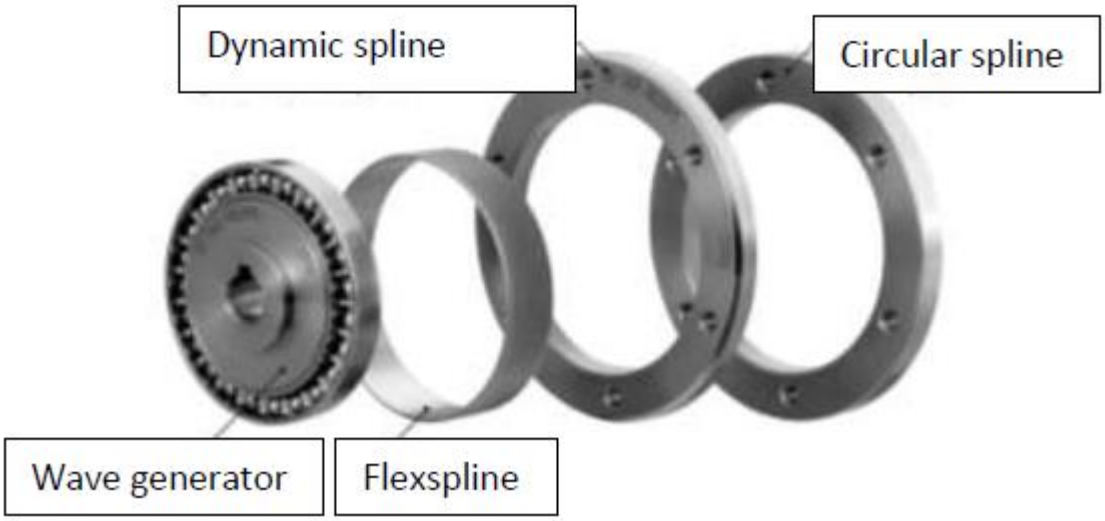

Figure 2: Pancake style strain wave gear[64]

3.2 Planetary Gearbox

It is not known for a fact who has invented the planetary gearbox. It has been around for centuries used in many different applications. However, it was first functionally described in 1490 by Leonardo da Vinci. The planetary gearbox gets is named that way because of its composition and functionality. The planetary gearbox consists of three types of gears. A sun gear, a ring gear and planetary gears. When the sun gear is driven it transmits torque to the planetary gears which moves in a locked carrier which is the ring gear. This is very much similar to the way the solar system works, if one looked at the sun gear as the solar and the ring gear as the satellite (Figure 3).[65]

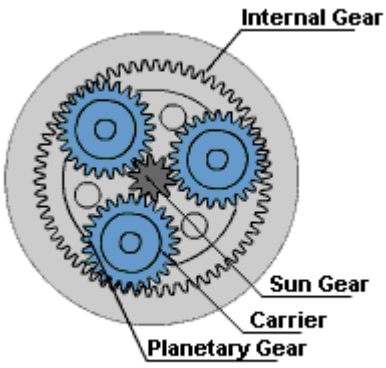

Figure 3: Planetary gearbox[66]

[64] Yu, Gong, 2014. P. 2
[65] WHAT IS A PLANETARY GEARBOX? https://www.apexdyna.nl/en/planetary-gearbox-introduction/. Date of access 6/11/2020
[66] WHAT IS A PLANETARY GEARBOX? https://www.apexdyna.nl/en/planetary-gearbox-introduction/. Date of access 6/11/2020

The planetary gearbox in robotics, printing machines, in applications where precise positioning is needed and in construction machinery. These are just some of the application, while planetary gearbox is very widely used. The planetary gearbox has many different arrangements, it depends on the function that is needed for and the workload and the torque needed. There are many different possibilities of the outcome of the planetary gearbox. The following table explains the possibilities if for example the input and output were changed.[67]

Table 1: Planetary gearbox output possibilities[68]

Driven side	Solid world	To be driven side	Result
Input shaft	Housing	Output shaft	Reduction
Input shaft	Output shaft	Housing	Reverse movement + Delay
Output shaft	Input shaft	Housing	Delay
Output shaft	Housing	Input shaft	Acceleration
Housing	Output shaft	Input shaft	Reverse movement + Acceleration
Housing	Input shaft	Output shaft	Delay
In- and output shaft	N.A.	Housing	1:1

3.3 Cyclo Gearbox

Cyclo gearbox is also referred to as cycloidal gearbox or cycloidal drive. It is known by this name because of the heart of the cyclo gearbox which is a cycloidal disk that is shaped as a cycloid (Figure 4). The cyclo gearbox has six main components. Alongside with the cycloidal disc that is already mentioned, there are fixed ring pins that the cycloidal disc rotates around from its outside, roller pins that the cycloidal disc rotates around from its inside, pin disk that contains the roller pins and is the output of the gearbox, an eccentric shaft which is the input of the gearbox and a bearing that is located around the eccentric shaft. In many cyclo gearboxes, two cycloid discs are often used to result in smoother operation at high speeds and to allow very high torques to be transmitted[69]. Cyclo gearboxes has the advantages of having a high torsional stiffens and a very low backlash. They are also very compact in design and have quite a low mass. They are usually used in driving technologies, robotics and where high positioning accuracy is needed.[70]

[67] WHAT IS A PLANETARY GEARBOX? https://www.apexdyna.nl/en/planetary-gearbox-introduction/. Date of access 6/11/2020

[68] WHAT IS A PLANETARY GEARBOX? https://www.apexdyna.nl/en/planetary-gearbox-introduction/. Date of access 6/11/2020

[69] How does a cycloidal drive work? https://www.tec-science.com/mechanical-power-transmission/cycloidal-drive-speed-reducer-gear/how-does-a-cycloidal-gear-drive-work/. Date of access 7/11/2020

[70] How does a cycloidal drive work? https://www.tec-science.com/mechanical-power-transmission/cycloidal-drive-speed-reducer-gear/how-does-a-cycloidal-gear-drive-work/. Date of access 7/11/2020

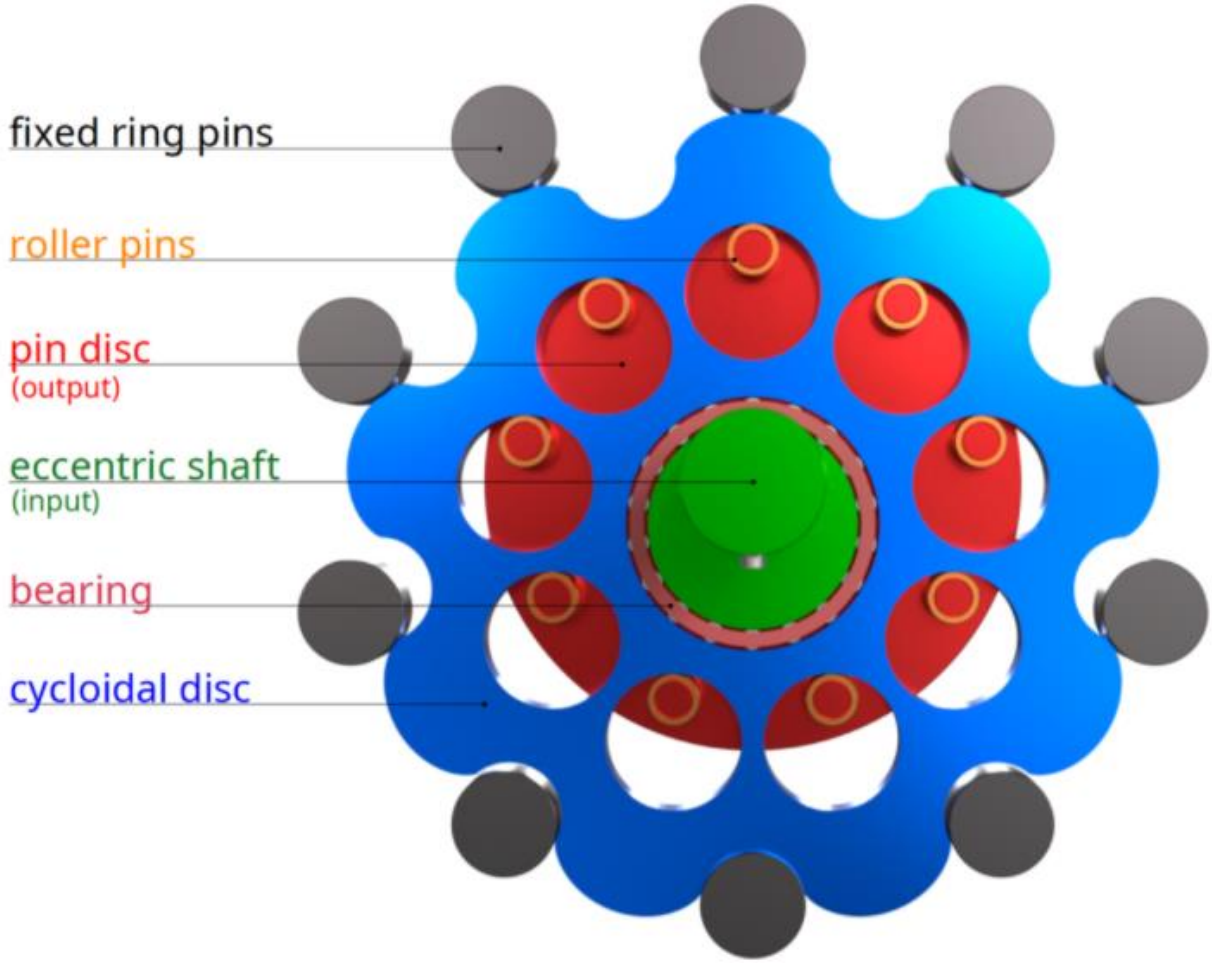

Figure 4: Structure of cyclo gearbox[71]

3.4 Gearbox manufacturers

Industrial gearbox manufactures are too many to be named briefly in one research. Thus, the research will only mention some of the big players in the market, especially the ones that have operations in Europe, which is the main market for Smart Gearing GmbH.

1- Harmonic Drive

Harmonic Drive is one of the well-known producers of the strain wave gearbox that it is basically named after it. It has many subsidiaries in Europe, it has one in Austria and in the neighbored countries. It also produces servo products, gears and planetary gears.

[71] How does a cycloidal drive work? https://www.tec-science.com/mechanical-power-transmission/cycloidal-drive-speed-reducer-gear/how-does-a-cycloidal-gear-drive-work/. Date of access 7/11/2020

2- Stöber

Stöber has a subsidiary in Austria and has a good network in German speaking countries. Stöber manufacture motors, geared motors, electronics and gear units.

3- Nabtesco

Nabtesco is a Japanese company which produce precision reduction gears, hydraulic and aircraft equipment. Their shares in the European and in the Austrian market are not big.

4- Wittenstein

Wittenstein is well implemented in the European and Austrian market. It produces servo gearboxes, controllers actuators and gearing.

5- ZF

ZF is one of the biggest manufacturers of all kind of machinery, material handling and driveline solutions. It is well implemented in the European market and in Austria.

6- Faulhaber

Faulhaber is present in Austria and in other European countries. It offers precision gearheads, motors, servo motors and electronics.

Table 1: Number of employees and turnover of the competitors

	Harmonic Drive[72]	Stöber[73]	Nabtesco[74]	Wittenstein[75]	ZF[76]	Faulhaber[77]
No. Of employees	384	More than 700	774,000	2942	147,797	2150
Turnover in million euros	94	115	223.517,63	392	36,518	222

[72]https://harmonicdrive.de/en/company#:~:text=384%20employees%20and%20a%20turnover,94%20million%20euros%20in%202016. Date of access 12/11/2020
[73] https://atbautomation.eu/en/stober/. Date of access 12/11/2020
[74] https://markets.ft.com/data/equities/tearsheet/profile?s=6268:TYO. Date of access 12/11/2020
[75] https://www.owler.com/company/wittensteinag. Date of access 12/11/2020
[76] ZF Friedrichshafen AG, 2020. 1-118
[77] https://www.owler.com/company/faulhaber. Date of access 12/11/2020

4. Company profile and Competitive Analysis

This chapter will give an overview of the company Smart Gearing GmbH and it will discuss its plans. A competitive analysis will also be made for Smart Gearing GmbH in this chapter.

4.1 About Smart Gearing GmbH

Smart Gearing GmbH is a small sized company with only seven employees. It started when the CEO of the company invented and designed a modified model of the coaxial gears used in robot joints that is more advanced than the commercial coaxial gears by a margin. The company is located in Graz, Austria, and is aiming to expand in the upcoming years to penetrate the European and the global gears market.[78]

4.1.1 The Product

The gearbox that Smart Gearing GmbH is offering is a new patented gear that outvalues the existing gearboxes by many means. It is almost as half the weight of the other coaxial gears and not just that, it is also more compact and smaller in size than its competitors (Figure 5). However, this is not even the best part of the Smart Gearing GmbH gearbox advantages, Smart Gearing gearbox offers double the amount of torque and workload that the other coaxial gearboxes can produce and endure. In other words, it offers two times more the gear ratio compared to the market standard.[79]

With these advantages of the Smart Gearing gearbox, the resultant revolution it can make in the industries are extraordinary. It can make robot arms more compact and withstand more loads, so as the load cranes. It can allow more space in machine tools and construction machinery, with a high accuracy of positioning, thanks to the zero backlash that the gearbox offers.[80]

Following are some of the advantages that Smart Gear offers[81]:

- High torque through flat contact of the teeth
- Compact form factor through high transmission ratio
- Integrated sensors thanks to the space available inside the unit as there are no rotating gears
- Integrated motor results in a small form factor
- Low production costs thanks to a modular design
- Communication offers the possibility of enabling different power levels without changing the unit
- Low operating costs through integrated condition monitoring and predictable maintenance

[78] Smart Gearing, 2020. P. 1-17
[79] Smart Gearing, 2020. P. 1-17
[80] Smart Gearing, 2020. P. 1-17
[81] Smart Gearing, 2020. P. 1-17

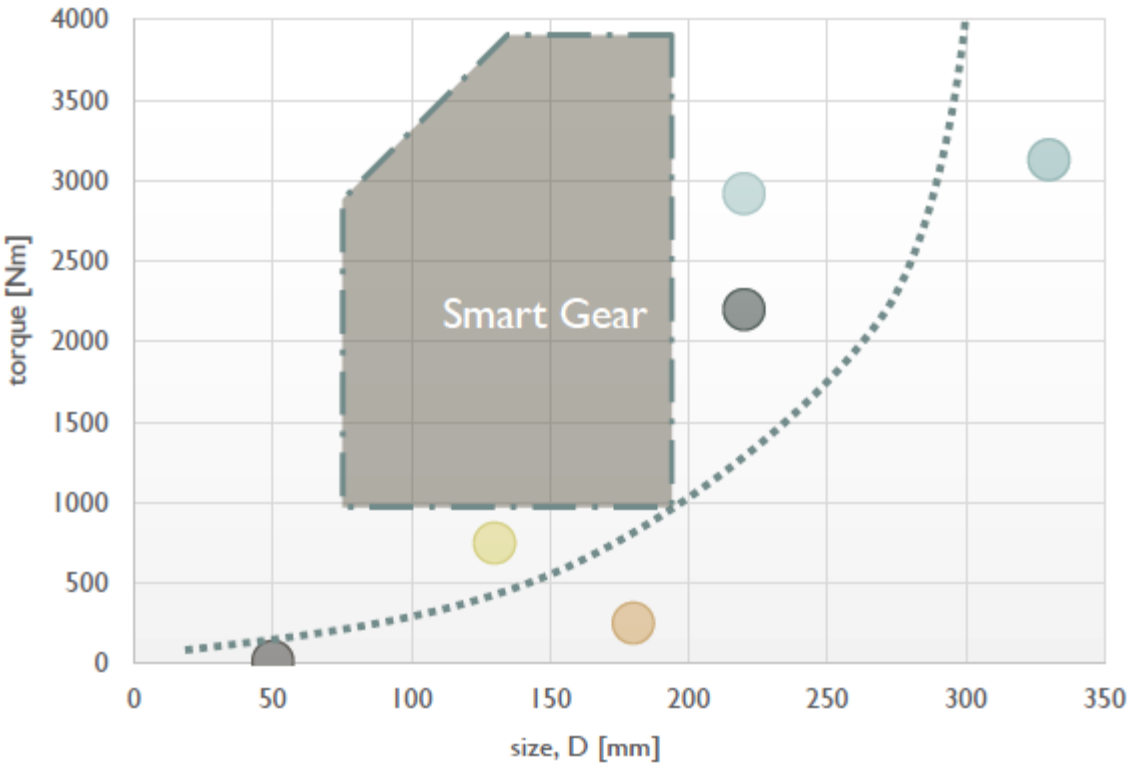

Figure 5: Output torque of Smart Gear based on its size compared to the competitors[82]

4.1.2 Projected Product Cost

Table 3 represents the cost per unit for the Smart Gear in case of a single prototype and in mass production.

Table 3: Smart Gear cost per unit[83]

Component	Single prototype cost	Mass production cost
Machinery and material	1405 €	830 €
Personal	120 €	70 €
Sum	1525 €	900 €
Overhead	1525 €	900 €
Total sum	3050 €	1800 €

[82] Smart Gearing, 2020. P. 1-17
[83] Smart Gearing, 2020. P. 1-17

4.2 Smart Gearing GmbH Time Plan

As mentioned earlier, Smart Gearing GmbH has been established earlier this year in 2020. The company plans to make the proper testing for the product and discuss the options of its further development in the first quarter of 2021. In the second quarter of 2021 the company plans to integrate the sensors that allows for real time monitoring of the gearbox and helps in providing predictive maintenance.

In the third quarter of 2021, the company would have discovered its best to date product and plans to produce the pilot product to have it tested as a final testing phase in the last quarter of 2021.

The planned market entry for the Smart Gear in a mass production phase is in the first quarter of 2022.

4.3 Competitive Analysis

In order to understand the current situation of the company and know where it stands in comparison to the current competitors in the market a SWOT analysis will be made to help understand the company's situation, followed by a Porter's Five Forces analysis (Figure 6) to know the external factors on the company.

4.3.1 SWOT Analysis

Table 4 shows the SWOT analysis of Smart Gearing GmbH based on its current status in the market.

Table 4: SWOT analysis for Smart Gearing GmbH

Strengths	**W**eaknesses	**O**pportunities	**T**hreats
- Smaller/more compact product. - Weights less than existing products. - Offers Double the gear ratio - Easily controlled and monitored wirelessly. - Offers Predictive maintenance. - Cheaper than current products. - Follows the trend of adding motor into the compact package. - New small company which allows flexibility. - CEO and team already introduced to the domestic market. - Good relation with domestic market.	- Lack of professional market experience. - New product so yet to be trusted by the target customers. - No brand loyalty. - Yet to gain full knowledge of the product performance due to ongoing testing. - Brand reputation of competitors is strong. - Financial limitation. - Production Limitation.	- Market is growing and demanding. - Target markets are in growth. - Product needed by many industries. - Product advantages gives it privilege. - Product known and on the watch domestically. - Good reputation of company's personals.	- Well Known experienced competitors. - Unstable economy. - Failure in testing. - Possible low cost imitation. - Rise in material costs.

4.3.2 Porter's Five Forces

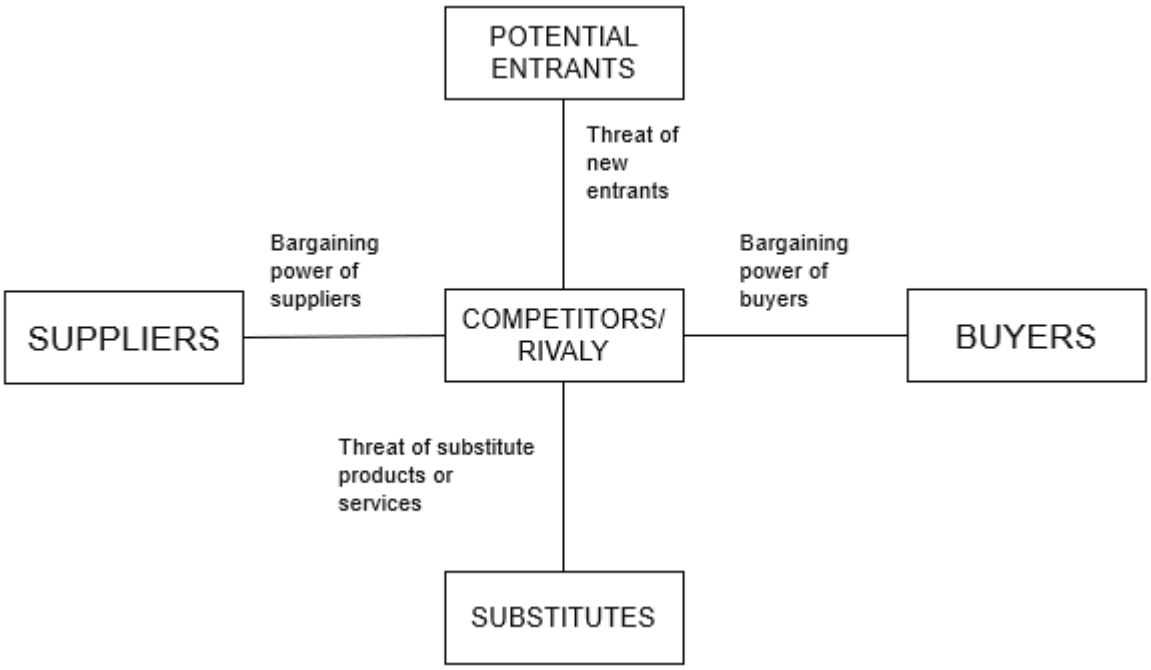

Figure 6: Porter's five forces[84]

Threat of new entrants

The possibility of new entries to the market is quite high however, this is not a major concern to Smart Gearing GmbH as it itself is a new entry to the market. Smart Gearing GmbH has to build up brand reputation before being threatened by new entries.

Competitors and Rivalry

The competition in the industrial gearboxes market is quite high. The number of existing manufacturers is large and growing. The high number of competitors makes the offering for the product comes in many shapes, performances and prices.

Threat of substitute products or services

The dependency on industrial gearboxes are quite high on many industries. Alternatives are not giving the same value to the costumers as existing technology and services. However, the rise of electronic components might be threatening.

[84] Porter, 2004. P. 4, own illustration

Bargaining power of suppliers

Suppliers can gain power if there are only a few suppliers to the material/product. However, this is not the case in this industry. There are many suppliers to get the needed materials from with a variety of qualities and prices.

Bargaining power of buyers

The high competition in the industry and the large number of manufacturers give the buyers some power to control the market and the pricing. The product is standard and available in a wide variety of performances and prices. Thus, the power of suppliers in the industry is quite high.

5. Robotics:

Industry 4.0 or the fourth industrial revolution is the latest technological trend in almost every branch in the industry. It is basically about using the benefits of digitalization and automation to achieve higher quality products, while minimizing the costs. These costs can include the cost of labor, inspection and down time. In the upcoming years, the society as we know it will differ from what it is today. The most dominant technologies are Robotics and Artificial Intelligence. Robotics and industrial automation have entirely transformed the production and manufacturing phase. Both work in the area of applying automation to maximize production and hence the economy.[85]

5.1 Classification of robots

One way to classify robots is in accordance to the environment in which they operate (Figure 7). According to this, robots can be divided into two groups, fixed and mobile robots. These two groups of robots work in a variety of different environments and therefore these robots must be equipped with different tools, in both hardware and software. Fixed robots mostly categorized as industrial robots that work in distinct environments that these robots can easily adapt in. Industrial robots make specific repetitive tasks, such as welding or assembling parts in car manufacturing factories. With the ongoing technologies in improving the sensors and devices for the interaction between the human and the robots, robotic manipulators are in the rise to be used in less controlled environments, such as high precision surgery.[86]

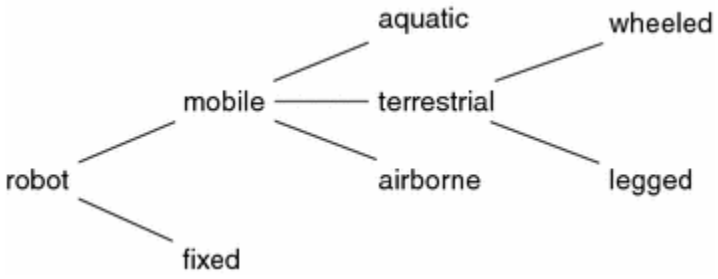

Figure 7: Classification of robots by environment and mechanism of interaction[87]

[85] Goel, Gupta. 2019. P. 157-169
[86] Ben-Ari, Mondanda. 2018. P. 1-18
[87] Ben-Ari, Mondanda. 2018. P. 2

Another way to classify robots is by the intended application field and the tasks in which they perform (Figure 8). Industrial robots which operate in distinct environments on production tasks were the first robots to be made. They were industrial robots because the distinct environment simplified the way they were designed. Alternatively, service robots assist humans in their tasks. These include house-work tasks like vacuum cleaning, transportation like the autonomous cars, and defense applications such as combat drones. The field of medicine has also seen an increase in the usage of robots, such as in surgery, rehabilitation and training. These are some of the applications that are used nowadays that require improvement in sensors and a closer interaction with the user.[88]

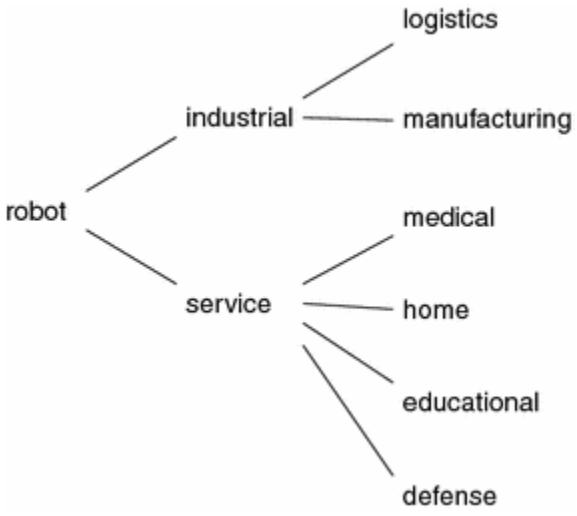

Figure 8: Classification of robots by application field[89]

However, industrial robots may also be classified into other branches, but this is not the main aim of this project. The structure of a commonly used industrial robot will be discussed next to have a main idea on how it operates, and most importantly, where the gearboxes are needed and how many of them is required in the robot.

[88] Ben-Ari, Mondanda. 2018. P. 1-18
[89] Ben-Ari, Mondanda. 2018. P. 3

5.2 The structure of industrial robots

In a way, humans and industrial robots share the same structure, regarding links and joints. The principle of moving joints and transmitting power through the links is common in both humans and robots (example, the movement of the hand around the elbow and the shoulder). The idea behind the movement of joints and transmitting power through the links is something that robots and humans have in common.[90]

There are various ways to categorize industrial robots, and on way to categorize it is by the type of joint and the mechanical structure of the robot. industrial robots are basically categorized into six major types.[91]

The most used robot in the industry is the articulated robot with six axes. (Figure 9)

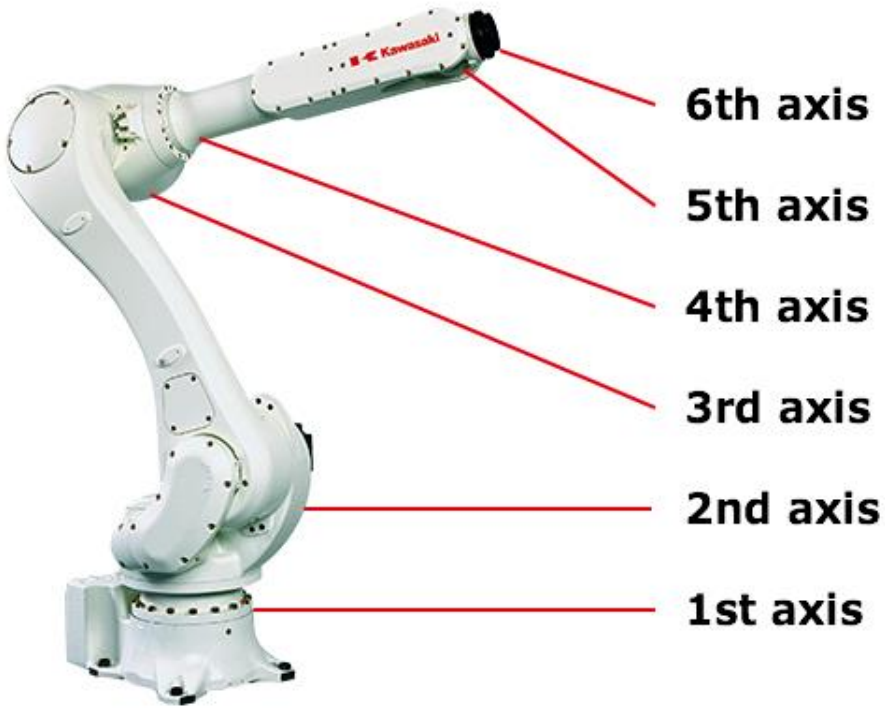

Figure 9: Articulated robot with six axes[92]

[90] How Are Industrial Robots Built? A Guide on the Components and the Movement of Robot Arms. https://robotics.kawasaki.com/ja1/xyz/en/1804-03. Date of access 12/8/2020

[91] What Kinds of Industrial Robots Are There? A Guide on the Features of the Major 6 Types. https://robotics.kawasaki.com/ja1/xyz/en/1803-01. Date of access 12/8/2020

[92] How Are Industrial Robots Built? A Guide on the Components and the Movement of Robot Arms. https://robotics.kawasaki.com/ja1/xyz/en/1804-03. Date of access 12/8/2020

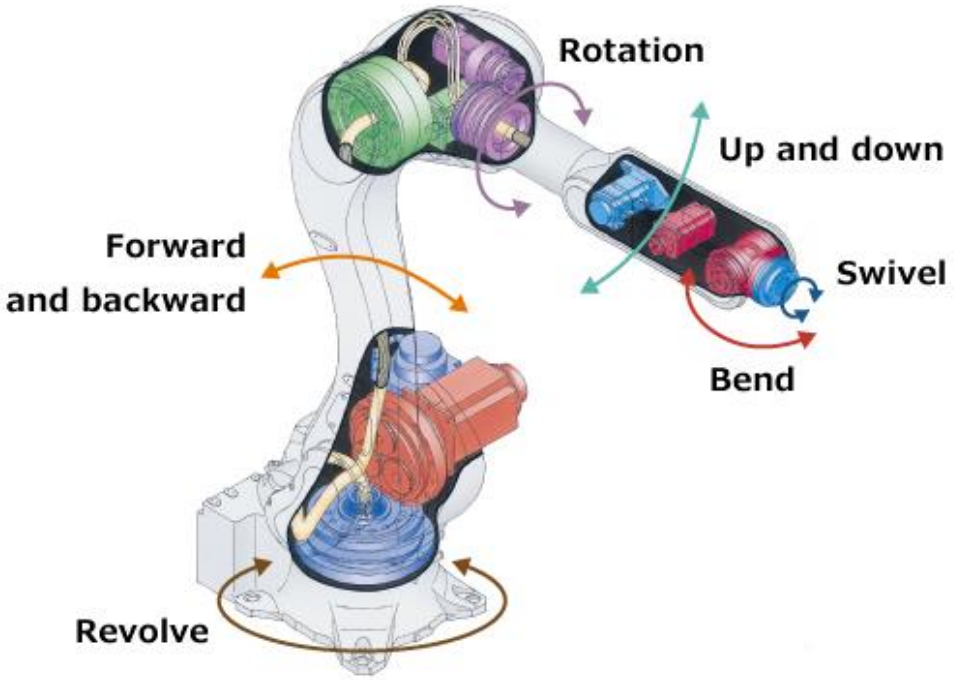

Figure 10: The internal structure of the articulated robot[93]

In every joint, where the power drive of the link is, there are two gear reducers. One of them is to help move the link linearly, the other one is to help rotate it around the joint. (Figure 10)

It is seen that the commonly used articulated robot contains six gearboxes in its structure. That is also noticed from the results gotten from the survey that has been sent out to the manufacturers of robots. (Figure 11)

[93] How Are Industrial Robots Built? A Guide on the Components and the Movement of Robot Arms. https://robotics.kawasaki.com/ja1/xyz/en/1804-03. Date of access 12/8/2020

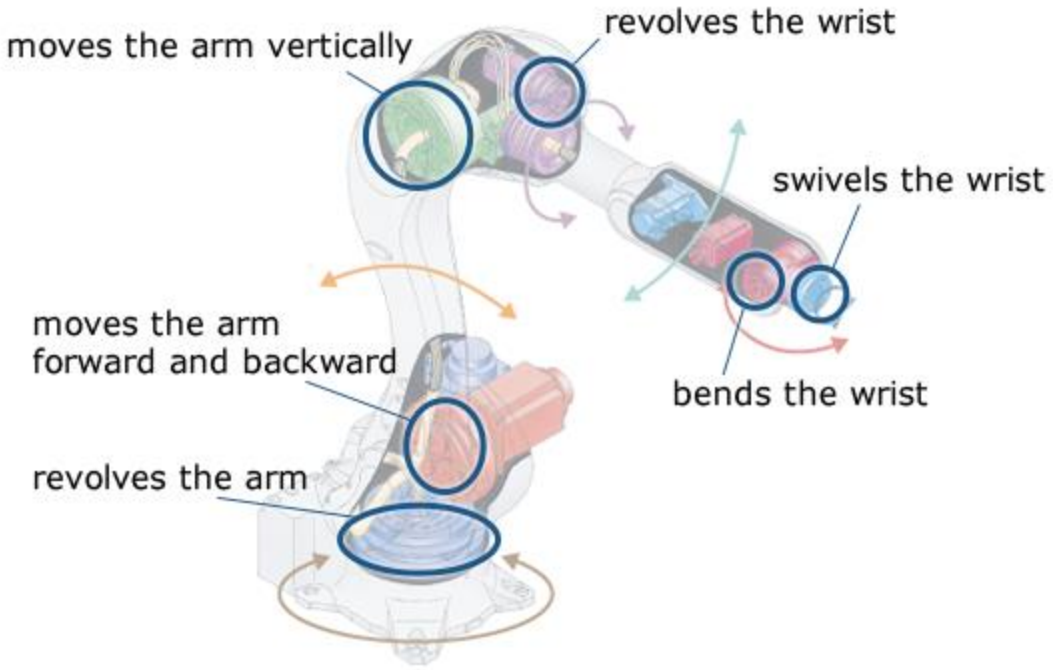

Figure 11: Location and role of gearboxes[94]

5.3 Robotics Industry

From the beginning of the third industrial revolution, the robotics industry is getting more and more attractive every day. Meanwhile, while the world is in depth of the fourth industrial revolution, the robotics industry is becoming even more attractive and the market in which investors invest in robotics industry are on the rise.[95]

5.3.1 Countries Interest in Robotics Industry

The rise in demand of automation and digitalization, is influencing major industrial countries, like the U.S, Germany, France, China and Japan to move towards digital transformation in their manufacturing process. Which means a demand for an increase of interaction of robotics in the industry.[96]

[94] How Are Industrial Robots Built? A Guide on the Components and the Movement of Robot Arms. https://robotics.kawasaki.com/ja1/xyz/en/1804-03. Date of access 12/8/2020
[95] Mehta, Hamke. 2019. P. 8-13
[96] Mehta, Hamke. 2019. P. 18

1- Germany – Industry 4.0

The initiative started in 2013. The name of the industrial revolution that is being used worldwide came out from this initiative. It was declared by the German government as one of ten “Future Projects” of its High-Tech Strategy 2020. Its main target is to establish smart factories and manufacturing innovation centers across Germany.

2- France – New Industrial France

This initiative has also started in 2013. The initiative outlines plans for 34 new industrial projects, and robotics industry is one of these projects among many other.

3- U.S. – The National Network for Manufacturing Innovation (NNMI)

The initiative launched in 2016 and is aiming to develop smart manufacturing technologies in 45 innovation centers in the US. The US has also started an imitative called the National Robotics Initiative to accelerate the developing of the co-robots manufactured in the US.[97]

4- Japan – Society 5.0

Started in 2016 as well, the initiative plans to make a societal transformation by focusing on developing solutions in many areas, and robots are one of these areas.

5- China – Made in China 2025

China plans to create 40 manufacturing innovation centers by 2025. One of the areas of focus of these innovation centers is automated machine tools and robotics.[98]

These are just examples of the countries interested in the robotics industry. However, the list of countries interested in the robotics industry contains many more. The Republic of Korea for example is one of the most countries investing in the robotics industry.[99]

[97] National Robotics Initiative. https://www.manufacturing.gov/programs/national-robotics-initiative. Date of access 15/8/2020
[98] Mehta, Hamke. 2019. P. 8-13
[99] IFR. 2019. WR Industrial Robotos 2019_Chapter_1. P. 20-21

5.3.2 Robotics Impact on Economy

A study done by Accenture and Frontier Economics, showed that the use of artificial intelligence (AI) and robotics can lead to double the economic growth in developed countries to the year of 2035 (Figure 12).[100]

The study made in estimate for the economic growth under two scenarios. One of which is the baseline, which is the estimated yearly economic growth without AI, and the other is AI scenario.

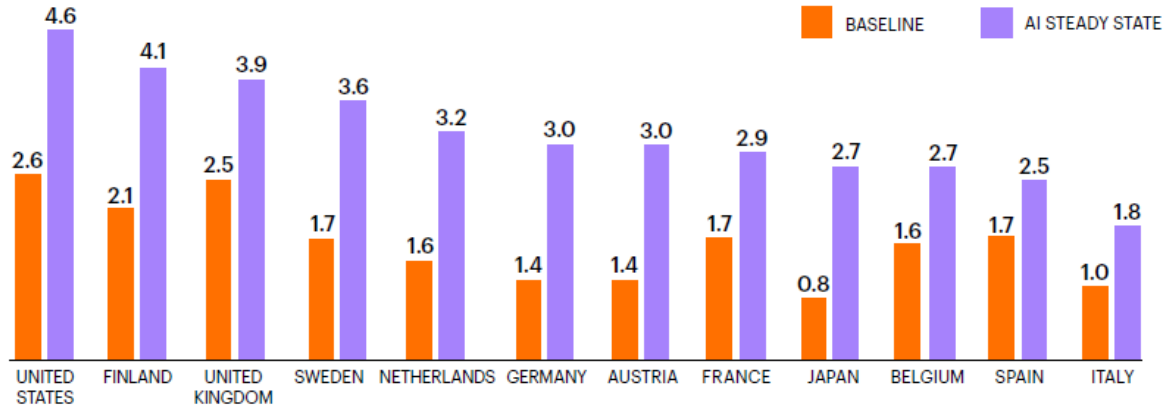

Figure 12: Economic growth with and without AI[101]

5.4 Robotics Market

Regarding operation, there are two subsegments in robotics industry: industrial robots that perform tasks in an industrial environment, and service robots that offer services in both industrial and non-industrial environment. According to a study made by a Statista, it shows that both subsegments are facing an impressive increase in CAGR in the upcoming years (Figures 13 & 14), the study has been made based on researches from industry associations and market research companies[102].

[100] Purdy, Daugherty. 2016. P. 16
[101] Purdy, Daugherty. 2016. P. 16
[102] Lorson, 2019. P. 9

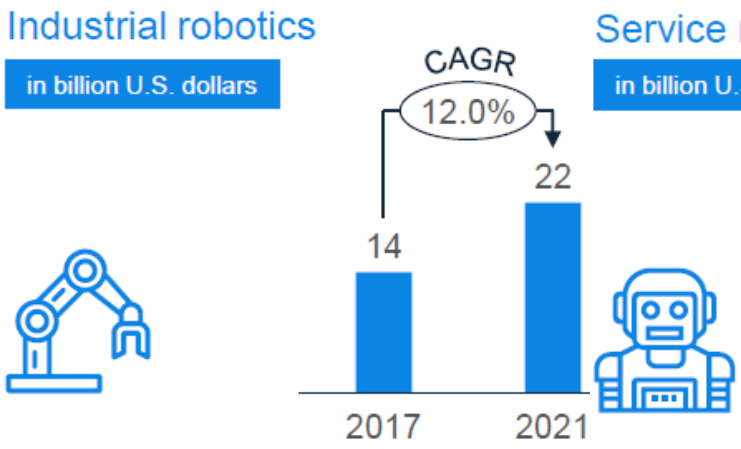

Figure 13: Industrial robotics CAGR[103]

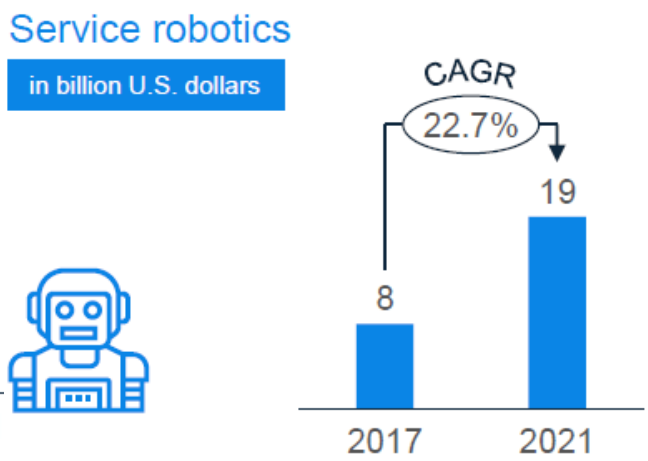

Figure 14: Service robotics CAGR[104]

5.4.1 Robot Installation

By the last quarter of each year, the International Federation of Robotics provides a summary of the number of the installations/sales of both industrial and service robots worldwide. According to their last report that has been done in 2019, the number of robots that has been installed worldwide for both segments is showing an increase regarding the previous years. More accurate, it shows an annual increase of robot's installation since the year of 2012.[105]

The industrial robot's industry however has faced an unexpected drop last year, the year of 2019. Experts in the industry has predicted an increase in the number of installations and sales in robotics in 2019, but many global aspects prevented that from happening. One of the main reasons that caused this drop in the industry is the issues that faced the automotive industry and the electronics industry last year. These two are the main customer industries for robotics. Experts refer this drop due to the unplanned political issues between China and the US. It has been spreading uncertainty in the whole global economy since the end of 2018. Also, Brexit has had its share in the drop of the automotive industry[106], says German Association of the Automotive Industry (VDA)[107].

[103] Lorson, 2019. P. 9
[104] Lorson, 2019. P. 9
[105] IFR. 2019. Executive summary world robotics 2018 industrial robots. P. 13-16
[106] The effects of Brexit on the automotive industry. https://www.vda.de/en/topics/automotive-industry-and-markets/the-effects-of-brexit-on-the-automotive-industry.html. Date of access 16/8/2020
[107] IFR. 2020. Executive summary world robotics 2019 industrial robots. P. 13-16

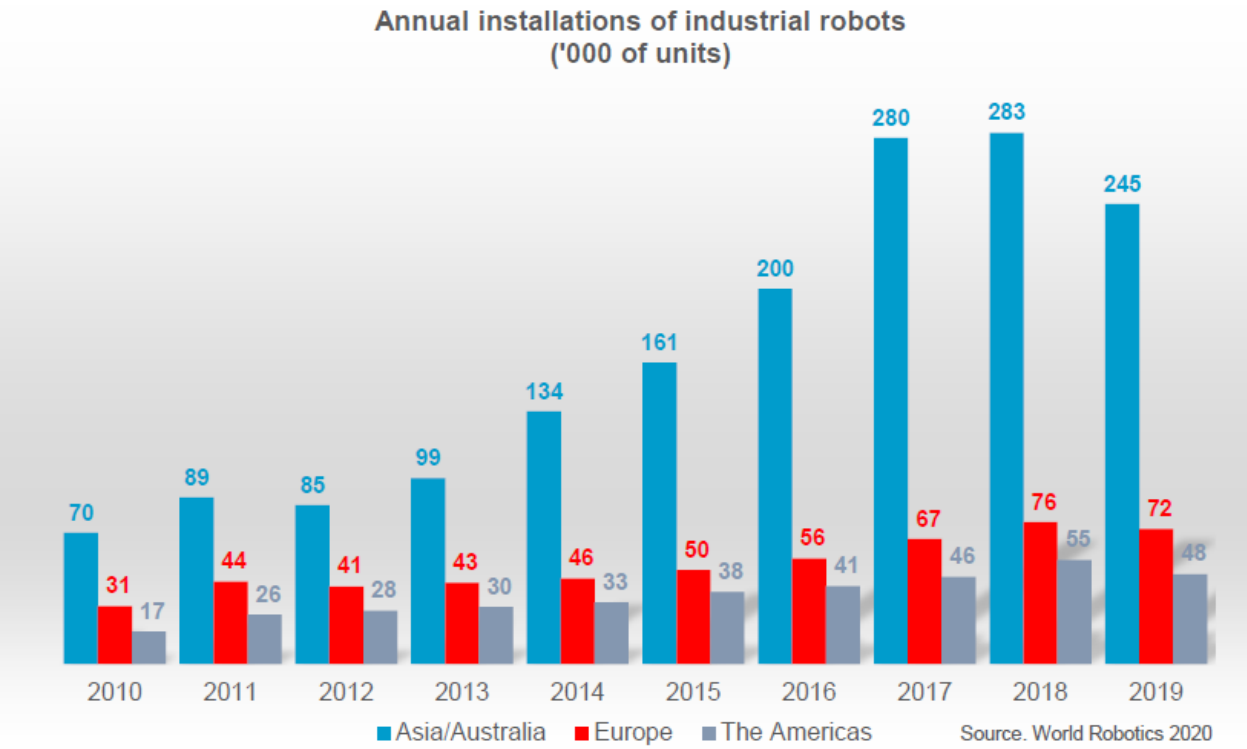

Figure 15: Annual installations of industrial robots[108]

For the industrial robot's industry (Figure 15), and in the year of 2018, reports show that an increase by 6% of the global industrial robot installations. That account to 422,271 of units. The demand for industrial robots has been on the rise since the year of 2010 due to the global trend towards automation. The annual installation of the industrial robots has shown an increase by 19% on average per year from the year of 2013 to 2018. Before the global economic crises that happened in 2008, and precisely between the year of 2005 and 2008, 115,000 units were sold on average per year. The impact of the crises on the installation of the industrial robots were clearly noticed, it nearly halved the number of the installations, as it caused the numbers to fall to just 60,000 unit in the year of 2009. However, from the year of 2010, the industry has revived from the crises and drove the installations to reach 120,000 units. Since then the installations has been increasing-with just a slight setback in the year of 2012- to reach 400,000 units of industrial robots installed globally in 2017.[109]

[108] IFR. 2020. Executive summary world robotics 2019 industrial robots. P. 13-16
[109] IFR. 2019. Executive summary world robotics 2018 industrial robots. P. 13-16

For the service robots however, there are no data of the robot's installation, that is because the service robot in many cases does not need to be installed in a fixed place in the first place. Therefore, the service robots are represented in the number of units sold each year.

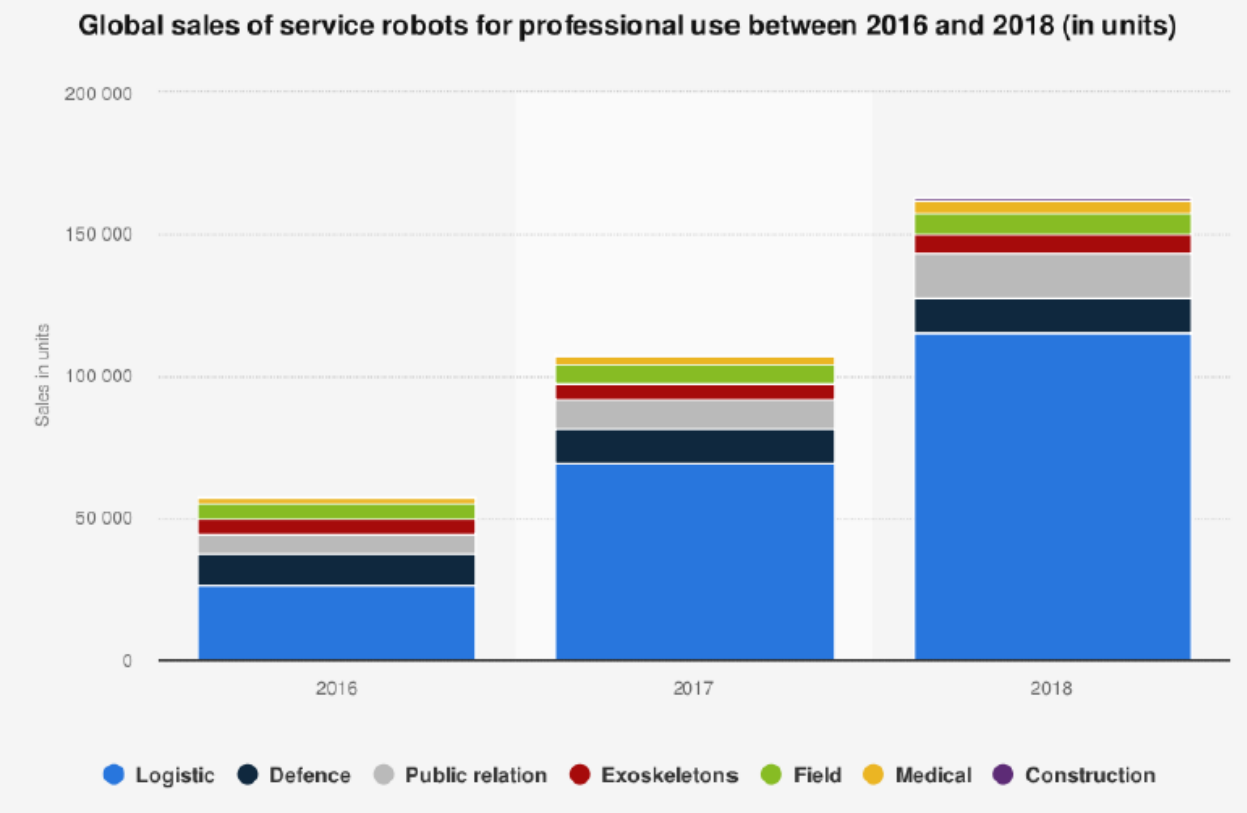

Figure 16: Global sales of service robots for professional use between 2016 and 2018[110]

As shown in Figure 16, the number of the sold units of the service robots are on the rise in the last couple of years.

5.4.2 Robot Sales and Forecast

It is well known fact that automation is the most followed trend in all the major industries nowadays. Industrial manufacturing has been named the most leading industry as a result of a worldwide survey made by Capgemini, in the presence of the modern smart factories.[111]

[110] IFR. 2019. Executive summary world robotics 2018 service robots. P. 13-16
[111] Lorson, 2019. P 14

The International Federation of Robotics IFR predict the sales of industrial robots to increase up to 12% per year on average from 2020 to 2022. It predicts the sales of industrial robots to reach 583,520 units in the year of 2022[112]. For the service robot's industry, the IFR expects sales to reach 537000 units in the year of 2023, with a CAGR of +31%[113].

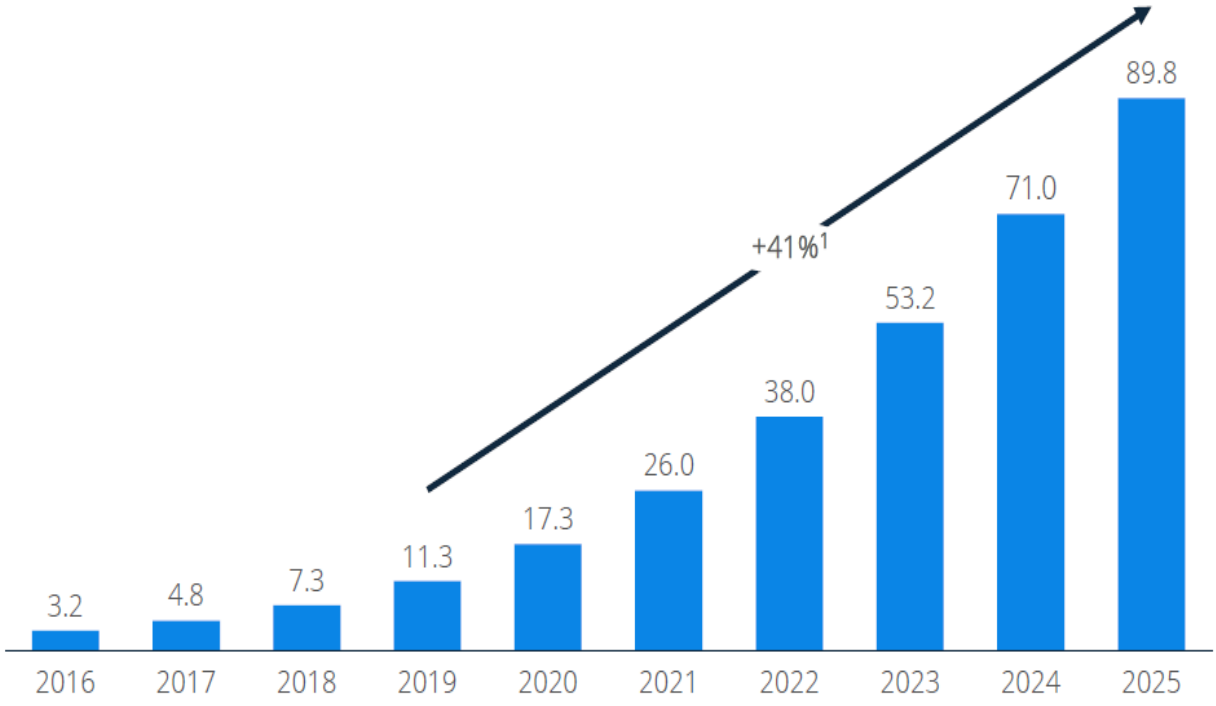

Figure 17: Global revenue projection from artificial intelligence and robotics in billion US dollars[114]

A study made by Statista forecasts the sales of both industrial and service robots to reach 89.8 billion U.S. dollars at the year of 2025 (Figure 17).

[112] IFR. 2019. Executive summary world robotics 2018 service robots. P. 13-16
[113] IFR. 2020. Executive summary world robotics 2019 service robots. P. 13-16
[114] Mehta, Hamke. 2019. P. 29

5.5 Survey

The primary research in this study relies on surveys. Therefore, a survey has been sent to some of the manufacturers of robots to gain information that will help in validating the secondary research that this study has made.

5.5.1 Survey Questions

The survey consisted of eight questions, some of which are mandatory questions and the others are not. The following are the questions of the survey with the suggested answers given for participants:

1 - In which region does your company operate?

- Asia
- Europe
- United States

2 – What type of robots does your company produce?

- Industrial robots
- Cobots
- Mobility robots
- Other ( )

3 – What type of gearboxes are used in the robot?

- Cyclo
- Planetary
- Harmonic Drive
- Other ( )

4 – On average, how many gearboxes used in one robot?

- 2
- 3
- 4
- More ( )

5 - Which gearbox manufacturer do you get your gearboxes from?

6 – How many robots did your company produce in 2019?

7 – How many robots did your company produce in 2020?

8 – Do you see a rise or downfall in the robotics industry in the upcoming years?

- Rise
- Downfall

5.5.2 Survey Results

1- Operation region:

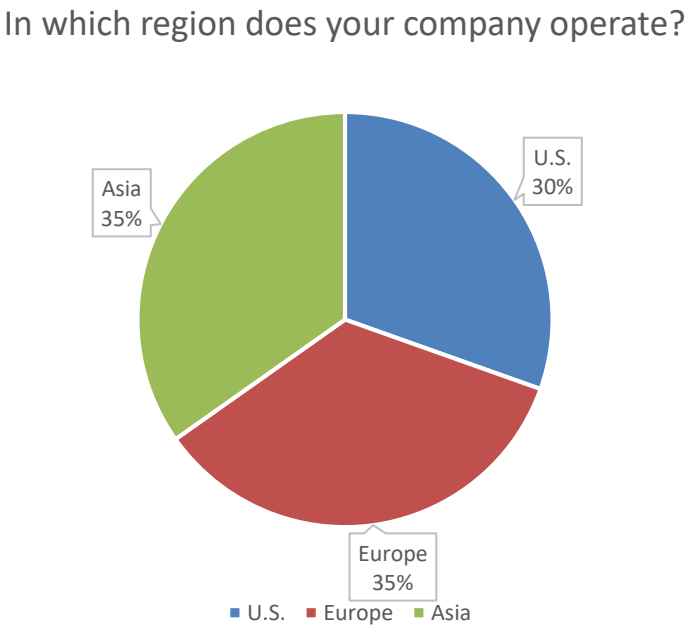

Figure 18: Participants operation region[115]

[115] Own illustration

2- Type of robots:

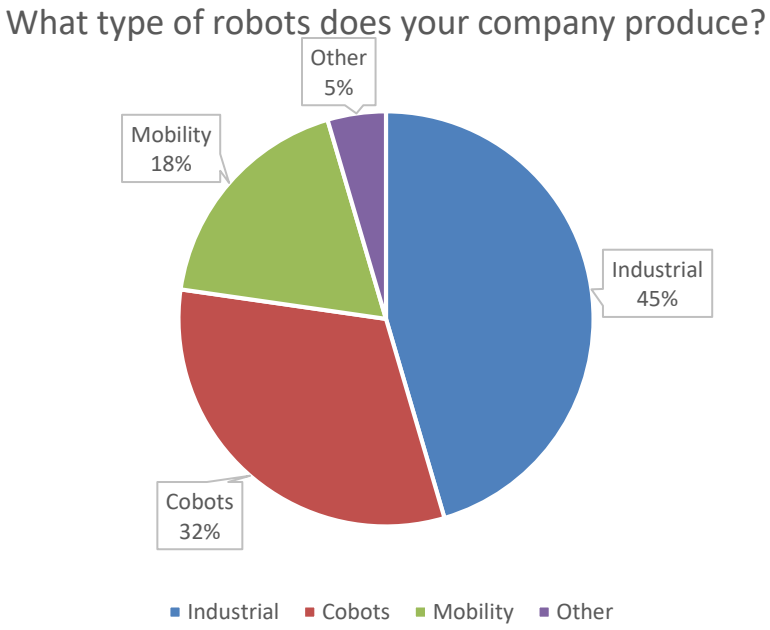

Figure 19: Participants robots' production type[116]

3- Type of gearboxes used:

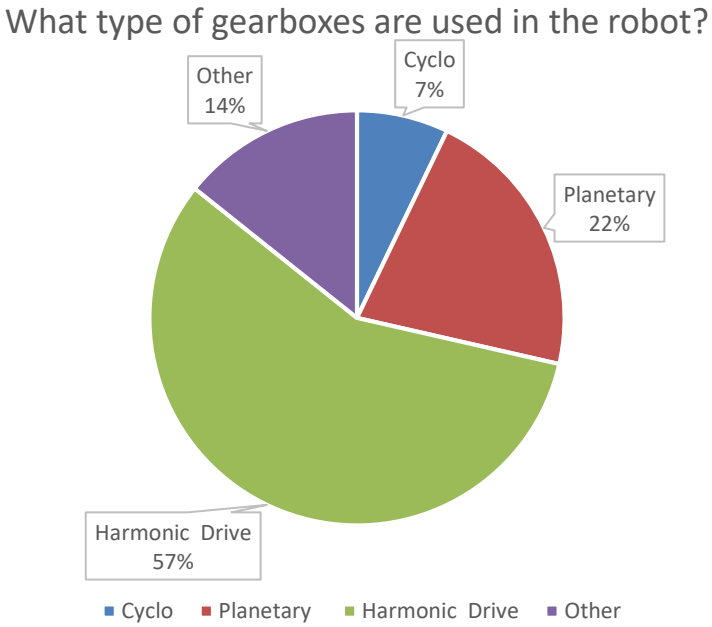

Figure 20: Type of gearboxes used in robots[117]

[116] Own illustration
[117] Own illustration

4- Number of gearboxes used in one robot:

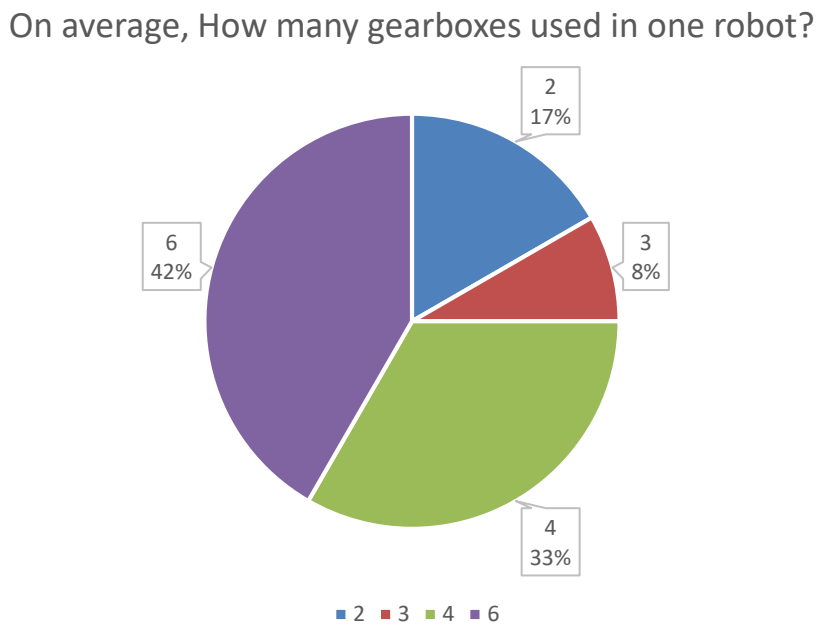

Figure 21: Number of gearboxes used in one robot[118]

5- Gearbox manufacturer:

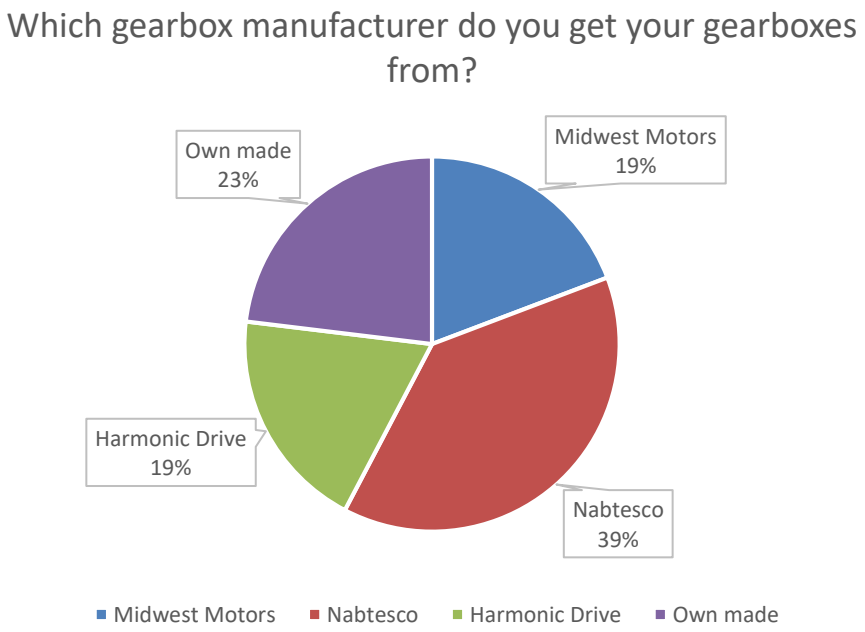

Figure 22: Gearbox suppliers[119]

[118] Own illustration
[119] Own illustration

6 & 7- Robots sold in 2019 & 2020:

The results for both the 6th and 7th question came out as confidential in most of the results. Therefore, it would be neglected in the analysis of the results.

8- A rise or downfall in the robotics industry:

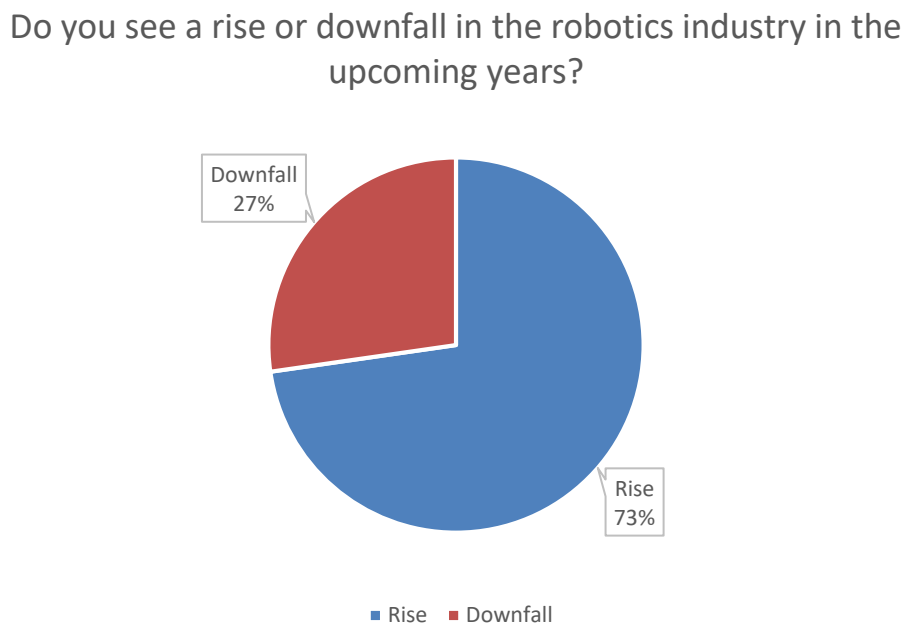

Figure 23: Prediction of robotics industry in the upcoming years[120]

5.5.3 Results Analysis

The results of the survey came with very interesting aspects. In a way, it validates the information that has been assumed before the start of the study, like the rise of strain wave (Harmonic Drive) gearboxes in the robotics industry. As it shows from the results, more than half of the users use this type of gearboxes. More the 2/3 of the survey participants predicted a rise in the robotics industry in the upcoming years.

These results, alongside with the secondary data from the reports of the experts in the robotics industry, will help this study to predict the sales of the smart gear in the industry.

[120] Own illustration

5.6 Market Plan

The robotics industry is a one of the significant markets that Smart Gearing GmbH is targeting. The number of robots sold each year is very high and is predicted to keep on increasing according to experts, more than 70% of the workers in industry predict a rise according to result of the survey. Also, the survey shows that the companies prefer the use of the strain wave gearing above other gearboxes options. While Smart Gearing GmbH is offering something that is better in size and performance than the current gearboxes used by a margin, it will not be a struggle to penetrate this market with the desired percentage share.

According to one of the most reliable sources in the field of robotics industry, which is the International Federation of Robotics, the number of industrial robots that will be sold in 2022 will reach 583,520 units[121]. According to the survey, the average number of gearboxes used in one industrial robot is five gearboxes. By multiplying the average number of gearboxes to the number of robots, the result will be the number of gearboxes forecasted to be sold in the year of 2022 in the industrial robot's industry. The predicted number of gearboxes to be sold is 2,917,600 units (Figure 24).

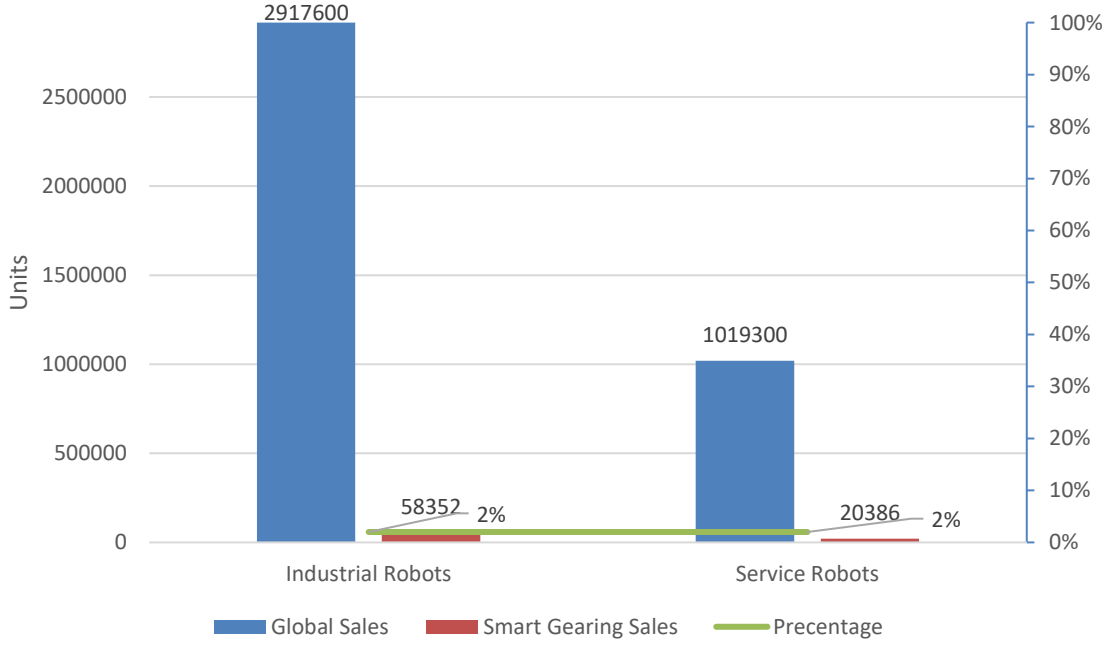

Figure 24: Gearboxes sales in robotics industry[122]

[121] IFR. 2019. Executive summary world robotics 2018 industrial robots. P. 13-16
[122] Own illustration

For the service robots, the IFR predict the sales of professional use service robots to reach 1,019,300 units in the year of 2022[123]. The service robots do not use many gearboxes such as the industrial robots, therefore the assumption of the gearboxes used in one service robots would be a minimum of one. Thus, the predicted sales of gearboxes used in service robots is 1,019,300 units.

Smart Gearing GmbH aim to hold a market share of 2% in the robotic industry gearboxes. As previously discussed, the robotics industry is significantly large and entering the market with the required percentage is something that is highly achievable.

5.6.1 Sales Profit

According to the determined cost per unit for the Smart Gearing gearbox, the gross sales profit from the robotics market in the first year of production are as shown in Figure 25.

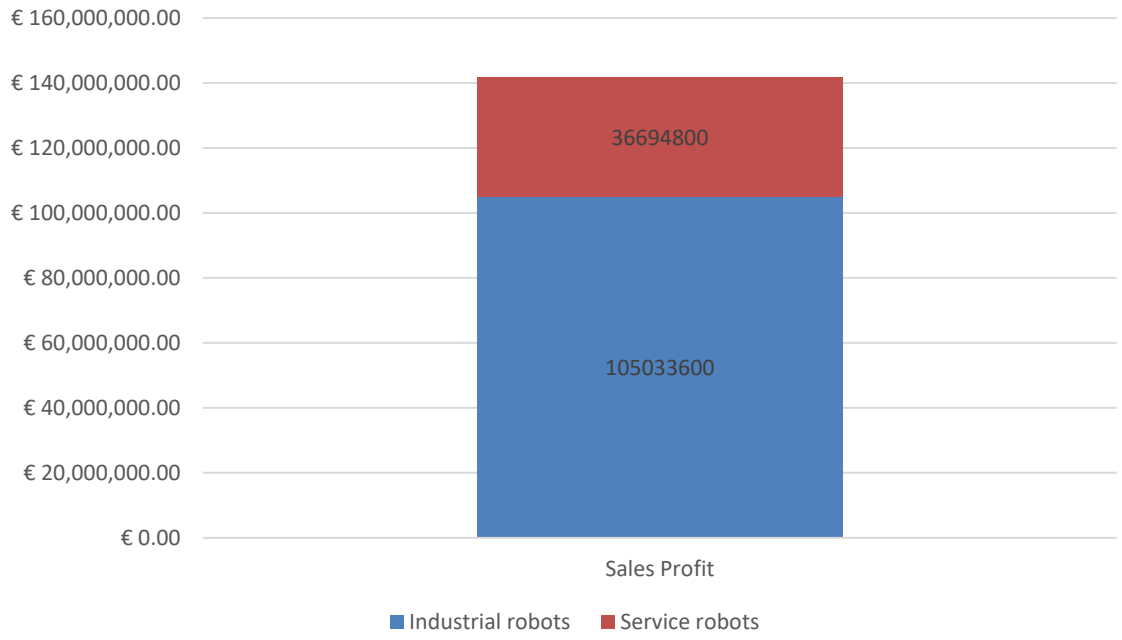

Figure 25: Sales profit from the robotic industry 2022[124]

[123] IFR. 2019. Executive summary world robotics 2018 service robots. P. 13-16
[124] Own illustration

6. Construction Machinery

Construction machinery is a term that is used to describe the machines and tools that are used in the civil industry and construction sites. One way to classify the construction machinery is by the application that they do. In terms of application they can be classified into earthmoving equipment (Figure 26), construction vehicles, material handling equipment and construction equipments[125]. Construction industry is one of the earliest industries that humankind ever known. The need for construction is something that is always there, and construction machinery keeps on developing every day to fulfil that need. Earthmoving equipment for example has been there since the invention of the blast furnace and the steam engine in the eighteenth century, and it has been used since then in roads, dams, canals and other civil engineering improvements[126].

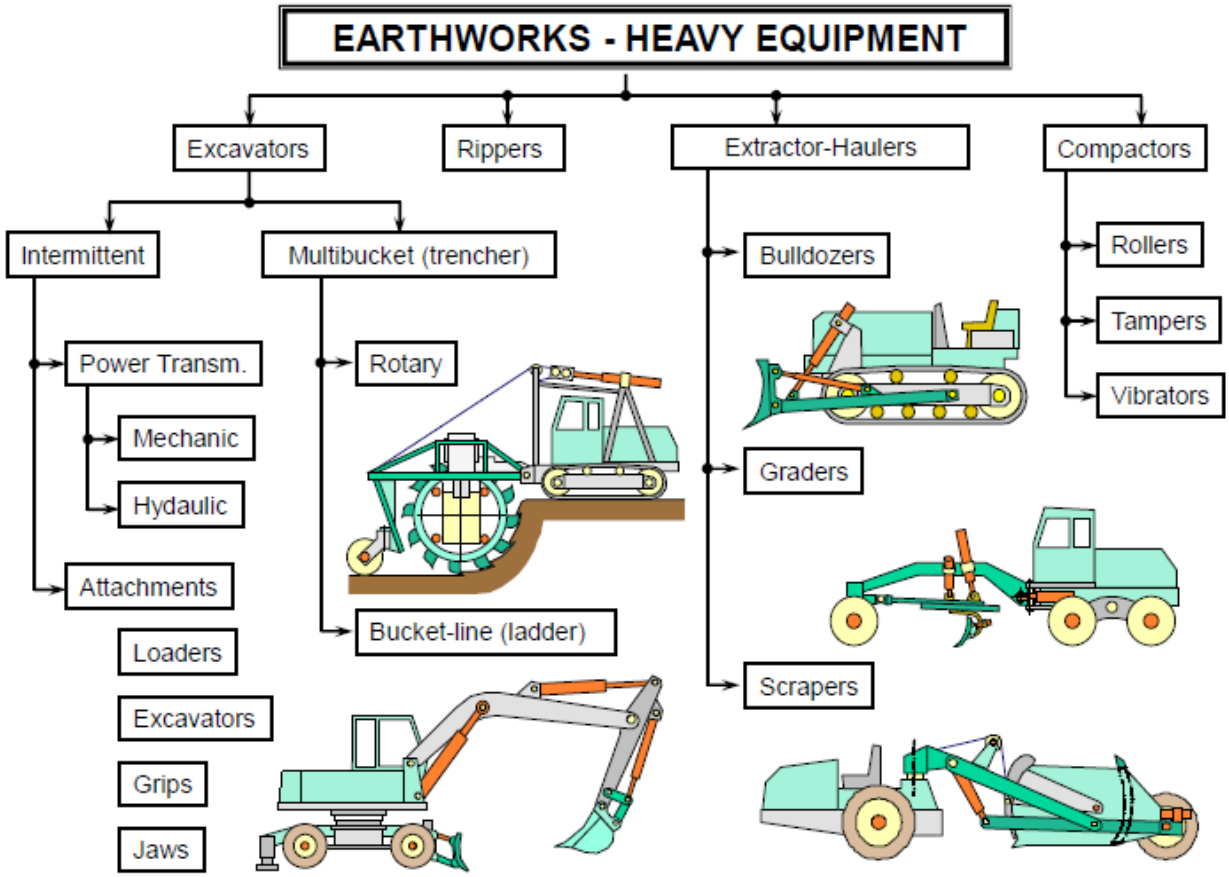

Figure 26: Earthmoving Equipments[127]

[125] Palanisamy, 2018. P. 1
[126] Haycraft, 2000. P. 1-3
[127] Károly, 2010. P.1

6.1 Gearbox Usage in Construction Machinery

Based on application, gearboxes can be used in various types of construction machinery with various numbers in each unit. Figure 27 shows gearboxes used in an excavator.

1- Drive gearboxes: used to move the wheels, tracks or rollers in the earthmoving machines and the machines that require mobility. These machines can weight of up to 800 tonnes.
2- Swing gearboxes: These gearboxes are used for positioning, when a very high accuracy is needed. It is used to provide fast and reliable rotary movement, like in cranes or excavators.
3- Winch gearboxes: used in material handling when heavy components are required to be lifted from different heights and moves to a certain place.
4- Pump distribution gearboxes: used in large hydraulic excavators, when different hydraulic pumps are driven simultaneously[128].

Figure 27: Gearboxes in an excavator[129]

[128] ZF Industrieantriebe Witten GmbH, 2019. P. 10-11
[129] ZF Travel Drives for Mining- and Large Construction Machines. https://www.zf.com/products/en/industrial_gearboxes/portfolio/drive_gearbox_gfa_gpt/drive_gearbox_gfa_gpt.html. Date of access 10/9/2020

6.2 Construction Machinery Industry

The industry of construction machinery is rather big and complex industry with a wide variety of machines and manufacturers. Industry analysts like McKinsey classify the industry into more than 100 machine types, which all perform tasks in construction activities. Most of these machines are being produced in a low volume, which makes the construction machinery industry a low volume with one with a high complexity.[130]

Although construction industry-which is the main customer for construction machinery industry-is one of the major industries in human lives, it also faces ups and down like any other industry. After the fall of the Lehman Brothers in 2008 and the global economic crisis that followed it, the construction machinery industry has faced a massive decline in global sales. The market in the U.S. and Europe had tried to recover after the crisis, but the plummeting sales in the Chinese market after the crisis and especially from the year of 2012 to the year of 2016 did not help in raising the global market sales. With many disruptive geopolitical events that happened in the period between 2011-2016, the construction machinery industry has seen a fall in sales from as high as more than 1 million units, to a huge decline and a low of 650,000 units.[131]

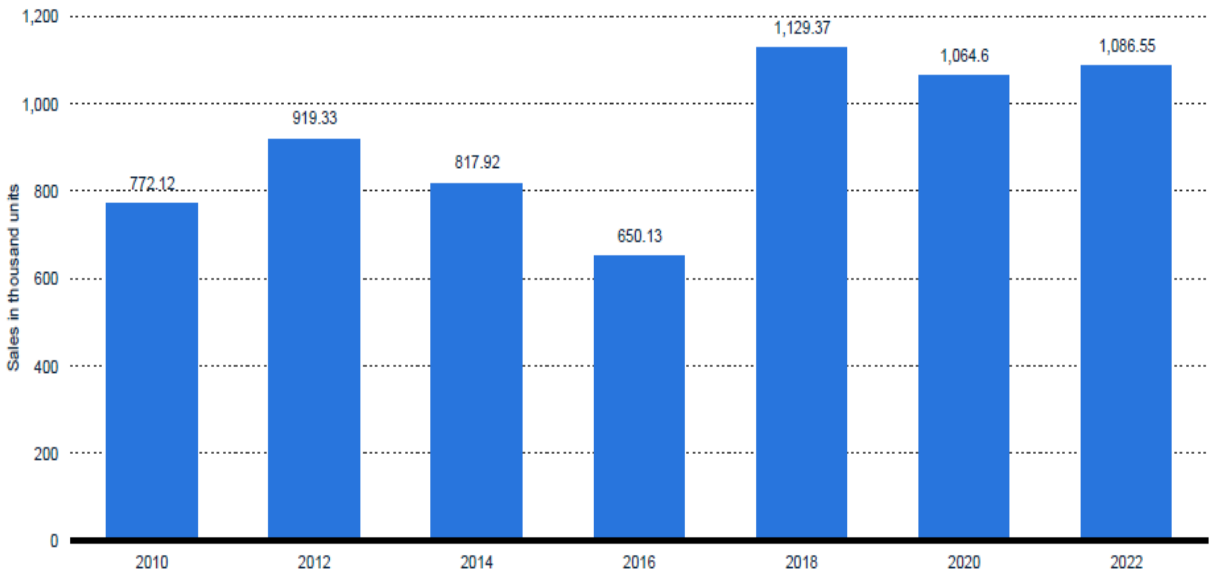

Figure 28: Construction machinery sales 2010-2022[132]

[130] Sjödin, Granskog, Guttman, 2016. P. 9-11
[131] Global Construction Equipment Market to Recover in 2017. https://blog.marketresearch.com/global-construction-equipment-market-to-recover-in-2017. Date of access 11/9/2020
[132] Statista, 2018. P. 4

However, a rise on construction machinery sales has been seen following the year of 2016. The number of sold units has reached a record high of 1,129,370 units in the year of 2018 (Figure 28).[133]

6.2.1 Construction Machinery Industry Forecast

A study made by Off-Highway Research, which is a management consultancy specialized in the research and analysis of international construction, and agricultural equipment markets, shows that the construction machinery units are projected to an increase in the upcoming years[134] (Figure 29).

Another study made by MarketWatch predict the sales of construction machinery to rise from almost 113 billion U.S. dollars in 2020, to around 132.6 billion U.S. dollars by 2026. It is predicted that the growth rate reaches 2.3% between 2020 and 2026. This is under the hope that the Chinese market will stabilize in the upcoming years, and that a huge growth will occur in the Indian market.[135]

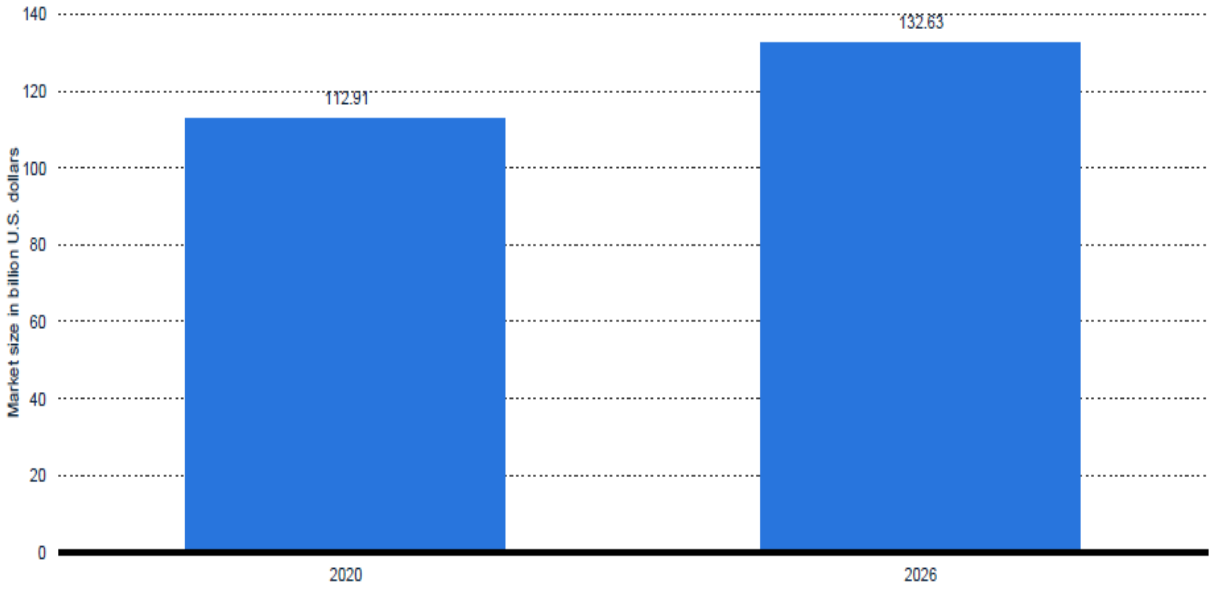

Figure 29: Global construction machinery market 2020-2026[136]

[133] Statista, 2018. P. 27
[134] Statista, 2018. P. 4
[135] Statista, 2018. P. 2
[136] Statista, 2018. P. 2

6.3 Survey

The primary research in this study relies on surveys. Therefore, a survey has been sent to some of the manufacturers of construction machinery to gain information that will help in validating the secondary research that this study has made.

6.3.1 Survey Questions

The survey consisted of eight questions, some of which are mandatory questions and the others are not. The following are the questions of the survey with the suggested answers given for participants:

1 - In which region does your company operate?

- Asia
- Europe
- United States

2 – What type of machinery does your company produce?

- Drive systems Cranes
- Machine tools
- Other ( )

3 – What type of gearboxes are used in the machinery?

- Cyclo
- Planetary
- Harmonic Drive
- Other( )

4 – On average, how many gearboxes used in one machinery?

- 1
- 2
- 3
- More ( )

5 - Which gearbox manufacturer do you get your gearboxes from?

6 – How many machineries did your company produce in 2019?

7 – How many machineries did your company produce in 2020?

8 – Do you see a rise or downfall in the machinery industry in the upcoming years?

- Rise
- Downfall

6.3.2 Survey Results

Unfortunately, this survey did not have as much participants as the survey in robotics industry, only 4% of the invited participants has participated (2 out of 50).

1- Operation region:

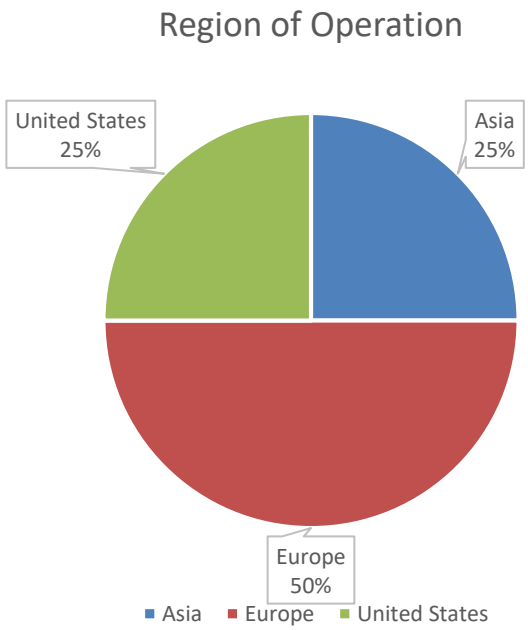

Figure 30: Region of operation of the participants[137]

[137] Own illustration

2- Type of machinery:

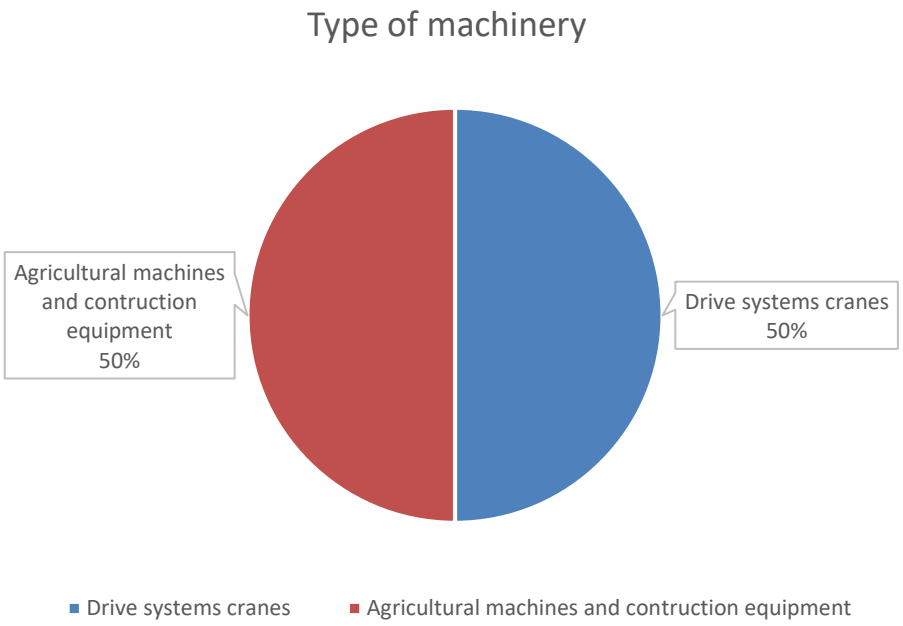

Figure 31: Type of construction machinery the participants produce[138]

3- Type of gearboxes used:

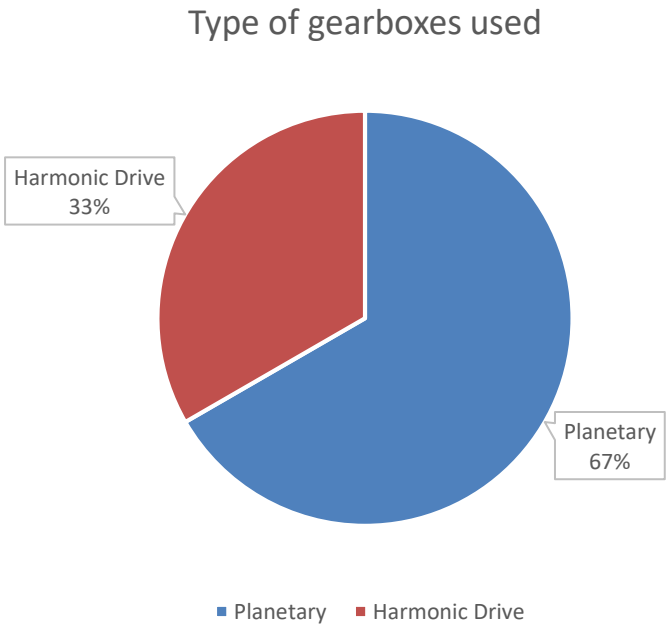

Figure 32: Type of gearboxes the participants use[139]

[138] Own illustration
[139] Own illustration

4- Number of gearboxes used in one machinery:

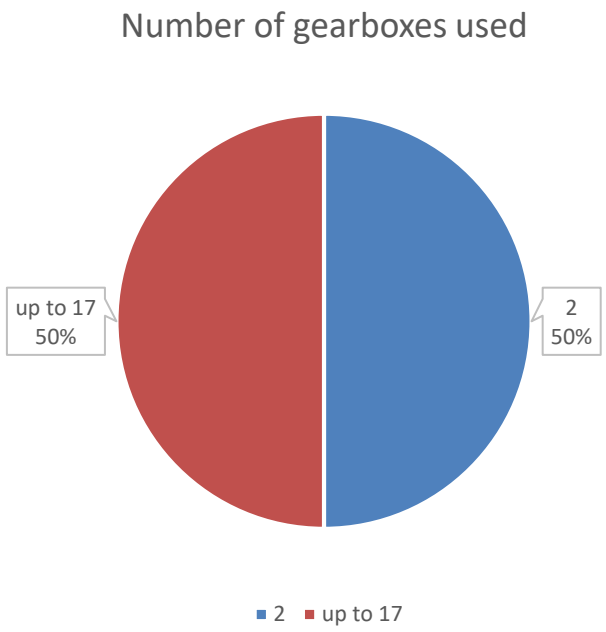

Figure 33: Number of gearboxes used in one machinery[140]

5- Gearbox manufacturer:

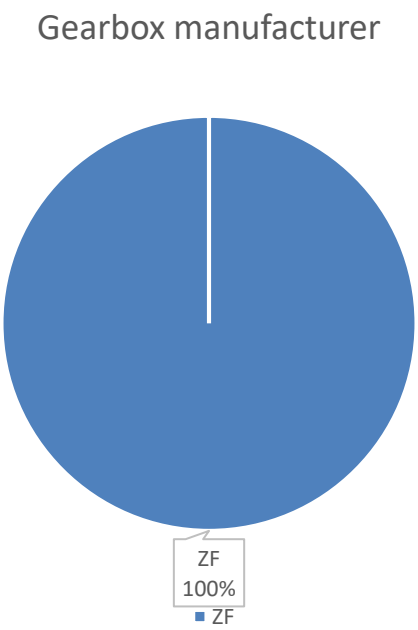

Figure 34: Gearbox suppliers[141]

[140] Own illustration
[141] Own illustration

6&7 – Units sold in 2019 & 2020:

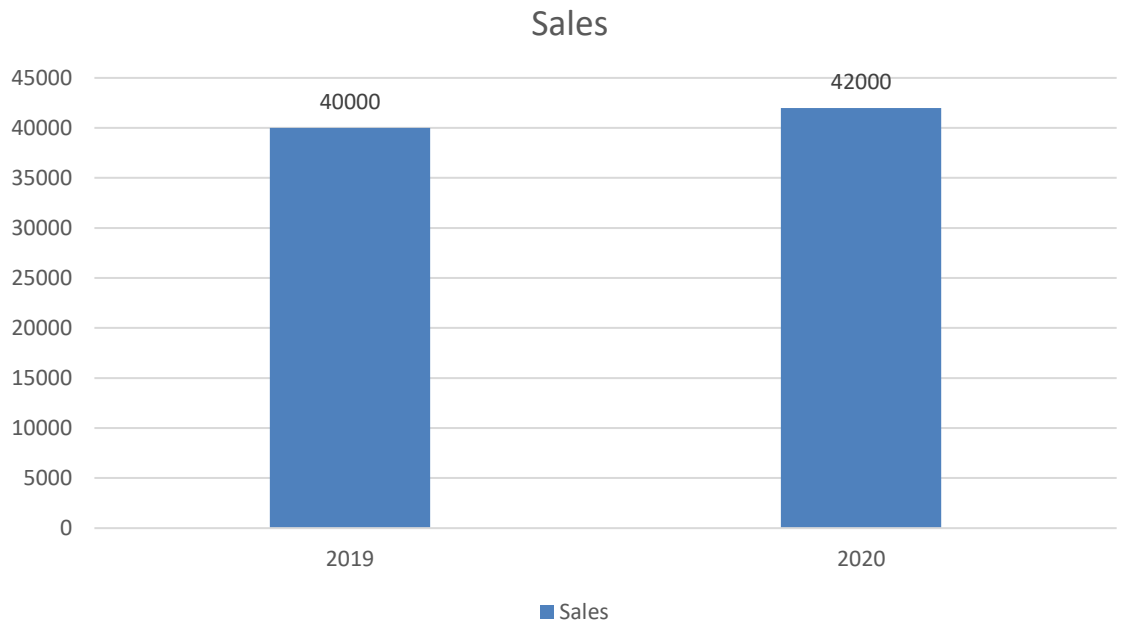

Figure 35: Number of sold units in 2019 & 2020[142]

8- A rise or downfall in construction machinery industry:

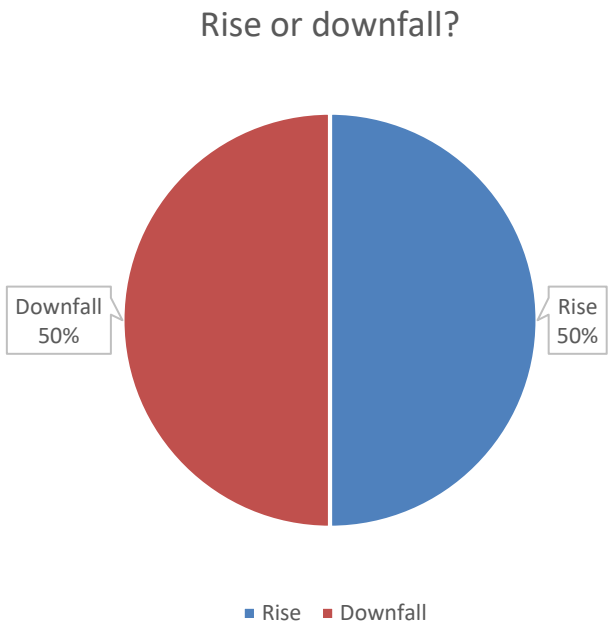

Figure 36: Rise or downfall in construction machinery[143]

[142] Own illustration
[143] Own illustration

6.3.3 Results Analysis

Analyzing the results of the survey might not be the most reliable source to know the industry because of the low participation percentage compared to the robotics industry. However, the results show a popularity of the planetary gearbox in the construction machinery industry, and it also shows a popularity of the gearboxes produced by ZF. The number of sold units came from only of the participants, however, the number is considerable and is quite large from only one manufacturer. This in a way validate the large scale that the construction machinery industry has. The divided opinion on the rise or fall of the industry also shows that the industry is predicted to face a nearly steady market in the upcoming years, with a slight rise forecasted as in the secondary research.

6.4 Market Plan

As shown in the research, construction machinery is quite an interesting market with a large number of produced units per year. Smart Gearing GmbH plans to be one of the suppliers of gearboxes used in the construction machinery. A market this big and with the advantages that the Smart Gearing's gearboxes has over its competitors will not be such a hard target to achieve. Especially that Smart Gearing plan to penetrate the construction machinery supply of gearboxes market with only 2% of the global supply.

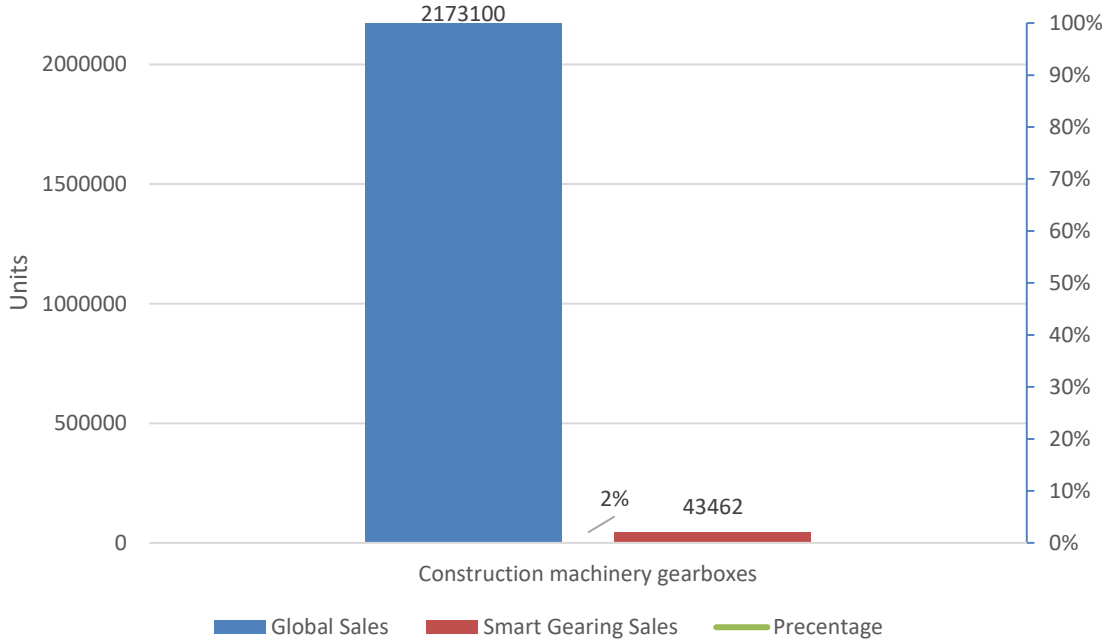

Figure 37: Gearboxes sales in construction machinery industry[144]

[144] Own illustration

Based on the forecast mentioned earlier by Off-Highway research center, the sales of construction machinery set to reach 1,086,550 units in the year of 2020. By considering the lowest average number of gearboxes per unit from the survey results, which is 2 per unit, the number of gearboxes set to be sold in 2022 is going to be 2,173,100 units. The share of Smart Gearing GmbH would be as shown in Figure 37.

6.4.1 Sales Profit

According to the determined cost per unit for the Smart Gearing gearbox, the gross sales profit from the construction machinery market in the first year of production are as shown in Figure 38.

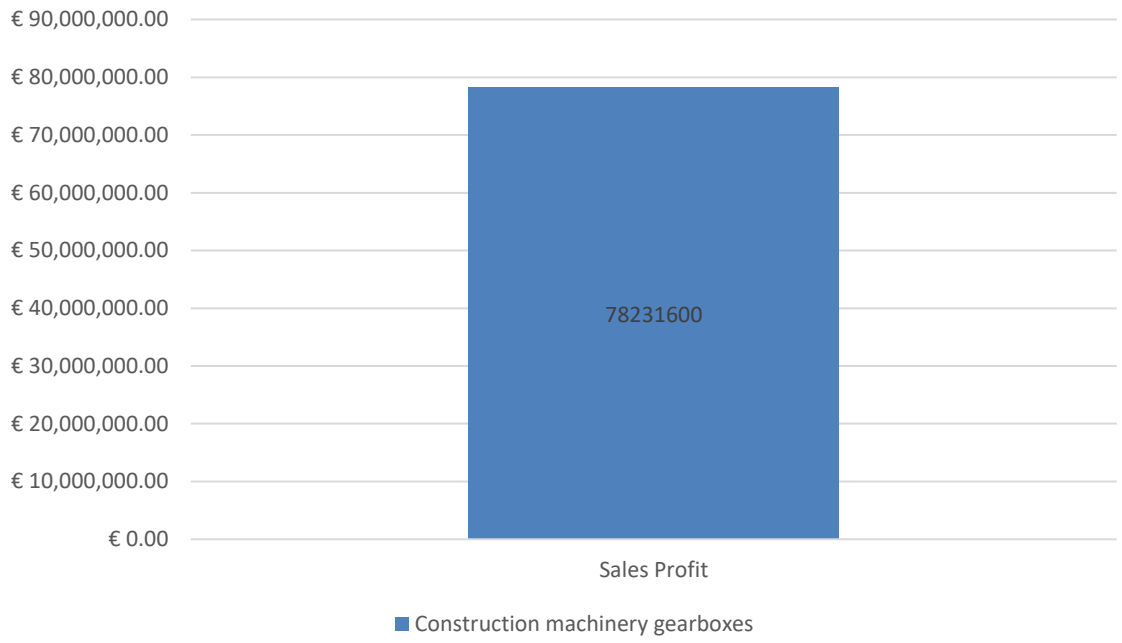

Figure 38: Sales profit from construction machinery industry in 2022[145]

[145] Own illustration

7. Wind Turbines and Solar Panels

This chapter will analyze the current market situation of both the wind turbine and solar panels industries with their forecasted market situation.

7.1 Wind Turbines

Extracting the kinetic energy from wind and conversing it to other useful types of energy is a process that goes many centuries back. The first windmills said to be invented by the Persians and the Chinese 2000 years ago, and they were used to grind corn and lift water. The Dutch developed the windmills later to drain their lands in the 14th century. The windmills were installed globally in the 19th century for pumping water and farm home water needs. By that time the windmills were developed into small wind machines in suburban areas in the United States to operate appliances. The wind turbines have been developed since then in order to find an energy source that could replace fossil fuels. In only 11 years, wind energy has shown a very positive growth, wind energy capacity has increased from 48 to 433 GW.[146]

Wind energy is considered a subordinate level form of energy, it relies on the uneven heating of the Earth's surface by the Sun's radiation, which creates a temperature difference, thus creating pressure and density differences in the air. The principle behind extracting the wind energy by the turbine blades is same principle which the aeroplane wings depend upon to give them their lift (Figure 39). A mix of lift force and drag force on the blades of the wind turbine makes the rotor spin. The spinning of the rotor turns on the generator which makes electricity.[147]

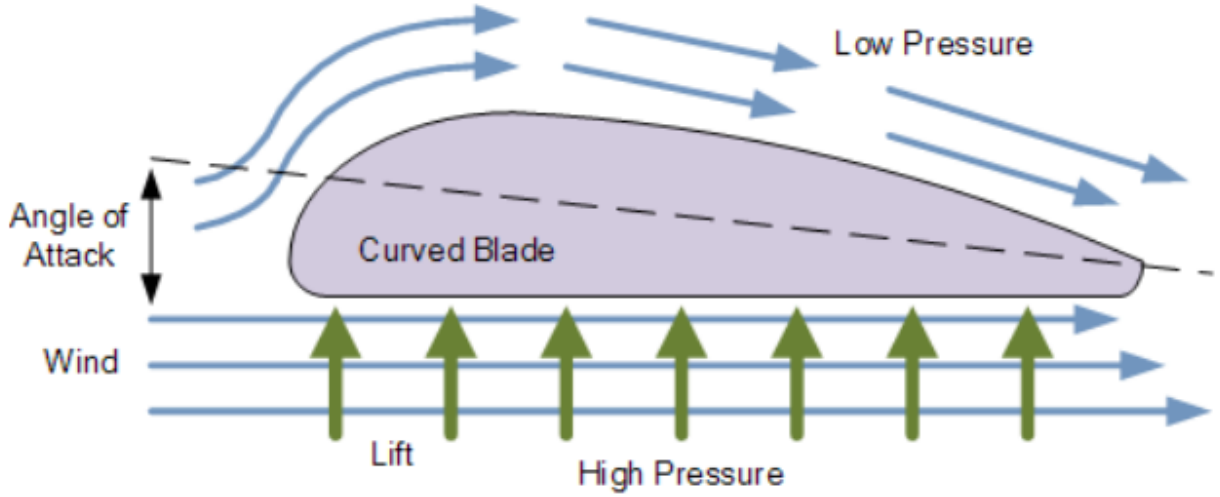

Figure 39: Forces on a wind turbine blade[148]

[146] Letcher, 2017. P. 5-7
[147] Letcher, 2017. P. 5-7
[148] Wind Turbine Blade Design, Flat or Curved. https://www.alternative-energy-tutorials.com/wp-content/cache/wp-rocket/www.alternative-energy-tutorials.com/energy-articles/wind-turbine-blade-design.html. Date of access 28/10/2020

7.1.1 Gearboxes in Wind Turbines

There are three types of gearboxes inside a typical wind turbine. The first gearbox transfers the rotational speed from the low speed shaft to the high-speed shaft. This process is required in order to supply the generator with the high speed required to generate electricity.[149]

The second gearbox is used to generate higher torques in order to move the blades of the wind turbine towards the direction of the wind to maximize the output of wind turbine generator. The system that is responsible for this action is called the Yaw Drive, and it gets its power supply from the Yaw Motor.[150]

The third gearbox has a similar function to the yaw drive. It helps on providing torque to rotate the blades to change its angle to make it face the wind. This system is called the pitch system. Figure 40 shows the three kinds of gearboxes in the wind turbine.

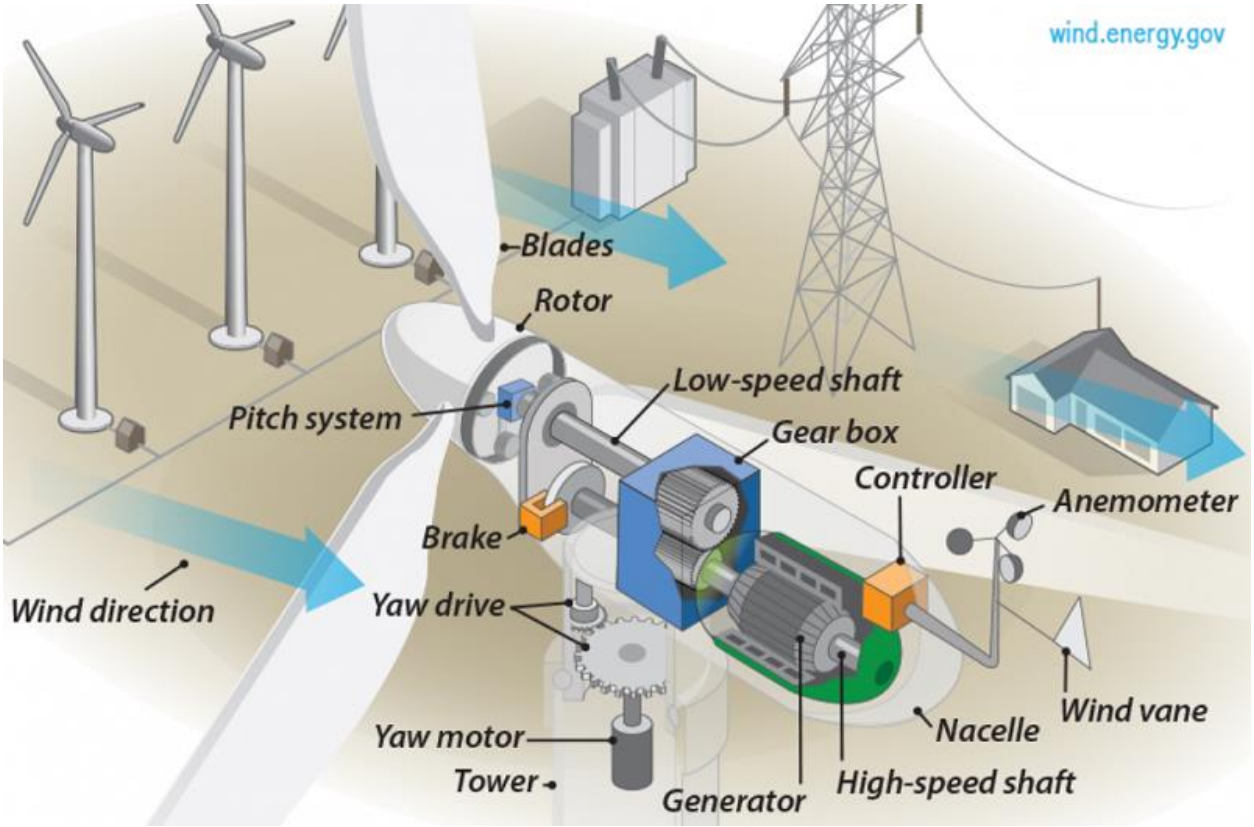

Figure 40: Wind turbine structure[151]

[149] Energiforsk, 2016. P. 11

[150] The Inside of a Wind Turbine. https://www.energy.gov/eere/wind/inside-wind-turbine. Date of access 29/10/2020

[151] The Inside of a Wind Turbine. https://www.energy.gov/eere/wind/inside-wind-turbine. Date of access 29/10/2020

7.2 Wind Turbine Industry

It is very tricky to find out the exact numbers of sold or installed wind turbines, as the wind turbine industry is measured by the installed capacity of the wind turbines fields. The number of produced or sold yaw and pitch drives that this research is concerned about in the industry of wind turbines is also not easy to acquire, as research companies ask for thousands of dollars to release such information. However, this research will talk about the wind turbine in a manner of growth or decline to figure out the situation of the wind turbine market.

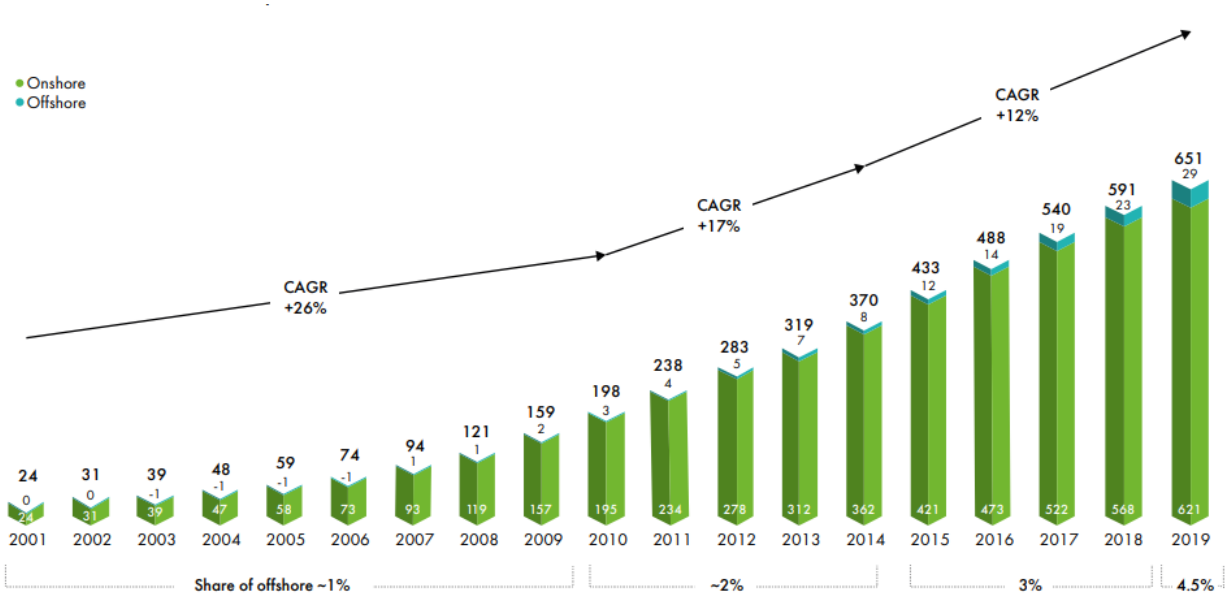

Figure 41: Historic development of total installations (onshore and offshore)[152]

Statistics from the Global Wind Energy Council shows a continues growth of the wind turbine installed capacity in the last decade (Figure 41). Countries has been investing in wind turbine installations in the search for a renewable and sustainable energy source to replace fossil fuels. Last year has seen a 10% growth in installed capacity to reach 650 gigawatts of installed capacity, the installed capacity was just 159 GW ten years ago.[153]

[152] Global Wind Energy Council, 2020. P. 43
[153] Global Wind Energy Council, 2020. P. 36

7.2.1 Wind Turbine Industry Forecast

Experts at the Global Wind Energy Council predict an ongoing growth in the installation of wind turbines. They expect the CAGR to reach 4% in the next four years. The forecasted installation of capacity is set to be 355 GW in total, which means a 71 GW of added capacity each year to the year of 2024 (Figure 42).[154]

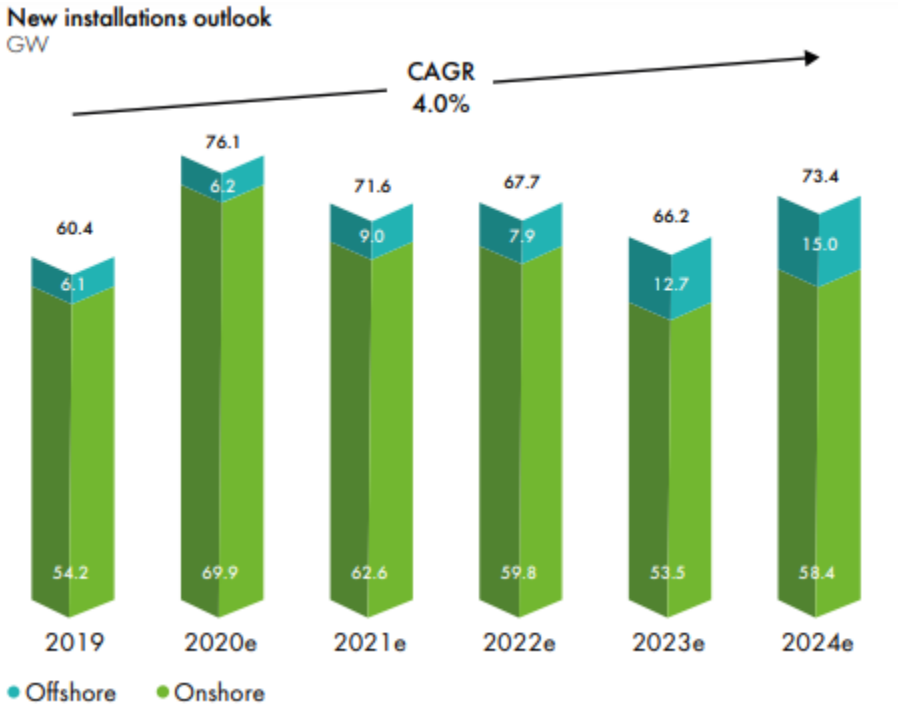

Figure 42: New installations outlook[155]

7.3 Solar Panels

A solar panel is an electronic device that has the function of converting sunlight into electricity. The requirement of this process is to have a material that when it absorbs the light, it raises an electron to a higher energy state. Afterwards, this electron moves to an external circuit from the solar cell. This electron then dissolves its energy into that external circuit, and afterwards it returns to the solar cell. The solar panels have many advantages that make it preferable by many countries and organizations, it does not require much maintenance and supervision, it has a life span of 20-30 years, it is non-polluting and require low running costs.[156]

[154] Global Wind Energy Council, 2020. P. 71
[155] Global Wind Energy Council, 2020. P. 71
[156] Bagher, Vahid, Mohsen, 2015. P. 94

7.3.1 Gearbox in Solar Panels

Gearbox in solar panels serves the same purpose as the ones in wind turbine, but instead of changing the direction and angels of the blades to face the wind, it helps in changing the angle of the solar panel to face the sun as the sun changes its position throughout the day. This is necessary to maximize the amount of solar energy captured by the solar panel as it is a matter of its orientation[157]. The system responsible for this operation is called the solar tracker (Figure 43).

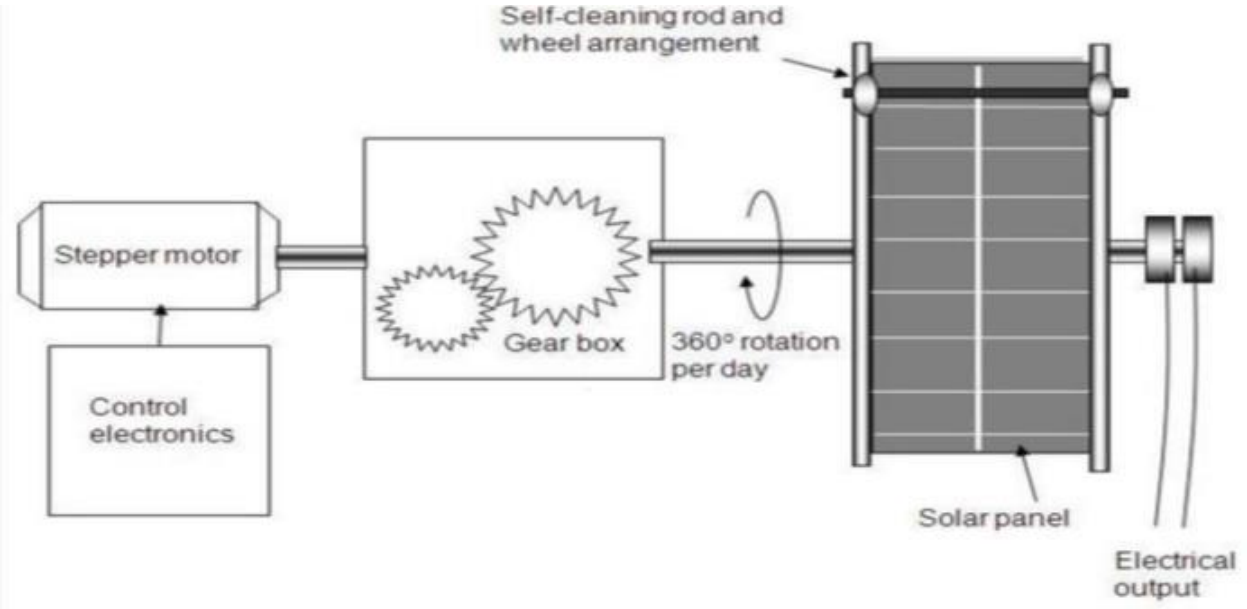

Figure 43: Schematic diagram of Sun tracking[158]

7.4 Solar Panels Industry

Like the wind turbine's industry, the solar panel's industry is described by the amount of installed capacity. Also, the number of sold solar trackers globally cannot be acquired as research companies ask for thousands of dollars to sell their researches. Therefore, this research will talk about the status of the solar panels industry in a manner of growth and decline.

[157] Dobson, Prinsloo, 2015. P. 3-32
[158] Kandalkar, Jaqtap, 2013. P. 2

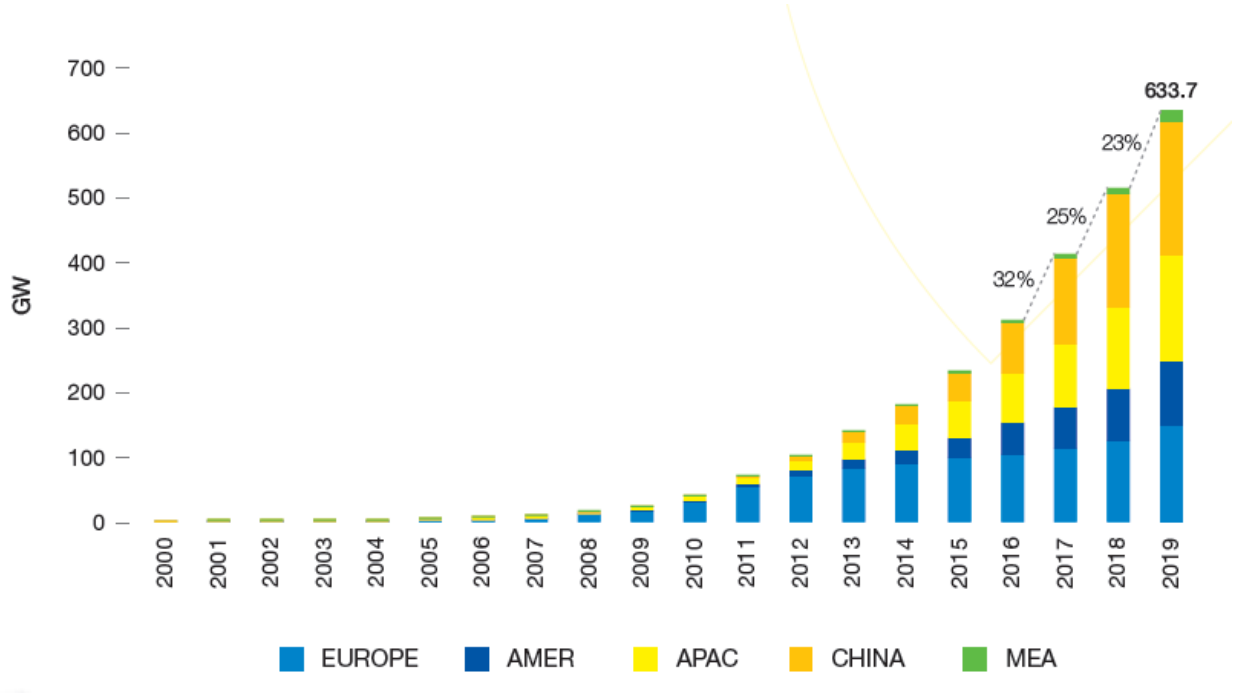

Figure 44: Total solar PV installed capacity 2000-2019[159]

Statistics coming from Solar Power Europe shows that solar power capacity installation has been in the rise since the beginning of the 21st century. The industry has seen an interest from governments and investors to replace fossil fuels especially in the last decade. Since the start of this century, solar power has seen a grown by nearly 400 times (Figure 44).[160]

7.4.1 Solar Panels Industry Forecast

Experts in Solar Power Europe expect the solar power industry to continue its growth in the upcoming years (Figure 45). They have made two scenarios for their prediction of growth in the next 4 years based on many reasons. One of the reasons is because the Chinese government has had restrictions on solar energy in the past years, even though China is the leading country in the solar energy installations. A significant growth is also expected in India, the United States and Europe.[161]

[159] SolarPower Europe, 2020. P. 20
[160] SolarPower Europe, 2020. P. 7-23
[161] SolarPower Europe, 2020. P. 24-29

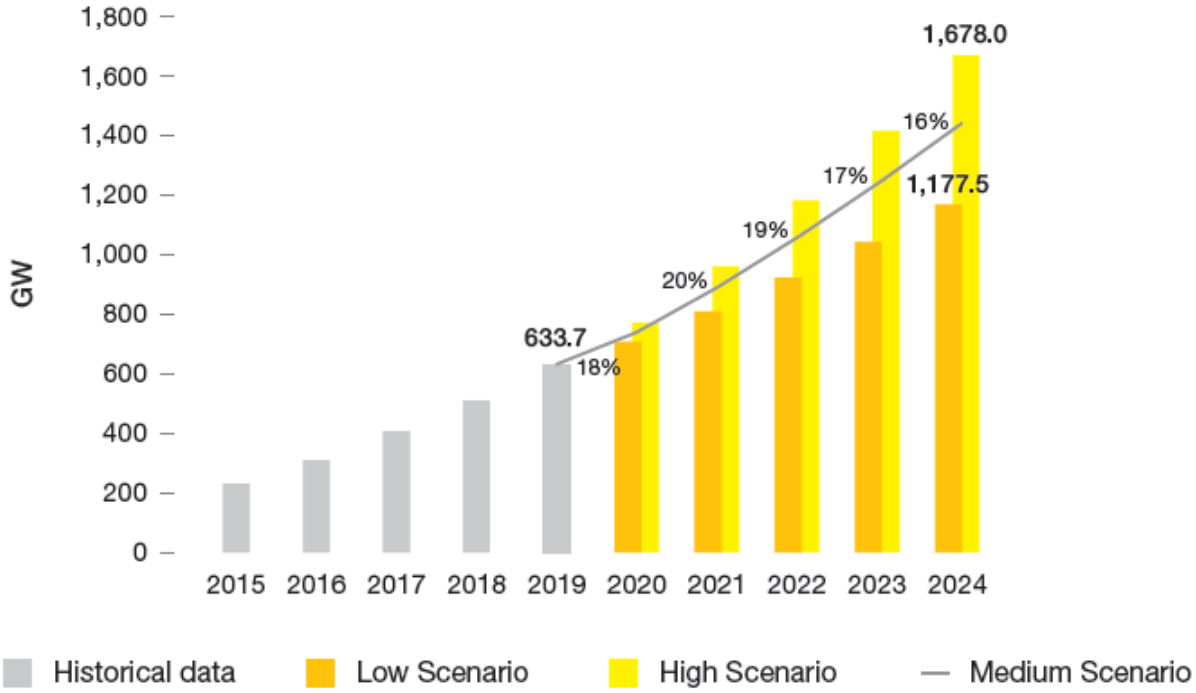

Figure 45: Total solar PV market scenarios 2000-2024[162]

7.5 Survey

The primary research in this study relies on surveys. Therefore, a survey has been sent to some of the manufacturers of wind turbines and solar panels to gain information that will help in validating the secondary research that this study has made.

7.5.1 Survey Questions

The survey consisted of eight questions, some of which are mandatory questions and the others are not. The following are the questions of the survey with the suggested answers given for participants:

1 - In which region does your company operate?

- Asia
- Europe
- United States

[162] SolarPower Europe, 2020. P. 27

2 – Do you use motors with gearbox to adjust the position of the blades/panels in the wind turbine/solar unit?

- Yes
- No

3 – What type of gearboxes are used?

- Planetary
- Strain wave
- Other( )

4 – On average, how many gearboxes used in one wind turbine/solar panel's adjustment?

- 1
- 2
- 3
- More( )

5 - Which gearbox manufacturer do you get your gearboxes from?

6 – How many wind turbines/solar panel's adjustment did your company produce in 2019?

7 – How many wind turbines/solar panel's adjustment did your company produce in 2020?

8 – Do you see a rise or downfall in the wind turbines/solar panel's adjustment industry in the upcoming years?

- Rise
- Downfall

7.5.2 Survey Results

Once again, the survey did not have much participants as this research aimed for. Only 3% of the approached companies has participated in the survey (2 out of 60, 1 from each industry).

1- Operation region:

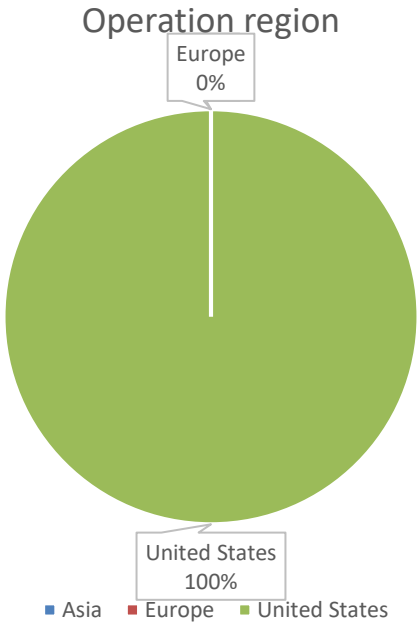

Figure 46: Operation region of the participants[163]

2- Whether the participant uses gearboxes or not:

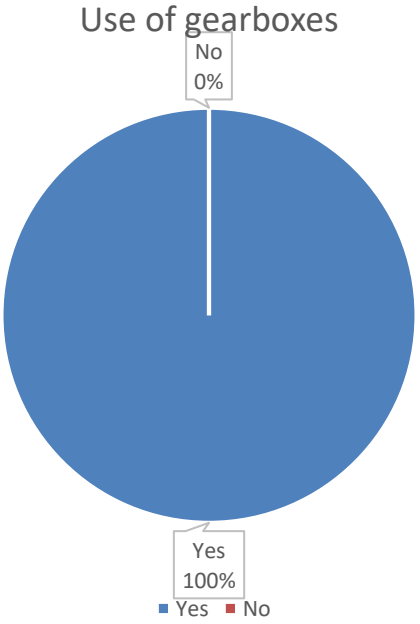

Figure 47: Whether the participant uses gearboxes or not[164]

[163] Own illustration
[164] Own illustration

3- Type of Gearboxes used:

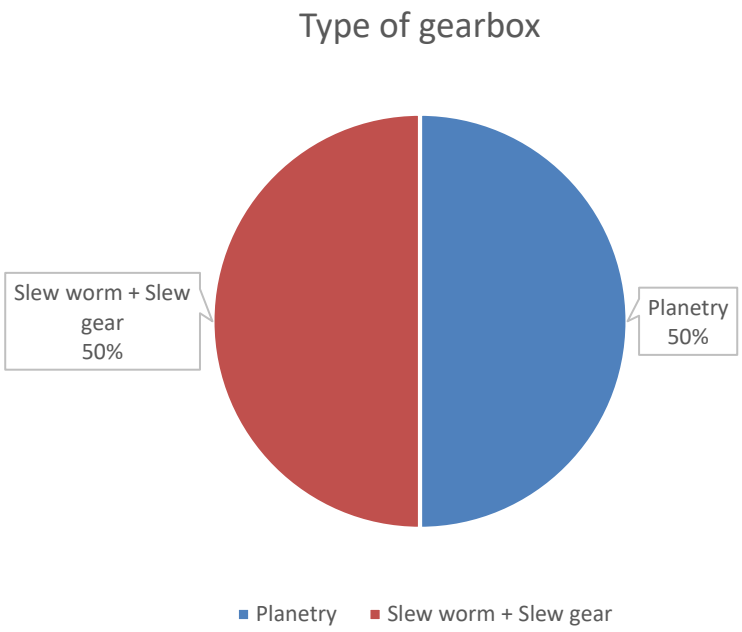

Figure 48: Type of gearbox used by the participant[165]

4- Number of gearboxes used in one unit:

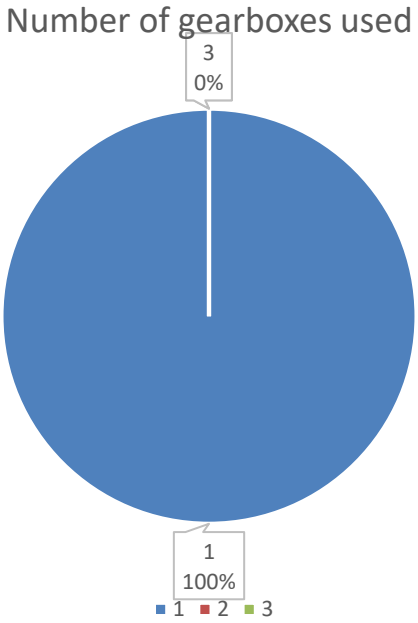

Figure 49: Number of gearboxes used in one unit[166]

[165] Own illustration
[166] Own illustration

5- Gearbox supplier:

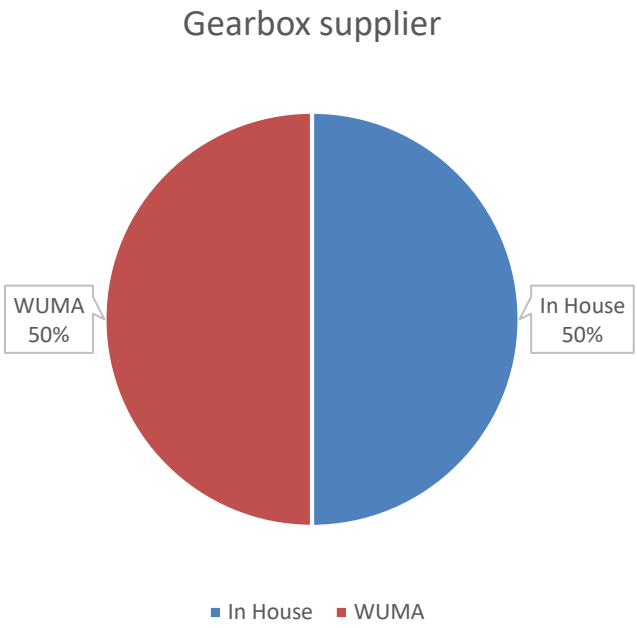

Figure 50: Participant's gearbox supplier[167]

6 & 7- Units produced in 2019 & 2020

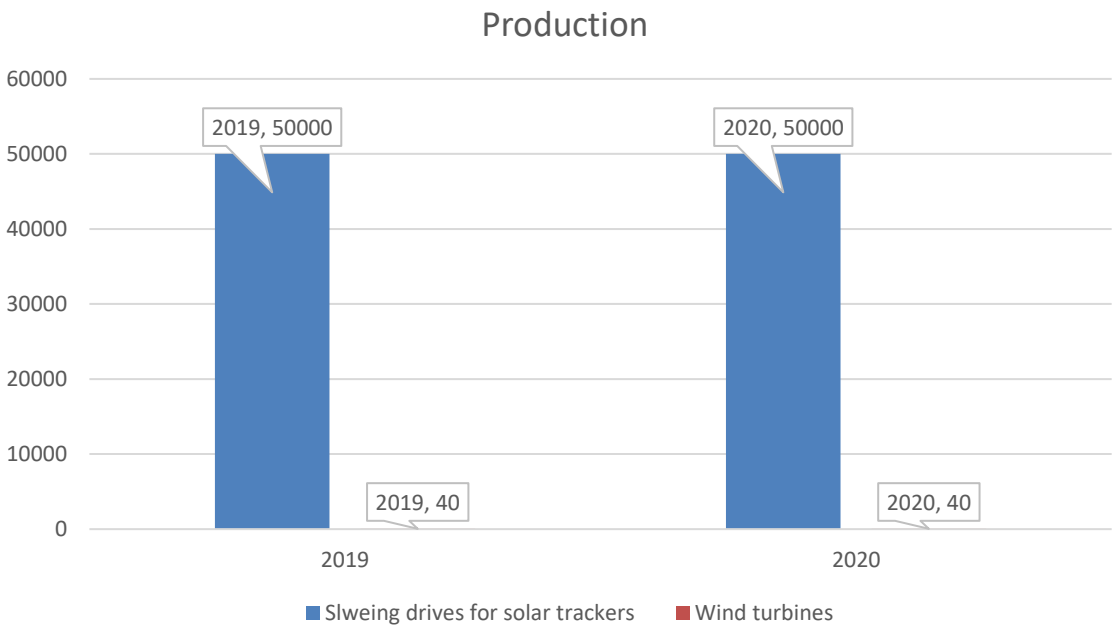

Figure 51: Number of produced units in 2019 & 2020[168]

[167] Own illustration
[168] Own illustration

8- Rise or downfall in the industry:

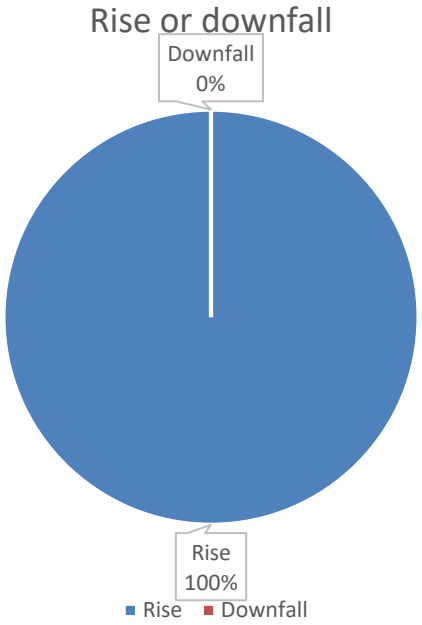

Figure 52: Participant's opinion on rise or fall of the industry[169]

7.5.3 Results Analysis

Due to the small number of participants in this survey, the results did not come out as expected. However, the results do validate the secondary research in this research in some areas. The results validate the use of gearboxes inside the wind turbine and in solar panel's installation to move the unit to maximize the output. The results show a big number in production of drives for solar tracker from just one manufacturer. This manufacturer is not even one of the leading manufacturers in the industry. The results also reveal the opinion of the participants on whether they see a rise or fall in the industry, and all the participants said that they see a rise in both industries.

7.6 Market Plan

It may not be possible to accurately set a market plan in this section due to the lack of accurate information about the two industries this research is considering and their market status. However, an assumption will be made based on the information gathered from the secondary research and from the results of the survey conducted.

[169] Own illustration

According to a research made by a consulting agency in 2008, the market estimate of the production of yaw and pitch drives for wind turbine was 118,000 units[170]. The wind energy has grown almost five times the number it was in 2008[171]. The minimum assumption is to assume that the pitch and yaw production has grown in the same way. Thus, based on this assumption, the production of pitch and yaw drives will be near 600,000 units this year. This assumption is also does not take into count the growth in the wind turbine industry in the upcoming years. The assumption of taking 2% of the industry will be 12.000 units.

In the solar tracker industry, one of the survey participants has indicated that his company produces 50,000 gearboxes for solar trackers per year. The company which this participant belongs two is a medium sized company in China that is not listed in the top providers of gearboxes to solar trackers manufacturers. A study made by Wood Mackenzie Power & Renewables shows that 89% of the PV tracker's market is distributed among 10 suppliers, and all other suppliers are rounded to just an 11% of the market share[172]. Therefore, an assumption will be made that Smart Gearing GmbH will penetrate the solar tracker's market with half of the production of this company. This means a sale of 25,000 units for solar trackers in the year of 2022 (Figure 53).

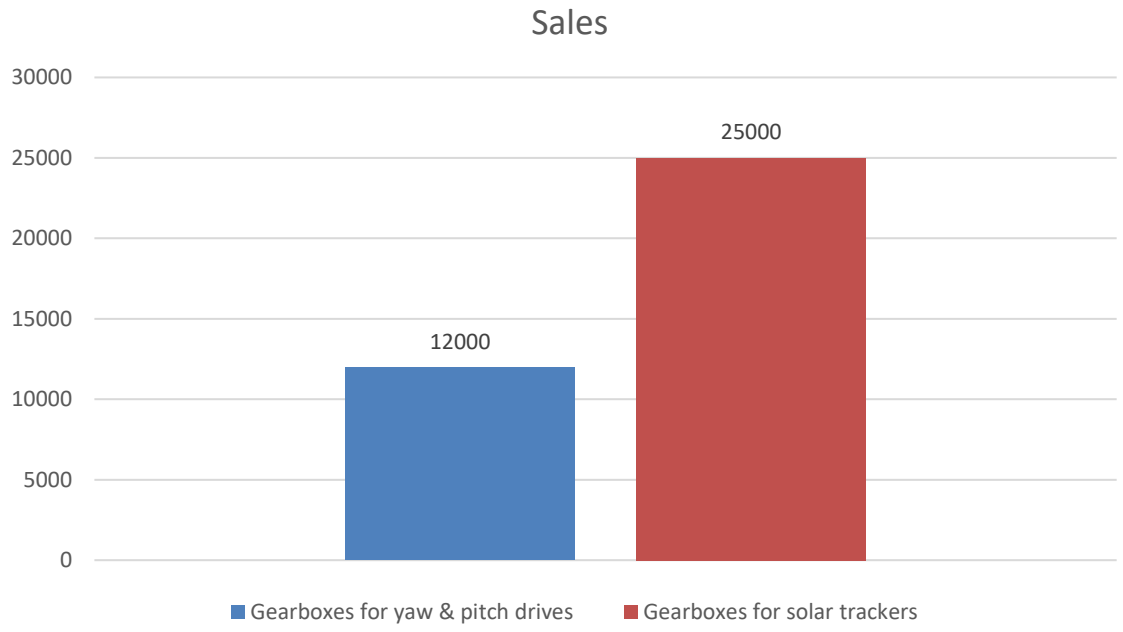

Figure 53: Gearboxes sales for wind turbine and solar panels industries[173]

[170] Marson, 2010. P. 30
[171] Global Wind Energy Council, 2020. P. 43
[172] Own illustration
[173] Wood Mackenzie Power & Renewables, 2019. P. 10-12

7.6.1 Sales Profit

According to the determined cost per unit for the Smart Gearing gearbox, the gross sales profit from the construction machinery market in the first year of production are as shown in Figure 54.

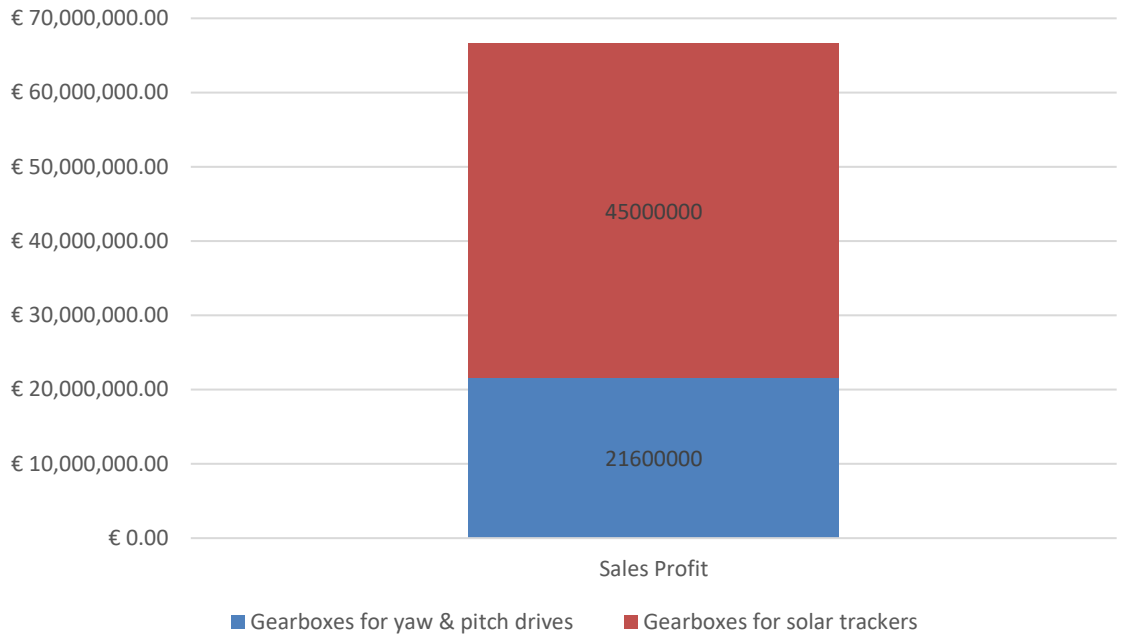

Figure 54: Sales profit from wind turbine and solar panels industries in 2022[174]

[174] Own illustration

8. Total Market Plan

The total market plan will be discussed here based on the research made in the previous chapters.

8.1 Sales Plan

Smart Gearing GmbH has a sales plan for its first four years in the market. This plan is as follow:

Table 5: Smart Gearing GmbH sales plan 2022-2025

Year	Sales
2022	Around 50,000 units
2023	Around 100,000 units
2024	Around 150.000 units
2025	Around 170.000 units

This plan defines the forecasted capacity of the company in the first years of initiation. This will be analyzed according to the four industries that this research has analyzed in the previous chapters.

8.1.1 Accumulative markets Forecast

The following table will represent the accumulative forecasted sales in all the industries mentioned earlier in this research in the year of 2022, which is the planned year for the start of selling the gearbox.

Table 6: Accumulative forecasted sales

Industry	Sales
Robotics	78,738 units
Construction machinery	43,462 units
Wind turbine	12,000 units
Solar Panel	25,000 units
Sum	159,200 units

This table shows that the accumulative forecasted sales in all the industries is more than three times bigger than the forecasted sales plan in the first year of production. This works out as a positive indicator to the significant market opportunity for Smart Gearing GmbH. The market of industrial gearboxes is quite large, demanding and is predicted to grow in the upcoming years. Hence that this is a market analyze for only four industries that require the use of industrial gearboxes, otherwise, the market of industrial gearboxes is much more than these four industries.

8.2 Sales Profit

According to the determined cost per unit for the Smart Gearing gearbox, the gross sales profit from all sales forecasted in the sales plan for the first four years will be as shown in the following table.

Table 7: Sales profit according to the Smart Gearing GmbH sales plan

Year	Sales profit
2022	90,000,000 Euro
2023	180,000,000 Euro
2024	270,000,000 Euro
2025	306,000,000 Euro

8.3 Other Sources of Profit

So far, this research has analyzed the gross profit coming from direct sales in four different industries. However, Smart Gearing GmbH has other services that it can provide to customers that is predicted to be significant sources of profit that is no less important than direct sales.

8.3.1 Pay by Hour & Pay by Power

Renting of equipment & equipment leasing is something that is popular in many industries, e.g. construction machinery renting and leasing. Smart Gearing GmbH plans to offer its customers the option paying for the gearbox either by an hourly rate or by usage and energy consumption.

8.3.2 Smart Services

Smart Gearing GmbH also plans to offer their customers a wide variety of smart services. These services include an optional integrated sensor inside of the gearbox-motor packing that enables the costumers to execute different tasks like changing the ratio of the gearbox. This will be done by the option of different installations of sensors and different versions of software. One major smart service that Smart Gearing GmbH is also providing is the possibility of predictive maintenance. Some industries work around the clock and cannot afford a downtime in one of its equipment's, and Smart Gearing predictive maintenance will help in preventing that. Also, some equipment has a low feasibility, and with the predictive maintenance it would be possible to know the exact timing of required repairs and maintenance to plan this ahead of time and avoid any loss of costs due to reparation and downtime.

9. Conclusion

The industrial gearbox's market is one of the most demanding markets. Almost every industry uses industrial gearboxes one way or another. By investigating only four of many industries that use industrial gearboxes, this research has found that penetrating the industrial gearbox market in a small planned market share is quite an achievable target. Especially that Smartt Gearing is providing a state-of-the-art technology that is unlike any other in the market at this period.

The strategy that this research was following during the analysis of the desired industries and in making the market plan was to penetrate the desired industries with only 2 % of its market share. After analyzing the accumulative forecasted sales in all the industries, it has been found that 2 % of each market is even three times more than the planned sales target of Smart Gearing GmbH. This means that if this research even lowered the percentage aiming for to half the initial percentage and make it only 1% of each industry, the accumulative forecasted sales will also surpass the planned sales target of Smart Gearing GmbH. This can be shown in the following table.

Table 8: Accumulative forecasted sales in 1% of each market share

Industry	**Sales**
Robotics	39,369 units
Construction machinery	21,731 units
Wind turbine	6,000 units
Solar Panel	12,500 units
Sum	79,600 units

This is again only the four industries that this research has analyzed. This shows that it is a very achievable target for Smart Gearing GmbH to penetrate the industrial gearboxes market with the full production capacity that Smart Gearing GmbH has planned for. Especially with the qualities that Smart Gearing GmbH is offering and the smart services it is providing to its customers.

Industries

The industries that this research has analyzed are:

1- Robotics
2- Construction machinery
3- Wind turbine
4- Solar Panels

Each one of these industries are predicted to grow in the upcoming years. However, there are many other interesting markets that are advised to be investigated in further studies.

9.1 Further Studies

There are some points that is advised to be analyzed in future studies in order to enhance the work of this research. These points are divided in the following sections.

Markets

As has been mentioned earlier that this research has investigated the market situation in only four industries. However, there are many more industries and markets that the use of industrial gearboxes is critical in them. Following are some of the most interesting markets:

- Medical equipment and laboratory equipment
- Industrial equipment and tools
- Aerospace and aviation
- Steel industry
- Cement Industry
- Paper Industry

The list of industries contains many more that all of them cannot be listed here.

Marketing Plan & Strategy

In order to reach out to the costumers, Smart Gearing GmbH should make a detailed marketing plan and strategy to convince costumers into buying its product. Especially that it is new to the market and business owners will need to hear what this product has to offer and what makes it better than the other known gearboxes from leading manufacturers in the market.

The Effect of Covid-19

The effect of Covid-19 and the pandemic it caused has not only affected the healthcare sector, it has reached out to almost every industry and made a huge effect to the global economy. Something that has not been seen since the global economic crisis in 2008. Therefore, it is advised to investigate the effect of Covid-19 in the industrial gearboxes market in precise and the targeted markets in general. While making the marketing plan and strategy for Smart Gearing GmbH it is a must to take in consideration the effect of Covid-19, in order to find ways to reach out to the customers in this economy and to avoid unplanned circumstances, like the ones that the world has seen this year.

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11. List of Figures

12. List of Tables

Appendix

List of Companies Which the Survey Has Been Sent to in Robotics Industry

1- PIAGGIO FAST FORWARD (USA)
2- SPHERO (USA)
3- DILIGENT ROBOTICS (USA)
4- PICKNIK ROBOTICS (USA)
5- ANYBOTS (USA)
6- BOSTON DYNAMICS (USA)
7- SARCOS (USA)
8- BARRETT TECHNOLOGY (USA)
9- AMP ROBOTICS (USA)
10-LEFT HAND ROBOTICS (USA)
11-HONEYBEE ROBOTICS (USA)
12-ENERGID TECHNOLOGIES (USA)
13-RETHINK ROBOTICS (Germany)
14-VECNA ROBOTICS (USA)
15-6 River Systems (USA)
16-ABB
17-Agility Robotics (USA)
18-ARM Institute (USA)
19-AutoGuide Mobile Robots
20-Blue Ocean Robotics ApS
21-Bossa Nova Robotics (USA)
22-Built Robotics Inc (USA)
23-Energy Robotics & ExRobotics (Germany)
24-Fetch Robotics (USA)
25-Geekplus Technology
26-Kinova (Canada & Germany)
27-New Scale Robotics (USA)
28-Robotics Plus (New zealnd)
29-Universal Robots (Germany)
30-Waypoint Robotics
31-Yaskawa Motoman
32-Clearpath Robotics (Canada)
33-Comau (Italy)
34-Dobot (China)
35-Fastbrick Robotics (Australia)
36-Genrobotics (India)

37-Robotics Design (Canada)
38-Robotnik Automation (Spain)
39-Sastra Robotics (India)
40-Stäubli (Swiss)
41-Mitsubishi Robotics (Japan)
42-Fanuc (Japan)
43-Omron robotics (USA)
44-Apex Automation and Robotics (Australia)
45-Aurotek Corp (Taiwan)
46-Kawasaki Robotics
47-German Robotics (Germany)
48-B+M Surface Systems GmbH
49-Kuka
50-Epson robots
51-Dürr (Germany)
52-DENSO Corporation
53-Nachi-Fujikoshi (Japan)
54-Yamaha (Japan)
55-IGM
56-Siasun Robot and Automation
57-Schunk (Germany)
58-HRG robotics
59-Doosan Robotics (Korea)
60-Techman Robot (Japan)
61-Hyundai Robotics (Korea)
62-Bosch (Germany)
63-Kawada
64-TAL Brabo (India)
65-TM Robotics
66-Toshiba Robotics
67-ST Robotics
68-Delta Electronics (Taiwan)
69-Franka (Germany)
70-Mecademic

List of Companies Which the Survey Has Been Sent to in Construction Machinery Industry

1- Caterpillar (USA)
2- Komatsu (Japan)
3- Volvo CE (Sweden)

4- Hitachi Construction Equipment (Japan)
5- Fiori Group (Italy)
6- Liebherr (Germany)
7- Zoomlion (China)
8- Terex (USA)
9- Sany (China)
10-Doosan Infracore (South Korea)
11-John Deere (USA)
12-BOMAG
13-CASE construction equipment (Germany)
14-Bobcat (USA)
15-Kobelco Construction Machinery
16-Metso
17-New Holland Construction
18-hyundai heavy industries
19-Wirtgen Group
20-Manitovoc (USA)
21-Tadano
22-Liugong (China)
23-wacker neuson (Germany)
24-Manitou (France)
25-Kubota (Japan)
26-sumitomo heavy industries (Japan)
27-Palfinger (Austria)
28-Lonking (China)
29-Shantui (China)
30-Hiab (Sweden)
31-Bauer Foundation
32-Takeuchi (Japan)
33-XGMA (China)
34-Ahern (Canada)
35-Frontline Machinery (Canada)
36-Bigge Crane and Rigging (USA)
37-Neremat (Belguim)
38-Maxim Crane Works (USA)
39-Morrow Equipment (Australia)
40-Wolffkran (Swiss)
41-Tat Hong Equipment Service (CHIna)
42-Uperio
43-NFT (UAE)

44-Shanghai Pangyuan Machinery Rental (china)
45-Xuzhou heavy machinery (XCMG) (china)
46-Buckner Heavylift Cranes (USA)
47-Prangl
48-Lampson International
49-Sarens (Belgium)
50-Mammoet

List of Companies Which the Survey Has Been Sent to in Wind Turbine and Solar Panel Industries

Wind turbine companies:

1- CSIC Haizhuang Windpower Equipment (China)
2- Goldwind (China)
3- HEAG (China)
4- Shanghai Electric (China)
5- Sinovel (China)
6- GE Renewable Energy (USA)
7- Inox Wind (India)
8- RRB Energy Limited (India)
9- Pioneer Wincon (India)
10-Suzlon (India)
11-Enercon (Germany)
12-Acciona (Spain)
13-Nordex SE (Germany)
14-NovaWind (Russia)
15-Senvion (Germany)
16-UNISON (Korea)
17-Hanjin (Korea)
18-Hitachi (Japan)
19-Mitsubishi (Japan)
20-Leitwind (Italy)
21-Siemens Gamesa Renewable Energy (Germany/Spain)
22-TECO (Taiwan)
23-Vergnet (France)
24-Vestas (Denmark)
25-WEG (Brazil)
26-Xant (Belgium)
27-Energie Burgenland (Austria)
28-DEIF Wind Power Technology (Austria/Denmark)

29-ATB
30-viking wind (Denmark)

Solar panels companies:

1- Infiniteercam (India)
2- Akcome (China)
3- Sunslew (China)
4- Jinhong (China)
5- Josef Reuke Maschinenbau (Germany)
6- Joyce/Dayton (USA)
7- JSolar (China)
8- Kipp & Zonen (Netherlands)
9- Kirchner Solar Group (Germany)
10-Konza Solar (USA)
11-KR Solar (USA)
12-KT-Electronic (Hungary)
13-LTE (France)
14-Mass Mega Watts (USA)
15-Mecasolar (Spain)
16-Morgan Solar (Canada)
17-Nclave (Spain)
18-Nevados Engineering (USA)
19-Nextracker (USA)
20-Nihon Dentaku (Japan)
21-OMCO Solar (USA)
22-Ontrack Solar (USA)
23-Optima Renovables (Spain)
24-Optimum Tracker (France)
25-Pars Makina (Turkey)
26-Paru (Korea)
27-Point Load Power (USA)
28-Politeconaço Industrial (Brazil)
29-Poulek Solar (Czech)
30-Suntracker (Austria)