Market Analysis of Automotive Thermal Testbeds

Master Thesis

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Graz, August 2017

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I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

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Abstract

The Austrian company qpunkt GmbH introduces a sophisticated air conditioning (A/C) system testbed (thermal walk-in chamber) on the automotive thermal system market. Since this testing system requires a lot of investment, it was decided to conduct a market research. The necessary information for this thesis was obtained through primary and secondary research which include telephonic interviews, e-mail interactions as well as reviews of company reports and technical journals. The research begins with the automotive market overview that considers current automotive trends affecting thermal systems industry and emerging automotive thermal technologies. The study also provides estimates in terms of alternative vehicles penetration and analyses their impact during the defined period. The findings indicate that thermal management is in demand at the moment, and therefore the release of a thermal walk-in chamber has a chance to succeed. To identify potential customers and define their needs, customer analysis is conducted. As a part of the customer analysis, market segmentation through hierarchical cluster analysis is presented and an individual approach as well as a strategies for each group of customers are developed. An implication of this is a recommendation for qpunkt GmbH to begin with targeting niche customers that represent luxury and sport cars. In order to provide deeper understanding of the current competitive situation and to assess the position of a new product on the market, in terms of technical characteristics, competitive benchmarking is used. The analysis shows that the thermal stand from qpunkt is competitive, but at the same time, there is still room for improvement with regard of temperature range. Additionally, to create possible business strategies for a new product and for the company qpunkt as a whole, a SWOT analysis with subsequent TOWS analysis is applied. Taken together, in order to strengthen the position in the market, the company should propose more innovative technologies as well as set a focus on internal and external communications. The automotive market is changing rapidly, and therefore the main recommendation for qpunkt is to track existing and emerging trends through regular marketing analysis.

Acknowledgement

I would like express my sincere gratitude to everybody who was important for successful realization of my thesis.

Firstly, I offer my utmost gratitude to my supervisors DI Sigrid Swobodnik and DI Julia Soos for the continuous support and valuable advices that given my thesis its present shape.

Secondly, I would like to thank each person of the qpunkt staff for their concern and support. But foremost I gratefully acknowledge DI Michael Bires for his guidance and encouragement. Many thanks go to Verena Klampferer, Maximilian Vilniskis, and Marijan Simek. It was a pleasure working with all of you.

My deepest gratitude goes to my family and my boyfriend for their love, patience, and unending support.

Content

1 Introduction

At present, despite various points of view, it is clear that marketing determines the success of a company, regardless of its form of ownership, size and organizational structure. Marketing defines the relationship between the company and the external environment through marketing analysis aimed at identifying the competitive position of the enterprise and its potential opportunities in the relevant market.[1] Especially it concerns the launch of a new product because it always involves some risk for the company.

This thesis is dedicated to the business of the qpunkt company, which plans to release a new product, which can bring great benefits to the company. In order to avoid expansive mistakes, the potential market for the A/C system testbeds was analysed and some strategies were created.

1.1 Background

The Austrian company qpunkt GmbH is a well-established and innovative specialist for vehicle development and sets new standards in the fields of automotive thermal management, air conditioning, vehicle cooling, computational fluid dynamics, test bed engineering, system- and component testing, design, acoustics, and e-mobility. qpunkt was founded in spring 2008 by five former Magna employees. The founders saw great potential in the field of thermal management in the automotive industry when they were working at Magna. However, Magna's strategy did not allow the division to grow further.[2]

The company was growing rapidly and currently qpunkt has more than 120 employees. Since February 2014 qpunkt has been a member of the AVL Group. The headquarters is situated in Graz, Austria, and four additional branches are located in Germany. qpunkt has thermal test fields in Graz, Ingolstadt, and Stuttgart which are used to test refrigeration cycles or entire air-conditioning systems of passenger cars, commercial vehicles and trucks as well as individual components such as a refrigerating compressor. This in-house test field can be adapted to meet a wide variety of customer needs.[3]

qpunkt has a lot of knowledge about pre-development and simulation methods. Unlike competitors who produce a large number of standardized test stands, qpunkt builds up modular test systems that can be adapted to individual customer requirements.
Most of qpunkt customers are Original Equipment Manufacturers (OEMs) such as Audi, VW and BMW, mainly positioned in the premium segment. Additionally qpunkt customers are automotive suppliers for thermal systems like Mahle. Currently, the export rate of qpunkt is 85%. Customers are mainly from Europe and a minor amount from Asia.

[1] Gerasimov, Konovalova, Satalkina N.I., and Terechova (2012, p. 3)
[2] qpunkt Gmbh (2016)
[3] qpunkt Gmbh (2016)

In the future, customers would like to operate tests at their own fields and therefore to purchase thermal A/C testbeds. This demand opens a new business area for qpunkt. In fact, qpunkt's customers are also the companies that are considered to be active in the thermal management business and are actually classified as competitors of qpunkt. Consequently, there is a risk that qpunkt will share the know-how with thermal engineering companies and later on they will offer thermal testbeds on the market as well.[4]

1.2 Aims and Objectives of the Work

The aim of the project is to investigate the potential market for a new product from the company qpunkt, an A/C system testbed. The study objectives include:

1. Determination of the potential market for automotive thermal testbeds in Europe, Asia, and North America
2. Identification and segmentation of potential customers of automotive thermal testbeds
3. Examination of qpunkt's competitors and their products in the automotive thermal testbeds area with further technical benchmarking
4. Analysis of the position of qpunkt in the market with the subsequent creation of possible business strategies for the automotive thermal testbed and the company as a whole

1.3 Scope and Limitation of the Study

This thesis focuses on air conditioning system testbeds, also called walk-in chambers, designed for testing cars.

Market analysis has been carried out in the following markets:

- Europe (Germany, Austria, Italy, Great Britain, Sweden, Holland, France)
- Asia (India, China, Japan, Korea)
- North America (USA, Canada)

The time interval which is considered in the thesis was limited to the year 2030 in order to obtain reliable and up-to date information regarding the automotive market.

1.4 Structure of the Thesis

The paper is divided into four following parts:

Part 1:
The first part gives an overview of the automotive industry, including its trends and limitations. The main focus on trends that can be relevant to thermal test systems.

[4] Bires (2016)

Part 2:
In the second part, a customer analysis is presented. This covers identification and description of current and potential customers of qpunkt, as well as their segmentation into 6 different clusters united by similar needs and characteristics.

Part 3:
In the third section benchmarking is conducted by comparing A/C system testbeds of main players of thermal testing technologies industry. Here, the main competitors of the company were identified.

Part 4:
In the final step, possible business strategies are defined by using two effective marketing tools: SWOT analysis and TOWS matrix.

2 Theoretical Background

This chapter gives a brief overview of theoretical principles of marketing and market research with a special focus on industrial marketing and marketing strategies. Furthermore, it gives an insight on the types of thermal testbeds

2.1 Defining Marketing

Various definitions of 'Marketing' can be found. American Marketing Association has provided a formal definition, in which marketing "is the activity, a set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large".[5] Kotler and Armstrong claim that handling these exchange processes causes a considerable amount of work and skill. Marketing management happens when at least one party to a potential exchange thinks about the ways of progress of other parties. That means that the purpose of marketing management is choosing target markets and getting, keeping, and growing customers through creating, delivering, and communicating customer value.[6]

2.1.1 Marketing Process

According to Kotler and Armstrong, the marketing process consists of a five-step model illustrated in Figure 1.

In the first step of the marketing process, it is necessary to understand customer needs and determine company marketplace in order to create a customer value. Subsequently, a customer-driven marketing strategy must be designed. Development of this strategy consists of three following stages: customer segmentation, market targeting, and market positioning (STP process). STP process is described in detail in Chapter 2.4. The next step will be the development of further marketing programs and plans that deliver superior value to target customers. This step involves marketing mix which is described in Chapter 2.1.1. At the forth step, customer relationships need to be built and managed by delivering outstanding value and satisfaction. The first four steps consist of the company's work which are activities that create value for customers and build strong customer relationships. These actions lead a company to the final step to getting results in the form of profit and customer equity.[7]

[5] American Marketing Association (2013)
[6] Kotler and Keller (2012, p. 5)
[7] Kotler and Armstrong (2012, p. 5)

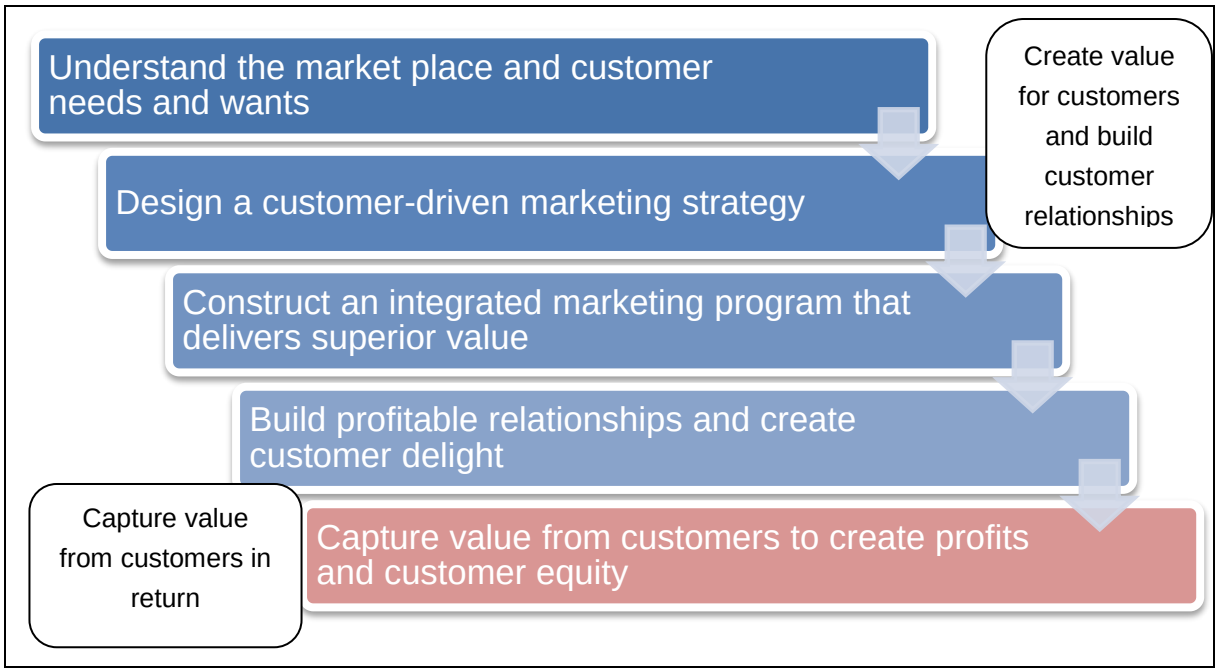

Figure 1: A Model of the Marketing Process[8]

2.1.2 Marketing Tools

In this section the most common marketing tools including marketing mix and SWOT analysis are presented.

2.1.2.1 Marketing Mix

Baker determined marketing mix as "a set of tools available to an organization to shape the nature of its offer to customers. The mix is not based on any theory, but on the need for marketing managers to break down their decision making into a number of identifiable and actionable headings."[9] Various marketing activities were classified by Perreault and McCarthy into marketing-mix tools of four major decision areas: product, price, place, and promotion.[10]

Product

The product is often seen as the most important element of the marketing mix and is the physical item that needs to fit customer requirements in order to reach company's targets. The product cannot succeed on the market if the price is far away from the price that customers are willing to pay.[11]

[8] Kotler and Armstrong (2012, p. 5)
[9] Baker (2003, p. 598)
[10] Perreault and McCarthy (2002, p. 58)
[11] Gerasimov et al. (2012, p. 7)

Price

The price refers to the amount of money that customers are ready to pay for a product.[12] A price process starts with a strategy. The market launch is a major gate for the competitiveness of the pricing. Annual updates follow as well as a possible re-positioning at mid-lifecycle and strong re-positioning for run-out.[13]

Place

The place describes the distribution channels and means the function where buyers meet a product or service.[14]

Promotion

Promotion defines marketing activities and communications and raises the awareness of the benefits of the product or service.[15]

Figure 2 demonstrates the four P's of the marketing mix.

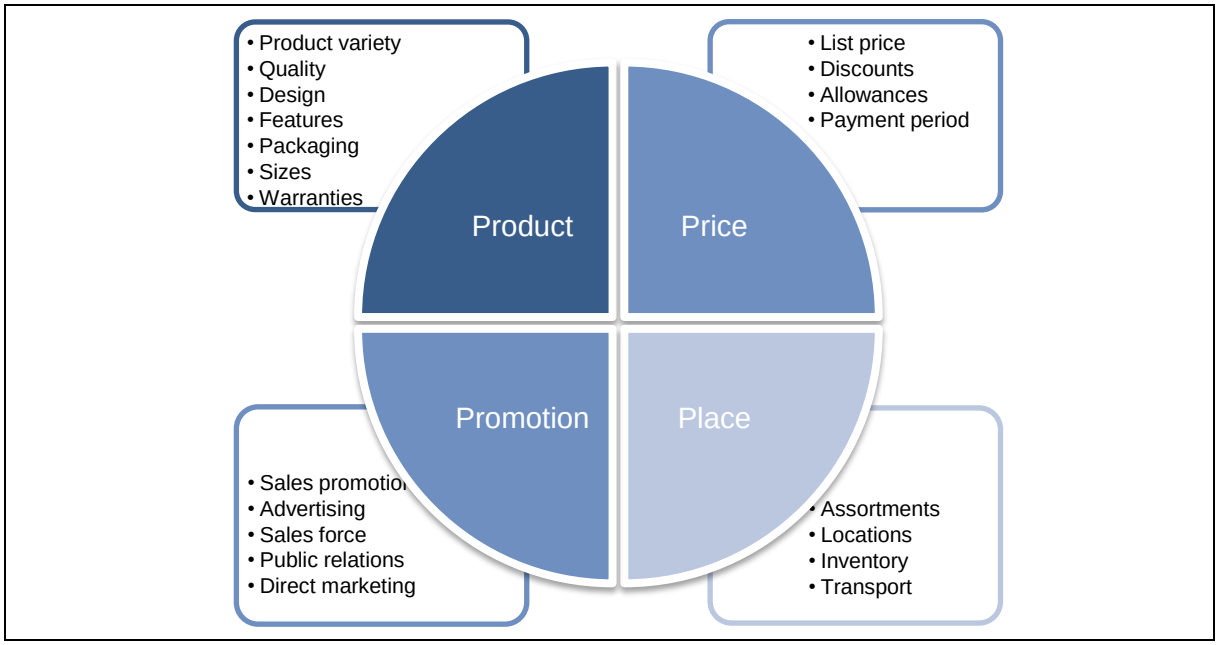

Figure 2: The Four P Components of the Marketing Mix[16]

2.1.2.2 SWOT Analysis and TOWS Matrix

The overall evaluation of a company's Strengths, Weaknesses, Opportunities, and Threats is called SWOT analysis. This method is a way of monitoring the external and internal marketing environment.[17] Threats and opportunities belong to the external environment and strengths

[12] Needham (1999, p. 53)
[13] Gerasimov et al. (2012, p. 8)
[14] Gerasimov et al. (2012, p. 8)
[15] Needham (1999, p. 58)
[16] Kotler and Keller (2012, p. 25)
[17] Kotler and Armstrong (2012, p. 53)

and weaknesses in turn belong to the internal environment.[18] The process is illustrated in Figure 3.

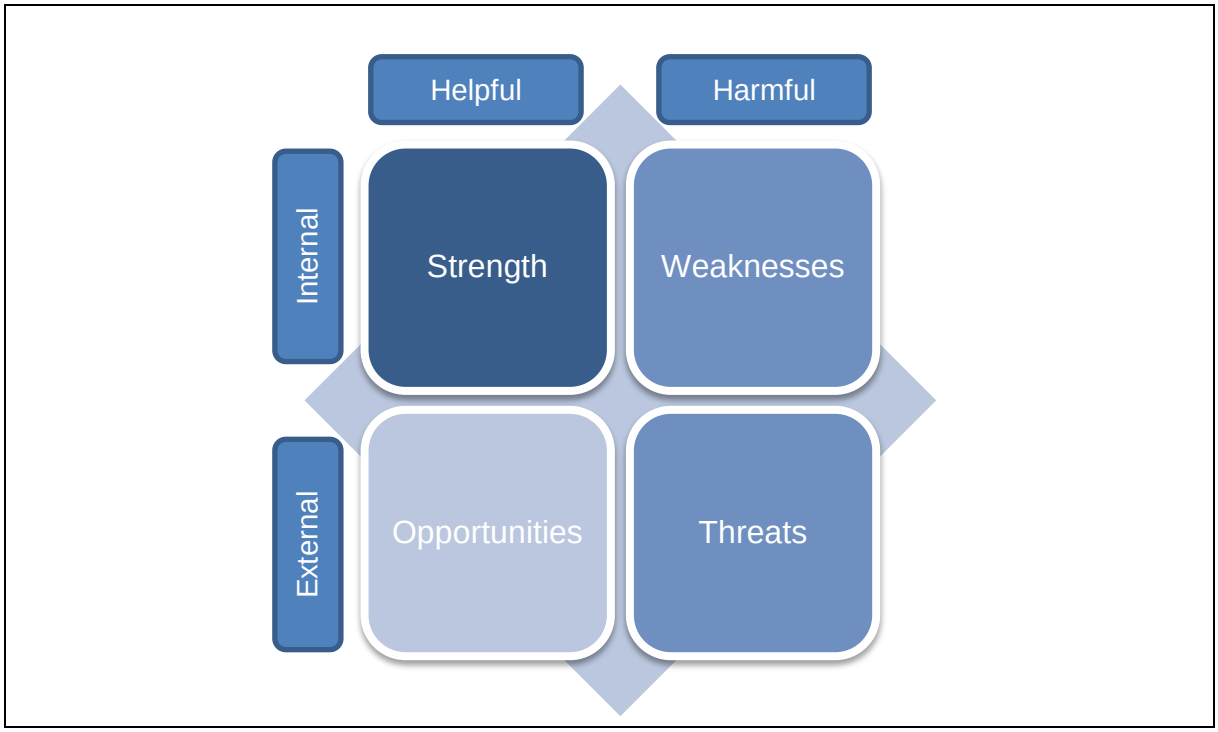

Figure 3: SWOT Analysis[19]

The terms can be defined as follows:[20]

- **Strengths** determine the advantages of the company which help to achieve intended goals and satisfy the customer.
- **Weaknesses** are internal factors that may impede the achievement of the company's objectives.
- **Opportunities** are external positive attributes that organization can use to give it an advantage.
- **Threats** refer to potential harm caused by external negative factors or trends.

After the SWOT analysis has been carried out, the TOWS matrix can be used to generate strategies. The acronym TOWS stands for the same words as SWOT but with a different arrangement. This situational analysis indicates four following alternative strategies:[21]

[18] Stone and Desmond (2007, p. 33)
[19] Stone and Desmond (2007, p. 33)
[20] Kotler and Armstrong (2012, p. 54)
[21] Weihrich (1982, p. 11)

1. **The Weaknesses- Threats Strategy** (mini-mini): The aim of this strategy is to minimize weaknesses and avoid threats.

2. **The Weaknesses- Opportunities Strategy** (mini-maxi): This strategy intends to take advantage of external opportunities to minimize weaknesses.

3. **The Strengths- Threats Strategy** (maxi-mini): The maxi-mini strategy involves usage of strengths to overcome threats.

4. **The Strengths- Opportunities** (maxi-maxi): This is the most desirable strategy for any company which can maximize company's internal strengths by using external opportunities.

2.1.2.3 Benchmarking

Benchmarking is a tool of a competitive analysis, which can be seen as a process of improving performance by systematic identifying and adapting best practices and processes found inside and outside a company. Benchmarking can be divided into two categories: internal and external. Internal benchmarking involves a comparison between the goods or departments within the organization. External benchmarking, in turn, compares processes or products to those of competitors or leading companies.[22]

In the benchmarking process the following phases can be distinguished:[23]

1. **Planning:** Firstly, it is necessary to determine product, service, or process for which benchmarking will be carried out. Then best-in class organizations should be selected. Subsequently, the evaluation criteria needs to be determined. Depending on the function, criteria can be qualitative or quantitative. The final stage of planning is the choice of the method of information collection, which can have different forms: interview, survey, review of existing data, or focus group.

2. **Data Collection:** This stage begins with the data collection about the under study company and only then its competitors. At the end, all information must be summarized and written.

3. **Analysis:** In this step the gathered data needs to be compared. The result of this comparison typically reveals a performance gap between benchmarked items that should be covered.

4. **Implementation:** The last phase involves practical application of the benchmarking results by implementation of specific actions as well as continuous monitoring.

[22] Sabisch and Tintelnot (1997, p. 25)
[23] Welge, Martin, Al-Laham, Andreas (2003, p. 283)

2.2 Difference between Consumer Marketing and Industrial Marketing

qpunkt is operating in industrial business and therefore it is important to have an essential understanding of specifics of Industrial marketing. At the moment, there exists a basic set of theories and knowledge that is typical for the whole marketing. On the other hand, in order to understand and intelligently solve issues in the industrial marketing field, it is important to be aware of difference between business-to-business (B2B) and business-to-customer (B2C) marketing.[24]

B2B organizations purchase goods and services with a purpose to use it in their own production of products or services, which will be sold to other businesses. In B2C business the final customer is the consumer, moreover most manufacturers of consumer products sell their goods to other businesses as well. It means that B2B sales are larger than those of B2C.[25]

In this thesis, the most common differences between B2B and B2C marketing will be considered.

Product complexity
The technical complexity is peculiar to industrial products. Due to the fact that the product characteristics are variable and strongly dependent on the client's preferences, some kinds of business strategies include high risk and innovation associated with costs of further developments. Moreover, a result of the product complexity is that the purchase process requires professionals on both sides. [26]

Demand
Demand is derived from consumers so manufacturer should always monitor demand as cycles emerge in order to escape a bullwhip effect. Additionally, B2B demand is more inelastic than B2C demand. The reason is the following: the industrial demand does not depend on an increase or decrease in price. Hence, it makes no sense to store material for future use because of the low price.[27]

Internationality
The next important difference is internationality. Industrial products are more complex than consumer products but at the same time, they have to meet international standards that make them similar in a way of functionality and performance. By contrast, B2C marketing includes many issues regarding cultural and national preferences that require further product adjustment.[28]

[24] Webster (1995, p. 26)
[25] Kotler, Pfoertsch, and Michi (2006, p. 20)
[26] Webster (1995, p. 29)
[27] Fill, Fill, and Fill (2004, p. 6)
[28] Kotler et al. (2006, p. 23)

Buying process

The buying process in industrial marketing tends to be more complex than the same process in consumer marketing. The complexity of decision-making process in the buying process is the result of the high number of participants, technical and economic factors, external environment, and significant costs that are involved in the business.[29] The buyer decision process involves considerable number of people that can have different goals and needs. Figure 4 shows roles of the buying center that includes initiators, users, influencers, deciders, approvers, buyers and gatekeepers.[30]

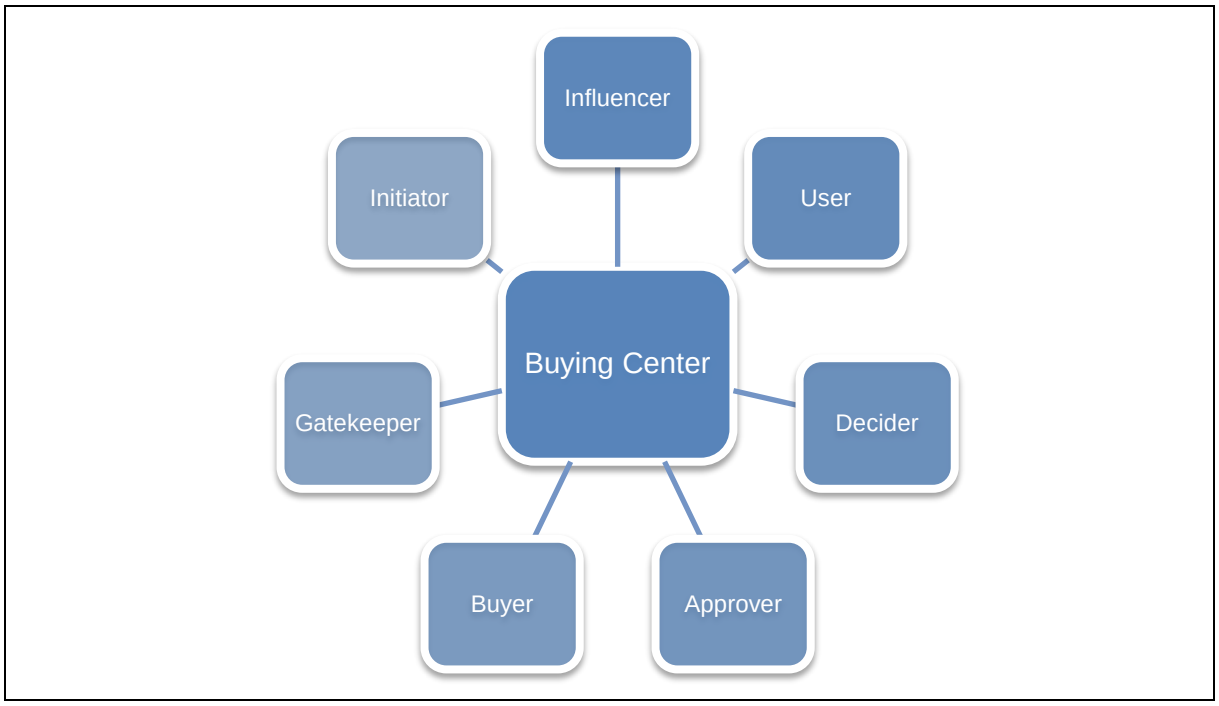

Figure 4: Roles of the Buying Center[31]

Relationships

Another major aspect of B2B marketing concerns relationships between manufacturer and consumer. Usually, industrial businesses do not have as much customers as consumer businesses have; hence, each customer becomes more valuable. Moreover, industrial goods often need long-lasting service and maintenance; thus, long-term relationships are inevitable.[32]

2.3 Marketing Research

Marketing Research is defined by American Marketing Association as “a function that links the consumer, customer, and public to the marketer through information- information used to identify and define marketing opportunities and problems; generate, refine, and evaluate marketing actions; monitor marketing performance; and improve understanding of marketing

[29] Webster (1995, pp. 31-32)
[30] Kotler et al. (2006, p. 26)
[31] Kotler et al. (2006, p. 26)
[32] Hague, Hague, and Harrison (2016)

as a process. Marketing research specifies the information required to address these issues, designs the method for collecting information, manages and implements the data collection process, analyses the results, and communicates the findings and their implications."[33]

2.3.1 Marketing Research Process

Marketing process begins with setting objectives of the research and **defining the research problem**. Probably, this step is crucial for the whole process. Often the reason of the marketing research is a real problem that marketers face but are not able to solve due to the lack of the information. Clear understanding of objectives of the work leads to the effective and focused market analysis.[34]

The next step of marketing research is a **method of inquiry**. The scientific method that can be applied for investigating new knowledge. It is a standard pattern for investigation and it can be used as a starting point.[35]

For the **research method,** two different methodologies can be used: experimental and non-experimental research. Experimental research is when a researcher is able to manipulate variables that influence on the process. Non-experimental research allows only observation and reporting on findings.[36]

The next step is **research design**. A plan for conducting an investigation and data collection should be provided. Then data collection techniques must be defined. It can either be interviews or observation. This step will be described in detail in Subchapter 2.3.2.[37]

Sample design stage includes method of selection, sample structure and determining the appropriate sample size. The purpose of using sample is a convenient way to examine an entire population.[38]

Data collection is a part of personal interviews, Internet surveys, focus groups etc. Data collection may include constant communication and high expenses.[39]

Analysis and interpretation of the collected data should be submitted in order to get full and structured information regarding the research and to be able to outline major trends.[40]

[33] American Marketing Association (2013)
[34] Smith and Albaum (2012, p. 5)
[35] Smith and Albaum (2012, p. 9)
[36] Smith and Albaum (2012, p. 10)
[37] Smith and Albaum (2012, p. 10)
[38] Smith and Albaum (2012, p. 10)
[39] Smith and Albaum (2012, p. 10)
[40] Smith and Albaum (2012, p. 11)

The last but not least step is **the research report** that provides all information including a description of the research process, the results, conclusions, and recommendations regarding further actions. The report should contain the answer on the initial question as well.[41]

The stages of marketing research process are presented in Figure 5.

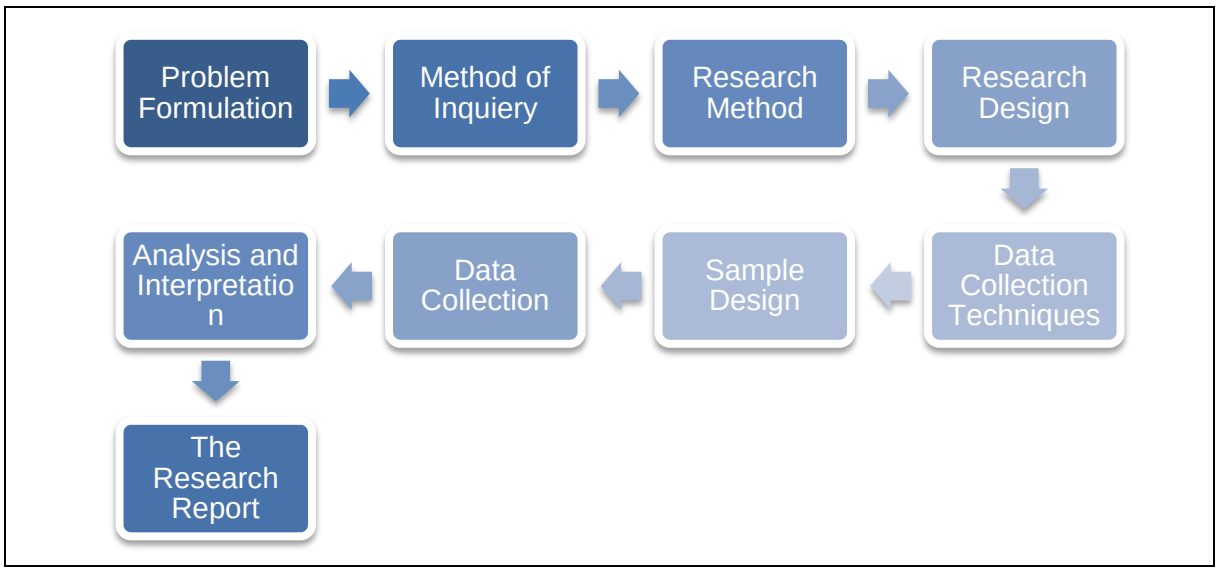

Figure 5: The Marketing Research Process[42]

2.3.2 Marketing Research Methodology

In literature numerous classifications of data collection methodologies exist. In this thesis, the most common classifications will be considered.

In order to conduct marketing research, secondary data, primary data, or both should be gathered. Primary data includes information, which is collected for the specific purpose by an investigator. Secondary data, in its turn, includes data that already exists and was collected for some other purposes by someone else.[43]

2.3.2.1 Secondary Data

Usually, marketers start gathering information from secondary data (desk research). It can be either the company's internal database or external information sources such as commercial online databases or government sources. There is no need to conduct primary research if there are already studies on the relevant topic available. Careful secondary data research can help to save time and money; and at the same time to provide data an individual company cannot collect on its own.[44]

[41] Smith and Albaum (2012, p. 12)
[42] Smith and Albaum (2012, pp. 5)
[43] Kotler and Armstrong (2012, p. 104)
[44] Kotler and Armstrong (2012, p. 104-106)

2.3.2.2 Primary Data

Despite all benefits of secondary data collection, in most cases, this method cannot provide enough information in order to meet the research objectives. Therefore, company must also gather primary data (field research) that has to be relevant, accurate, current, and unbiased. Kotler and Armstrong have distinguished three following research approaches of primary data collection:[45]

1. Observation: Observation research collects data by observing relevant people, actions, and situations.

2. Experiment: The aim of experimental research is to explain cause-and-effect relationships. The method is most suitable for gathering casual information.

3. Survey: The survey research is commonly used for gathering descriptive information. If a company wants to know feelings, motives, preferences of their customer, the easiest way is simply ask them directly. This method is the most commonly used for primary data collection. Survey research can be done through personal and telephone interviews, as well as online questionnaires.

2.4 Market Segmentation, Targeting, and Positioning

This chapter deals with a three-stage process called STP. STP stands for segmentation, targeting, and positioning. This approach deals with the process of customer groups identification, selection of target markets, and then positioning the company through marketing mix implementation.[46]

2.4.1 Market Segmentation

Market segmentation is a process of identification special groups of buyers on the market with similar needs or characteristics.[47] In order to carry out an effective market segmentation, five following criteria should be met:[48]

1. **Adequate size** is a degree to which the segments are large or profitable enough to be worth considering for separate marketing cultivation.

2. **Measurability** is a degree to which information on particular buyer characteristics exists or can be obtained.

[45] Kotler and Armstrong (2012, p. 106)
[46] Hollensen (2015, p. 289)
[47] Kotler and Keller (2012, p. 214)
[48] Hollensen (2015, p. 293)

3. **Accessibility** is a degree to which the firm can effectively focus its marketing efforts on chosen segments.

4. **Responsiveness** is a degree to which segments respond differently to diverse marketing mix elements, such as pricing or product features.

5. **Compatibility** is a degree to which the firm's marketing and business strengths match the present and expected competitive and technological state of the market.

The main difference between industrial market segmentation and consumer market segmentation is a set of variables by which they are measured.[49]

Consumer markets are typically segmented on the basis of psychographic and demographic variables. Industrial markets, in its turn, segment organizations on the basis of size and end use, and organizational buyers on the basis of decision style and other criteria. [50]

The B2B variables can be divided into two following categories[51]:

Macro-variables

- Industry
- Organizational characteristics
- End use markets
- Product application

Micro-variables

- Organizational variables
- Purchase variables
- Individual variables

Five general segmentation criteria for an industrial market, which were identified by Benson P. Shapiro and Thomas V. Bonoma, are shown in Figure 6: demographics, operating variables, purchasing approach, situational factors, and personal characteristics.[52]

[49] Stone and Desmond (2007, p. 186)
[50] Hollensen (2015, p. 302)
[51] Hollensen (2015, p. 303)
[52] Shapiro and Bonoma (1984, p. 3)

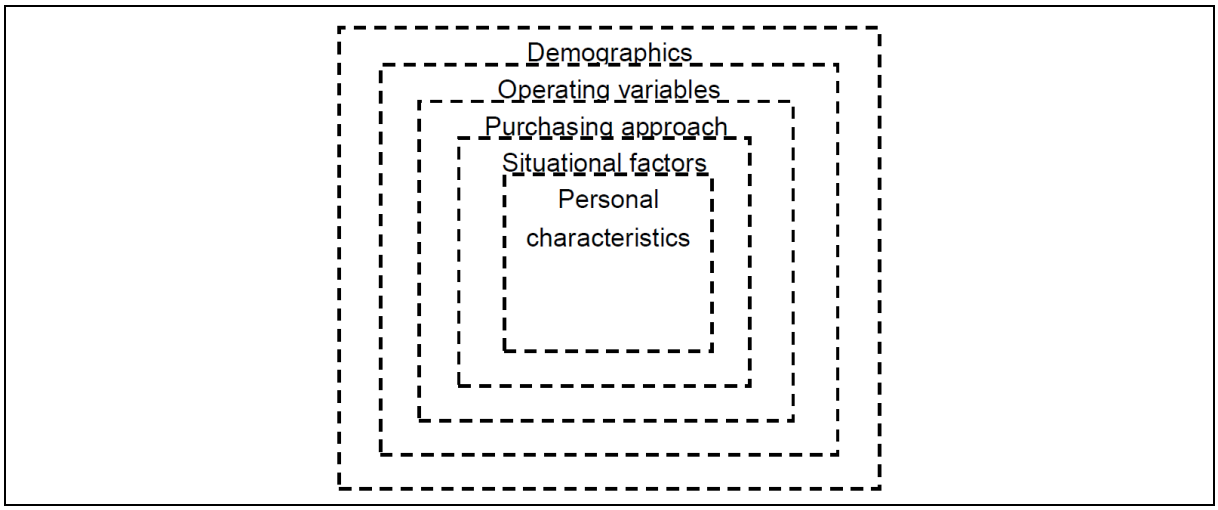

Figure 6: Nested Approach[53]

Demographics include industry, company size, and customer location. These useful criteria give a general idea of the company and its needs. Often segmentation is limited to demographics since the data is freely available and easily gathered. Nevertheless, if possible, it is recommended to continue segmentation at a deeper level.[54]

Operating Variables include company's technology, user status, and customer capabilities. In contrast to demographics, these variables are more specific, but they are still relatively easy to determine. Company's technology variable gives information about a production process. User status determines the way how customers use a particular product. Customer capabilities, in turn, indicate the financial or technical features of the company such as importance of delivery time or quality check.[55]

Purchasing Approaches include purchasing function organization (size of a purchasing unit), power structures (the impact on the purchasing unit by other organizational units), general purchasing policies (leasing, contract), and purchasing criteria (quality, price, service). Grouping on this principle is the most significant on the way to understanding the needs of the client.[56]

Situational Factors include the urgency of order fulfilment, product application, and the size of the order. All these criteria require direct partnership with the company, which is not always possible in case if segmentation is conducted for a new product or service.[57]

[53] Shapiro and Bonoma (1984, p. 3)
[54] Shapiro and Bonoma (1984, p. 3)
[55] Shapiro and Bonoma (1984, p. 4)
[56] Shapiro and Bonoma (1984, p. 5)
[57] Shapiro and Bonoma (1984, p. 6)

Behind each purchase is a real person with its strength and weaknesses. Some people like to take risk, some are more conservative. **Personal Characteristics** variable will help to divide such people into segments and then a supplier can find the best approach to each group.[58]

It can be noted that the closer to the middle of the square, the more personal information becomes and the more difficult it is to gather. However, the authors of this theory recommend to keep a balance between the importance of information and its cost.[59]

2.4.2 Cluster analysis

There are many methods of data analysis that can be used for carrying out marketing research. Multivariate techniques are commonly used in marketing because of the ability to analyse complex, often interrelated and interdependent data.[60] In this thesis, one of the multivariate methods will be used, namely, cluster analysis. Cluster analysis is a method of classification entities and characteristics that describe these entities.[61]

Figure 7 illustrates the cluster analysis procedure according to Sarstedt and Mooi.

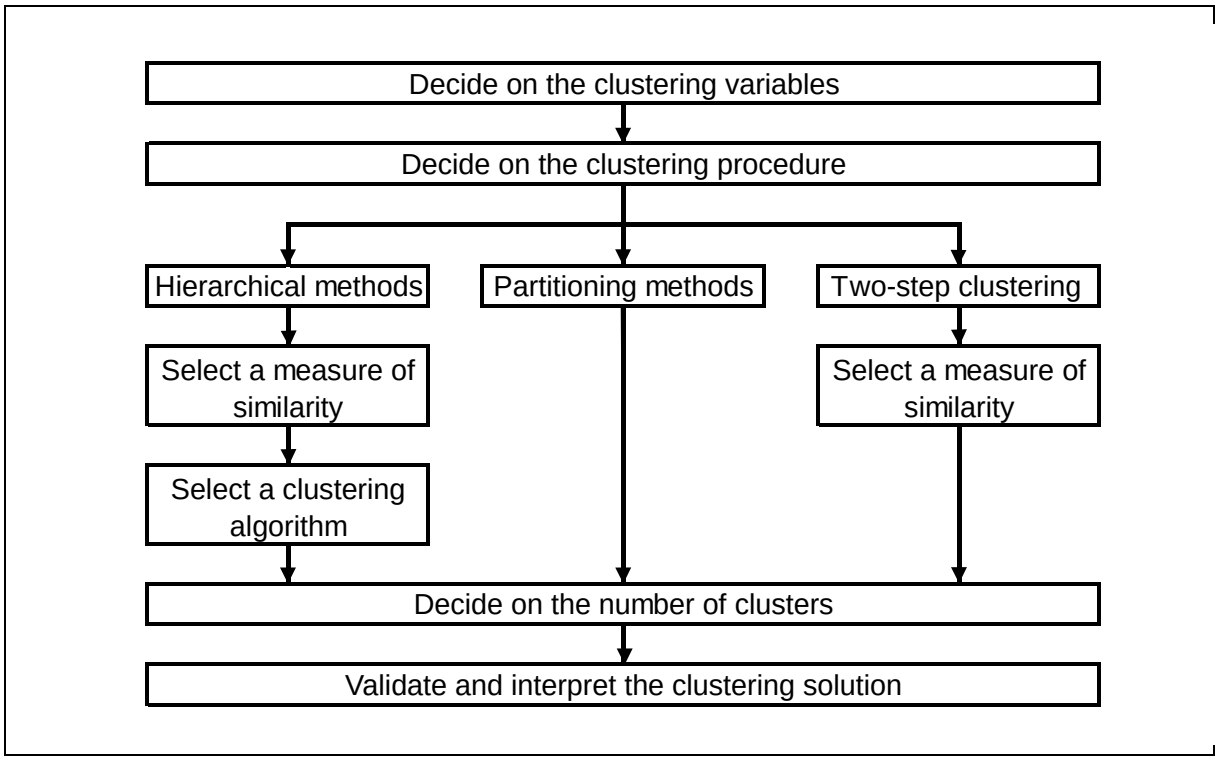

Figure 7: Steps in a Cluster Analysis [62]

[58] Shapiro and Bonoma (1984, p. 6)
[59] Kotler and Keller (2012, p. 230)
[60] American Marketing Association (2013, p. 240)
[61] Gerasimov et al. (2012, p. 13)
[62] Sarstedt and Mooi (2014, p. 277)

The first step in cluster analysis is a decision on clustering variables. The success of the whole segmentation strongly depends on the chosen variables. They should differentiate the segments, be highly correlated, and, importantly, the data collected for the analysis should be accurate.[63] The possible types of variables are described in the previous Chapter 2.4.2.

The next step is to decide on the clustering procedure. There are many different methods of clustering. In this thesis, the three most commonly used procedures will be reviewed: hierarchical, two-step clustering, and partitioning methods.

Hierarchical Method

Hierarchical analysis can be carried out in two ways: from bottom to top (agglomerative) and from top to bottom (divisive). The first method is used more often in marketing and therefore will be considered here. The purpose of agglomerative algorithm is to combine objects into clusters, using some measure of similarity (distance between the objects). The most direct way to calculate the distances between objects is to calculate the Euclidean distances (1).[64]

$$d_{Euclidean}(i,j) = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} \qquad \text{Equation 1}$$

In addition to the Euclidean distance, the Chebyshev equation (2) and the Manhattan equation (3) can be applied.[65]

$$d_{Chebyshev}(i,j) = max\left|x_i - x_j\right|, \left|y_i - y_j\right| \qquad \text{Equation 2}$$

$$d_{Manhattan}(i,j) = \left|x_i - x_j\right| + \left|y_i - y_j\right| \qquad \text{Equation 3}$$

The use of different functions leads to different segmentation results.

As soon as distances between the objects have been calculated, you can proceed to the next step- merging objects into clusters. There are several following options how to do it:[66]

Single linkage (nearest neighbour): In this method, the distance between two clusters is determined by the distance between the two closest objects (nearest neighbours) in different clusters.

Complete linkage (furthest neighbour): In this method, the distances between clusters are determined by the largest distance between any two objects in different clusters (i.e., the "farthest neighbours").

[63] Sarstedt and Mooi (2014, p. 278)
[64] StatSoft, Inc. (2012)
[65] Sarstedt and Mooi (2014, p. 284)
[66] StatSoft, Inc. (2012)

Average linkage: In this method, the distance between two different clusters is calculated as the average distance between all pairs of objects in them.

Centroid: In this method, the distance between two clusters is defined as the distance between their centers of gravity.

The final step of the hierarchical clustering is to decide on the number of clusters. At the moment, there is no single method for determining the amount of clusters. Therefore, when selecting the clusters, the researcher should rely on the practical considerations.[67]

Partitioning Methods

The most valuable partitioning method for market research is “k-means” method. This method differs significantly from the hierarchical clustering. In order to begin grouping the objects, the number of clusters *k* needs to be pre-specified and the center of each cluster needs to be defined. Subsequently, the Euclidean distances (Equation 1) from each cluster’s center to each subject are measured. Afterwards, separation by assigning or reassigning all data objects to their closest cluster center and then computation of new cluster centers as mean value of the objects in each cluster. The last two steps must be repeated until there are no changes in the cluster center calculation. This method is preferable to use in case of large datasets.[68]

Two-Step Clustering

The two-step method can be applied when the variables are measured on a different scale. This algorithm includes two steps. First step is very similar to the “k-means” procedure, then the objects are grouped into clusters through modified hierarchical agglomerative clustering. In comparison with other cluster analysis methods described (“hierarchical” and “k-means” clustering), this method is probably the least frequently used method.[69]

The last but not least step in clustering is validation and interpretation the clustering solution. The goal of cluster analysis is to divide clients into groups that are different from one another. Therefore, it is important that objects are similar within clusters and diverge between clusters. The interpretation of the results is a characteristic of the final clusters by means of considered variables.[70]

2.4.3 Market Targeting

After market segmentation, the company needs targeting market. It describes the process of evaluation and selection of one of segmented markets and development of products that are intended for this market.[71]

[67] Sarstedt and Mooi (2014, p. 294)
[68] Sarstedt and Mooi (2014, pp. 294-298)
[69] StatSoft, Inc. (2012)
[70] Baker (2003, p. 240)
[71] Hollensen (2015, p. 307)

Evaluation of segmented market takes three dimensions into account: the size and growth potential, segment attractiveness and company fit.[72]

Porter has identified five following forces that can determine long-term attractiveness of the market segment that were described in detail in Chapter 2.1.1.1.[73]

1. Industry competitors and the threat of segment rivalry.
2. Potential entrants to the market and the threat of mobility.
3. The threat of substitute products.
4. Buyers and their relative power.
5. Suppliers and their relative power.

The next step after market segments evaluation is choosing a number of segments that a company will cover. There are four following strategies that can help a manager to make a decision:[74]

1. Undifferentiated marketing (all customers are treated the same)
2. Differentiated marketing (particular marketing mix for each segment)
3. Concentrated marketing (particular marketing mix for selected segments)
4. One-to-one marketing (particular mix for each customer)

2.4.4 Market Positioning

When market segmentation and market targeting were carried out, you can move on to positioning.[75] According to Baker, positioning is the process of designing an image and value so that consumers within the target segment understand what the company or brand stands for in relation to its competitors.[76]

Stone and Desmond highlight five major stages in the positioning process[77]:

Stage 1: Identify key product characteristics
Characteristics that are most important for the target market must be identified through the marketing research.

Stage 2: Draw a perceptual map
This marketing tool is useful in order to visualize existing brands on the market segment and to make a decision on a competitive strategy. The map consists of a grid that shows two most important attributes identified at Stage 1 placed at two axes on the grid.

[72] Stone and Desmond (2007, p. 190)
[73] Baker (2003, p. 277)
[74] Hollensen (2015, p. 309)
[75] Fill et al. (2004, p. 69)
[76] Baker (2003, p. 279)
[77] Stone and Desmond (2007, p. 195-197)

Stage 3: Decide on a competitive strategy
By using a perceptual map, a manager can decide whether the company should compete head-on or avoid the competition.

Stage 4: Design a product attributes and associated imagery
At this stage, product features that can best meet customer needs should be developed, such as brand name, price, packaging, advertising, distribution.

Stage 5: Sustain a competitive advantage
Competitive advantage sets a product or company apart from competitors. The marketing information must always be up to date in order to keep an advantage.

2.5 Competitive Analysis

In order to be successful, a company needs to provide greater customers value and satisfaction than its competitors do.[78] Therefore, in this subchapter, principles of identification and analysis of competitors will be considered.
The competitor analysis process consists of six following steps:[79]

1. **Identifying competitors**

There are a few levels of competition. The higher the level, the more competitors can be identified. The first level consists of direct competitors and includes products that look the same as yours. Since this definition is narrow, it might be useful only in the short term; therefore, for the long term analysis other levels must be considered. The second level of competition is the product type competition, which includes products that have similar features and perform the same function. The third level refers to the product class competition. At the fourth level of competition are the products that satisfy the same customer needs. The last level is the broadest form of competition and is called budget competition. This competition takes place when the resources that a customer is willing to spend on something are limited.

2. **Identifying the information required and the information sources of competitor intelligence**

In order to identify current and potential competitors' strategies, the company needs to gather primary and secondary information from available sources such as internet, competitors' suppliers, former and current employees, customers, etc. The information should be useful in order to understand what the competitors are doing and why it works.

[78] Kotler and Armstrong (2012, p. 68)
[79] Hollensen (2015, pp. 165-180)

3. **Analysing strengths and weaknesses of competitors with respect to the market requirements**

A competitive analysis should summarize the strengths and weaknesses of each competitor on the market. Understanding these aspects can help the company develop a competitor strategy.

4. **Assessing the company's competitive position vis-à-vis key competitors**

There is always a room for improvement and benchmarking is a good tool in order to evaluate the company and improve its performance. Moreover, assessing the company can help in further positioning.

5. **Investigating the goals and long-term strategies of competitors**

This step can help the company to predict further actions of their competitors and, as a result, to design an effective strategy.

6. **Selecting the company strategies to compete against the competitor, locally and globally, taking into account possible competitor reactions**

Having done previous steps, the final task is to generate a successful strategy that takes into account weaknesses and strengths of the company compared to rivals.

2.6 Portfolio Analysis

According to Kotler and Armstrong "portfolio analysis" is the process by which management evaluates the products and businesses that make up the company and is the major activity in strategic planning. [80]

The first step in business portfolio analysis is strategic business units (SBU) identification and evaluation. An SBU can be either a company division or a single product. Company decides which SBUs are most profitable and deserve additional support, and which SBUs are weak and should be phased down or dropped.[81]

2.6.1 The Boston Consulting Group (BCG) model

The BCG is one of the best known portfolio models and was developed by the Boston Consulting Group, a leading management group, in the late 1960s. [82] Figure 8 represents a matrix that classifies SBUs according to market growth rate and relative market shares.[83]

Each cell of the matrix represents a different type of strategy[84]:

[80] Kotler and Armstrong (2012, p. 42)
[81] Kotler and Armstrong (2012, p. 42)
[82] Hollensen (2015, p. 259)
[83] Gerasimov et al. (2012, p. 44)
[84] Hollensen (2015, p. 260-261)

1. Stars

Stars are the market leader in a high-growth industry. The company should support and strengthen this type of business, and therefore increase investment. Usually after a while star's growth slows down and they become cash cows.

2. Cash Cows

Cash cows represent high-share and low growth businesses. These SBUs are main generators of profits and cash and do not require high investment. The company can use the cash from the sale of such SBUs to develop stars or question marks.

3. Question Marks

Question marks are high-growth and low-share businesses. Such SBUs require high level of investment in order to grow and strengthen positions on the market. If the company can rapidly increase a market share for question marks, it turns into a star. In case of failure, a question mark becomes a dog.

4. Dogs

Dogs are low-share business units in low-growth markets. Usually these SBUs generate low profits, or losses.

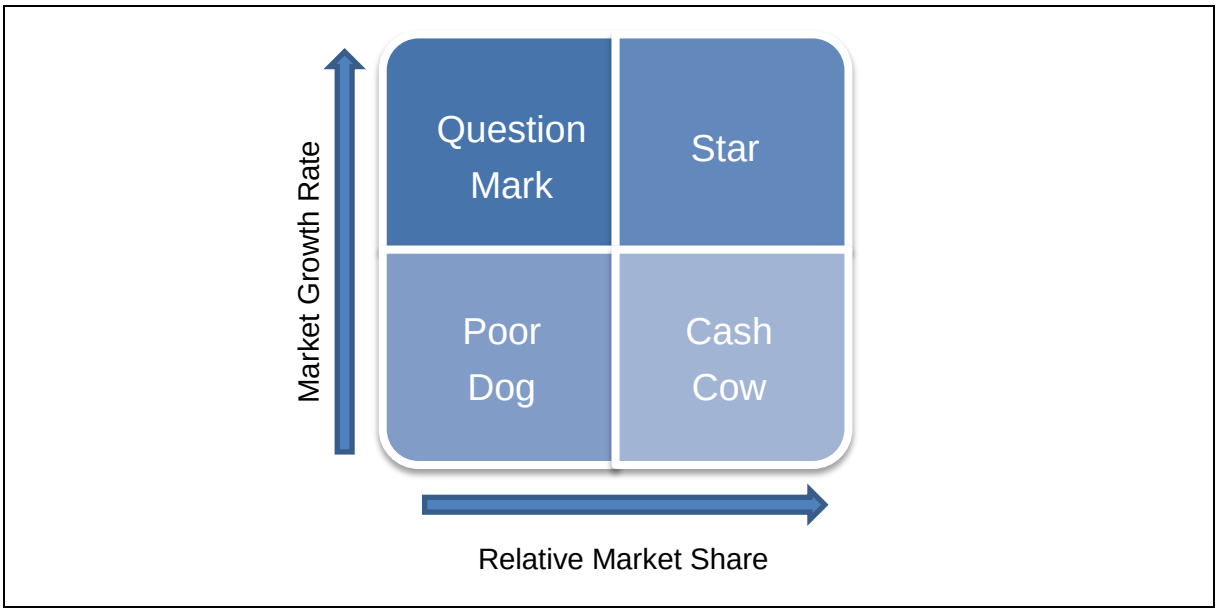

Figure 8: The BCG Growth-Share Matrix[85]

Despite the fact that the BCG Matrix was designed for the consumer market, this approach can also be applied to the industrial business.[86]

[85] Kotler and Armstrong (2012, p. 43)
[86] Fill et al. (2004, p. 85)

2.6.2 Product Life Cycle Concept

Product life cycle concept can help companies that have more than one product or operate in several markets to manage their product portfolio in order not to have all products at one stage in their life cycles.[87]

Changes in the product, market, and competitors over the product life cycle (PLC) have an impact on marketing strategies and marketing mix. Kotler and Keller pointed out four following things that affirm that a product has a life cycle:[88]

1. Products have a limited life.

2. Product sales pass through distinct stages, each posing different challenges, opportunities, and problems to the seller.

3. Profits rise and fall at different stages of the product life cycle.

4. Products require different marketing, financial, manufacturing, purchasing, and human resource strategies in each life-cycle stage.

Figure 9 demonstrates the product life cycle process that includes five following stages:[89]

1. **Product development** occurs during generation and development of a new product idea. At this stage company does not sale a product but makes an investment.

2. During the **introduction** stage, the product penetrates the market and sales are slowly growing. Despite the sales growth profits are insignificant because of heavy expenses of product introduction.

3. At the market **growth** stage, industry sales and profits growth fast.

4. **Maturity** is a period of industry sales and profits off because the product has achieved the most of potential customers.

5. During the **decline** stage**,** sales and profits drop down.

[87] Hollensen (2015, p.)
[88] Kotler and Keller (2012, p. 310)
[89] Kotler and Armstrong (2012, p. 273)

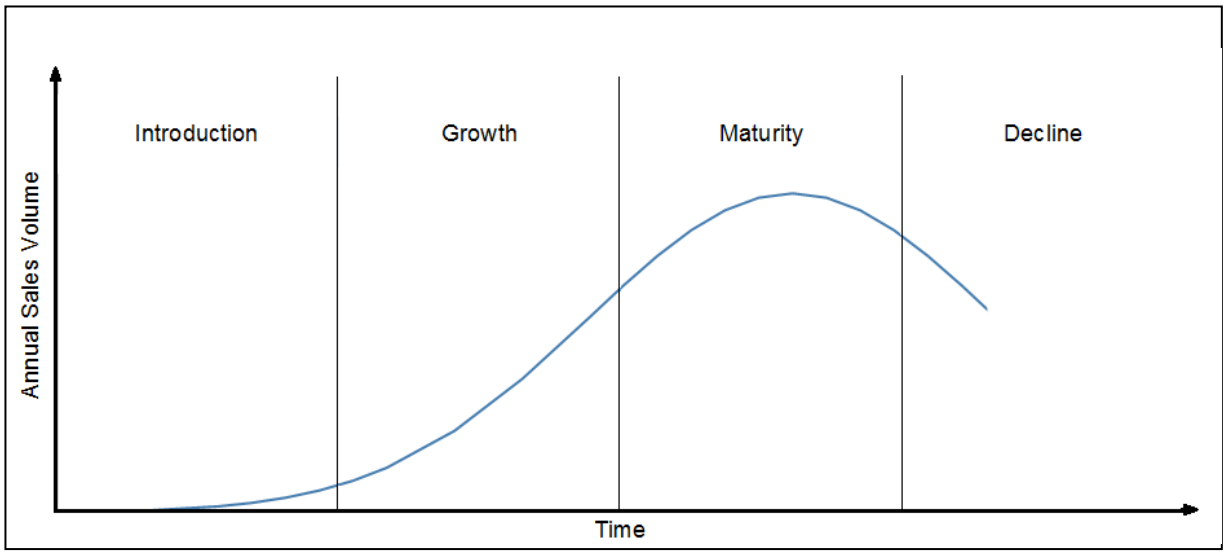

Figure 9: Product Life Cycle[90]

The impact of PLC on the marketing mix, depending on the stage, is described in Table 1.

Table 1: Summary of Product Life Cycle Strategies[91]

	Introduction	Growth	Maturity	Decline
Product	Offer a basic product	Offer product extensions, service, warranty	Diversify brand and models	Phase out weak items
Price	Use cost-plus	Price to penetrate market	Price to match or beat competitors	Cut price
Distribution	Build selective distribution	Build intensive distribution	Build more intensive distribution	Go selective: phase out unprofitable outlets
Advertising	Build product awareness among early adopters and dealers	Build awareness and interest in the mass market	Stress brand differences and benefits	Reduce to level needed to retain hard-core loyals
Promotion	Use heavy sales promotion to entice trial	Reduce to take advantage of heavy consumer demand	Increase to encourage brand switching	Reduce to minimal level

[90] Kotler and Keller (2012, p. 310)
[91] Kotler and Armstrong (2012, p. 279)

2.7 Automotive Thermal Testbeds Classification

Advanced passenger and powertrain thermal technologies are crucial for the efficient performance of conventional and electrified vehicles. Powertrain thermal management includes engine and transmission lubrication, electrical systems, and coolant subsystems.[92] Cabin thermal management includes heating, ventilation, and air conditioning (HVAC) to maintain good air quality and deliver thermal comfort through adequate ventilation inside vehicles.[93] At the moment, to ensure the proper operation of these components, thermal test systems are used. This subchapter gives a brief overview of various automotive thermal testbeds.

2.7.1 A/C Testbed

A/C testbed is an environmental chamber which illustrated in Figure 10. The chamber artificially replicates temperature conditions under which a vehicle might be exposed. The testbed can be used in order to develop a new A/C system, evaluate air conditioning performance, and analyse potential flaws in the system.[94] It is possible to generate a controlled outdoor climate with a temperature range between -25 °C and 60 °C, including control of the humidity in the test environment.[95] Such test chamber can support the shortened lead times that OEMs are now targeting, as well as verifying things from a real driving emissions (RDE) perspective.[96]

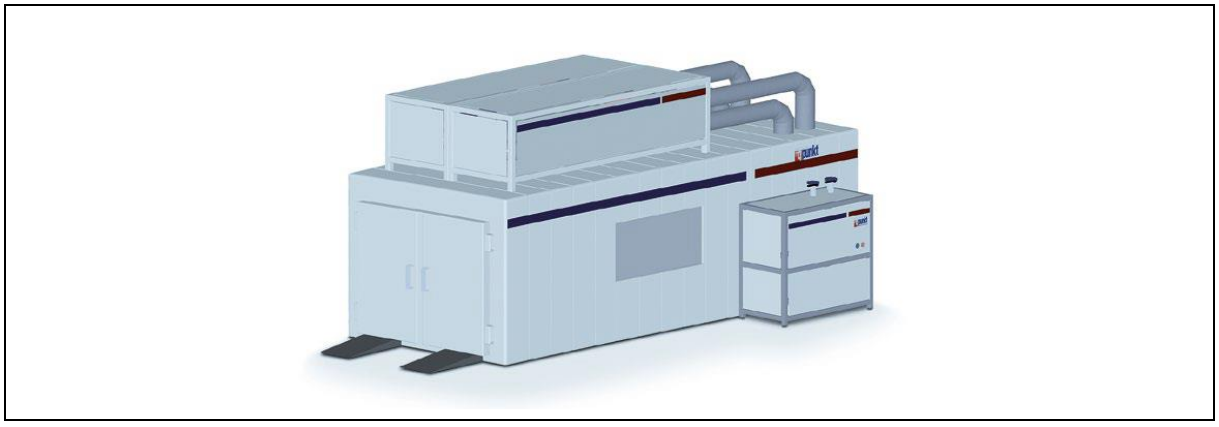

Figure 10: A/C testbed[97]

2.7.2 A/C Compressor and Component Testbed

Compressor is one of the main components of the refrigerant cycle, and therefore it is important to test its efficiency and endurance. A/C compressor testbed can provide fully automatic

[92] Osborne et al. (2016, p. 16)
[93] Technavio (2016, p. 12)
[94] qpunkt Gmbh (2016)
[95] AVL List GmbH (2016)
[96] Pickering (2017)
[97] AVL List GmbH (2016, p. 71)

determination of performance characteristic maps and corresponding compressor efficiency of all types of refrigerant compressors.[98]

2.7.3 Filter- and Valve Testbed

The filter- and valve test stand (Figure 11) is used for testing hydraulic filters and its elements performance during development process and quality assurance process. The scope of the testing is to measure the differential pressure across the filter housing or filter element as a function of the volumetric flow rate and the viscosity.[99]

Figure 11: Filter- and Valve Testbed[100]

2.7.4 Heat Exchanger Testbed

Heat exchanger testbed (Figure 12) can evaluate dynamic behaviour and behaviour during real-life driving cycles of a heat exchanger. The test stand can measure following heat exchangers:[101]

- Charge-air intercoolers
- Water coolers
- Oil coolers
- Plate heat exchangers
- Evaporators – using a variety of refrigerants
- Condensers – using a variety of refrigerants
- Battery coolers – conventional cooling and direct evaporation

[98] AVL List GmbH (2016)
[99] GMN GmbH (2013)
[100] AVL List GmbH (2016, p. 73)
[101] qpunkt Gmbh (2016)

Figure 12: Heat Exchanger Testbed[102]

2.7.5 Thermal Shock Testbed

Thermal shock test bed is used in order to test products and components on an ability to resist sudden temperature changes. The temperature during the test changes very quickly, more than 15 °C per minute.[103]

[102] AVL List GmbH (2016, p. 75)
[103] Delserro Engineering Solutions (2015)

3 Practical problem solving

This chapter is divided into five sections. The first section begins with examining of market trends and restraints which have a potential impact on the automotive thermal market. The second section analyses current and potential customers of qpunkt GmbH through secondary and primary research methods. The next section compares competitors' products and their strategies. In Subchapter 3.4, SWOT analysis, and TOWS matrix are presented. The conclusion can be found in Chapter 4.

3.1 Industry Description and Outlook

This subchapter analyses automotive thermal market trends and restraints. The data in this part is obtained from online journals and databases.

3.1.1 Introduction

The automotive thermal system contains heating ventilation and air conditioning, battery thermal management, powertrain cooling, powertrain device cooling, and waste heat recovery. Transparency Market Research, a consulting agency, expects the automotive thermal system market to grow from US$32.20 billion in 2013 to US$48.48 billion in 2020.[104] Nevertheless, the economy is drastically changing over the time due to development in emerging markets, pollution control regulations, and changes in buying preferences.[105] Therefore, the aim of this paper is to evaluate potential impact of disruptive automotive trends on the qpunkt's business and offer possible solutions.

3.1.2 Automotive Market Trends

A consulting company PricewaterhouseCoopers assumes that the automotive market is attaining its maximum as the models of alternative mobility are emerging. However, as shown in Figure 13, Compound Annual Growth Rate (CAGR) will continue to grow for some time: from 3.906% between 2010-2015 to 3.910% between 2015 and 2020.[106]

[104] Transparancy Market Research (2014, p. 14)
[105] Hanebrink and Cook (2016, p. 3)
[106] PwC (2016)

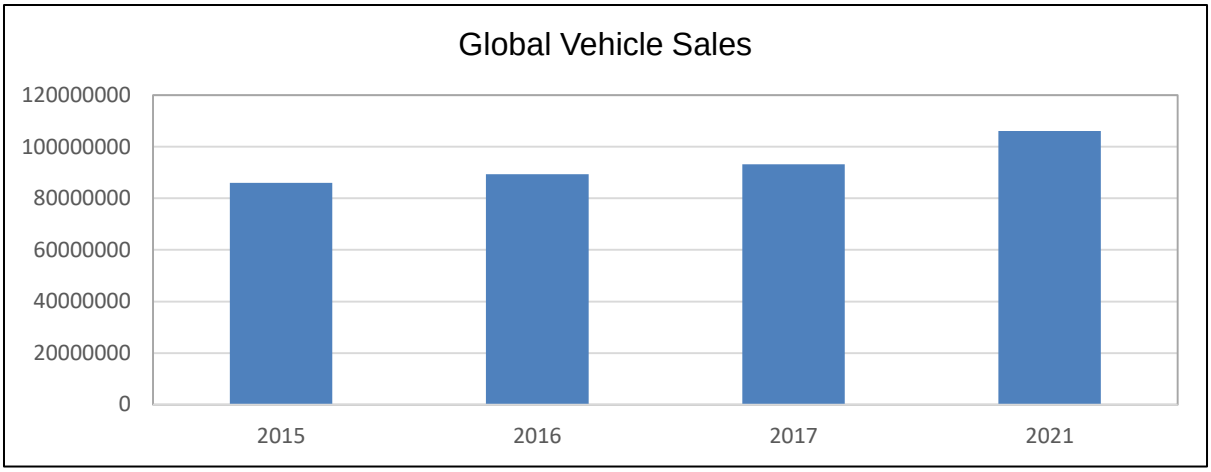

Figure 13: Global Vehicle Sales[107]

In this thesis four main trends that will shape future mobility were considered: connectivity, autonomous driving, shared mobility, and electrification. [108]

Connectivity trend means connected vehicle technology. This technology enables cars on the road to communicate to each other and share safety and mobility data such as speed and position. Connectivity can significantly reduce number of accidents and commute time.[109]

Autonomous driving is a technology that allows relinquishing control of a vehicle.[110] At the moment, a human factor is responsible for more than 90% of all crashes.[111] Hence, autonomous driving along with connectivity could minimize number of accidents. Moreover, autonomous driving can increase convenience of driving and let people go around their business during the trip.[112]

Shared mobility is becoming more popular especially in dense cities thanks to its convenience. Residents of megacities realize that use services like “Uber” and “Luft” can be cheaper than keeping their own car. Figure 14 demonstrates how autonomous cars together with car sharing will influence future private-use vehicle sales.[113]

[107] PwC (2016)
[108] Hanebrink and Cook (2016, p. 3)
[109] Hirsch, jullens, Singh, and Wilk (2016)
[110] Hirsch et al. (2016, p. 4)
[111] Wood (2016, p. 7)
[112] Hirsch et al. (2016)
[113] Wood (2016, p. 6)

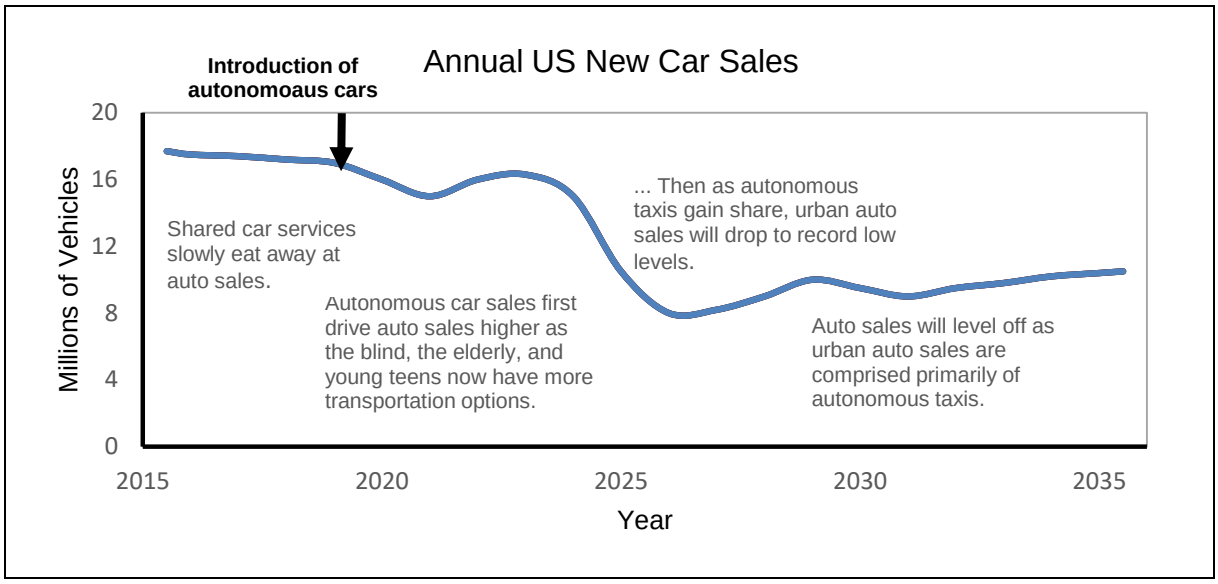

Figure 14: Annual US New Car Sales[114]

In order to meet government emission regulations, OEMs bring fully or partly **electrified** vehicles on the market. As shown in Figure 15, electrification of the vehicle brings a lot of changes such as electric motor, battery, DC/DC converter into powertrain. According to CALSTART, a member-supported organization which promotes clean technologies, about 70% of electric vehicle's parts may differ from a conventional vehicle's parts.[115] These changes lead to different thermal management.[116] For instance, the temperature of the battery is an important parameter, which has a significant impact on vehicle's reliability and performance.[117]

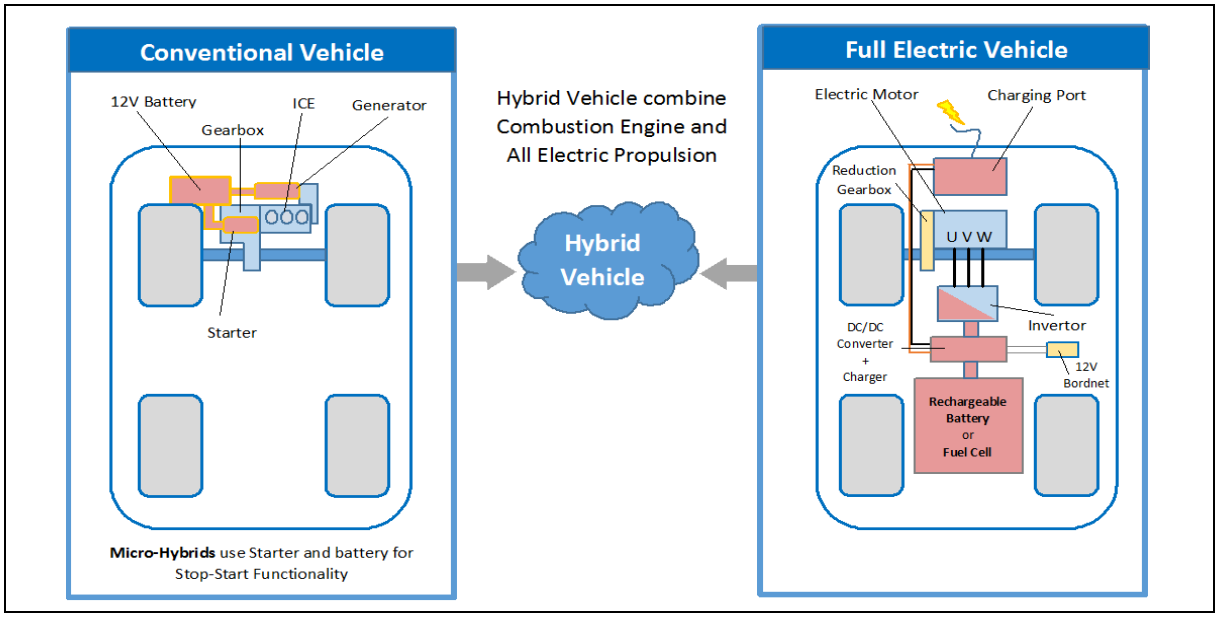

Figure 15: Conventional, Hybrid, and Electric Vehicles[118]

[114] Wood (2016, p. 6)
[115] Idaho National Laboratory (2017)
[116] Maier (2015, p. 10)
[117] Rugh, Pesaran, and Smith (p. 12)
[118] Maier (2015, p. 10)

Within the qpunkt group was decided that electrification trend has potential impact on qpunkt's business; and therefore, will be further considered.

3.1.2.1 Alternative Vehicles

Global warming has negative impact on the planet and mankind: floods and storms, lack of clean water, sea-level rise, formation and dispersion of air pollutants, and many other destructive consequences.[119] Greenhouse gas (GHG) emissions are the main indicators of global change and at the moment account for 23% of global energy-related GHG emissions, and have grown at a rate of 1.9% per year over the last decade.[120] [121] Nevertheless, science does not stay still and innovations in the automotive field can help greatly reduce the amount of harmful gases in the atmosphere thanks to alternative fuels and propulsion systems.[122]

Before describing the trend of electric vehicles, the key definitions will be given:

- **Internal Combustion Engine (ICE)** is the most common type of engine. ICE can utilize gasoline and diesel as well as renewable or alternative fuels (e.g. natural gas, propane, biodiesel, or ethanol).[123] Combustion of gasoline or diesel fuel leads to the formation of CO_2 and other unwanted pollutants like HC, CO, NO_X that adversely affect the environment.[124]

- **Battery Electric Vehicle (BEV)** is a fully electric vehicle that produces zero emissions during utilization. Nevertheless, BEVs can increase global emissions indirectly through the use of energy that comes from fossil-fuelled power plants, as well as battery and material production and recycling.[125]

- **Plug-in Hybrid (PHEV)** uses primarily electric motor but in addition has a small internal combustion engine that can extend vehicle's range between charges. PHEVs produce harmful emissions but at lower level compare to conventional vehicles.[126]

- **Hybrid Electric Vehicle (HEV)** is powered by an internal combustion engine and in addition has an electric motor that uses energy stored in battery to help power the vehicle and reduces fuel consumption.[127]

- **Hydrogen Fuel Cell Vehicle (HFCV)** is also a form of electric vehicle which uses a fuel cell and does not produce CO_2 emissions. However, this type of vehicle is not very common because of complexity and high production cost. Hybrid and electric vehicles

[119] NASA (2017)
[120] United States Environmental Protection Agency (2017)
[121] International Energy Agency (2016a, p. 36)
[122] Burston (2016)
[123] Energy Efficiency & Renewable Energy (2013b)
[124] Burston (2016)
[125] Fergusson (2016, p. 7)
[126] Fergusson (2016, p. 7)
[127] Energy Efficiency & Renewable Energy (2013a)

are more in-demand and develop more rapidly than HFCVs.[128] Therefore the main focus of this chapter will be on HEVs and EVs.

As can be seen in Figure 16, the market of electric vehicles grew by 160% between 2010 and 2016.[129] Despite the rapid growth of the market in recent years, there are many conflicting opinions about the future of electric vehicle models.

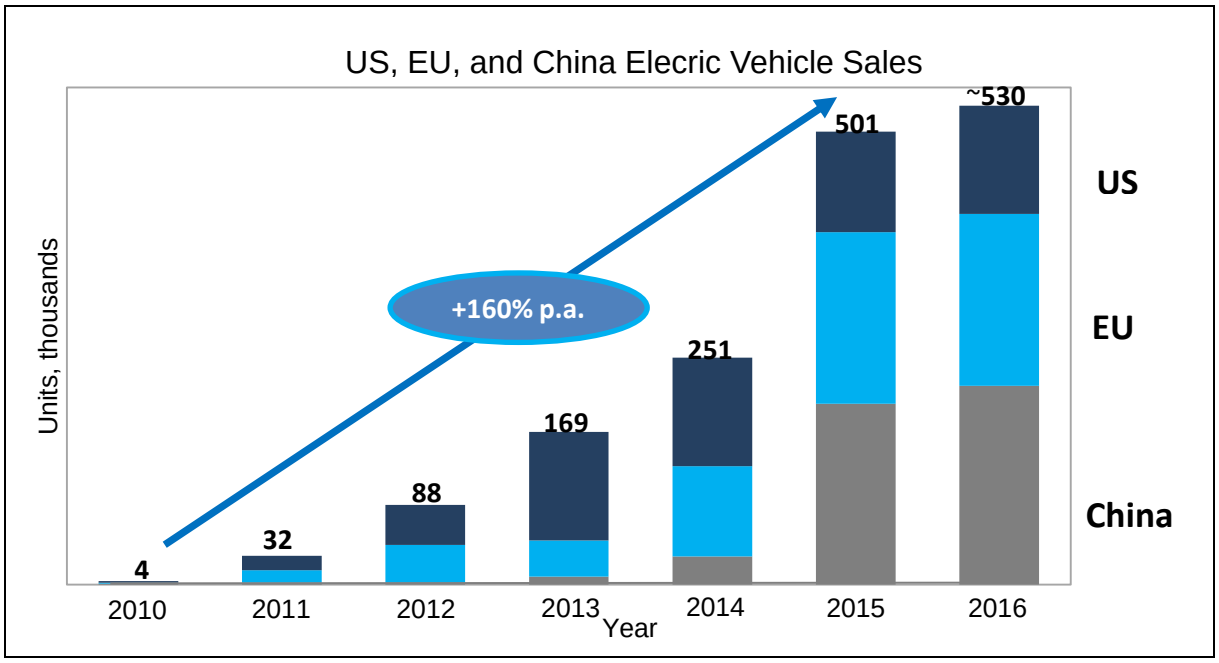

Figure 16: US, EU, and China electric vehicle sales [130]

McKinsey published a report predicting that electric vehicles could range from 10 to 50 percent of new vehicle sales in 2030. The report highlights four following challenges for electric vehicles market penetration: high battery cost, limited vehicle range, poor charging infrastructure and government emission regulations.[131]

High battery cost and limited vehicle range

The main difference in design and cost between electric vehicle and internal combustion vehicle is the powertrain, in particular the battery. Consequently, in order to compete with conventional vehicles in global scope, electric vehicles should fall in price by lowering costs of batteries.[132] As shown in Figure 17, from 2010 to 2016, prices of batteries fell from about US$1,000 per kWh to US$227. A recent study by Knupfer, Hensley, Hertzke, Schaufuss, and Laverty Nicholas suggests that battery packs will cost below US$190 kWh by 2020 and below US$100 kWh by 2030 that will make EVs cost competitive in comparison to ICE vehicles.[133]

[128] Fergusson (2016, p. 7)
[129] International Energy Agency (2016b, p. 10)
[130] Knupfer, Hensley, Hertzke, Schaufuss, and Laverty Nicholas (2017, p. 10)
[131] Randall (2016, p. 12)
[132] Nykvist and Nilsson (2015, p. 2)
[133] Knupfer et al. (2017, p, 8)

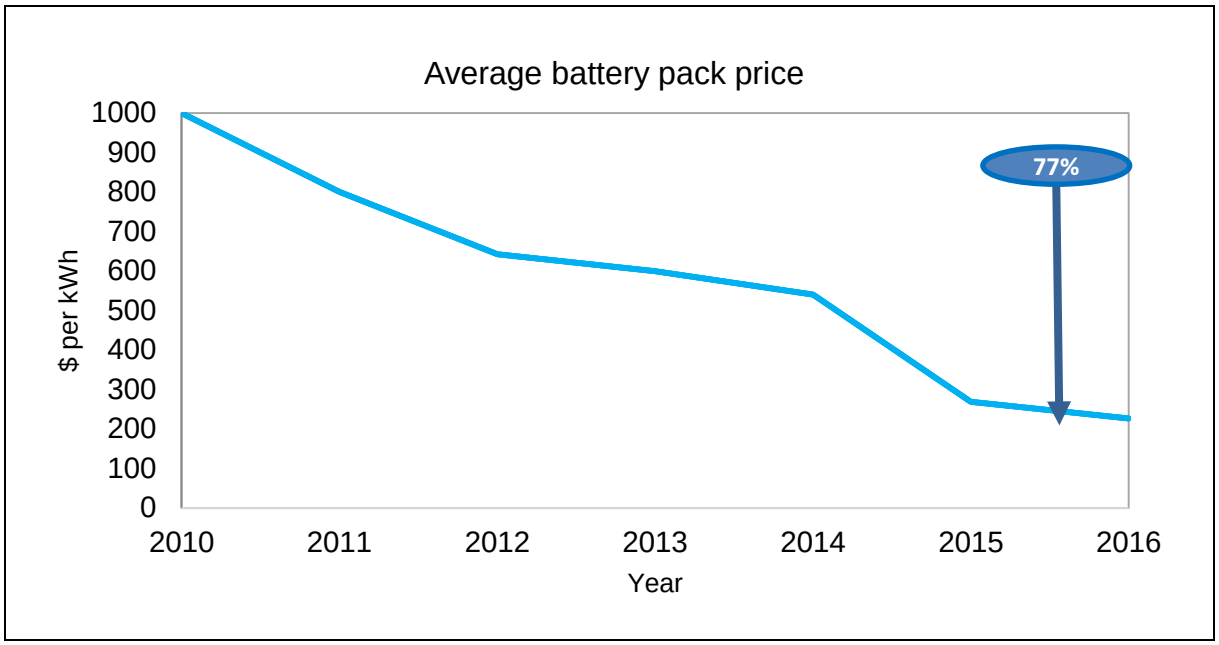

Figure 17: Average battery pack price [134]

Moreover, lower battery prices directly linked to improved energy density, which is responsible for range of electric vehicle, due to material and weight reduction.[135] For example, the first generation Chevrolet Volt grew from 35 miles per charge in 2011 to 50 miles per charge in 2016 with almost same size but lighter-weight battery pack.[136]

Charging infrastructure

Within the next ten years is likely to see a considerable rise in investments on development of charging infrastructure from automotive OEMs and tech companies in the United States, Europe, and China. Thus, a number of private and public charging stations can grow from two million in 2016 up to 12 million by 2020.[137]

Consumer incentives and emission regulations

Fuel consumption is an important criterion for an average user when choosing a car. Nevertheless, low oil prices stimulate customers to buy less fuel efficient vehicles such as sport utility vehicles (SUVs) and thus, reduce EVs sales. For instance, due to low oil prices, in the US, hybrid vehicle sales fell by 20% from their 2013 peak.[138] Figure 18 shows that SUVs represent the majority of vehicles sold worldwide within the year 2016. Their sales have grown by 4.4% in one year. However, the number of sales of sport utility vehicles had a negative impact on the sales of B-segment cars, which fell from 13.9% in 2015 to 12.4% in 2016.[139]

[134] Knupfer et al. (2017, p. 10)
[135] Lamberd (2016)
[136] Tuttle and Baldick (2015, p. 10)
[137] Knupfer et al. (2017, p. 9)
[138] Osborne et al. (2016, p. 10)
[139] JATO (pp. 11-12)

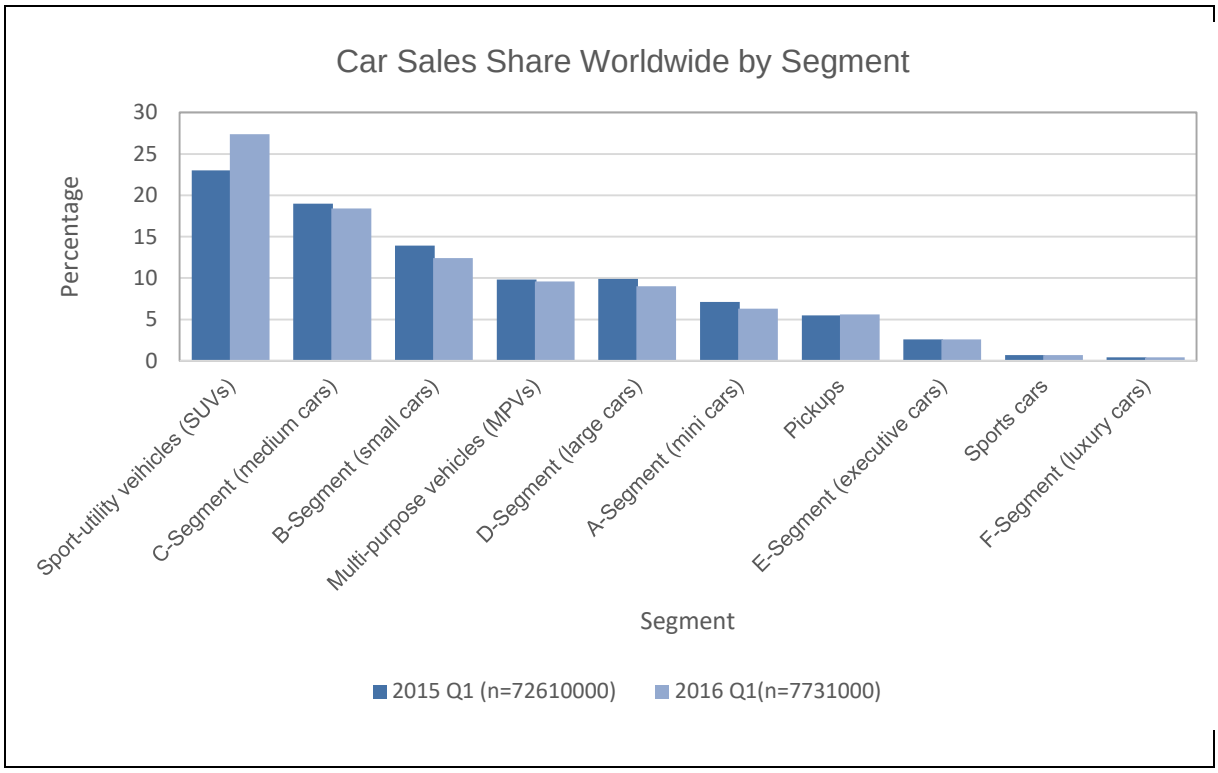

Figure 18: Car Sales Share Worldwide by Segment[140]

As can be seen in Figure 19, oil price did not exceed $ 60 per barrel since 2015. Consequently, motivation to buy an electric car was lower. However, emission regulations (European Union 95 gCO_2 /km, 2021; United States 54.5 mpg, 2025, California 15% Zero Emission Vehicle (ZEV) 2025)[141] will soon come into force and automotive OEMs will be faced with a choice: either accept a penalty or invest money into lowering emission technologies such as electrification or ICE efficiency improvement. McKinsey claims that the second option will be cheaper up to 70%.[142]

[140] JATO Dynamics (2016, p. 11)
[141] Hanebrink and Cook (2016, p. 12)
[142] Knupfer et al. (2017, p. 12)

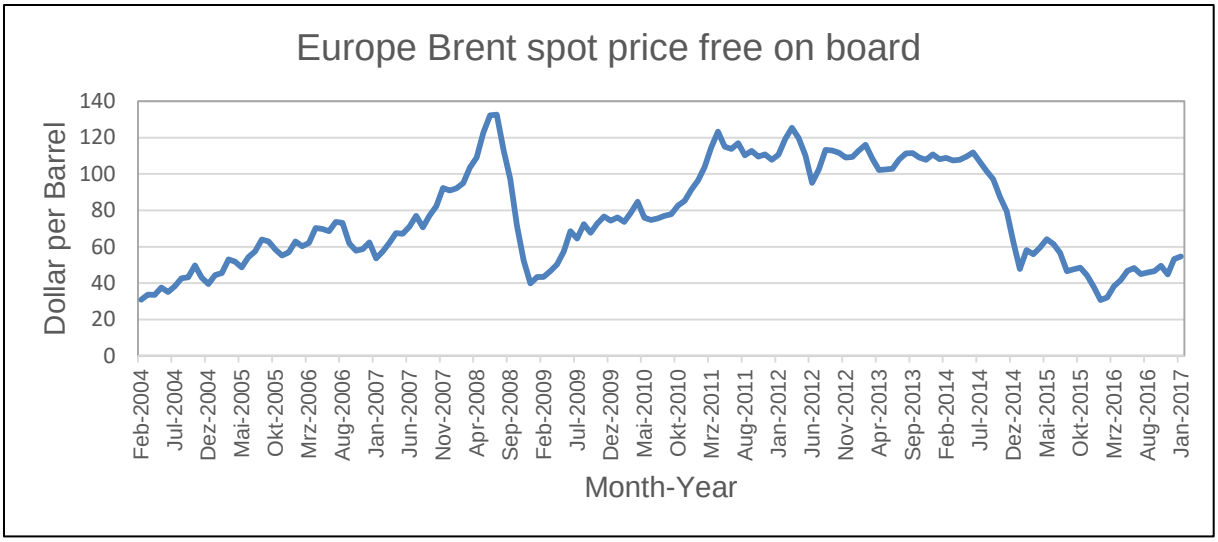

Figure 19: Europe Brent spot price free on board [143]

Furthermore, in some countries government incentives are already in place and facilitate the acceptance of electric vehicles. A few of them are listed below:[144]

- In China, the Netherlands, Denmark (BEVs weighting less than two tonnes), and the United States electric vehicles' owners are exempted from circulation taxes
- In Germany BEVs and PHEVs are exempt from circulation tax for first ten years from the date of their registration
- In France, BEVs and some PHEVs are exempted from annual taxation for company cars

Projections on Alternative Vehicles

The opinion of experts diverges when it comes to the future of alternative vehicles. Therefore, five most significant scenarios will be selected and compared. On the recommendation of qpunkt GmbH, the time spare from 2015 to 2025 was chosen.

Scenario 1: Organization of the Petroleum Exporting Countries (OPEC) has recently released its annual "World Oil Outlook Report" where it is said that automotive market will grow from current one billion passenger cars up to 2.1 billion in 2040 of which 22% are alternative vehicles. However, by 2025, the ratio between electric, hybrid, and conventional vehicles varies slightly (see Figure 20).[145]

[143] US Energy Information Administration (2017)
[144] International Energy Agency (2016b, p. 17)
[145] Griffin et al. (2016, pp. 11-13)

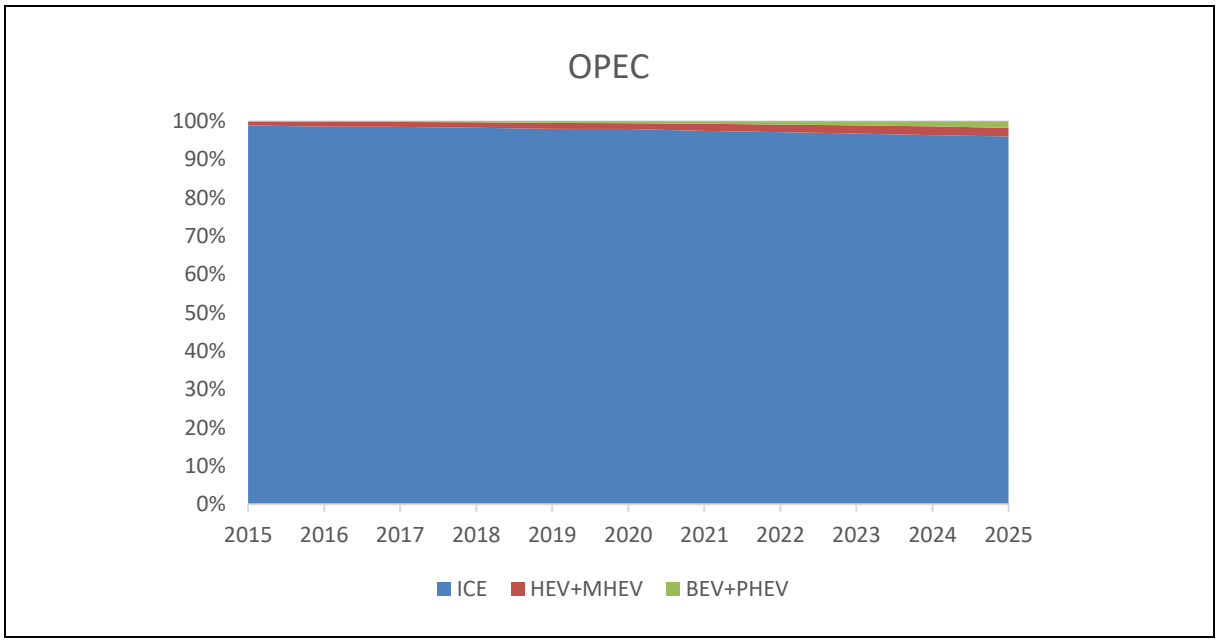

Figure 20: Projections on Alternative Vehicles from OPEC[146]

Scenario 2: BOSCH, the largest automotive supplier,[147] has similar opinion as OPEC, on the future of alternative vehicles. Nevertheless, the company sees more potential in vehicles with alternative powertrain and says that BEV sales will grow around 80% by 2025 (see Figure 21).[148]

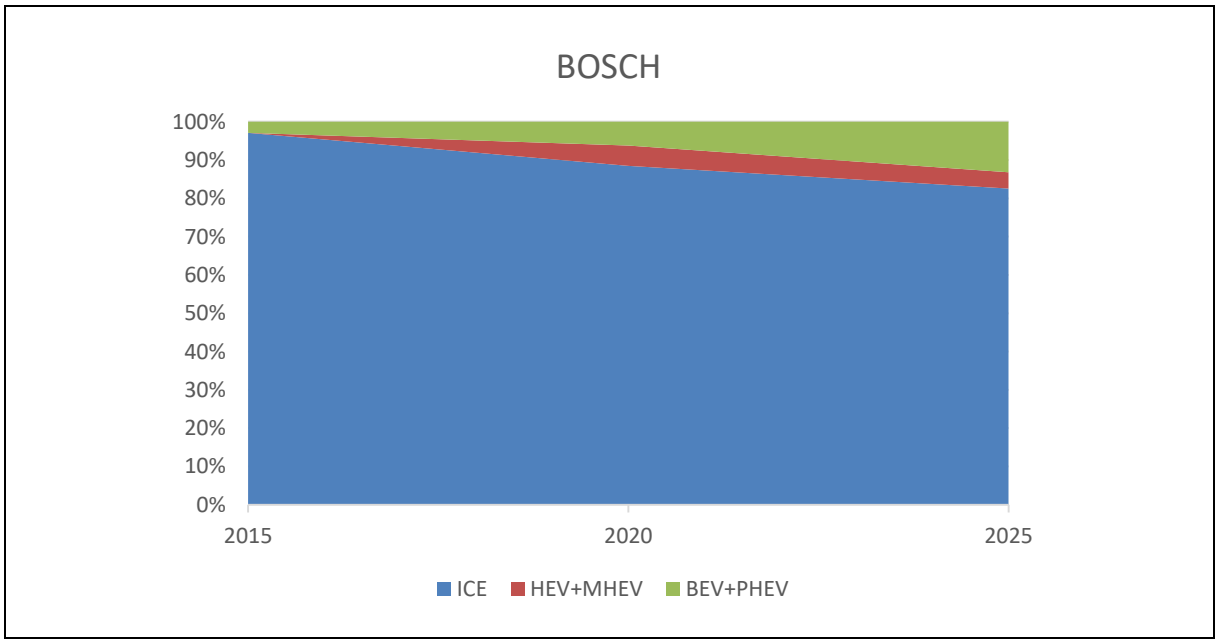

Figure 21: Projections on Alternative Vehicles from BOSCH[149]

[146] Griffin et al. (2016, p. 11)
[147] Automobilwoche (2016, p. 17)
[148] M. Simek (personal communication, March 10, 2017)
[149] M. Simek (personal communication, March 10, 2017)

Scenario 3: AVL, the largest independent company for the development of powertrain systems,[150] assumes a significant drop of conventional vehicle sales in NAFTA, European Union, and China since 2022. Meantime, hybrid electric vehicles and battery electric vehicles will take a leading position in the market with around 40% and 25% of global vehicle sales respectively by 2025 (see Figure 22).[151]

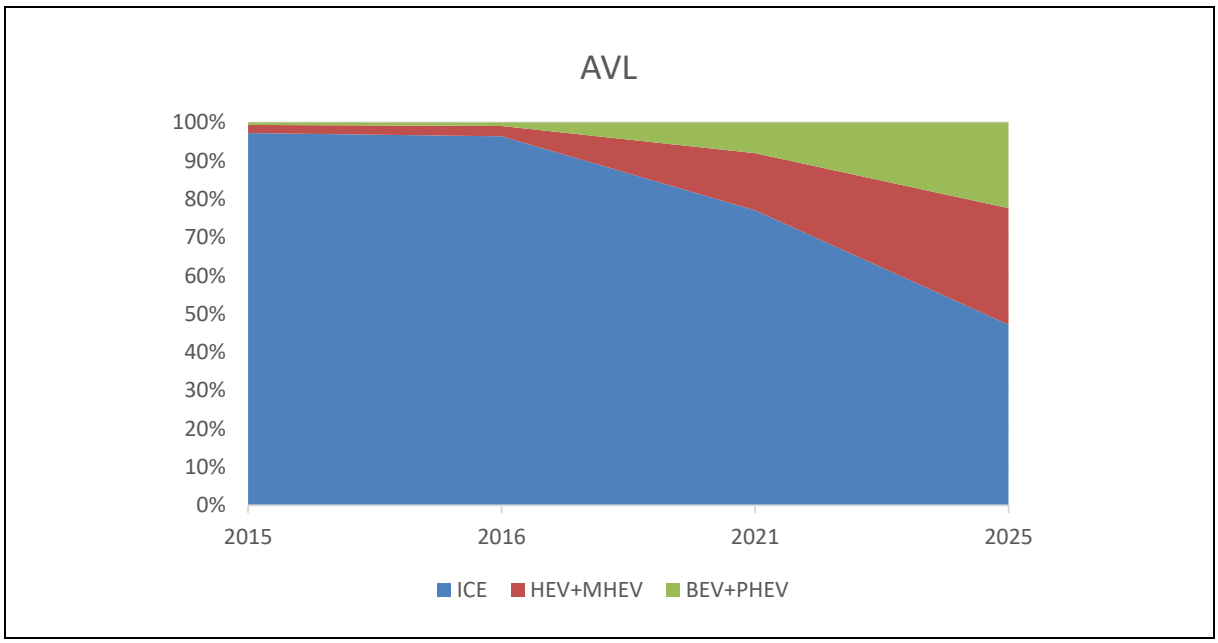

Figure 22: Projections on Alternative Vehicles from AVL[152]

Scenario 4: Strategy Engineers, an automotive consulting company, predicts linear reduction of ICE vehicles and growth of HEVs and EVs. By 2025, according to the organization hybrid vehicles may be accounted for 35% and electric vehicles for 12% (see Figure 23).[153]

[150] AVL List GmbH (2017)
[151] M. Simek (personal communication, March 10, 2017)
[152] M. Simek (personal communication, March 10, 2017)
[153] M. Simek (personal communication, March 10, 2017)

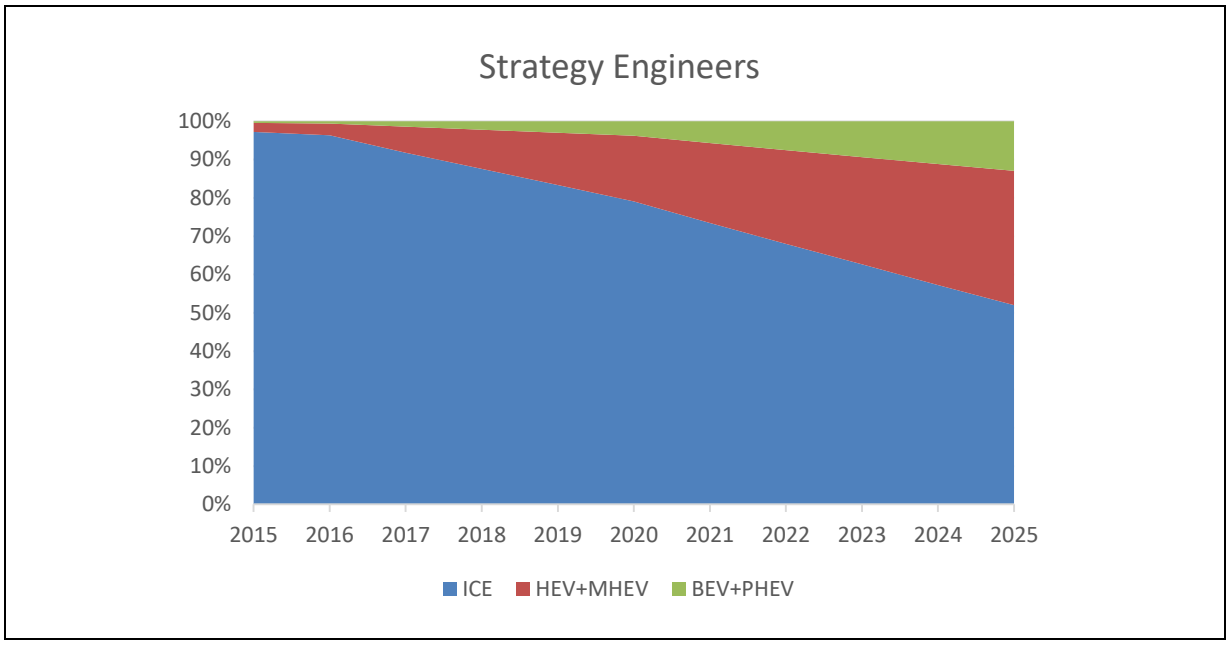

Figure 23: Projections on Alternative Vehicles from Strategy Engineers[154]

Scenario 5: The same as Strategy Engineers, IHS Markit (consulting agency) believes that sales of conventional vehicles will cut back from 98% in 2015 to 75% in 2025. As for hybrids and electric vehicles, the agency believes that their sales could grow to 20% and 7% by 2025, respectively (see Figure 24).[155]

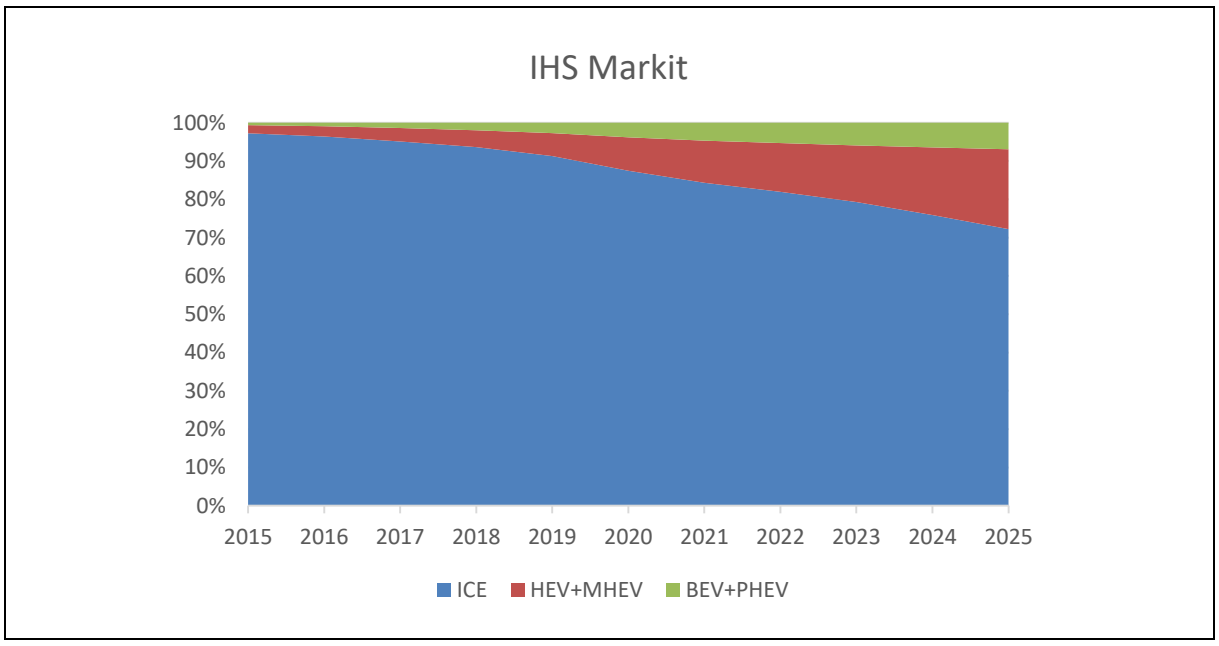

Figure 24: Projections on Alternative Vehicles from IHS Markit[156]

[154] M. Simek (personal communication, March 10, 2017)
[155] M. Simek (personal communication, March 10, 2017)
[156] M. Simek (personal communication, March 10, 2017)

Table 2 compares data on projections given from Figure 20 to Figure 24. From the column 2015-2025 can be noted that AVL and Strategy Engineers expect greater than 50% reduction of conventional vehicle sales. Other companies either believe that sales will stay still or slightly grow. No one has doubts regarding the growth of amount of HEVs and EVs. Despite fast growth of electrified vehicles, internal combustion engine will remain very relevant from around 50 to 95 percent of total sales as seen from the column 2025. Three out of five companies believe that vehicles with hybrid powertrain will range from 20 to 30 percent by 2025. Number of electrified vehicles will grow by an average of 11%.

Table 2: Projections on the future of electric vehicles

	2015-2025			2025		
	ICE	HEV+MHEV	BEV+PHEV	ICE	HEV+MHEV	BEV+PHEV
OPEC	23,05%	67,74%	96%	96,05%	2,23%	2%
BOSCH	1,25%	53%	81,43%	82,55%	4%	13,21%
AVL	-65,05%	94,40%	97,70%	47,22%	30,41%	22,38%
Strategy Engineers	-51,81%	94,52%	97,39%	52,00%	35,07%	12,94%
IHS Markit	-8,48%	91,79%	92,55%	72,22%	20,84%	6,94%

3.1.3 Diffusion of Advanced Technology

For conventional vehicles, thermal management system can significantly reduce fuel consumption by improving engine efficiency. As for electric vehicles, it is known that hot or cold ambient conditions have a powerful influence on electric vehicle range. With a purpose of avoiding the influence of ambient temperature and increasing vehicle range, advanced thermal technologies should be applied. Moreover, some thermal management technologies like heated seats combine both passenger comfort and loss reduction functions.[157]

Recently, Osborne and co-workers in their Automotive Thermal Management Technologies carried out an analysis of thermal management technology development and trends. The authors have identified and assessed 60 thermal management technologies that are potentially useful within automotive applications. In Table 3 the most relevant technologies that will be deployed by 2025 are shown. Each of the technologies was evaluated according to five following criteria: effectiveness, availability, market penetration, long-term cost viability, and technical maturity.[158]

[157] Osborne et al. (2016)
[158] Osborne et al. (2016)

Table 3: Thermal Technology Market Penetration and Maturity Assessment [159]

Thermal Management Technology	Definition	Overall Rating	Cost-Value Rating
Active Grille Shutters	Mechanically actuated flaps that control radiator airflow and reduce drag	8.8	Very High
Variable Engine Oil Pump	Variable mechanical engine oil pump to better match pump flow with engine requirement	8.4	Very High
Active Transmission Warm-Up	A system that uses waste heat from the vehicle to quickly warm the transmission fluid to an operating temperature range using a heat exchanger[160]	8.0	High
Intelligent Cooling System	Improved function of a cooling system	8.0	High
Integrated Liquid Cooled Exhaust/EGR	Cooling exhaust/EGR using coolant in a tightly coupled exhaust manifold design	8.0	Very High
Aero Drag (10%)	The resistance caused by a gas to the motion of a solid body moving through it[161]	8.0	High
Passive Cabin Ventilation	Passive mechanism allowing heat transfer to continue even after the engine and HVAC system have shut off in order to maintain an ambient temperature in the cabin	7.8	High
Low-E/IRR/PVB Glazing	Automotive glass incorporating solar reflective or absorbing features to reduce passenger cabin thermal effects which require higher cooling energy usage	7.6	Low
Turbo-Cooling + Transthermal	Capture of heat from the turbocharger housing in conjunction with rapid transmission warm-up	7.6	Low

[159] Osborne et al. (2016, pp. 9-15)
[160] Williams (2016)
[161] Webster's Revised Unabridged Dictionary (1913)

Engine Thermal Mass Reduction	A variety of techniques ranging from improved design and better component integration to application of lighter and higher-strength materials.	7.4	Very High
Coolant Heat Storage Tank	Device which stores coolant thermal heat energy for rapid powertrain and passenger cabin warm-up	7.2	Low
EGR Cooling (HP+LP)	Combustion concept that involves utilizing cooled exhaust gas as a charge diluent for controlling combustion temperatures prior to its introduction to the combustion system. A dual-loop system incorporates high and low pressure EGR loops and dual EGR coolers	7.0	Moderate

3.2 Customer Analysis

In previous Subchapter 3.1, projections on alternative vehicles were considered. In this section, in turn, the largest automotive brands and their plans and strategies for the next few years will be presented. Through their example, conclusions about the truthfulness of forecasts of automotive industry experts can be drawn. Consequently, customers will be divided into segments using cluster analysis and each segment will be described. The methodology of clustering is outlined in Chapter 2.

3.2.1 Customer Profiles

BMW AG

BMW Group is a global automotive group that includes three brands BMW, Mini, and Rolls-Royce. BMW brand produces premium vehicles with a focus on performance and technology.[162] Currently, BMW has an “i” subbrand that represents full electric (BMW i3) and plug-in hybrid (BMW i8) models. The CEO of BMW Harald Krüger said that the company wants to offer all existing models also with an electric drive. Moreover, Mini with a hybrid powertrain will be released in 2018 and the one with an electric powertrain in 2019.[163] Furthermore, speaking about alternative powertrains, BMW does not exclude the possibility of development of hydrogen fuel cell technology and therefore conducts research in this area.[164]

[162] BMW Group (2017)
[163] Luca Ciferri (2016)
[164] BMW Group (2017)

Daimler AG

Daimler is an automotive company with a headquarters in Stuttgart, Germany. The company is one of the largest manufacturers of premium cars and the biggest manufacturer of commercial vehicles.[165] Daimler believes that connectivity, autonomous driving, car sharing, and electrification will shape future mobility. For this reason, Daimler makes lots of investments into car sharing services, autonomous driving technology, and digital brand. Regarding electrification, a Mercedes's strategy supposes to produce more than ten all-electric vehicles by 2025. Daimler is going to invest one billion euros into battery production.[166]

Fiat Chrysler Automobiles (FCA)

Fiat Chrysler Automobiles is an Italian-American automotive group that includes following automotive brands: Abarth, Alfa Romeo, Chrysler, Dodge, Fiat, Fiat Professional, Jeep, Lancia, Ram, SRT, Maserati and Mopar, the parts and service brand.[167] In early 2016 the CEO of FCA Sergio Marchionne announced that Fiat Chrysler will invest money into SUVs, trucks, and luxury cars since these segments generates the highest margin. Neither new mobility technologies nor vehicles with electric drive were included in this strategy.[168] However, in 2017 FCA has changed its direction and decided to keep an eye on these matters and thus has revealed fully electric vehicle, which is based on the Chrysler Pacifica minivan. Moreover, according to Bloomberg, Maserati is working on an electric car and will try to compete with Tesla.[169]

Ford Motor Company

Ford Motor Company is an American multinational company that includes Ford and Lincoln brands.[170] Currently, Ford ranks first in the sale of hybrid cars and second in the sale of electric cars in the US. The company is not going to give up its positions in the market of green cars and is going to release 13 new electric vehicles by 2020 including a small fully electric SUV, and together with other automakers creates about 400 ultra-fast charging sites. Moreover, Ford is investing $700 million in the plant called Flat Rock (Michigan) where high-tech electrified vehicles will be produced.[171]

Geely

Geely is a Chinese company that owns a Scandinavian brand Volvo that produces premium cars. Volvo set the goal of selling a million electrified cars by 2025. The company wants to achieve this target by introducing at least two hybrid versions to each model and launching the first electric car by 2019.[172]

[165] Daimler AG (2016)
[166] Daimler AG (2016)
[167] FCA (2017)
[168] Niedermeyer (2016)
[169] Ebhardt and Butters (2016)
[170] Rueters (2017)
[171] The Ford Motor Company (2017)
[172] Volvo (2016)

General Motors Company

General Motors (GM) is the third biggest automotive OEM[173] that produces all types of vehicles and includes following brands: Chevrolet, Buick, GMC, Cadillac, Opel, Vauxhall, Holden, Baojun, Wuling, and Jiefang.[174] In 2016 GM has announced a growth strategy for China with a focus on SUVs, MPVs, and luxury cars. The company claimed that it will release up to 60 new or modified vehicles by 2020 and more than 10 “green" vehicles under Chevrolet, Buick, Cadillac and Baojun brands.[175]

Honda Motor Co.

Honda Motor Co. is a Japanese company that mostly operates in manufacturing of motorcycles, automobiles, and power products.[176] As for the automotive industry, the company pays great attention to safety and new technologies.[177] Honda plans to electrify up to two thirds of their cars in the European market by 2025. The first two-motor hybrid is expected to be released in 2018.[178]

Hyundai Motor Group

Hyundai Motor Group is a South Korean multinational conglomerate. The company includes KIA Motors and Hyundai Motor Company, and ranks the first cars manufacturer in South Korea and the fifth in the world.[179] By 2020, Hyundai and Kia plan to introduce 26 alternative vehicles that include plug-in, hybrid, electric, and fuel cell powertrains. Thus, they want to compete in the market of electric vehicles and to reach Toyota’s level.[180]

Jaguar Land Rover

Jaguar Land Rover (JLR) is a British premium automaker that is a subsidiary of Tata Motors since 2008.[181] In December 2016 the CEO of JLR Ralf Speth gave an interview to Automotive News where he shared his opinion on the future of electric vehicles. Back in 2015, Speth spoke very negatively about electric cars but now he assumes that many vehicles will have an electric drive by 2025. However, he is not able to give any projections of his own company and number of EVs by that time. At the moment, JLR being in a partnership with Magna Steyr are building an electric crossover I-Pace in Austria. Speth claims that both Jaguar and Land Rover brands are well prepared for the electric vehicles entry.[182]

PSA Group

PSA Group owns three French automotive brands (Peugeot, Citroen, and DS Automobiles) and a mobility service Free2Move.[183] PSA expects to have a new generation of electric

[173] Automobilwoche (2016, p. 4)
[174] General Motors (2017a)
[175] General Motors (2017b)
[176] Honda Worldwide site (2017a)
[177] Honda Motor Co. (2017)
[178] Honda Worldwide site (2017b)
[179] KIA MOTORS EUROPE (2010)
[180] Greimel (2016)
[181] Tata Motors (2017)
[182] Ciferri and Johnson (2016)
[183] PSA Group (2017)

vehicles along with conventional cars. For both vehicles with electric drive and internal combustion engine, common modular platforms (CMPs) have been developed. CMP was designed in cooperation with DongFeng Motors for compact and subcompact cars for all PSA brands and anticipated to be launched by 2020.[184]

Renault-Nissan Alliance

Brands Renault and Nissan in 1999 formed the Alliance, which today is the fourth largest car manufacturer in the world and the number one on the electric vehicle market. The Alliance includes nine following brands: Renault, Nissan, Mitsubishi, Renault Samsung Motors, Infiniti, Venucia, Dacia, Datsun and Lada.[185] The Alliance has ambitious targets for 2020. It involves achieving zero-fatalities and zero-emissions, as well as the launch of more than 10 vehicles with autonomous driving technology at affordable prices by 2020.[186]

Toyota Motor Corporation

In 2015 Toyota sold the largest number of cars around the world and was recognized as the largest car manufacturing company.[187] In January 2017 total sales of hybrid cars reached 10,000 units and by 2020 Toyota plans to sell another 5 million. In addition to hybrids, Toyota also does not deprive of attention electric cars and fuel cells. The goal of Toyota is to reduce CO_2 emissions by 90% by 2050. The automaker believes that a wide range of environmentally friendly cars will help protect the environment. In addition, Toyota has not avoided the trend of autonomous cars. The company has been developing autonomous driving technology since the 1990s and still invests a lot of money in it.[188]

Volkswagen AG

Volkswagen is a German automaker that includes following famous brands: Volkswagen, Seat, Skoda, Audi, Porsche, Bentley, Lamborghini, Man, Bugatti, Ducati, and Scania.[189] In 2016 Volkswagen was named the world's largest car manufacturer.[190] After an emission scandal that took place in 2015, Volkswagen revised its strategy and began to focus on the production and introduction of environmentally friendly cars. At the moment, the company plans to launch up to 30 new electric models over the next ten years. With regard to Volkswagen brand only, they want to sell one million vehicles per year and become the leader on the electric vehicle market. The brand will seek to increase sales of electric vehicles due to the Chinese market. As for Europe, to begin with, they will try to fit into the norms thanks to hybrid cars, and then increase sales of electric vehicles. Other Volkswagen Group brands also meet the era of environmentally friendly cars fully armed. So, for example, Audi plans to compete with Tesla in the segment of premium electric vehicles,[191] and Bentley will release a fully electrified vehicle after 2020.[192]

[184] PSA Group (2016)
[185] Renault-Nissan Alliance (2017)
[186] Renault-Nissan Alliance (2016)
[187] Automobilwoche (2016, p. 4)
[188] Toyota Motor Corporation (2017)
[189] Volkswagen AG (2017)
[190] Automobilwoche (2016, p. 4)
[191] Cremer and Taylor (2016)
[192] Stanley (2016)

From the descriptions of the companies and their strategies can be noticed that nearly all of them are aware of the importance of a trend towards alternative vehicles. Some companies, for instance Volkswagen AG and Toyota Motors have long been confident that electric cars are the future and already largely incorporated them into their model lines. Others such as Jaguar Land Rover and Fiat Chrysler Automobiles several years ago denied that the era of gasoline will soon come to the end, and still hoped that low oil prices and high customer demand for SUVs will not let alternative vehicles to take over conventional ones on the market. However, nowadays, even they have recognized the need for electric cars and are preparing for the EVs boom.

The next unresolved issue is if alternative cars capture the market, then what kind of cars will they be: electric cars, hybrids or fuel cells? At the moment, the data of different studies diverge as well as the plans of automakers. Nevertheless, it is possible to track a tendency on HPEVs and pure EVs but keep an eye on FCEVs. Thereby, the main advice for qpunkt GmbH is to monitor the situation on the market, be ready for any option and quickly respond to the needs of its customers.

3.2.2 Customer Segmentation

This chapter outlines a process of customer segmentation. To begin with, qpunkt's current and potential customers that will be analysed are selected. Subsequently, clustering variables are chosen and described. When these steps have been completed, customer segmentation can be carried out. In this thesis hierarchical method of clustering was used.

3.2.2.1 Clustering Variables

To sort the qpunkt's current and potential customers into segments united by similar features, cluster analysis was applied. In order to determine possible market segmentation variables, the data gathered through the internet research was analysed. As a result of this analysis, the following segment criteria were chosen: location area, market share, and price segment.

Table 4 represents automotive brands that were chosen for conducting the cluster analysis.

Table 4: Car Manufacturers and Brands

Corporation	Brand
BMW AG	Mini
	BMW
Daimler AG	Mercedes-Benz
DongFeng	DongFeng
FCA Group	Alfa Romeo
	Maserati
	Jeep
	Fiat
Ferrari	Ferrari
Ford Motor Company	Ford
GEELY	Volvo
General Motors	Buick
	Chevrolet
Great Wall Motors	Great Wall
Honda Motor Company	Honda
Hyundai Motor Group	KIA
	Hyundai
Mazda Motor Corporation	Mazda
McLaren Group	McLaren
PSA Group	Citroen
	Opel
	Peugeot
Renault-Nissan Alliance	Renault
	Nissan
Subaru	Subaru
TATA	Land Rover
Toyota Motor Corporation	Toyota
Volkswagen AG	Bentley
	Lamborghini
	Porsche
	Seat
	Skoda
	Audi
	Volkswagen

Customer Location

Location area is an important factor in B2B (Business to Business) market segmentation. Transportation costs, taxes, local competitors, and etc. can be crucial in choosing a market for the promotion of a service or product. Therefore, the first criterion for choosing such clients will be their proximity to qpunkt. The closer the client, the higher likelihood can be that he will cooperate with qpunkt. Thus, the majority of potential customers is from central Europe, especially from Germany, since qpunkt has 5 branches and already cooperates with most automakers from this area. Despite the great distance between Austria, where qpunkt

headquarters is located, some Asian companies can be very potential, as the company has already established contact with some local OEMs, for instance Toyota and DongFeng, and plans to continue the partnership. As for USA, qpunkt has never cooperated with any American automaker. However, in the long term, this area could become very profitable for the firm because of the large number of automotive companies.

As illustrated in Figure 25, the majority of the brands considered in this thesis are concentrated in Europe (65%), about a quarter are located in Asia and the remaining 14% in North America.

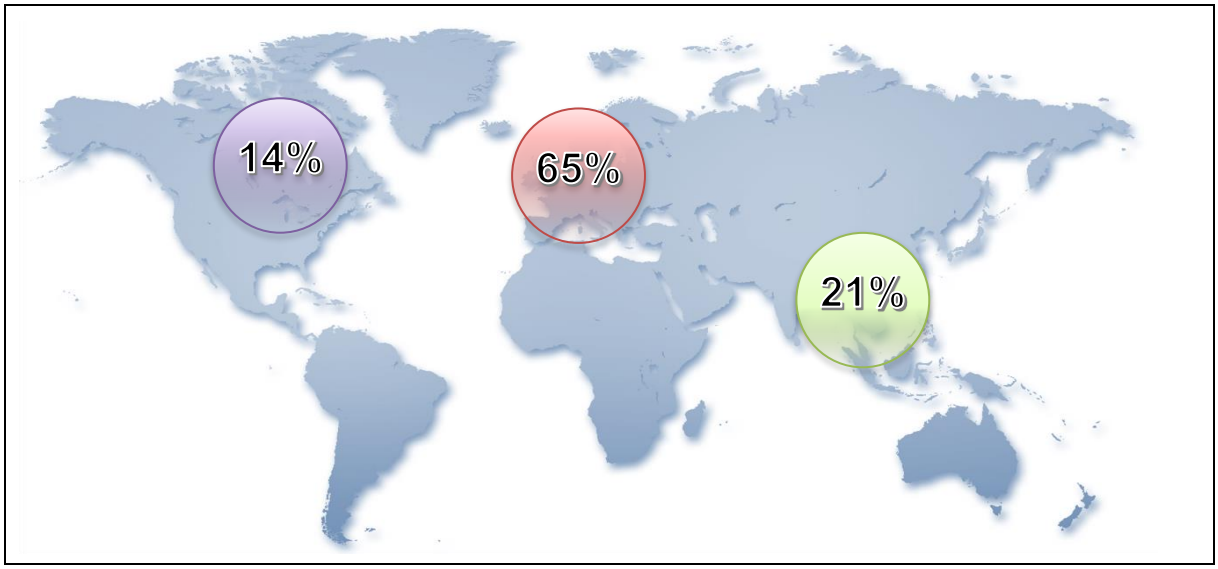

Figure 25: Automotive Manufacturers by Region[193]

Market Share

Market share represents the position of the company in the market relative to its competitors. In this work, market share was chosen as one of variables of a customer segmentation because of the correlation between company's market share and its profitability. [194] As shown in Figure 26, in the first quarter of 2016 the largest share of the market belonged to Toyota-Volkswagen and then Ford were behind. Meanwhile, Mercedes-Benz, BMW, and Audi improved their performance compared to the previous quarter due to the growing popularity of premium cars. However, manufacturers with a low market share can also cause interest, in particular supercars, sports cars and luxury cars that make a large profit from each vehicle. More details on it will be given in the next paragraph. The market share is variable, and therefore, there is a need for monitoring slightest changes.

[193] Outline world map images
[194] Gerasimov et al. (2012, p. 17)

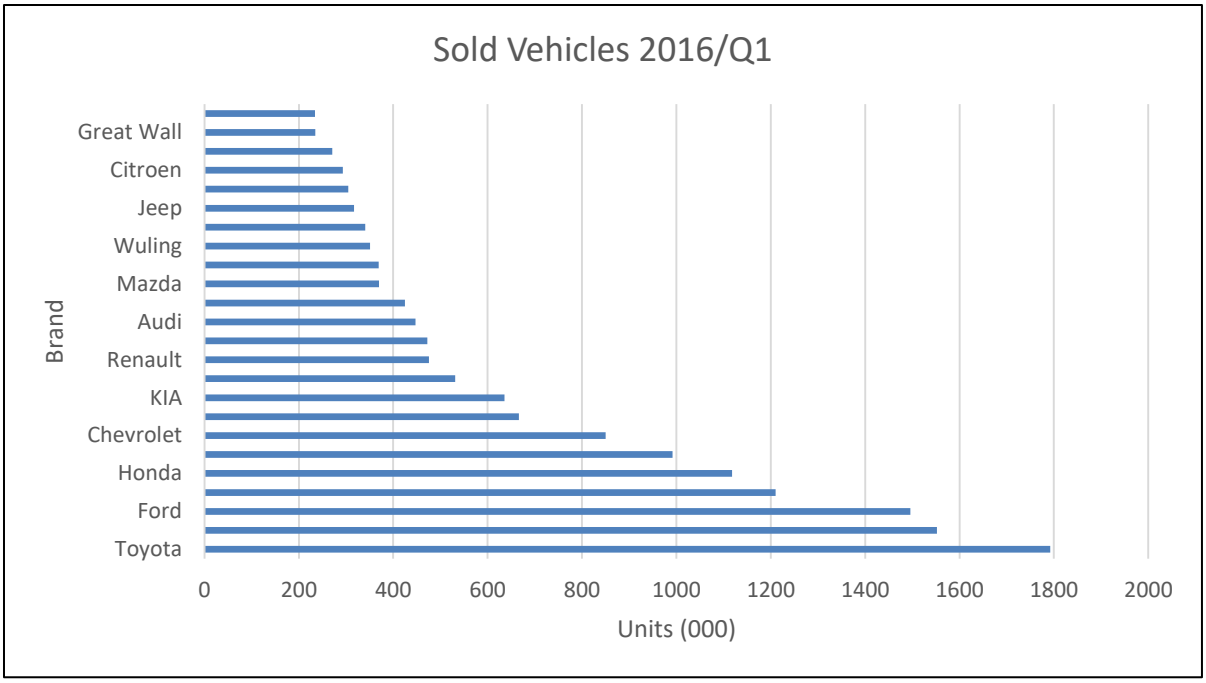

Figure 26: Car Manufacturers by Sales Volume 2016-Q1[195]

Price range of a vehicle

The third variable is the average price for a car of each brand presented in the analysis. Jason Lancaster, an auto industry marketing expert, claims that the more expensive a car is, the more profit the manufacturer receives for each sale. In addition, Lancaster says that expensive cars are distinguished by their impeccable performance and comfort.[196] Since the implementation of these important features requires an excellent thermal management in the car, including A/C and overall heat exchange system,[197] brands whose cars exceed the price of $130,000 can be of great interest as a customer. Nevertheless, mass production of mid-price cars with relatively low profit per vehicle cause an interest too, especially those brands that have the largest market share as development costs and comfort level are still high.[198] For this reason, the customers were divided by average price for a single car into following groups: less than $35,000, from $36,000 to $70,000, from $100,000 to $130,000, more than $130,000. As shown in Figure 27, most cars belong to a <$35,000 segment and from $36,000 to $70,000 segment. Premium cars, luxury cars, and sports cars represent minority.

[195] JATO Dynamics (2016, p. 7)
[196] Jason Lancaster (2015)
[197] Technavio (2016, p. 12)
[198] Jason Lancaster (2015)

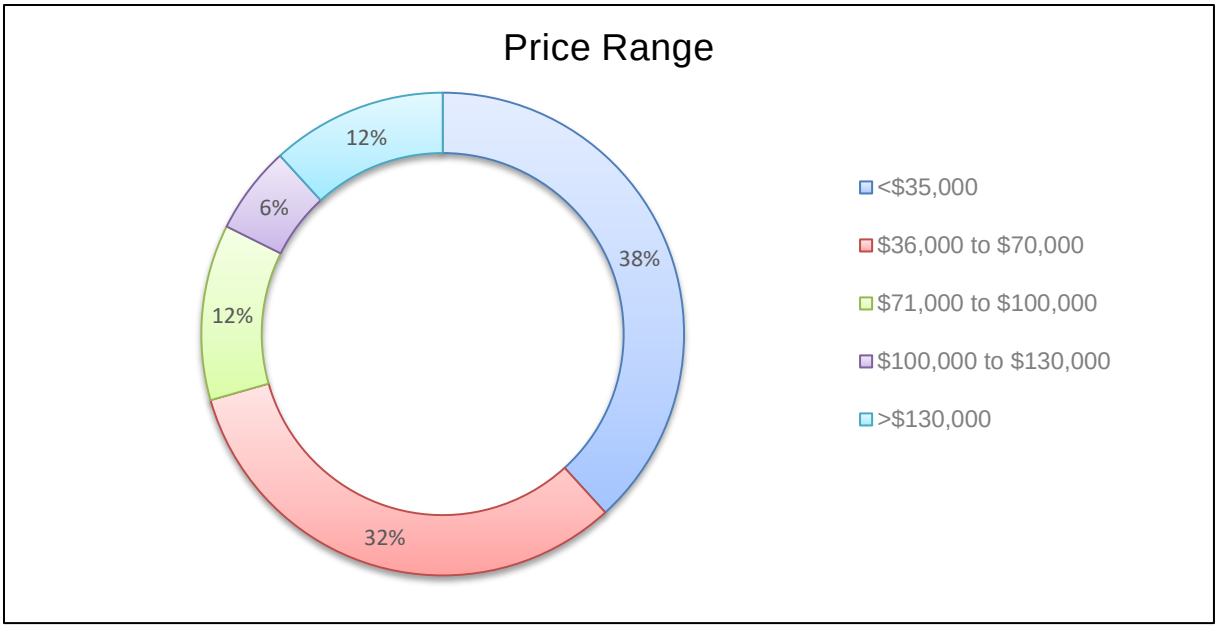

Figure 27: Customer Segmentation by Price Range

3.2.2.2 Clustering Procedure

Once the variables are defined, it is possible to go directly to the cluster analysis procedure. To form clusters (groups), it was decided to use a hierarchical agglomeration method, in which each object is an individual cluster and further, it combines with other clusters-objects in accordance with their similarity.[199] Due to a small dataset (34 objects), the hierarchical method was chosen. More details on different clustering procedures can be found in chapter 2.4.1.

First, the similarity measure between pairs of objects needs to be found. In this work, in order to calculate the distance between similarities the Euclidean distance is used.

$$d_{Euclidean}(i,j) = \sqrt{\left(x_i - x_j\right)^2 + \left(y_i - y_j\right)^2} \qquad \text{Equation 1}$$

Please refer to Appendix 1 for the matrix with the results of this step.

Subsequently, as shown in Figure 28, objects are grouped into a hierarchical cluster tree by the nearest neighbour method (single linkage). In this method, the distance between two clusters is determined by the distance between the two closest objects (nearest neighbours) in different clusters. Single linkage is considered the most universal. [200]

[199] Sarstedt and Mooi (2014, p. 273-293)
[200] StatSoft, Inc. (2012)

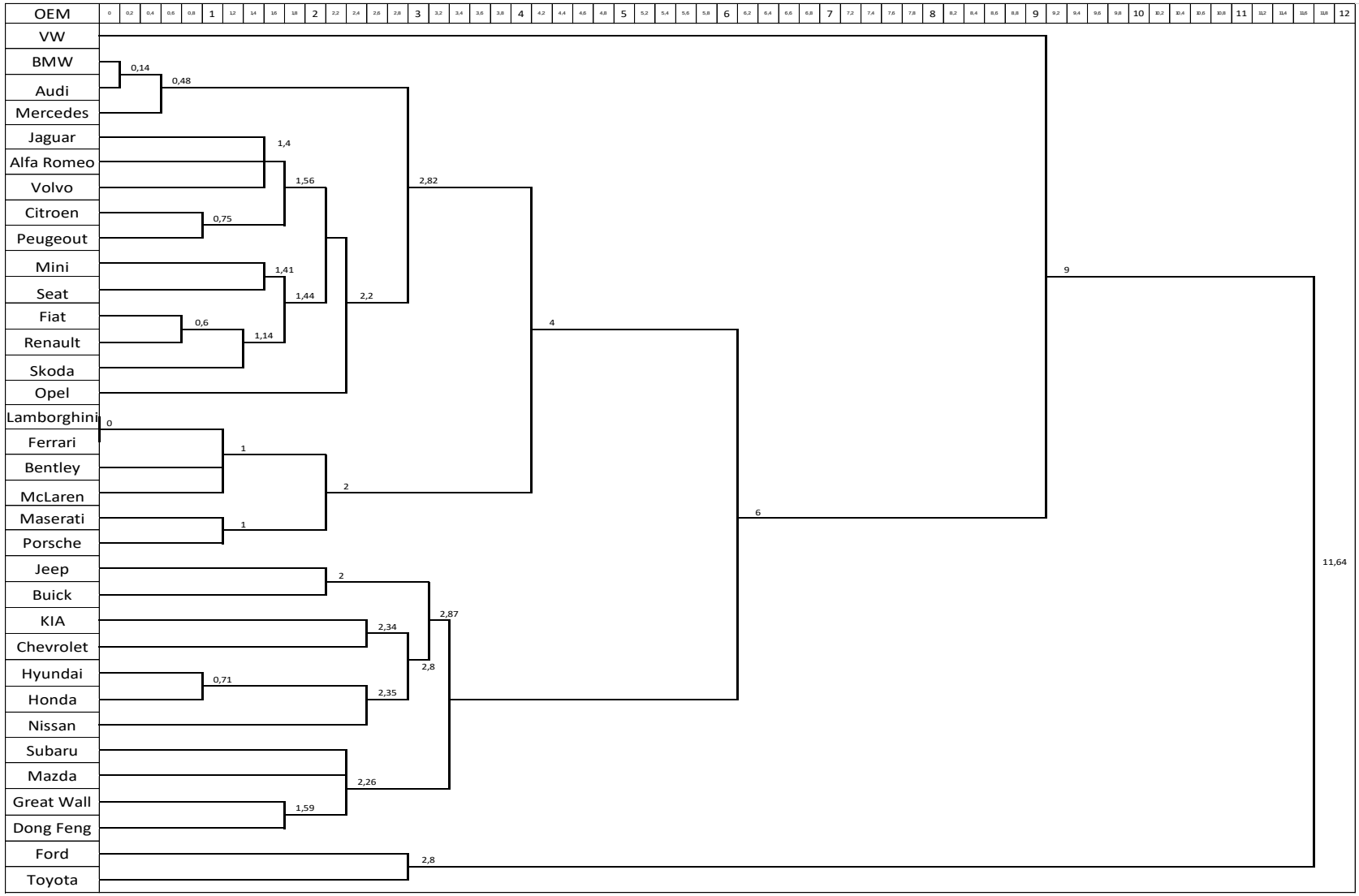

Figure 28: Hierarchical Cluster Analysis

As soon as distances have been calculated and the dendrogram has been produced, it is possible to determine the final clusters and interpret them. In this thesis, the following five clusters have been identified and determined with participation of the qpunkt's Key Account Manager Maximilian Vilniskis[201]:

Cluster 1

Lamborghini, Ferrari, Bentley, McLaren, Maserati, and Porsche represent luxury and sports cars that are located in Europe. The company qpunkt has already worked with most of these brands, which facilitates the path to a new deal. This cluster is the most attractive for selling a highly customized and featured testbed since these brands are extremely focused on the driving performance as well as on excellent comfort for the passenger. Additionally, most often these brands introduce technological innovation a few years earlier than mainstream cars.[202] Cluster 1 can be found in Table 5.

Table 5: Cluster 1

Brands	Lamborghini, Ferrari, Bentley, McLaren, Maserati, Porsche
Location	Europe (incl. Germany)
Market Share	Low
Price Range	From $130,000

Cluster 2

Volkswagen represents the smallest cluster (see Table 6). The brand uniqueness lies in large market share and its location, specifically Europe, Germany. Despite the average prices per car, Volkswagen is investing a huge amount of money in innovations and technologies. For instance, according PwC, in 2016 VW was in charge of twenty R&D spenders with $13.2 billion.[203] All this makes Volkswagen an attractive consumer A/C thermal testbed.

Table 6: Cluster 2

Brands	Volkswagen
Location	Germany
Market Share	High
Price Range	$18,000-$40,000

[201] M. Vilniskis (personal communication, August 1, 2017)
[202] Jason Lancaster (2015)
[203] Jaruzelski, Staak, and Shinozaki (2016)

Cluster 3

As shown in Table 7, cluster 3 includes European automotive OEMs with a market share that varies from low to medium and the price range from $10,000 to $130,000. The price range is quite wide. Thus, the cluster contains both mainstream and premium brands from different parts of Europe. Therefore, it was decided to divide this cluster into two sub-groups.

First sub-group includes following premium brands with a medium market share: Alfa Romeo, Audi, BMW, Land Rover, Mercedes, and Volvo. The main difference between luxury and premium cars is their production volume.[204] In this way, these automakers can be potential buyers of the A/C testbed as they also pay much attention to performance and comfort. In addition, qpunkt has built long-term relationships with some of these brands, for instance with Audi and Mercedes.

Second sub-group includes European mainstream cars at an affordable price such as Citroen, Fiat, Mini, Opel, Peugeot, Renault, Seat, and Skoda. Since these manufacturers try to save as much money as possible within the development process, it is unlikely that they will order a highly advanced testing chamber to test their A/C circuit or improve overall thermal management in the car. However, these brands are still attractive as customers, since qpunkt can offer them less expensive ways of conducting tests.

Table 7: Cluster 3

Brands	Alfa Romeo, Audi, BMW, Citroen, Fiat, Land Rover, Mercedes, Mini, Opel, Peugeot, Renault, Seat, Skoda, Volvo
Location	Europe
Market Share	From low to medium
Price Range	$10,000-$130,000

Cluster 4

As can be seen in Table 8, cluster 4 includes two carmakers with a large market share. Toyota and Ford are located far away from qpunkt offices, which makes transportation of a walk-in thermal chamber costly and complicated. In addition, local thermal testing products manufacturers, such as ESPEC in Asia and Russells Technical Products in the USA, can seriously compete. However, despite the long distance, the company is trying to cooperate with these two OEMs and plans to establish long term relationships within the next five years.

[204] NowCar (2015)

Table 8: Cluster 4

Brands	Ford, Toyota
Location	USA, Asia
Market Share	High
Price Range	$14,000-$84,000

Cluster 5

The fifth cluster contains American and Asian brands with a market share from low to medium. For the same reasons as cluster 4 (distance and local competitors), at the moment these brands can be attractive to qpunkt only in terms of engineering and component testing. Cluster 5 can be found in Table 9.

Table 9: Cluster 5

Brands	Jeep, Buick, KIA, Chevrolet, Hyundai, Honda, Nissan, Subaru, Mazda, Great Wall, DongFeng,
Location	USA, Asia
Market Share	From low to medium
Price Range	$10,000-$100,000

3.3 Competitor analysis

At the beginning of this section, the key industry players from Germany, Italy, North America, China, and Japan and their products are discussed in detail. Consequently, in order to evaluate the qpunkt's position in the market compared to other key players in the field of environmental testbeds, in particular thermal walk-in chambers, competitive benchmarking was used.

The basis for this chapter was taken from the qpunkt's internal research which was carried out by Gerald Weinbauer in 2017.[205] Because of the lack of valuable information in it, it was decided to extend and modify it.

3.3.1 Competitor Profiles

Angelatoni Test Technologies (ATT)

Angelatoni Test Technologies is an Italian company that was founded in 1932 and is a member of the Angelatoni Industrie Group. In the meantime, ATT has s turnover of around 40 million

[205] Weinbauer (2017, p. 49-60)

euro and more than 200 employees. The company has branches in Germany, France, China and India, as well as representatives in more than 50 countries worldwide. One of the leading ATT's brands is ACS (Angelatoni Centro Sud) that operates in the field of environmental chambers since 1952. ACS has been developing and producing climate chambers for the international market for all possible tests on materials, components and finished products. ACS operates in following industries: electronics, automotive, military, aerospace, and plastic and rubber materials.[206]

ACS offers a wide range of environmental test chambers:[207]

- Temperature and Humidity Test Chambers (Figure 29)
- Thermal Shock Test Chambers
- Vibration Test Chambers
- Standardized and Customized Modular Walk-in Chambers
- HALT and HASS Chambers
- Altitude Test Chambers
- Thermal Vacuum Chambers
- Environmental Stress Screening
- Battery Test Chambers
- Explosion Proof Chambers
- Sun Simulation Chambers
- Dry Corrosion Test Cabinet
- Sand/Dust and Rain Chambers
- Calorimeters

In addition to this range of testing stands, the company offers an intelligent control system "MyKratos". This software provides an access to the chamber in real time via smartphone or tablet and at the same time has a high degree of security.[208]

Figure 29: Walk-in Chamber from Angelatoni Testing Technologies[209]

[206] Angelantoni Test Technologies (2017)
[207] Angelantoni Test Technologies (2016)
[208] Angelantoni Test Technologies (2016, p. 5)
[209] Angelantoni Test Technologies (2016, p. 9)

ESPEC

ESPEC Corporation was founded in 1947 and at the moment is the largest manufacturer of environmental chambers with a turnover around $275 million. The company has six production facilities situated in Japan, China, the USA, and Korea as well as representatives in Europe. ESPEC offers environmental test chambers (Figure 30), secondary battery-related equipment, and measurement and evaluation systems for semiconductors and other electronic products. In addition, the corporation provides worldwide service support and 3 year international warranty for their products.[210]

ESPEC offers following environmental chambers that can also be customized:[211]

- Temperature and humidity chamber
- Thermal shock chamber
- Bench-top type temperature and humidity chamber
- Walk-in type temperature and humidity chamber
- Combined temperature and humidity chamber
- HAST chamber
- FPD (flat panel display) equipment

For ease of use, ESPEC provides touchscreen controllers with USB or Ethernet access.

Figure 30: Walk-In Chamber from ESPEC[212]

Hastest Solutions

Hastest Solutions is an American company that was founded in 2000. The company designs and manufactures following environmental simulation equipment:[213]

- Temperature humidity chamber
- Pressure vessels (HAST/PCT)
- Solar/PV and UV, salt spray/fog

[210] ESPEC CORP. (2017)
[211] ESPEC CORP. (2016, p. 7)
[212] ESPEC North America, Inc. (2015, p. 24)
[213] Hastest Solutions (2010)

- Settling and blowing dust
- Blowing sand
- Walk-in chambers (Figure 31)

In addition, Hastest Solutions provides environment and reliability test services as well as quality and reliability engineering services.

Figure 31: Walk-In Chamber from Hastest Solutions [214]

Russells Technical Products (RTP)

Russells Technical Products is a privately held company which was established in 1972. RTP is based in Michigan, USA and distributes its products throughout North America. A company has a large portfolio of environmental chambers, both standard and customized. An example of a walk-in test chamber is shown in Figure 32. Some of its products are listed below: [215]

- Environmental Stress Screening (ESS) chambers
- Walk-in chambers
- AGREE chambers
- Altitude chambers
- Temperature chambers
- Temperature and humidity chambers
- Environmental test chambers
- Stability chambers
- Thermal test chambers
- Solar panel test chambers
- Thermal shock chambers
- Climate chambers
- Vibration test chambers
- Drive-in chambers
- Explosion proof chambers

[214] Hastest Solutions (2017)
[215] Russells Technical Products (2015a)

In addition, RTP provides three different environmental chamber controllers for monitoring, recording, and reporting data from its chambers:[216]

- "VS1" is a Windows-based control system that can be applied to any environmental chamber, regardless of its brand. The system allows to monitor data at any time and any place and export it into convenient computer programs such as "Excel".
- "Blue Star" control system is featured with a colour touch screen with a friendly interface that shows current setpoint, process variables, and chamber state.
- "F4T" control system from "Watlow" offers modular and simple design for ease of use and installation. The controller is equipped with graphical, colour touch panel.

Figure 32: Walk-In Temperature/Humidity Chambers from Russells Technical Products[217]

Thermal Product Solutions (TPS)

Thermal Product Solutions is an American manufacturer of industrial and laboratory ovens and furnaces, as well as environmental temperature cycling and stability test chambers.[218]

Under a brand "Tenney Environmental", TPS produces following comprehensive environmental test chambers:[219]

- Wide-range testing chambers
- Walk-in rooms (custom and standard) (Figure 33)
- Steady-state environmental rooms
- Compact temperature test chambers
- Temperature humidity cycling chambers
- Altitude chambers
- Thermal vacuum ovens
- Thermal shock chambers
- Temperature and humidity chambers
- Environmental cycling test chamber

[216] Russells Technical Products (2015b)
[217] Russells Technical Products (2015b)
[218] Thermal Product Solutions (2017)
[219] Thermal Product Solutions (2014)

Figure 33: Walk-In Chamber from Thermal Product Solutions [220]

TPS's environmental chambers are provided with a control system called "Smart 1.0" which is equipped with a high resolution touchscreen, real-time colour graph displays, built-in Ethernet with 3 serial ports, intuitive password protected security, remote networking, etc.[221]

Thermotron

Thermotron is an American company that was established in 1962 and now is North America's largest manufacturer of environmental test systems. Thermotron designs and manufactures its products at company headquarters in Holland, Michigan. In addition, it has a European office in the UK.[222]

Thermotron offers following range of environmental equipment:[223]

- Temperature chamber (Figure 34)
- Humidity chamber
- AGREE chambers
- Vibration test systems
- Thermal shock chambers
- HALT HASS chambers
- Speciality environmental chambers
- Altitude chambers
- Test tools
- Controllers
- Refurbished chambers

[220] Thermal Product Solutions (2014)
[221] Thermal Product Solutions (2014, p. 38)
[222] Thermotron (2017a)
[223] Thermotron (2017b)

The manufacturer also provides a Windows-based control system. “8800 Programmer Controller” equipped with a colour touchscreen and multi-level password-based security system. In addition, a chamber can be controlled by PC or mobile devices (tablet, smartphone) through VNC server in real time.[224]

Figure 34: Walk-In Chamber from Thermotron [225]

Weiss Technik

Weiss Technik was founded in 1956 and is part of the Schunk Group, an international company with a total turnover of 1,065 million euros (2015), since 1978. Weiss Technik is based in Griessen, Germany and has additional offices in Austria, Germany, Belgium, Brazil, China, France, the UK, India, Italy, the Netherlands, Russia, Switzerland, and the US. The company specializes in the automotive, aerospace, electronics, pharmaceutical, biological, and medical industries.[226]

Weiss Technik offers automotive environmental chambers for following tests:[227]

- Temperature tests
- Climate test
- Corrosion tests
- Emission tests
- Stability tests
- Plant growth chambers and rooms
- Vacuum tests
- Material tests
- Leakage test
- Vibration tests

A walk-in chamber from Weiss Technik is shown in Figure 35.

[224] Thermotron (2013, p. 3)
[225] Thermotron (2013, p. 1)
[226] Bloomberg (2017)
[227] Weiss Technik (2017a)

Along with their simulation products the company provides a software called “S!MPATI”. “S!MPATI” allows networking up to 99 devices to one another, operate all test equipment in the same way and get an email notifications of faults. Together with “S!MPATI-Web” option, it is possible to control and monitor processes at any place and access the process via mobile devices. In addition, Weiss Technik promises their customers that this software has high security level and is easy to use.[228]

Figure 35: Walk-In Chamber from Weiss Technik [229]

3.3.2 Competitive Benchmarking

Benchmarking is the process of systematic and continuous measurement. To obtain information useful for improving management processes or product characteristics, evaluation of the company and its comparison with the processes of the world's leading companies can be significant.[230] Therefore, to compare the qpunkt’s thermal walk-in chamber with the competitors' chambers, described herein above, benchmarking is used.

In the first step, the main evaluation parameters were defined: usable interior volume, adjustable temperature range, adjustable moisture range. Subsequently, the measures of these criteria were rated from 1 to 10 with 10 being the best and 1 the worst. After evaluation was carried out, the results of each company were compared and the best chamber was identified.

The results on comparison can be seen in Table 10. Most of the companies offer customized sizes of environmental chambers and wide range of humidity level. So that, a temperature range of the chambers can represent the greatest interest within the benchmarking process. From Table 10 can be seen that the best temperature range performs Russels Technical Products which offers an outstanding regime from -70 to +180 °C. RTP is followed by Weiss Technik and Angelatoni Test Technologies with the identical temperature ranges from -70 to +80 °C. The same companies occupy the highest position in the overall ranking.

[228] Weiss Technik (2017b)
[229] Weiss Technik (2017a)
[230] Berezin (2008, p. 385)

Thermal walk-in chamber from qpunkt ranges with the chambers from ESPEC and Thermal Product Solutions. The chamber has good indicators on the criteria of volume and humidity, but it lags behind the leaders in the temperature regime. Nevertheless, qpunkt has designed its testbed to test cars in a natural environment, which ranges from about -70 to +60°C around the World.[231] Consequently, the company should first of all focus on these temperatures and thus, try to reach lower temperatures within testing process.

Table 10: Competitive Benchmarking

Criteria	Measure	qpunkt[232]	ATT[233]	Hastest Solutions[234]	ESPEC[235]	Thermal Product Solutions[236]	Thermotron[237]	Weiss Technik[238]	Russels Technical Products[239]
Usable interior volume	m3	9	9	7	7	5	5	9	9
		custom	custom	>10	4,2 - 52,7	9 - 38,2	8-40 , 0	custom	custom
Adjustable temperatur e range	°C	6	9	6	7	9	7	9	10
		-25 to +60	-70 to +80	-25 to +60	-40 to +80	-73 to +85	-35 to +85	-70 to 80	-70 to +180
Adjustable moisture range	% RH	8	9	8	9	9	9	9	8
		10 to 90	10 to 95	10 to 90	10to 95	20 to 95	5 to 95	10 to 95	10 to 90
Summary		23	27	21	23	23	21	27	27

3.3.3 Identification of the Main Competitors

In this section, qpunkt's competitors in the field of environmental chambers will be considered in terms of their location, income and perfection of the test bed. From previous chapter, can be seen that qpunkt has quite strong competitors around the world. However, at the moment,

[231] Sharp (2012)
[232] Weinbauer (2017, p. 69)
[233] Weinbauer (2017, p. 69)
[234] Weinbauer (2017, p. 69)
[235] Weinbauer (2017, p. 69)
[236] Weinbauer (2017, p. 69)
[237] Weinbauer (2017, p. 69)
[238] J. Ruppert (personal communication, June 7, 2017)
[239] J. Carson (personal communication, June 9, 2017)

the company management is focusing on the European market so the competitors that operate in American market can be irrelevant as long as they remain there. The next important indicator of the company's success is an annual revenue. Annual income typically determines the size of the company.[240] And also, knowing the income, we can assume how good production capabilities of the company. Table 11 details data on following parameters of evaluation: testbed, location, revenue. The same as in the previous chapter, the measures of these criteria were rated from 1 to 10 with 10 being the best and 1 the worst.

Table 11: Comparison of Companies, WW*-Worldwide, MEUR* -Million Euros

Criteria	qpunkt	ATT	Hastest Solutions	ESPEC	Thermal Product Solutions	Thermotron	Weiss Technik	Russels Technical Products
Testbed	6	10	3	6	6	3	10	10
Location	5	10	5	7	5	10	10	5
	AT, G	WW	USA	USA, Asia	USA	WW	WW	USA
Revenue (MEUR)	1	4	1	8	4	3	10	1
	9	40	4,5	245	38	27	930	11

Figure 36 illustrates the results from Table 11. As can be seen, the most relevant competitors for qpunkt are Weiss Technik, Angelatoni Test Technologies, and ESPEC. Weiss Technik represents the biggest threat for qpunkt as a competitor in the field of thermal testbeds. It is a large company with revenue of 930 MEUR and is located in Germany, in the immediate vicinity of qpunkt and its automotive customers such as Volkswagen, Audi, BMW etc. In addition, the company has extensive experience in thermal stands since 1956. ATT is another company that has a lot of experience and revenue of 40 MEUR. ATT is located in Italy and therefore there is a great chance that Italian customers will prefer this particular manufacturer because of its proximity and origins. ESPEC is an Asian company that has been present on the environmental testing market since 1947 and with an income of 245 MEUR. This company has its European representatives in the UK. However, all their production sites are located in Asia and USA that makes this company less competitive in Europe.

[240] Flamholtz and Randle (2015, p. 15)

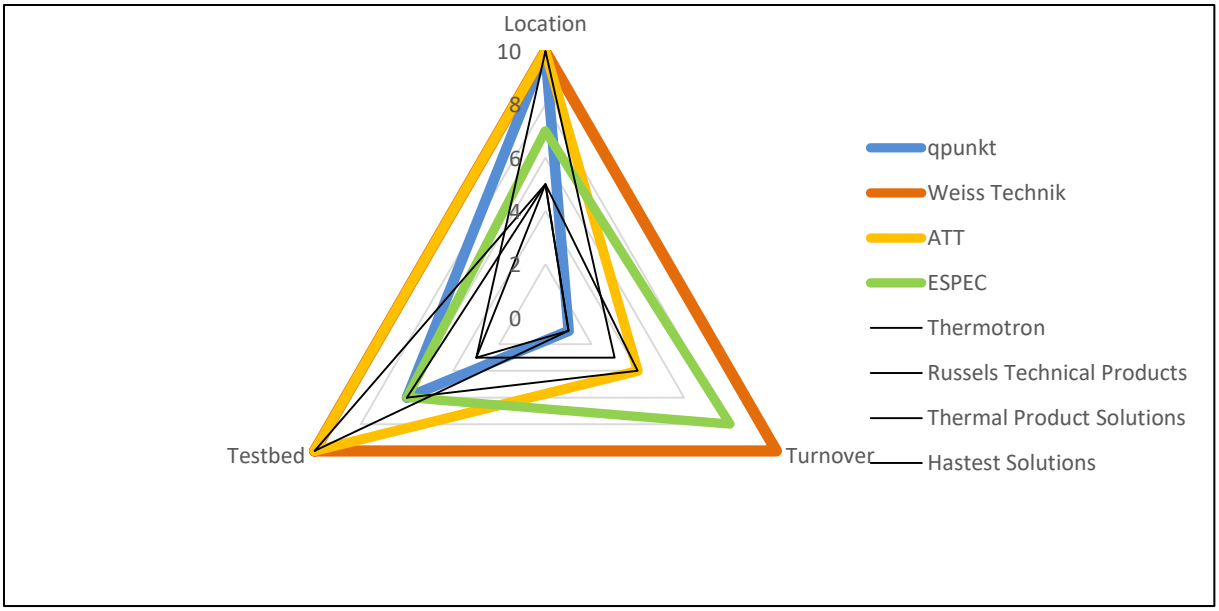

Figure 36: Comparison of Companies

3.4 SWOT Analysis and TOWS Matrix

The aim of this chapter is to conduct a SWOT analysis of the company qpunkt and its thermal testbed as well as to generate and select possible strategic options using a TOWS matrix.

3.4.1 SWOT Analysis

SWOT is an acronym of the words: Strengths, Weaknesses, Opportunities, and Threats. The analysis was carried out in conjunction with the sales and marketing department. As a result of the discussion, following strengths, weaknesses, opportunities, and threats, were identified. For better understanding, the company and the testbed in some cases were considered separately.

Strengths

qpunkt

- Essential understanding of the vehicle process development
- Delivery time
- Fast reaction time on market needs
- Highly qualified and experienced employees
- AVL support (AVL network, cooperation with other AVL group members)
- Established long-term relationships with some largest automotive OEMs (BMW, Volkswagen)
- Located next to some biggest automotive OEMs (Austria, Germany)

Thermal Walk-In Chambers

- Modular design
- Wide range of temperatures
- Simple monitoring process
- Modular software that can interact with Kuli, MathLab, and other computer programs

Weaknesses

qpunkt

- High labour costs in Austria
- Still on the learning curve (lack of experience)
- Improvement of an internal communication is needed

Thermal Walk-In Chambers

- The company's current production capacity will not be able to cope with the mass production of standard walk-in thermal chambers
- Only one walk-in thermal testbed has been sold so far
- High acquisition cost of the testbed

Opportunities

qpunkt/ Thermal Walk-In Chambers

- Expand collaboration with AVL Group
- Thermal management is in demand more than ever. Emerging of new powertrain technologies and overall optimization and modification of conventional powertrains due to government regulations regarding carbon dioxide reduction. This leads to the emergence of new temperature control systems as well as new thermal tests.[241]
- For EVs, improving electric range, reducing size, weight and cost of the cooling system, as well as charging time[242]
- For conventional vehicles, possibility to reduce fuel consumption and improve comfort level in the vehicle due to optimization of HVAC systems[243]
- Growth of automotive thermal market [244]
- Need on the market for understanding the operation of the system and its components e.g. transmission
- Verification of things of Real Driving Emissions (RDE) perspectives[245]

Threats

qpunkt/ Thermal Walk-In Chambers

- Cost pressure from the automotive OEMs
- Geographical proximity of competitors (Weiss Technik, Angelatoni Testing Technologies)
- Competitors have more experience in building and selling thermal testbeds

[241] Osborne et al. (2016, p. 2)
[242] Osborne et al. (2016, p. 2)
[243] Osborne et al. (2016, p. 2)
[244] Transparancy Market Research (2014, p. 2)
[245] Pickering (2017, p. 40-42)

- Uncertain future regarding types of vehicles (EVs, Fuel Cell, Hybrid)
- Large upfront costs for building each thermal walk-in chamber

3.4.2 TOWS Matrix

In order to generate possible strategies out of SWOT analysis, TOWS matrix is used. TOWS stands for Threats, Opportunities, Weaknesses, and Strengths. The result of this matrix will answer four following strategic questions[246]:

- Strengths- Opportunities Strategies: How to use strengths to exploit opportunities?
- Weaknesses- Opportunities Strategies: How to overcome weaknesses and take advantage of opportunities?
- Strengths- Threats Strategies: How to exploit strengths to overcome potential threats?
- Weaknesses- Threats Strategies: How to minimize weaknesses and to avoid possible threats?

Figure 37 represents the TOWS matrix and possible strategies that can be applied for the company qpunkt. It is important to note that this technique does not indicate which strategy can work best, but it indicates which areas require action, as well as gives some clues about the nature of these actions.

	Strengths	Weaknesses
Opportunities	**SO Strategies** • Increase cooperation with AVL Group • Introduce last thermal automotive technologies • Get ready to an e-vehicles boom • Build up a concept for RDE testing that can reduce lead time for OEMs • Create innovations, to be always in trend and up to date, gather actual first-hand information	**WO Strategies** • Target customers that are Insusceptible to costs (luxury cars, sports cars, premium cars, and SUVs) • In order to compensate lack of experience, offer innovative products
Threats	**ST Strategies** • Leverage use of AVL support, know-how and location to compete • Target customers that appreciate personal approach, customization, quality, delivery time, as well as Innovation approach	**WT Strategies** • Focus on the processes within the organization, aware each employee about company's goals, values, and vision • Focus on quality, delivery time, and service • Build long term relationships with customers • To find the right balance between automation and human labor

Figure 37: TOWS Matrix

[246] Oxford College of Marketing (2016)

4 Conclusion

The aim of this work was to assess the potential of a new product from the qpunkt company, an A/C system testbed, in the automotive market. For this purpose, the automotive market was investigated, potential customers of the A/C system testbed were identified, competitors were made known and possible business strategies for the company were generated.

During the research of the automotive market, trends affecting to some extent the market of thermal test technologies were revealed. Alternative vehicles penetration, straightening emission regulations, diffusion of advanced thermal technologies, as well as shifting preference of customers to SUVs and premium cars are contributing to the growth of the automotive thermal system market. Currently, thermal management is in demand like never before. Optimization of the air conditioning system, fuel consumption reducing, improving the performance of the lithium-ion battery is just a small part of what is important at the moment and can be successfully implemented by using a test bed.

In the process of the market segmentation through clustering, six segments were identified, among which there a luxury European cars segment is claimed to be the most suitable for promotion of the qpunkt test bed. This group of cars is attractive by the fact that in the development of each car a large amount of money and resources for unrivalled quality and performance is invested. Since qpunkt still lacks the productivity for assembling a large number of standard A/C system testbed, the best option for the company will be to promote customized high-quality testbeds with unsurpassed service at a high price.

In the third part of the thesis competitive benchmarking was conducted, in the course of which eight thermal walk-in chambers from different companies were compared among themselves. This comparison showed that the thermal test system from qpunkt still needs some improvement. For example, Russells Technical Products, Weiss Technik, and Angelatoni Testing Technologies testbeds have a wider range of temperatures than qpunkt test beds. However, the advantage of the A/C system testbed from qpunkt is the flexibility of its use when combined with other test stands for component testing, which is a competitive advantage.

In order to generate possible strategies for qpunkt and its thermal stand, SWOT analysis and TOWS matrix were used. As a result, four strategic options were proposed that are aimed at strengthening the company's position in the market and promoting a new product as well as improving the company's internal environment.

Nowadays technologies are developing rapidly, that makes impossible to accurately predict the future for the next decade. Therefore, the main recommendation for qpunkt is to track existing and emerging trends through regular marketing analysis. In addition, I would like to recommend the company to offer more innovative and advanced technologies to its customers in order to compensate for a small experience in the market of thermal test systems.

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List of Abbreviations

A/C	Air Conditioning
AG	Aktiengesellschaft
B2B	Business to Business
B2C	Business to Customer
BCG	Boston Consulting Group
BEV	Battery Electric Vehicle
CAGR	Compound Annual Growth rate
CEO	Chief executive officer
EGR	Exhaust Gas Recirculation
etc.	et cetera
EUR	Euro
EV	Electric Vehicle
GHG	Greenhouse Gas
HAAS	Highly Accelerated Stress Screening
HALT	Highly Accelerated Life Test
HAST	Highly Accelerated Stress Test
HEV	Hybrid Electric Vehicle
HFCV	Hydrogen Fuel Cell Vehicle
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine
IRR	Infrared Reflective
MEUR	Million Euros
NAFTA	North American Free Trade Agreement
OEM	Original Equipment Manufacturer
OPEC	Organization of the Petroleum Exporting Countries
PHEV	Plug-in Electric Vehicle
PLC	Product Life Cycle
PVB	Polyvinyl Butyral
RDE	Real Driving Emissions
R&D	Research and Development

SBU	Strategic Business Unit
STP	Segmentation, Targeting, Positioning
SUV	Sport-utility Vehicle
SWOT	Strengths, Weaknesses, Opportunities, Threats
TOWS	Threats, Opportunities, Weaknesses, Strengths
WW	Worldwide
ZEV	Zero Emission Vehicle

List of Equations

Appendices

Appendix 1: Cluster Analysis

Appendix 1: Cluster Analysis

Step 1:

OEM	mkt share	cation Poi	ctiveness P	lfa Romeo	Dongfang	Ferrari	ar Land Ro	Maserati	Mini	Seat	Volvo	Subaru	Great Wall	Skoda	Citroen	Opel	Jeep	Buick	Fiat	Mazda	Audi	KIA	Chevrolet	Hyundai	Nissan	Ford	VW	Toyota
Alfa Romeo	0,1	2	5	0	6,403124	4	1,414214	2	3,162278	2	1,414214	6,443051	5,961342	2,464467	1,56	4,43361	8,178631	8,449	3,605551	7	2,820213	7,022827	9,347347	8,700092	9,108699	11,64302	9,002133	11,73058
Dongfang	0,1	7	1	6,403124	0	9,433981	6,403124	7,81025	6,082763	5,385165	5	2,552038	1,592985	5,57437	6,590417	6,217467	5,281098	4,047913	5,477226	2,44949	8,182518	4,724415	6,353967	5,717657	7,481203	9,410632	10,77211	10,89066
Ferrari	0,1	2	9	4	9,433981	0	3,162278	2	7,071068	6	5,09902	8,573966	8,691237	6,170381	4,293437	8,225381	9,104395	10,16787	7,28011	9,433981	3,994196	8,562716	10,55334	10,756	10,34255	12,63171	10,63195	12,3938
Land Rover	0,1	3	6	1,414214	6,403124	3,162278	0	1,414214	4,472136	3,162278	2	5,95927	5,791166	3,474709	2,105612	5,626446	7,272551	7,834896	4,582576	6,708204	3,154933	6,428071	8,681757	8,467089	8,658429	11,11575	9,436016	11,2963
Maserati	0,1	2	7	2	7,81025	2	1,414214	0	5,09902	4	3,162278	7,315251	7,178969	4,251306	2,536454	6,297372	8,41962	9,131572	5,385165	8,062258	2,820213	7,571004	9,765905	9,575573	9,537736	11,98165	9,645642	11,89985
Mini	0,1	1	2	3,162278	6,082763	7,071068	4,472136	5,09902	0	1,414214	2,828427	7,177249	6,126794	2,018316	3,526131	1,912302	9,637946	9,240433	2,236068	7,28011	4,685467	8,082085	10,36209	8,927015	9,948286	12,47237	8,777152	12,63354
Seat	0,1	2	3	2	5,385165	6	3,162278	4	1,414214	0	1,414214	6,124778	5,247628	1,44	2,536454	2,76711	8,41962	8,208873	2,236068	6,403124	3,994196	7,022827	9,347347	8,227491	9,108699	11,64302	8,777152	11,89985
Volvo	0,1	3	4	1,414214	5	5,09902	2	3,162278	2,828427	1,414214	0	5,245274	4,640862	2,018316	2,105612	3,95688	7,272551	7,306545	3	5,744563	3,735452	6,109018	8,448248	7,726034	8,424274	10,93435	9,002133	11,2963
Subaru	1,33	8	3	6,443051	2,552038	8,573966	5,95927	7,315251	7,177249	6,124778	5,245274	0	1,414249	6,003674	6,333159	7,29109	2,867211	2,090957	6,131305	1,262101	7,711297	2,489659	4,153312	4,424489	5,639371	7,510586	10,25183	9,073175
Great Wall	1,34	7	2	5,961342	1,592985	8,691237	5,791166	7,178969	6,126794	5,247628	4,640862	1,414249	0	5,10294	5,839726	6,095252	4,267505	3,218695	5,05743	1,256025	7,310267	3,186362	5,017978	4,414748	5,974245	8,016583	9,641079	9,388589
Skoda	1,54	2	3	2,464467	5,57437	6,170381	3,474709	4,251306	2,018316	1,44	2,018316	6,003674	5,10294	0	2,003597	2,244126	8,250309	8,009994	1,146124	6,108486	3,316625	6,425333	8,707703	7,33553	8,094171	10,6509	7,34836	10,70746
Citroen	1,66	2	5	1,56	6,590417	4,293437	2,105612	2,536454	3,526131	2,536454	2,105612	6,333159	5,839726	2,003597	0	4,1237	8,001225	8,250964	3,032095	6,722619	1,665653	6,387683	8,663077	7,800026	8,01551	10,57287	7,50104	10,42067
Opel	1,73	1	1	4,43361	6,217467	8,225381	5,626446	6,297372	1,912302	2,76711	3,95688	7,29109	6,095252	2,244126	4,1237	0	9,849107	9,221936	1,461814	7,080741	5,065185	7,844387	9,980481	8,080105	9,193612	11,65474	7,366689	11,67915
Jeep	1,8	10	5	8,178631	5,281098	9,104395	7,272551	8,41962	9,637946	8,41962	7,272551	2,867211	4,267505	8,250309	8,001225	9,849107	0	2,004894	8,549269	3,618011	9,085571	2,876821	3,190752	5,267409	5,550351	6,774216	11,58794	8,615358
Buick	1,94	10	3	8,449	4,047913	10,16787	7,834896	9,131572	9,240433	8,208873	7,306545	2,090957	3,218695	8,009994	8,250964	9,221936	2,004894	0	8,063845	2,241785	9,505788	2,79086	3,05812	4,323193	5,422509	6,635782	11,32848	8,711923
Fiat	2,1	2	2	3,605551	5,477226	7,28011	4,582576	5,385165	2,236068	2,236068	3	6,131305	5,05743	1,146124	3,032095	1,461814	8,549269	8,063845	0	6	4,146517	6,502315	8,686363	6,966463	7,927698	10,43839	6,867197	10,50173
Mazda	2,1	8	2	7	2,44949	9,433981	6,708204	8,062258	7,28011	6,403124	5,744563	1,262101	1,256025	6,108486	6,722619	7,080741	3,618011	2,241785	6	0	8,074255	2,506013	3,931018	3,54	5,181544	6,997142	9,754917	8,618956
Audi	2,54	1	6	2,820213	8,182518	3,994196	3,154933	2,820213	4,685467	3,994196	3,735452	7,711297	7,310267	3,316625	1,665653	5,065185	9,085571	9,505788	4,146517	8,074255	0	7,358322	9,499689	8,637708	8,475588	10,97823	6,95977	10,41007
KIA	3,61	8	4	7,022827	4,724415	8,562716	6,428071	7,571004	8,082085	7,022827	6,109018	2,489659	3,186362	6,425333	6,387683	7,844387	2,876821	2,79086	6,502315	2,506013	7,358322	0	2,342733	2,849719	3,27	5,28319	8,783171	6,645668
Chevrolet	4,83	10	4	9,347347	6,353967	10,55334	8,681757	9,765905	10,36209	9,347347	8,448248	4,153312	5,017978	8,707703	8,663077	9,980481	3,190752	3,05812	8,686363	3,931018	9,499689	2,342733	0	2,942125	2,864001	3,67	9,895459	5,798491
Hyundai	5,64	8	2	8,700092	5,717657	10,756	8,467089	9,575573	8,927015	8,227491	7,726034	4,424489	4,414748	7,33553	7,800026	8,080105	5,267409	4,323193	6,966463	3,54	8,637708	2,849719	2,942125	0	2,353211	4,022387	7,753219	5,441654
Nissan	6,88	8	4	9,108699	7,481203	10,34255	8,658429	9,537736	9,948286	9,108699	8,424274	5,639371	5,974245	8,094171	8,01551	9,193612	5,550351	5,422509	7,927698	5,181544	8,475588	3,27	2,864001	2,353211	0	2,573791	7,332367	3,448188
Ford	8,5	10	4	11,64302	9,410632	12,63171	11,11575	11,98165	12,47237	11,64302	10,93435	7,510586	8,016583	10,6509	10,57287	11,65474	6,774216	6,635782	10,43839	6,997142	10,97823	5,28319	3,67	4,022387	2,573791	0	9,061037	2,796855
VW	8,82	1	3	9,002133	10,77211	10,63195	9,436016	9,645642	8,777152	8,777152	9,002133	10,25183	9,641079	7,34836	7,50104	7,366689	11,58794	11,32848	6,867197	9,754917	6,95977	8,783171	9,895459	7,753219	7,332367	9,061037	0	7,406052
Toyota	10,18	8	5	11,73058	10,89066	12,3938	11,2963	11,89985	12,63354	11,89985	11,2963	9,073175	9,388589	10,70746	10,42067	11,67915	8,615358	8,711923	10,50173	8,618956	10,41007	6,645668	5,798491	5,441654	3,448188	2,796855	7,406052	0

Step 2:

OEM	mkt share	Location P	Attractiver	Alfa Rome	Ferrari	Great Wal	Opel	Jeep	Buick	Audi	KIA	Chevrolet	Hyundai	Nissan	Ford	VW	Toyota
Alfa Rome	0,1	2	5	0	4	5,961342	4,43361	8,178631	8,449	2,820213	7,022827	9,347347	8,700092	9,108699	11,64302	9,002133	11,73058
Ferrari	0,1	2	9	4	0	8,691237	8,225381	9,104395	10,16787	3,994196	8,562716	10,55334	10,756	10,34255	12,63171	10,63195	12,3938
Great Wal	1,34	7	2	5,961342	8,691237	0	6,095252	4,267505	3,218695	7,310267	3,186362	5,017978	4,414748	5,974245	8,016583	9,641079	9,388589
Opel	1,73	1	1	4,43361	8,225381	6,095252	0	9,849107	9,221936	5,065185	7,844387	9,980481	8,080105	9,193612	11,65474	7,366689	11,67915
Jeep	1,8	10	5	8,178631	9,104395	4,267505	9,849107	0	2,004894	9,085571	2,876821	3,190752	5,267409	5,550351	6,774216	11,58794	8,615358
Buick	1,94	10	3	8,449	10,16787	3,218695	9,221936	2,004894	0	9,505788	2,79086	3,05812	4,323193	5,422509	6,635782	11,32848	8,711923
Audi	2,54	1	6	2,820213	3,994196	7,310267	5,065185	9,085571	9,505788	0	7,358322	9,499689	8,637708	8,475588	10,97823	6,95977	10,41007
KIA	3,61	8	4	7,022827	8,562716	3,186362	7,844387	2,876821	2,79086	7,358322	0	2,342733	2,849719	3,27	5,28319	8,783171	6,645668
Chevrolet	4,83	10	4	9,347347	10,55334	5,017978	9,980481	3,190752	3,05812	9,499689	2,342733	0	2,942125	2,864001	3,67	9,895459	5,798491
Hyundai	5,64	8	2	8,700092	10,756	4,414748	8,080105	5,267409	4,323193	8,637708	2,849719	2,942125	0	2,353211	4,022387	7,753219	5,441654
Nissan	6,88	8	4	9,108699	10,34255	5,974245	9,193612	5,550351	5,422509	8,475588	3,27	2,864001	2,353211	0	2,573791	7,332367	3,448188
Ford	8,5	10	4	11,64302	12,63171	8,016583	11,65474	6,774216	6,635782	10,97823	5,28319	3,67	4,022387	2,573791	0	9,061037	2,796855
VW	8,82	1	3	9,002133	10,63195	9,641079	7,366689	11,58794	11,32848	6,95977	8,783171	9,895459	7,753219	7,332367	9,061037	0	7,406052
Toyota	10,18	8	5	11,73058	12,3938	9,388589	11,67915	8,615358	8,711923	10,41007	6,645668	5,798491	5,441654	3,448188	2,796855	7,406052	0

Step 3:

OEM	mkt share	Location P	Attractiver	Alfa Rome	Ferrari	Great Wal	Opel	KIA	Ford	VW
Alfa Rome	0,1	2	5	0	4	5,961342	4,43361	7,022827	11,64302	9,002133
Ferrari	0,1	2	9	4	0	8,691237	8,225381	8,562716	12,63171	10,63195
Great Wal	1,34	7	2	5,961342	8,691237	0	6,095252	3,186362	8,016583	9,641079
Opel	1,73	1	1	4,43361	8,225381	6,095252	0	7,844387	11,65474	7,366689
KIA	3,61	8	4	7,022827	8,562716	3,186362	7,844387	0	5,28319	8,783171
Ford	8,5	10	4	11,64302	12,63171	8,016583	11,65474	5,28319	0	9,061037
VW	8,82	1	3	9,002133	10,63195	9,641079	7,366689	8,783171	9,061037	0

Step 4:

OEM	mkt share	Location P	Attractiver	Cluster 3	Cluster 1	Cluster 5	Cluster 4	Cluster 2
Alfa Romeo, Audi, BMW, Citroen, Fiat, Land Rover, Mercedes, Mini, Opel, Peugeot, Renault, Seat, Skoda, Volvo	0,1	2	5	0	4	5,961342	11,64302	9,002133
Lamborghini, Ferrari, Bentley, McLaren, Maserati, Porsche	0,1	2	9	4	0	8,691237	12,63171	10,63195
Brands Jeep, Buick, KIA, Chevrolet, Hyundai, Honda, Nissan, Subaru, Mazda, Great Wall, DongFeng,	1,34	7	2	5,961342	8,691237	0	8,016583	9,641079
Ford, Toyota	8,5	10	4	11,64302	12,63171	8,016583	0	9,061037
Volkswagen	8,82	1	3	9,002133	10,63195	9,641079	9,061037	0