Marketing analysis of the Chinese automotive market for an European supplier

Master Thesis
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Abstract

The business model of the automotive supplier company *"AB-Mikroelektronik GmbH"* is customer specific development and production of power electronics. The company has access to international resources of the owner-group like a factory site in China but enjoys a high degree of freedom concerning the management of its product lines *"LED lighting"* and *"power modules and control units"* simultaneously. The objective of this thesis was to analyse business opportunities for the latter product line in China. Thereby, a top-down approach starting with an analysis of the five-year plan of the Chinese central government was prescribed. Market potentials and potential customers for the enterprise's technologies and products should be found and specifics for the initiation of business relations analysed.

The methodical approach of Kotler's marketing-research-process was followed. After a secondary literature analysis, primary data have been gathered from expert-interviews in Austria and China, speeches, conferences and meetings with potential customers.

The results are introduced with a short historical consideration. The compulsory Joint-Ventures (JV) for Original-Equipment-Manufacturers (OEM) are a reason for the complexity of the contemporary automotive market and for the progress of Chinese OEMs as well. Suppliers haven't been forced to JVs, which may explain the dominating position of international Tier-1s. The total and segment specific market shares of important brands and manufacturers are shown. SUVs (Sport-Utility-Vehicle) and NEVs (New-Energy-Vehicle) have gained significant market shares in a few years and Chinese OEMs are dominating both segments. The government has clearly determined NEVs as the future of mobility and pursues this goal persistently. Experts expect a distinctive change in trend towards NEV also on other important global markets by 2020 due to new regulations. OEMs have announced correlating model offensives and want to introduce them in China first.
Concerning market potentials, systems for efficiency improvements of Internal-Combustion-Enginges (ICE) are of minor importance compared to NEVs in China. Additionally, the former is a highly competitive market dominated by the big international suppliers. Better chances for the company are expected with high voltage applications.
From 2025 on, increasing market potentials for Fuel-Cell-Electric-Vehicles are predicted, whereby Japan and Europe are likely to be earlier than China. This powertrain entails great application opportunities for core competencies of AB-Mikroelektronik.

The thesis shows key success-factors and cultural specifics for business in China, such as the relative importance of personal networks and competent Chinese employees at customer interfaces. The business model of customer specific development is inappropriate for the Chinese market. Therefore, a management-workshop with the objective of selecting a strategic own product for the further development was moderated. The results of this work have been considered.

Kurzfassung

Die *"AB-Mikroelektronik GmbH"* ist eine Automobil-Zulieferunternehmung die kundenspezifische Entwicklung und Produktion von Leistungselektronikmodulen, hauptsächlich auf Tier-2 Ebene, als Geschäftsmodell betreibt. Als Tochter der *"TT Electronics plc"* Gruppe hat die Unternehmung Zugriff auf internationale Ressourcen, wie z.B. ein Werk in China und genießt zugleich große Freiheiten in der Geschäftsgestaltung auf Basis von zwei eigenständigen Produktlinien *"LED lighting"* und *"power modules and control units"*. Aufgabenstellung dieser Arbeit ist es Geschäftsmöglichkeiten mit Leitungselektronik-Produkten in China aufzuzeigen. Dabei sollte ein Top-Down Ansatz, ausgehend vom Fünf-Jahresplan der chinesischen Zentralregierung, verfolgt werden um Markttrends und Beeinflussungsmechanismen festzustellen. Daraus abgeleitet sollten Marktpotenziale und potenzielle Kunden für Technologien und Produkte von AB-Mikroelektronik analysiert werden. Auch auf Besonderheiten beim Aufbau von Geschäftsbeziehungen sollte Bezug genommen werden.

Methodisch wurde in Anlehnung an den Marketing-Forschungsprozess nach Kotler vorgegangen. Nach Analyse von Sekundärliteratur wurden Primärdaten aus Experten-Interviews in Österreich und China, Vorträgen, Konferenzen und Meetings mit potenziellen Kunden gewonnen.

Um den Einfluss der Zentralregierung auf die Automobilindustrie beurteilen zu können, wird den Ergebnissen ein geschichtlicher Abriss voran gestellt. Der Joint-Venture Zwang für OEMs ist eine Ursache für die Komplexität des heutigen Marktes und für Entwicklungsfortschritte chinesischer OEMs. Dessen Fehlen für Zulieferer begünstigte die heutige Vormachtstellung internationaler Tier-1.
Als erstes Ergebnis werden die Marktanteile von Herstellern und Marken sowohl am Gesamtmarkt als auch an den Segmenten New-Energy-Vehicle (NEV) und SUV dargestellt. SUVs und NEVs haben innerhalb weniger Jahre die Marktanteile am größten Automobilmarkt der Welt vervielfacht. Beide Segmente werden von chinesischen OEMs dominiert. Die Regierung hat Fahrzeuge mit rein elektrischem Antrieb zur Zukunft der Automobilität erklärt und verfolgt dieses Ziel mit Nachdruck. Es wird starke Einflussnahme mit Regulierungen, Beschränkungen und Förderungen ausgeübt. Mit geringer Verzögerung erwarten Experten um 2020 auch auf anderen wichtigen globalen Märkten eine Trendwende Richtung Elektromobilität. Die wichtigsten OEMs haben dementsprechende Modellprogramme mit bevorzugter Einführung in China angekündigt.
Hinsichtlich Marktpotenzial für Produkte und Technologien des Unternehmens wird im Vergleich zu den NEV für Systeme zur Effizienzsteigerung von Verbrennungskraftmaschinen eine untergeordnete Rolle in China erwartet. Bei konventionellen Antriebssträngen und daher auch 48V-Hybrid Systemen besteht aufgrund der Dominanz großer Zulieferer eine ausgeprägte Wettbewerbssituation. Die Chancen mit hochvolt-Anwendungen werden besser eingeschätzt.

Ab 2025 wird ein wachsendes Marktpotenzial für Brennstoffzellen-Fahrzeuge erwartet, wobei Japan und Europa dem chinesischen Markt vorangehen dürften. Es ergeben sich hervorragende Anwendungsmöglichkeiten für Kernkompetenzen von AB-Mikroelektronik.

Kulturelle Besonderheiten mit geschäftlicher Relevanz und Erfolgsfaktoren für ausländische Unternehmungen in China werden beleuchtet. So spielen beispielsweise persönliche Netzwerke und technisch kompetente chinesische Mitarbeiter an den Kundenschnittstellen eine wichtige Rolle.

Das Geschäftsmodell kundenspezifischer Entwicklung ist für den chinesischen Markt ungünstig, standardisierte Modullösungen werden bevorzugt. Deshalb wurde als Abschluss ein Management-Workshop mit dem Ziel der strategischen Auswahl eines Neuproduktes zur Eigenentwicklung, unter Einbeziehung der Ergebnisse dieser Arbeit moderiert und methodisch begleitet.

Vorwort

Mein besonderer Dank gilt meiner Partnerin Anita, Andreas und Matthias Viehhauser aus meiner engen Verwandtschaft, meinen Eltern und meinem Kollegen Peter Stefan Kühleitner, die mich durch Ihren Zuspruch überhaupt erst dazu ermuntert haben noch ein Vollzeitstudium anzugehen. Dieser Dank gilt aber allen voran Herrn Geschäftsführer Dipl.-Ing. Hermann Hauser, der letztlich die entscheidende Überzeugungsarbeit geleistet hat. Darüber hinaus aber auch für das Ermöglichen einer flexiblen und facheinschlägigen Beschäftigung bei der Firma AB-Mikroelektronik GmbH während des Studiums und in Zusammenhang mit dieser Masterarbeit.

Die fünf Jahre Studium in Graz haben mir nicht nur fachlich und beruflich neue Dimensionen eröffnet, sondern auch meinen persönlichen “Horizont” deutlich erweitert. Nicht zuletzt habe ich viele gute Freundschaften gewonnen. Daher werde ich immer positiv auf diesen bedeutenden Zeitabschnitt meines Lebens zurückblicken.

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Table of content

1 Introduction

This chapter explains the initial situation at the time of the project start, the objectives, scope and region under examination for this thesis. The last subchapter provides a short overview about the project-procedure.

1.1 Initial situation

The *"AB-Mikroelektronik GmbH"* is situated in Salzburg and is owned by the English *"TT Electronics plc"* group. Although integrated in the *"Transportation Sensing and Control"* business division of the *TT group, AB-Mikroelektronik* enjoys a high degree of freedom concerning business development on the one hand and access to global TT infrastructure like production sites and sales offices on the other hand.
There are two automotive product lines "LED lighting" and "power modules and control units" in Salzburg. At the moment the main market for both product lines is Europe.
The "power modules and control units" product line exclusively covers customer specific products like power electronic control and converter units for electric motorcycle propulsion systems, in-wheel-drive-systems, pumps, compressors, centrifuges and other secondary ancillary electrical engines. All these products can be integrated in mechatronic modules. The main field of application is for emission reduction purposes in conventional internal combustion engines (ICE) and in new energy vehicles (NEV) with different grades of electrification as well as in fuel cell (FC) propelled cars. Thus, the company expects a significant market potential in China, as the Chinese automotive market as a whole is growing rapidly and legislation is getting very restrictive concerning emissions.
Some business does already exist in China. Furthermore, *AB-Mikro* has access to an appropriate production site and a small sales office. The problem is that all the existing business has been gained in Europe through western companies and transferred to China. Additionally, the Chinese sales office is not familiar with the technology developed in Salzburg and is therefore limited to a supportive role.
The knowledge about the local market and especially the know-how to achieve contracts directly with local customers is missing.

1.2 Objectives

The objectives are distinguished into primary and secondary goals.

The primary goals are:

1. Overview of the Chinese legislation development concerning the transportation sector (short term perspective until 2022) and how the Chinese government intends to influence and promote the branch in order to reach the desired progress.

2. Representation of how that will affect the field of applications for technologies of AB-Mikroelektronik. Thus, the current and upcoming market potential on technologies which could be delivered by AB-Mikroelektronik.
3. Report on potential customers for these technologies.
4. Proposal how to initiate business and how to achieve consistent business relationships with Chinese companies. Local social aspects should be considered in that context.

A secondary goal is the identification of potential threats through substitutive products with strategic analysis tools.

1.3 Tasks

This Master Thesis should be a work base for a future product manager of AB-Mikroelektornik whose responsibility will be the business development in China.

Overall, systematic market analysis- and qualitative research methods must be used.

Goal 1/2) A top-down approach must be followed. This means that one of the first steps is the acquisition and analysis of the technological future plans of the Chinese central government. The following steps will be influenced by the results.

Goal 2) Analysis of the product and technology portfolio of AB-Mikroelektronik. Focus lies on potential core competences or outstanding features and attributes.

Goal 3/4) Use of qualitative research methods. In particular, interviews with internal (TT group) and external experts must be done.

1.4 Region of examination

The field of examination is limited to the product line “power modules and control units” and to the Chinese market.

Not to be analysed:

- Product line LED
- Other Asian markets
- The field of existing and potential competitors

1.5 Procedure

The procedure was basically following the marketing research process which will be introduced in chapter 2.2 in detail.
Figure 1 shows the time plan for the research project in gantt diagram format. A special opportunity was to accompany the General Manager of AB-Mikroelektronik on a one week

business trip to China for the conduction of interviews. This required an early elaboration of an interview guideline after a brief literature and secondary data study.
Black bars indicate tasks related to the collection of primary data. Interruptions of the work on this thesis are visualised in grey.

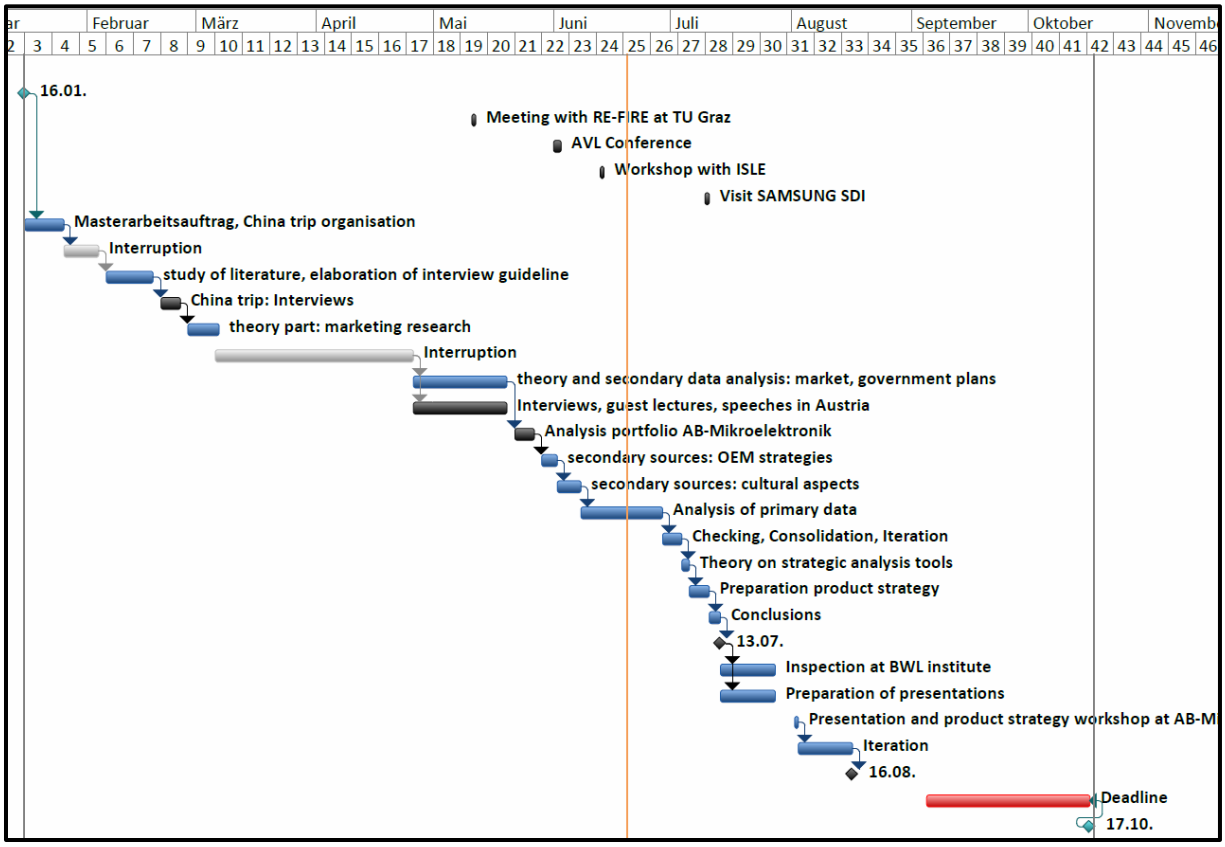


Figure 1: Gantt diagram of procedure

2 Theoretical basics

Marketing research methods have been used to pursue the prescribed objectives. In this chapter, related basics and terms are described. Furthermore, some strategic analysis tools are introduced and a technical overview about different types of New-Energy-Vehicles (NEV) is provided.

2.1 Definition of basic terms

This subchapter describes some essential terms.

Market

A market consists of potential customers who have demands or wishes, possess enough resources and are willing to exchange those resources in order to satisfy the demand of wish. The entirety of the customers is considered as the market by a marketer; the size of a market subsequently depends on the number of potential customers.[1]

Market segmentation

When splitting a market into segments, this must happen under the premise to gain advantages concerning a more effective and profitable marketing and management of the market. Extreme forms of segmentation are the zero-segmentation and the atomistic segmentation. The former means no segmentation and all potential customers are treated the same way, whereas the latter perceives every customer as an own segment. In between there are several possibilities for the segmentation of markets, all aiming to identify essential common attributes within a group of customers. Such attributes could be age, gender or income in a consumer market, branch and size of an enterprise or the technology of an industrial market.[2]

Market potential

A market potential is the upper limit of the overall demand under the circumstance that the marketing efforts are at the highest possible level in the whole branch. It depends on the given environment, which means that the market potential will be lower in periods of weak economy compared to a boom.[3]

Overall demand

The overall demand on a product is the whole volume that can be bought by a certain group of customers in a specific geographic area, within a certain time period considering the environment as well as the marketing efforts.[4]

[1] Cf. (Kotler, Keller, & Bliemel, 2007, S. 16)
[2] Cf. (Kotler, Keller, & Bliemel, 2007, S. 387 et seqq.)
[3] Cf. (Kotler, Keller, & Bliemel, 2007, S. 198)
[4] Cf. (Kotler, Keller, & Bliemel, 2007, S. 197)

Core Competencies

A fundamental prerequisite for an enterprise's success is to focus on the core competencies. It is important to be aware which of those competences should not be outsourced but must be fostered instead.[5] There are slightly different definition-criteria for core competencies depending on the literature, the most recurrent ones are:

- A core competence must be applicable to several products and markets
- They must provide value or a benefit to customers
- Imitation must be difficult[6]

Marketing-/market research

Marketing research is the systematic approach of data elicitation and analysis followed by a transfer of results and data which are needed by an enterprise in a certain marketing situation in order to support marketing decisions with solid information.

Thereby it must be distinguished between marketing- and market research, because the latter is just a component of marketing research. An example of the scope of a ***market research*** would be the estimation of the sales potential of a new product or the analysis of competitor products, whereas marketing research activities could also cover the investigation of trends, predictions, prices, market structure analysis and more.[7]

Considering the top down approach of this thesis, a classification as a market research project would be too narrow. This thesis is a marketing research project.

Therefore, the following chapter 2.2 provides a theoretical background on the marketing research process as well as useable research methods.

2.2 The marketing research process

The aim of marketing research is to achieve a better understanding of a marketing problem. Every marketing research process should follow a systematic approach, basically consisting of the steps that can be seen in Figure 2.[8]

1. Definition of the marketing problem and the research goals
2. Conception of the research plan
3. Data collection
4. Data analysis
5. Representation of results
6. Decision suggestion

[5] Cf. (Hamel & Prahalad, 1995)
[6] Cf. (Kotler, Keller, & Bliemel, 2007), (Hamel & Prahalad, 1995)
[7] Cf. (Kotler, Keller, & Bliemel, 2007, S. 158 et seqq.), (Hesse, Neu, & Theuner, 2007, S. 43 et seqq.), (Qualtrics, 2010)
[8] Cf. (Kotler, Keller, & Bliemel, 2007, S. 163), (Hesse, Neu, & Theuner, 2007, S. 51)

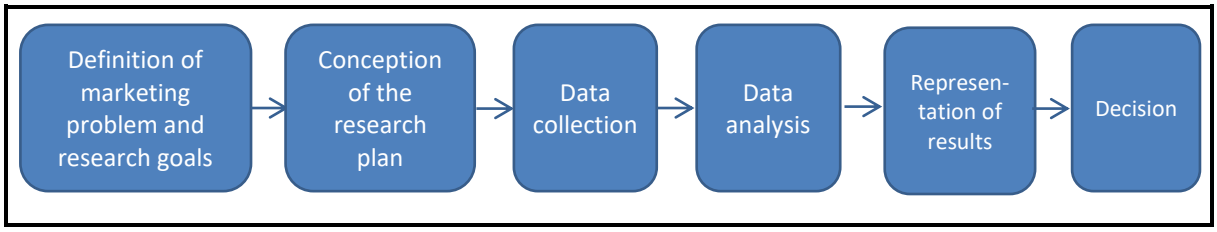


Figure 2: Marketing research process[9]

Certainly, slightly deviating process descriptions can be found in the literature. Other sources specify a four step process, whereby the last four steps of the process given in Figure 2 are compressed into two steps.[10] However, there is no substantial difference between them.

2.2.1 Definition of the marketing problem and the research goals

As in every project the first and very important step is to make the problem concrete and to specify clear goals. Thereby, a too narrow description of the problem and goals could influence the researcher's perspective and lead to not fully elaborated results. A too wide description could lead to exceeding project durations and abundant information. A compromise must be found.[11]

When formulating the research goals it must be considered that there are three types of research approaches that can be distinguished:[12]

1. ***Explorative research*** projects aim to collect data in order to develop a better understanding of a problem, to gain new ideas and to create hypotheses which could be the object of a follow up research.
2. ***Descriptive research*** is used when a quantitative description of a known problem with existing hypothesis should be done.
3. A ***causal research*** strives for the finding of connections between cause and effect.[12]

For this thesis, the first step of the marketing process is already completed and was discussed in the previous chapter. For a definition of the marketing problem see chapter 1.1, the research goals are described in chapter 1.2.
So far, no hypotheses exist. The task of this paper is to create several. Thus, this master thesis can clearly be classified as an ***explorative research*** project.

[9] Cf. (Kotler, Keller, & Bliemel, 2007, S. 163)
[10] Cf. (Bruhn, 2004), (Hesse, Neu, & Theuner, 2007, S. 51)
[11] Cf. (Kotler, Keller, & Bliemel, 2007, S. 164), (Hesse, Neu, & Theuner, 2007, S. 51)
[12] Cf. (Kotler, Keller, & Bliemel, 2007, S. 165), (Herrmann & Huber, 2013, S. 37)

2.2.2 Conception of the research plan

The main scope of the research plan is to define how to get satisfying data. Decisions must be made according to which data sources, data collection methods, collection instruments, samples and interview types are used.[13]
Chapter 1.5 provides the research plan for this thesis and 3.1 explains how the data were collected. Both chapters are based on the following theory.

Secondary sources provide existing data which have not been gathered for the specific research topic. Examples are internal data sources of companies, external data sources of official agencies or offices, associations like a chamber of commerce, research institutes and publishing platforms, books, magazines, journals etc. Secondary data are cheap and available within short time, but they seldom provide answers to specific questions. Furthermore, they are often outdated, which is a severe disadvantage when considering fast growing and changing markets like the automotive market of China.[14]
Compared to secondary data, the collection of **primary data** is expensive. Collection methods like observation, experiment, group discussions and interviews raise significant efforts. Thus, a researcher will gather and analyse secondary data and subsequently define whether and to which extent the exploration of primary data is necessary. Preliminary knowledge gained from secondary data and/or out of initial interviews can be leveraged for the elaboration of a detailed interview concept.
In the end, most marketing research projects require the collection of primary data in order to investigate specific questions.[15]

Observations, group discussions and experiments are rather applicable for investigations with a large number of participants (quantitative studies), such as for business to customer marketing problems. Experiments are especially suitable for causal research projects.[16] Interviews carried out with open questions are beneficial for explorative research with limited financial and personal resources as it is the case in this thesis.[17]

For that reason, more theoretical details about interviews as a data collection method are provided in chapter 2.2.3.

2.2.3 Data collection methods

This subchapter describes the difference between quantitative and qualitative research and provides an overview about different interview methods.

[13] Cf. (Kotler, Keller, & Bliemel, 2007, S. 166), (Hesse, Neu, & Theuner, 2007, S. 51)
[14] Cf. (Bruhn, 2004, S. 110), (Hesse, Neu, & Theuner, 2007, S. 53 et seqq.)
[15] Cf. (Kotler, Keller, & Bliemel, 2007, S. 166), (Hesse, Neu, & Theuner, 2007, S. 55 et seqq.)
[16] Cf. (Kotler, Keller, & Bliemel, 2007, S. 169)
[17] Cf. (Kotler, Keller, & Bliemel, 2007, S. 175)

2.2.3.1 Qualitative and quantitative research methods

There are two main types of measurement, namely ***quantitative*** and ***qualitative*** research methods. Quantitative market research is based on exact measurement of data and utilizes statistical procedures for the analysis, but there are also marketing problems and goals where research results hardly can be expressed in figures as it is the case in this thesis.[18] Qualitative methods aim to generate theories and hypotheses. They are suitable for the exploration of a new field and the discovery of new contexts. Applications in the field of market research are strategic consultancy, the research about new markets and the development of new products. The epistemological principle has priority.[19]

The most important method for the collection of primary qualitative data is conducting interviews with single persons and group discussions.[20] Group discussions are an appropriate method if different perspectives, opinions and ideas need to be gathered in short time.[21] However, this method is not applicable for the current work, because there is no access to a group of people with knowledge in the field of interest at the same time and location.

The next section focuses on interviews with single persons.

2.2.3.2 Characterisation of interview methods

Basically, it can be distinguished between “open” or “not standardised” and “closed”, “standardised” or “structured” interviews.
“Standardised” or “structured” interviews follow a prepared questionnaire with a fixed formulation and sequence of questions. The questions themselves are mainly not open, which means that there are predefined answer options. The results can be easily compared and analysed afterwards. Because of this, standardised interviews are more applicable for quantitative surveys.[22]

Considering qualitative interviews, Mayring defines them by the use of three criteria:

1. Mainly open questions are used. That gives a high degree of freedom to the interview partner when formulating the answers.
2. Qualitative interviews are half-structured, which gives the interviewer a high degree of freedom when formulating and sequencing the questions.
3. Qualitative-interpretative techniques are used for the analysis of the interview material (refer 2.2.4).[23]

According to that, problem-centred-, focused, in-depth- as well as explorative interviews are all open, half-structured, qualitative interview methods. The narrative interview is less structured.[23]

[18] Cf. (Bruhn, 2004, S. 91), (Hesse, Neu, & Theuner, 2007, S. 56)
[19] Cf. (Sackl-Sharif, 2015), (Mruck & Mey, 2009, S. 33)
[20] Cf. (Bruhn, 2004, S. 101), (Hesse, Neu, & Theuner, 2007, S. 56)
[21] Cf. (Berekoven, Eckert, & Ellenrieder, 2001, S. 96)
[22] Cf. (Buber, Aghamanoukjan, & Meyer, 2009, S. 421)
[23] Cf. (Mayring, 2002, S. 66 et seqq.)

Qualitative interviews are especially useful when the interviewer has to adapt to the individuality of the interview partner and the situation in order to create a confident atmosphere. Due to that, interview partners are more willing to share information. The open questions allow them to decide which information is important. Moreover, spontaneous statements could provide additional insights and there may be chances to address awkward topics. This makes qualitative interviews the ideal tool for explorative research.[24]

In addition to Mayrings three criteria, qualitative interview methods have in common that they are conducted personally and verbally.[25] Besides that, some different main types are briefly introduced in the following.

The **narrative interview** asks for story-telling of experiences. It produces text with implicit retrospective interpretation.[26]

A distinctive attribute of the **problem-centred interview** is that the researcher prepares the research task trough literature studies and develops a preliminary concept. Still, the storytelling principle is valid, but the researcher questions specific parts and confronts the interview partner with emerging contradictions.[27]

The **in-depth interview** intends to reveal important structures and connections the interviewees themselves are probably not aware of. One field of application is for example psycho analysis.

In contradiction to “in-depth interviews”, the **explorative interview** aims at subjective relevant information, opinions and attitudes to the problem under investigation.[28] The **expert interview** could be seen as a special type of “explorative interview”. Thereby the term “expert” is not clearly defined. To a certain degree it is up to the researcher to decide who is an “expert” and who is not. This is the reason why the methodical status is sometimes questioned in literature. A possible interpretation is that “experts” are persons who are assumed to have a specific knowledge due to their education, professional, political or scientific position and/or experience.[29] Central dimensions of the expert interview are the reconstruction of technical knowledge (facts), process knowledge (routines, action guidelines) and subjective perceptions. The aim is to reconstruct the knowledge of several experts.[30]
That corresponds with the demand for primary data for this thesis. Hence, expert interviews are used.

[24] Cf. (Berekoven, Eckert, & Ellenrieder, 2006)
[25] Cf. (Buber, Aghamanoukjan, & Meyer, 2009, S. 417)
[26] Cf. (Lamnek, 2005, S. 357 et seqq.)
[27] Cf. (Lamnek, 2005, S. 363 et seqq.)
[28] Cf. (Kepper, 1995)
[29] Cf. (Gläser & Laudel, 2010, S. 11 et. seqq)
[30] Cf. (Sackl-Sharif, 2015, S. 43), (Gläser & Laudel, 2010, S. 11 et seqq.)

2.2.3.3 Practical suggestions for the conduction of interviews

Some important practical issues should be considered when conducting interviews:[31]

- Corresponding to the research questions, an adequate interview method must be selected.
- The interviewee must be respected and feel respected. That entails respect for the limited time experts can effort. The interview material must be anonymised and confidential. It must not be possible to retrace information back to an interview partner.
- The influence of the interviewer on the interview partner must be as low as possible. The interviewer should act conservatively, be reserved and open for alternative processes suggested by the interview partner.
- Qualitative research processes must be comprehensible. Interviews must be recorded and transcribed. That does not mean that the transcript must be attached to the report, but the results must be documented through anonymized texts and their interpretation must be understandable step by step.
- Economic aspects must be considered. Sometimes an interview via phone must be sufficient.
- There are strict legal requirements which must be considered when collecting and publishing personal related data.[31]
  Note: In this thesis no personal data are processed.

Last but not least, intercultural aspects must be considered when conducting interviews.[32] Therefore the next section provides some interview related cultural specifics about China.

2.2.3.4 Qualitative interviews in China

Chinese people tend to an intensive use of an inductive communication and argumentation structure. The cause will be presented before the effect. This means that often questions are not answered directly. At first, a lot of peripheral information and facts are provided and the question is answered as a conclusion in the end.
This communication style entails the danger of missing the key point of an answer. In order to avoid that, audio records are even more important than elsewhere. This can be a sensible issue, because in China it is rather common to make notes instead of records when doing interviews.[33]

According to Chinese rules of politeness a too self-confident appearance could be perceived as arrogant. This is why phrases like “I don’t know if that what I said is correct” are also used just due to cultural politeness, even if experts know very well about the matter of discussion.[34]

[31] Cf. (Buber, Aghamanoukjan, & Meyer, 2009, S. 431 et seqq.)
[32] Cf. (Buber, Aghamanoukjan, & Meyer, Qualitative Interviews, 2009, S. 431 et seqq.)
[33] Cf. (Alpermann, 2012, S. 180)
[34] Cf. (Alpermann, 2012, S. 182)

In general, when conducting expert interviews, the interviewer should be accepted as a "co-expert" by the interview partner. In China, the relationship between interviewer and interviewee is more critical than in Austria/Germany. Age, sex and social position can have a crucial effect. Hence, it can easily happen that a Chinese interview partner takes a teacher role when questioned by a younger interviewer.[35]

Chinese people tend to generalise statements. The interviewer should be prepared to ask in detail or for examples in order to achieve less abstract answers. On the other hand, one should not go into detail too fast because a warm up phase, such as small talk plays a very important role in creating a confident atmosphere. Furthermore, persistent inquiry can lead to evasive behaviour.[36]

2.2.3.5 Interview guideline

Finally, although qualitative interviews are open and half-structured, an interview guideline has to be prepared. The guideline should be tested in a pre-test interview.[37]
This section gives instructions for the setup of such a guideline.

The most important requirement to a guideline for qualitative interviews is that it must allow openness. It should not be overloaded with questions. The questions should be neatly organized and sequenced following a guiding thread concept behind. Spontaneous story telling must be a priority. Consequently, the questions also must be handled in a flexible way and should not be read off notes. Summarised, a guideline for qualitative interviews should be "as open and flexible as possible, but as structured as necessary"[38].[38]

In her workshop about qualitative interview methods, Susanne Sackl-Sharif suggests a four step process for the development of interview guidelines:[39]

1. Up to 50 questions should be collected.
2. Check the questions if they fulfil the openness requirement and if they ask for new information which is not known yet. Complex formulated pure information questions should be eliminated.
3. The questions should be sorted in a logical sequence. One to four groups of questions shall be formed.
4. Design one main question for each group of questions.[39]

Due to their statistical background, a systematic approach for the selection of test or interviewees is especially important for quantitative research. The following section explains an applicable sample strategy for the current work.

[35] Cf. (Alpermann, 2012, S. 183)
[36] Cf. (Alpermann, 2012, S. 184)
[37] Cf. (Buber, Aghamanoukjan, & Meyer, Qualitative Interviews, 2009, S. 143 et seqq.)
[38] Cf. (Sackl-Sharif, 2015, S. 47)
[39] Cf. (Sackl-Sharif, 2015, S. 49)

2.2.3.6 Sample strategy

For this thesis, a pragmatic approach will be followed. Human, financial and especially time resources are limited. Furthermore, there is no access to a statistical relevant number of interview partners with “expert-knowledge”. Because of this, the not-probability-driven selection method “convenience sample” is used, where the interviewer selects reachable experts according to his own criteria.[40] Still, the “convenience sample” strategy is well suitable for explorative research.[41]

2.2.4 Data analysis

The main objective of this process step is to get the most important information out of the collected data. Considering secondary data, this is basically summarizing. [42]
For the analysis of qualitative primary data, there is no unique solution. Different theoretical suggestions exist, but it is common that researchers develop their own deviating approach. Philipp Mayring has created such a standardized analysis procedure suggestion. This process shall be introduced in the following.[43]

1. **Determination of the raw material**
   In the first step the raw material which shall be analysed is determined. It must be described from whom and under which conditions this raw material was collected and in which form it is at hand.
2. **Objective of the analysis**
   First, it must be defined which type of content shall be excerpted out of the material. This may be information about a certain topic, information about the interview person or about the effect of the text on a reader.
   Second, precise questions and maybe sub-questions must be formulated for the analysis.
3. **Selection of the analysis model**
   Mayring suggests either a summarising, a structuring or an explicating analysis model. The explicating model involves additional material and by utilizing the structuring model a structure can be developed out of the material in form of categories. The summarizing model aims to gather relevant content from the material. It is the appropriate approach for this thesis.
4. **Summarizing content analysis approach**
   Before starting with the analysis it must be defined on which level the raw material shall be analysed. Depending on criteria and objectives, this can be the whole text or just content relevant parts down to sentence or even word level.
   The summarizing model also follows a standardized process for which Mayring suggests to work with a table consisting of a column for each of the following steps:

[40] Cf. (Kotler, Keller, & Bliemel, 2007, S. 180)
[41] Cf. (Bruhn, 2004, S. 95)
[42] Cf. (Kotler, Keller, & Bliemel, 2007, S. 185)
[43] Cf. (Zepke, 2001)

- Paraphrasing (Z1-rule): content carrying parts of the raw material are transformed into a grammatical short version with uniform language style.
- Abstraction (Z2-rule): Generalisation of the paraphrases to a desired abstraction level.
- Reduction through selection (Z3-rule): Paraphrases with redundant/similar content are eliminated.
- Optional second reduction to a higher abstraction level for large texts (Z4-rule).
- Result: Abstracted short version with uniform language style of relevant content organised in categories. Distributed paraphrases are joined together, all paraphrases must be used.

5. **Interpretation of the results**
   The last step of the process is the interpretation of the results out of the content analysis with respect to the research questions.[44]

2.2.5 Representation of results

When presenting results to the management or the client, the marketing researcher should not try to overwhelm them with explanations or a lot of figures. Only findings which are relevant for marketing decisions shall be presented. The research project is only valuable if it strengthens the certainty of management decisions.[45]

2.2.6 Make the decision

The decisions are made by the management team on the basis that the researcher provides to them with the representation of his results and considering other influencing factors such as if management is willing to invest or not.[46]

During the work process on this thesis it became clear that AB-Mikroelektronik will have to develop an own standard product in order increase its chances on the Chinese market. It has been decided that this decision process shall be supported by the conclusion of this master thesis. Therefore, the next chapter presents a theoretical framework including tools for this strategic decision process.

2.3 Strategic decision processes and tools for new products

A basic task of a product manager is the continuous development of the product portfolio. For new products it can be distinguished between the following approaches:

[44] Cf. (Mayring, 2003), (Zepke, 2001)
[45] Cf. (Kotler, Keller, & Bliemel, 2007, S. 185)
[46] Cf. (Kotler, Keller, & Bliemel, 2007, S. 186)

- ***Product innovation:*** Development of a product that is completely new on the market and/or the enterprise.
- ***Product improvement:*** Improvement of certain features of an existing product. The old product will be replaced by a new one.
- ***Product differentiation:*** Additional variations of a product are developed as a supplement for an existing product.[47]

Product innovations usually entail a high risk. Therefore, it is necessary to follow a systematic approach to plan such a new product in order to make sound decisions. Kotler suggests a complex eight-step process, which seems to be exaggerated for the purpose AB-Mikroelektronik pursues. Bruhn's five-step approach is more practically orientated:[48]

1. Searching for product ideas
2. Rough selection of product ideas
3. Development and validation of product concepts
4. Fine selection of product concepts
5. Introduction of new products to the market[48]

The development of a standard product does not fit into the current business model of AB-Mikroelektronik, which is customer specific development. Hence, also the structure of the enterprise is not designed for simultaneous advance development of several product concepts. The task is to select one or two products from existing ideas, which will be developed afterwards. Therefore, the focus must be on selection methods for process step two.

2.3.1 Selection method: value-benefit-analysis

A variety of selection criteria must be considered in such a complex decision procedure. Therefore, either the scoring model or the more advanced value-benefit-analysis method is appropriate here. [49] In the following, the latter is introduced.

The principle of a value-benefit-analysis is illustrated in Table 1. Every alternative is rated with points e.g. from one to ten on each criterion, whereby ten is the highest score (most beneficial). Those points are weighed with the importance of the criterion and summed up.
Thereby, the criterions can be sorted in groups in order to ensure a better overview. The weighed points result out of a multiplication of the criterion group weight with the weight of the subcriterion and the assigned points. The alternative with the highest sum of weighed points in total is the preferential alternative.[50]

[47] Cf. (Bruhn, 2004, S. 131)
[48] Cf. (Bruhn, 2004, S. 131 et seqq.)
[49] Cf. (Bruhn, 2004, S. 136)
[50] Cf. (Bruhn, 2004), (Kühnapfel, 2014)

Table 1: Scheme of a value-benefit-analysis[51]

					Alternative A		Alternative B	
Criterion group	**Group weight**	**Criterion**	**Criterion weight**	**Res. Weight**	**Points [1-10]**	**weighed points**	**Points [1-10]**	**weighed points**
group A	40%	A1	40%	16%	10	1,6	5	0,8
		A2	10%	4%	8	0,32	4	0,16
		A3	50%	20%	6	1,2	5	1
group B	60%	B1	5%	3%	10	0,3	5	0,15
		B2	15%	9%	10	0,9	7	0,63
		B3	50%	30%	3	0,9	5	1,5
		B4	30%	18%	10	1,8	5	0,9
				100%		**7,02**		5,14

An advantage is that the method allows individualisation according to the specific situation of an enterprise. A lot of quantitative and qualitative criteria can be considered. The assessment is transparent and comprehensible.
Disadvantages are a relatively high effort and that the method appears objective although it is still subjective.[52]

Several points should be considered when conducting a value-benefit analysis:[53]

- ***Work environment***
  The assessment must be done in a group of experts who are qualified to do estimations and/or authorised decision makers. The ideal group size is five to ten persons. A moderator shall be announced, who has the necessary appearance and sufficient know-how concerning the method. Enough time must be scheduled, at least two hours depending on the scope.
- ***Alternatives***
  The value-benefit method can be used to decide between two alternatives, but it also allows a prioritisation of more than two alternatives. The number of alternatives under assessment should not exceed five, because otherwise it becomes difficult to differentiate between them during the group discussion.
- ***Formulation of the objective***
  Every decision pursues a certain objective which has to be followed. This objective must be formulated because it affects the definition of the criteria.
- ***Collection of decision criteria***
  Only criteria which are relevant for the achievement of the objectives are gathered in a creative process. It is recommended to limit the number of criteria to a set of 20 as a maximum. Requirements for the criteria are:

[51] Cf. (Bruhn, 2004), (Kühnapfel, 2014)
[52] Cf. (Bruhn, 2004, S. 135)
[53] Cf. (Kühnapfel, 2014)

- Completeness
- Relevance
- Assessment must be possible and reproducible.

- ***Weighing of the decision criteria***
  The sum of weights must be 100%. When having more than ten criteria, it is not possible to set weight factors with reasonable differentiation anymore. Permanent iteration of all weights and discussions within the group would be the consequence.
  One option to avoid this is structuring the criteria in groups as illustrated in Table 1. The groups are weighted first with a sum of 100%. The sub-criteria are weighted second, also with a sum of 100% for each group. The groups can have different quantities of criteria. This approach makes changes easier and the weight gaps are clear enough.[54]

A first essential criterion will be whether a product fits into the strategic orientation of an enterprise or not. Therefore, the position in a SWOT analysis could be evaluated as explained in the following subchapter 2.3.2.

2.3.2 SWOT Analysis

SWOT stands for “strength”, “weaknesses”, “opportunities” and “threats”. It is a comprehensive analysis method which considers the external environment (“threats” and “opportunities”) as well as the internal capabilities (“strength” and “weaknesses”) of an enterprise (refer Figure 3).[55] It can be used for the assessment of products, services and markets.[56]

	Helpful	Harmful
Internal Origin	Strengths	Weaknesses
External Origin	Opportunities	Threats

Figure 3: SWOT Analysis, own illustration[57]

For the determination of internal strengths and weaknesses, the use of checklists is suggested. Essential capabilities could be assessed with categories such as big weakness, little weakness, sufficient performance, little strength and big strength.[58]

[54] Cf. (Kühnapfel, 2014)
[55] Cf. (Kotler, Keller, & Bliemel, 2007, S. 108)
[56] Cf. (Team FME, 2013)
[57] Cf. (Team FME, 2013)
[58] Cf. (Kotler, Keller, & Bliemel, 2007, S. S. 111)

A primary objective of an environment analysis is to find marketing chances. Such chances are projects with high probability of serving customers and generating profit. There are three main sources for such chances. The first is to satisfy a demand where there is a scarcity of supply. The second is to substitute existing products with improved solutions and the third would be the introduction of completely new products or services.
Threats are detrimental developments or trends in the environment of an enterprise or a whole branch.[59] For the evaluation of the external environment, especially the threats, Porter's "Five Forces" analysis could be used (refer 2.3.3).

The most obvious strategy would be to focus on products with the best correlation of opportunities and strengths, but it may also be worth considering to improve on weaknesses in order to make the exploitation of attractive opportunities possible.[60]

2.3.3 Porter's Five Forces Analysis

Together with the "PESTLE" Analysis, Porter's "Five Forces" analysis is one of the two most common methods for the assessment of the external environment when developing a strategy. It is a qualitative method which is especially useful when entering new markets. Porter has defined five forces that are essential for the determination of the market attractiveness as shown in Figure 4. The horizontal (green) and vertical (blue) competitive environment are integrated.
It is important to keep in mind that this method applies to a "line-of-business" perspective. This means that at least a group of related products or even a whole business branch is examined, but not the entire business level. When taking different products under consideration, the method must be applied to each group separately.[61]

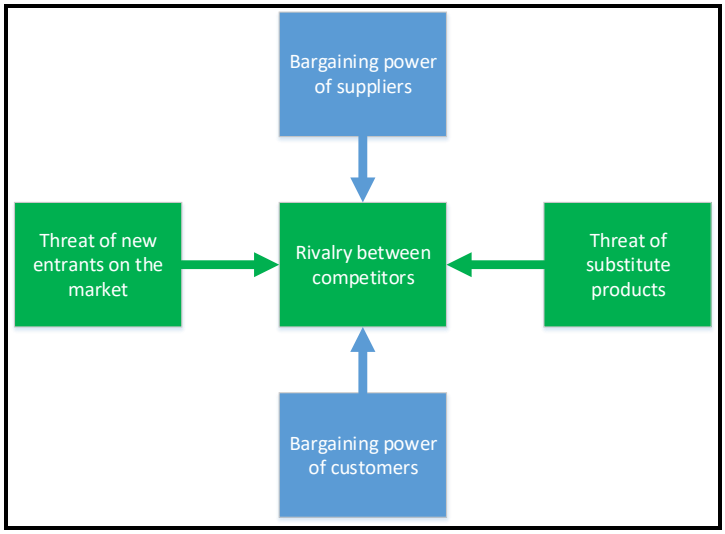


Figure 4: Porter's Five Forces model, own illustration[62]

[59] Cf. (Kotler, Keller, & Bliemel, 2007, S. 109 et seqq.)
[60] Cf. (Kotler, Keller, & Bliemel, 2007, S. 113)
[61] Cf. (Team FME, 2013)
[62] Cf. (Team FME, 2013)

Typical factors that increase the **rivalry intensity** between competitors are:

- Number of competitors
- Slow growth of the market
- High fixed costs and storage costs
- Low differentiation between the products
- Low costs to switch between sources
- High exit barriers[63]

Factors that keep the threat of **new market entrants** low are:

- a high density of patents and intellectual property
- restrictions set by the government
- highly specific equipment
- a high level of Minimum Efficient Scale (MES) [63]

Substitute products are those that make the own product obsolete. This can be products coming form other industries. An example would be online news as a substitute for conventional newspapers.[63]

The factors affecting the **bargaining power of suppliers and customers** are basically the same:

- The relation between the number of suppliers and buyers
- The switching costs between the suppliers
- Ability of vertical integration; e.g. the supplier starts to produce the purchaser's product themselves
- Differentiation grade of the supplier's product
- Substitute products
- The purchaser's share on the sales of the supplier[63]

2.4 Types of New Energy Vehicles (NEV)

New Energy Vehicle (NEV) is a collective term which, by Chinese definition, comprises Battery Electric Vehicles (BEV), Fuel-Cell Electric Vehicles (FCEV) and Plug-in Hybrid Electric Vehicles (PHEV).[64]

The technical concepts behind these terms are introduced in this chapter starting with the hybrid systems.

[63] Cf. (Team FME, 2013)
[64] (Innovation Center for Energy and Transportation, 2016)

2.4.1 Hybrid Electric Vehicles (HEV and PHEV)

Hybrid Electric Vehicles can either be divided into parallel, serial or power-split types according to their technical structure or into micro-, mild-, full-, plug-in- and extended-range-hybrids depending on their degree of electrification as shown in Table 2.[65]

Table 2: Classification depending on degree of electrification[66]

	Micro-Hybrid	Mild-Hybrid	Full-Hybrid	Classic Plug-in Hybrid (PHEV)	Extended Range Electric Vehicle (EREV)
Constructive characteristics	Powerful starter and adjustable generator (often belt start generator)	Crankshaft start generator	Decoupling of ICE and E-machine possible (clutch)	Same as HEV, but battery can be directly charged from electricity grid	BEV with an additional ICE+generator for battery charging
Technical structure	Parallel	Parallel	Parallel, serial, power-split	Parallel, serial, power-split	Parallel, serial, power-split
Function	• Start/stop • Limited Recuperation	• Start/stop • Recuperation • Boost • Generator operation • Limited pure E-drive	• Start/stop • Recuperation • Boost • Generator operation • Short range E-drive	• Start/stop • Recuperation • Boost • Generator operation • Mid-range E-drive • External electrical charging	• Pure e-drive • Recuperation • External electrical charging • ICE can extend the range with generator
Power E-engine	2-3kW	10-15kW	>> 25kW	>> 25kW	>> 40kW
Voltage level	12-48V	48-150V + 12V	> 200V + 12V	> 200V + 12V	> 200V + 12V

[65] (Hofmann, 2014)
[66] (Hofmann, 2014)

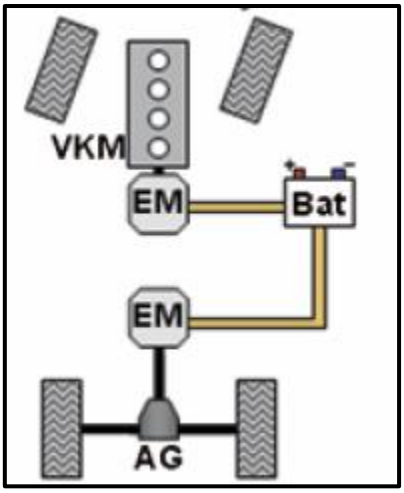


Figure 5: Serial hybrid system with one e-engine[67]

Figure 5 shows a serial hybrid system with one electric engine.

There is no mechanical connection between ICE and the wheels. A generator plus rectifier combination transforms the mechanical energy from the ICE into electrical energy and stores it in a battery. This energy, again transformed by an electrical converter, supplies the electric engines (up to four) which are steering the wheels.

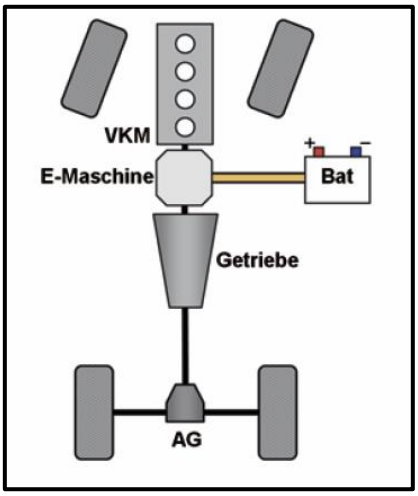


Figure 6: Parallel hybrid system with torque addition[68]

A parallel hybrid system as displayed in Figure 6 enables the use of either both engines simultaneously or separately.

Both engines can be coupled or decoupled from the drivetrain. The power form ICE and electric engine can be combined by rotational speed addition (planetary transmission), torque addition (direct coupling, refer Figure 6) or traction addition (ICE and e-engine act on different axle).

Note: VKM = ICE = Internal Combustion Engine, Getriebe = transmission, EM = Electric Machine

A power-split hybrid system represents a combination of a serial and parallel hybrid concept. The power transmission is split in a mechanical and an electric path. Such a concept is also called Electrically-Continuous Variable Transmission (E-CVT).[69]

2.4.2 Battery Electric Vehicle (BEV)

A BEV doesn't have an ICE anymore. BEVs have the same functions, voltage level and electric engine power than EREV vehicles, but more battery capacity or a reduced range instead of a generator.

[67] (Hofmann, 2014)
[68] (Hofmann, 2014)
[69] (Hofmann, 2014)

The most important components that a conventional car doesn't have are explained in the following list. This is basically valid for all NEVs.

- **High-Voltage (HV) battery:** The most important battery types are lithium-polymer, lithium-titanate, lithium-manganese and lithium-iron-phosphate, whereby the most common one is lithium-manganese. A traction-battery-pack consists of numerous battery-cells.
- **Battery Management System (BMS):** The BMS controls the battery and monitors critical parameters like the state of charge, the load-distribution, the temperature of the single cells and the whole battery pack as well as the aging of the capacity. Furthermore, it serves as a communication interface e.g. to charge stations.
- The **power electronic** supplies and controls the electric engine by converting the electric energy which is stored in the HV battery from Direct Current (DC) to Alternating Current (AC).[70]
- The **electric engine** transforms the electric energy into kinetic energy. Different types can be used depending on the requirements.
    - The most common type is the Permanent Magnet Synchronous Machine (PMSM) because of its high efficiency and high torque.
    - Tesla uses induction motors (asynchronous machine). They are simple, robust, have a wide speed range but are less efficient than PMSM.
    - Switched Reluctance motors are capable of extremely high speed, but are not often used in NEVs.[71]

2.4.3 Fuel-Cell Electric Vehicle (FCEV)

Fuel-Cell powertrains are comprised of the basic components as illustrated in Figure 7:

- Hydrogen tank
- Fuel-Cell (FC) stack with ancillary units (water cooling, hydrogen and air supply)
- DC/DC converter, typically central realization. It converters the fluctuating voltage of the FC Stack (among others load dependent) to a stable high voltage.
- HV battery, different concepts:
    - Small capacity (around 1kWh): Battery acts as a buffer for boost and recuperation functions.
    - Large capacity: Typically combined with a smaller hydrogen tank, the battery is used as the main energy storage and the FC acts as a range extender.
- Traction engine and converter units are the same as for BEV.
- LV-consumers must be supplied with a DC/DC buck converter which transforms HV to LV.[72]

[70] Cf. (Elektromobilitaet.com, 2017)
[71] Cf. (Qin, 2016)
[72] Cf. (Dehne, 2015), (AB-Mikroelektronik GmbH)

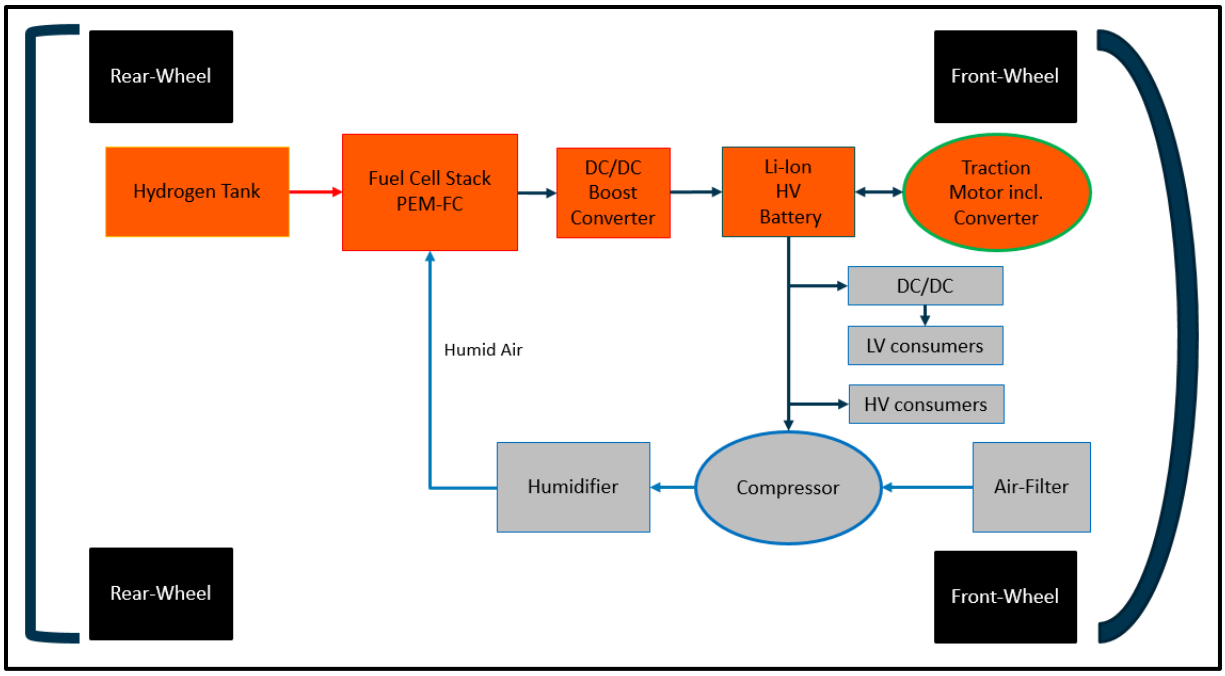


Figure 7: Basic FCEV concept. Own representation[73]

Alternative concepts as shown in Figure 8 do not use a central boost converter anymore. The HV consumers must cope with high voltage fluctuations. A small battery just serves as a buffer for recuperation and boost functions.[74]

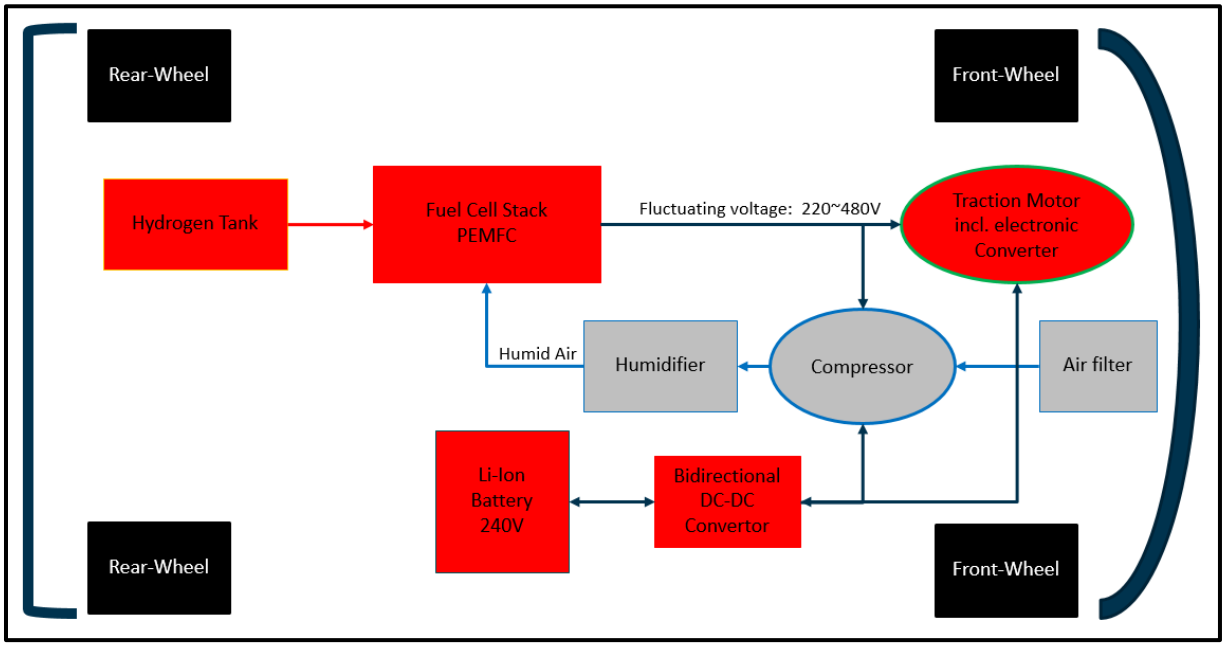


Figure 8: FCEV concept without central DC/DC boost converter. Own representation based on information out of meetings Hyundai/AB-Mikroelektronik.[75]

[73] Cf. (Dehne, 2015)
[74] (AB-Mikroelektronik GmbH)
[75] (AB-Mikroelektronik GmbH)

3 Practical problem solving

Following the marketing research process as explained in 2.2, this chapter contains the process steps three to five, namely data collection, data analysis and representation of the results. Thereby the structure of this chapter is as follows: At first the way how the data were collected and analysed is described in the chapters 3.1 and 3.2 respectively. The subsequent chapters 3.3 to 3.7 are structured based on the objectives of the thesis (1.2) and represent the results of the analysis.

3.1 Data collection

This chapter describes how the data have been collected and distinguishes between primary and secondary data collection.

3.1.1 Secondary data

The theory presented in chapter 2.2.2 mentions typical secondary data sources and most of them have been used for the collection of secondary data in this thesis. Reports, books, articles, papers and raw data have been gathered from or were provided by the following main sources:

- Online research
- Advantage Austria Shanghai and Beijing (Commercial Section of Austrian Consulate)
- EU SME Centre
- Conference Proceedings received via participation at the AVL “Engine & Environment” Conferences in Graz in the years 2016 and 2017
- Some interview partners have provided useful data or reports in addition to their expertise

3.1.2 Primary data

Primary data have been collected utilizing expert interviews due to the reasons mentioned in the theoretical chapter 2.2.3. Additionally, guest lectures, an ÖVK speech and two international AVL “engine & environment” conferences have been attended. Meetings with two potential customers have been held and several meeting minutes from AB-Mikroelektronik with further potential customers have been analysed.

3.1.2.1 Expert interviews

As a preparation an interview guideline following the theory given in 2.2.3.5 has been designed. A special requirement was that the first interviews had to be done during a China business trip with AB-Mikroelektronik’s General Manager of at the end of February 2017. The following procedure was followed in order to cope with the short preparation time:

1. As a first step, secondary data were collected.
2. In this short period it was not possible to fully analyse the data. As a first approach, the data were examined with a focus on comprehensive branch reports and papers. The goal was to determine which answers could be gathered from secondary data and for which information primary data would have to be collected.
3. Simultaneously, for the examination of the secondary data at hand, a brainstorming process of further or unclear questions was done. Doing so, approximately 50 questions were gathered.
4. Following the guideline of the theory in chapter 2.2.3.5, these questions were checked for compliance with the interview requirements and the objectives. Unsatisfying questions were reformulated or eliminated.
5. The questions were structured in bundles fitting the objectives as specified in chapter 1.2, because those are the main research questions.
6. Further structuring into guiding main questions and sub questions was done.
7. Using this draft interview guideline, a trial interview with the director of AB-Mikroelektronik's field application department, who is the most experienced employee at the site in Salzburg concerning the Chinese market, was done.
   The trial interview was basically satisfying for both sides. Still, an iterative improvement step was done.
8. This stage of the interview guideline was the basis for a consultation with the supervisors of the TU Graz. After some further small improvements, the guideline was approved.
9. These steps were done in German as there were German and Chinese/English speaking interview partners. The finalized interview guideline was translated to English in a last step. The English guideline can be found in the Appendix Table 27.

For the conduction of the interviews the practical and cultural suggestions as given in 2.2.3.3 and 2.2.3.4, respectively, were followed. For example, the questions had been memorized and were not read from a sheet of paper. The General Manager participated in the interview along with a top manager of a Chinese automotive supplier company in order to emphasize the expert status on the interviewer side.
Table 3 lists all interview partners with justification of their expert status for the topic under investigation as well as place and date of the interview. Not all interview partners were confronted with all five question bundles, the bundles were selected with consideration of the individual background. The interviews lasted about one hour each.
All interview partners, except one, allowed to recording of the conversation. Most of them also gave their consent to mention their name with the condition that the content must be anonymised (section 3.2 shows how that is ensured).

Table 3: Interview partners

Interview partner	Company	Function	Comment	Place	Date
Ing. Marcus Auer	AB-Mikroelektronik	Director Application	Started with groundwork for China business, trial interview	Salzburg	14.02.2017
Dr. Werner Johler	Littelfuse Europe GmbH	Vice President Engineering, Electronics Business Unit	Several years of China experience, workplace in China since 2 years. Littelfuse is automotive component supplier.	Shanghai	21.02.2017
Kevin Hu	Austrian Consulate General Shanghai, Commercial Section	Senior Marketing Officer	Responsible for automotive affairs	Shanghai	22.02.2017
Mag. Christina Schösser	Austrian Consulate General Shanghai, Commercial Section	Austrian economics delegate	Provided additional expertise and secondary data after the interview with Mr. Hu	Shanghai	22.02.2017
Dr. Michael Sikora	abc Automotive Business Consulting (HK) Ltd.	Managing Director	Specialised on market entry services, promotion, SCM a.o. for automotive suppliers out of the DACH region in China.	Shanghai	22.02.2017
Henry Zhao	TT-Electronics Suzhou	Sales manager	Partly responsible for AB-Mikroelektronik	Suzhou	22.02.2017
Anonymous	Cqrebo	Top management	Chinese automotive lighting supplier company, could be seen as potential customer and competitor simultaneously. GM of AB-M participated the interview.	Chongqing	23.02.2017
Assoc.Prof. Dipl.-Ing. Dr.techn. Mario Hirz	TU Graz, Institute of Automotive Engineering	Head of the Research Area for Automotive Mechatronics	NEV automotive and China experience, due to cooperation with TONGJI University in China.	TU Graz	04.05.2017
Univ.-Prof. Dipl.-Ing. Univ. Dr.rer.nat. Marcel Carsten Baunach	TU Graz	Professor and researcher for embedded automotive systems	No experience in automotive trends and power electronic components, but China business experience. No audio record, just notes!	TU Graz	16.05.2017

3.1.2.2 Guest lectures, speeches and conferences

Apart from the interviews, guest lectures and an ÖVK speech (see Table 4) perfectly fitting the topic under investigation have been attended. Furthermore, it was possible to ask specific questions with relation to the interview guideline during and after the presentations. These speeches including the subsequent mini-interviews (5-10 minutes) have also been recorded.

Table 4: Speeches and guest lectures fitting the objectives of this thesis

Speaker	Company	Function	Title	Place	Date
Dr. Martin Hauth	AVL List GmbH	Leading Engineer, Stationary Solid Oxide Fuel Cell	Fuel Cell Electric Vehicles	TU Graz	25.04.2017
Dr. Koller	VARTA micro innovation		Elektrochemische Energiespeicher/-Wandler für HEV und EV	TU Graz	02.05.2017
Dr. Matjaz Korman	AUDI AG	Head of Properties Total Vehicle Product Line B	Alternative Antriebskonzepte	TU Graz	02.05.2017
Dipl.-Ing. Jürgen Rechberger	AVL List GmbH	Manager Fuel Cell Research and Technology Development	Die Rolle von Brennstoffzellen in einem nachhaltigen Energie- und Transportsystem	TU Graz	03.05.2017

Furthermore, the 28th and 29th international AVL Conference “Engine & Environment” were attended. The topic of the conference 9th-10th June 2016 was “Powertrains for the Chinese Market” and the “Competition of Powertrain Systems” was on the agenda on 1st-2nd of June 2017. Other than the conference proceedings as secondary data source it was possible to gather information in short discussions with various experts and the concluding panel discussions with top representatives of OEMs and Tier-1s.

The information gathered in this way has been processed in the primary data analysis (refer chapter 3.2) together with the interview records.

3.1.2.3 Meetings with potential customers

Finally, first contact with two potential customers has been made and initial meetings were held (refer Table 5). On the agenda of both meetings was a presentation of the enterprise TT-Electronics/AB-Mikroelektronik, its technologies and products as well as a discussion about potential future collaborations.
Furthermore, an existing contact with AVL has been revitalized. There hasn’t been a meeting yet, but two face-to-face talks to Mr. Rechberger as well as on-going phone and e-mail correspondence with development engineers, because AVL is interested in a product by AB-Mikroelektronik (refer 3.6.5 and 3.6.6).

Table 5: Meetings with potential customers

Company	Description	Participants	Main interest	Place	Date
RE-FIRE	Chinese commercial FCEV OEM	AB-Mikroelektronik: P. Hoeller Re-Fire: - Audrey Ma (Senior Manager Overseas Markets Division) - Robin Lin (CEO) - Prof. Dr.-Ing. Su Zhou (Tongji University)	Products for FCEV	TU Graz	11.05.2017, ongoing correspond-ence
Samsung SDI	Manufacturer of battery cells and complete batty systems for NEV		Electronic main battery power switches	Customer site, Premstätte n	10.07.2017, ongoing correspond-ence
AVL	Powertrain development services	AB-Mikroelektronik: P. Hoeller AVL: - Jürgen Rechberger (Manager FC) - Rudolf Enzendorfer (Senior Design Engineer)	FC applications, especially HV water pump	TU Graz, Helmut List Halle, Phone-calls and e-mails	Ongoing correspond-ence

3.1.2.4 Workshop meetings

A technical workshop with three experts from AB-Mikroelektronik's long year electronic development service partner "ISLE Steuerungstechnik und Leistungselektronik GmbH", development engineers from AB-Mikroelektronik as well as the Product Line and Field Application Directors was participated. The scope was the evaluation of the technical development efforts for battery protection, DC/DC and traction inverter applications.

In course of the final thesis presentation at AB-Mikroelektronik, a concluding workshop with the aim to make a decision which own product shall be developed was moderated. Details and results are shown in chapter 4.2.

3.2 Data analysis

The data analysis has follows the theory in chapter 2.2.4.
A special challenge when doing a marketing research project about the Chinese automotive market is its incredible fast development. A branch report issued in the year 2015, for example, is completely outdated and not reliable anymore in 2017. Therefore, especially statistical data had to be collected from up to date Chinese sources like the website of the China Association of Automobile Manufacturers (CAAM) which has the peculiarity to just publish monthly data and no comprehensive data collections. Hence, when analysing the secondary data, an important task was to continuously cross check data with other sources and interpretations as well as with older data in order to ensure plausibility.

Concerning the analysis of primary data, Mayring's procedure was carried out as follows:

1. Most of the raw material is present in form of audio records. The interview partners and speakers are listed in the previous section 3.1.2.
   The outcome of the customer meetings and the workshops was not processed according to this procedure. Short reports are provided at the adequate positions in the sections of the results instead. Meeting minutes can be found in the appendix.
1. The objective of the analysis is to gather content information from the raw material. This is not a human related sociologic or psychologic research; information on the interview partners is not from interest. This is why the analysis focuses on content carrying text parts and not on sentence or word level.
   The research questions are basically identical with the objectives of the thesis and are more detailed in the interview guideline (refer Table 27).
2. The summarizing content analysing approach was followed. It can be reconstructed and understood from Table 29 in the Appendix. The process was conducted in German in order to avoid translation mistakes, because a majority of the interviews was done in German. English interviews have been translated into German in order to ensure anonymity.
3. The results are represented together with results out of secondary sources in the following chapters 3.3 to 3.7.

3.3 Top-down analysis of the Chinese automotive market development

This chapter provides the results of the data analysis concerning goal one out of 1.2 Objectives. A brief retrospective, explaining the historical development and the current situation of the Chinese automotive market is necessary in order to make an evaluation of the future development plans justifiable. Subsequently, the 13th five-year plan of the Chinese central government and related official plans are analysed for potential effects on the automotive industry, including an overview of relevant regulations. Finally, assessments of other countries and branch insiders as well as the opinions of the consulted experts are given.

3.3.1 Historical development of the Chinese automotive market

The history of China's automotive industry started with the first five-year plan of the communist central government, as it contained the goal of establishing their own automotive vehicle industry. This plan was realized with the help of the Sowjet Union and resulted in the First Automobile Works enterprise (today FAW Group Corp.). The focus was on commercial vehicles, mainly for military purposes. The first passenger car out of Chinese development was the "Fenghuang", from which a total accumulated amount of 79 thousand cars was produced by SAIC in the period from 1964 until 1991.[76]

China's opening up, starting in the year 1978, was the reason for a significant increase in demand for passenger vehicles, because private car ownership was allowed. The existing car manufacturers were not able to satisfy the demand, therefore the import rate increased, although the import duties were high. SAIC started searching for a partner who would help to close the supply side gap and signed a contract with Volkswagen (VW) for the production of the VW Santana in the year 1983. 1984, the joint-venture (JV) "Shanghai Volkswagen Automotive Co. Ltd." Has been founded. In the 1990s, a yearly amount of 100 thousand Santana was produced.
Volkswagen established another JV together with FAW for the production of VW Jetta and Audi 100 (under the name Hongqi CA7200) in the year 1991. With its two JVs, Volkswagen dominated the Chinese automotive market until 1997, when General Motors entered the market.
Besides the JVs, 120 Chinese car manufacturers were established at this time and the annual production rate reached 1.2 Million in the year 1999.[76]

From 2000 on, more international automotive OEMs have entered the market with JVs, but also independent Chinese car producers ("Original Brands") have emerged which are striving for achievements with self-developed cars. Due to a lack of research and design capabilities, these ambitions were not successful in the beginning and just brought forth cheap copies. But

[76] Cf. (Aussenwirtschaftscenter Shanghai, 2015)

in the last years, Chinese OEMs have learned fast, mainly through experience with their JV partners. There are more models with own design on the market.[77]
The market share of Original Brands was below 10% in the year 2002, but it has reached around 40% recently.[78]

Lower tariffs resulting from China's membership in the World Trage Organisation (WTO), rising competition between numerous vendors and subsequently decreasing prices, but also rising wealth of the population have led to significantly increasing sales rates. The annual production rate continuously rose to 5.71 million vehicles in 2005, 9.35 million in 2008. The number doubled in just two years to 18.26 million units in 2010 and reached 23.77 million vehicles in 2014. Significant investments in production facilities were spent in this period. Thereby production sites have been built in the interior of the country also, because wages and production costs in the coastal provinces have risen.
In the recent years development efforts concerning electric cars have increased due to subsidies, but also pressure executed by the central government.[79]

3.3.2 Chinese automotive-industry politics since the year 2000

The automotive industry is recognised as a key industry and therefore highly influenced by the government.[80]
There are several policies which have strongly shaped the Chinese automotive industry and still continue to have an effect. Obviously, they are the basis for future policies and hence it is important to explain the most important mechanisms in this chapter before the future policy development can be analysed in the subsequent chapters 3.3.4 to 3.3.8.

3.3.2.1 Production licence and joint-venture dictate

Permission from the central government in form of a production licence is a prerequisite for the production of automobiles in China. This is valid for foreign as well as for domestic manufacturers and represents a first very powerful steering tool for the government.[81]

Due to very high import taxes before 2001, when China became a member of the WTO, foreign manufacturers were forced to localise their production in China. This was and is still only possible when founding a JV with a Chinese partner, whereby the foreign partner is not allowed to hold more than a maximum share of 50%. Furthermore, the government is heavily involved in the selection process of the Chinese partner and it also dictates a minimum investment and sales rate as well as a compulsory engine production.
Chinese manufacturers have the allowance to cooperate with more than one foreign partner and the latter is allowed to work with two Chinese manufacturers as well. Due to that, strange constellations have evolved where competitors are somehow tied together like it is the case with SAIC, which is the most important partner of both VW and GM.[81]

[77] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 8,9)
[78] Cf. (Dr. Sikora, AWO Branchen Report, Die Fahrzeugindustrie in der V.R. China, 2010, S. 25)
[79] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 8,9)
[80] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 10)

When having a JV, the Chinese partner must produce cars with an independent brand as well. If not, the production of the JV would be ceased. The goal of this rule is to force foreign OEMs to support their Chinese partners with technology to make sure that they can comply with it. Obviously, the profit of JVs must be shared. Hence, financial capabilities are shifted to the Chinese partners.[81]

Actually, such a JV dictate, which is the reason for the complex structure of the Chinese automotive industry, does not exist for automotive part suppliers (exceptions: electronic bus systems and electronic power steering (EPS) systems). Foreign OEMs utilize this fact through holding 100% ownership on important supplier companies.[81]

3.3.2.2 Localisation of suppliers and Research & Design

Before China became a member of the WTO, another constraint for founding a JV had been that a minimum of 40% of the components and parts had to be purchased locally. Unofficially, this rate rose to 60% and 80% in the second and third year of existence respectively. This regulation was abolished when China entered the WTO, but there was still a certain discrimination of imported parts which lasted until 2009 when it was abolished due to a suit at the WTO. Meanwhile, China reached its goal and most international supplier companies had established local production sites.
Nowadays it is still important to have a high localisation rate when government approvals are required. Due to that, but also because of cost-reduction reasons, all OEMs in China insist on local production of Tier-1 and Tier-2 suppliers. The Volkswagen group has reached a localisation rate of 91% with its brands VW and Skoda by 2015.[82]

Since 2004 it has been compulsory for JVs to establish a R&D department in China in order to foster innovation. Still, foreign OEMs did most of the development abroad and just assigned adaption work to the local R&D centres. To counteract that, authorities and also the CAAM have put more pressure on the JVs to start developing themselves instead of using technology from their foreign mother companies since the 12th five-year plan.[83]

3.3.2.3 Initial regulations fostering the development of alternative powertrains and Chinese brands

The “plan for adaption and revitalisation of the automotive industry” in 2009 encouraged manufacturers to produce at least one car model with an alternative powertrain in China. Additionally, pressure was exerted on foreign manufacturers to establish local brands together with their JV partners.
Some OEMs have combined these requirements, such as Daimler that has created the “Denza” brand together with BYD. BMW and Brilliance created “Zinoro” and “Springo” was founded by GM and SAIC. Actually, all the models which were developed under these brands

[81] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 10,11)
[82] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 12)
[83] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 14)

are equipped with simple components and technologies. They appear like compulsory exercises.[84] As chapter 3.3.3 will show, those models have not been successful on the market. Approximately 4500 DENZA EV have been sold since start of production in 2014 (accumulated until the end of 2016). This accounts for a 0.6% share on the NEV-market segment.[85]

The mentioned plan also aims for a 50% market share of Chinese brands ("self-owned brands"). However, the definition of this term is unclear – Geely, for example, also claims Volvo as a "self-owned brand" and so GM does with "Wuling".[86]

3.3.3 Current situation and market overview

There are more than 120 manufacturers of cars and light commercial vehicles in China, but only 12 of them exceed an annual production volume of 500 thousand units. The central government does not see a future for 50 of them and strives for a consolidation of the industry for example through encouraging OEMs to merge.[87]
The target of this chapter is to provide an overview about this complex car market. The first section deals with the volume development in the recent years, followed by more detailed analyses of trends and market shares.

3.3.3.1 Market volume and development of conspicuous segments

In 2016, the total vehicle production volume was 28.199 million units, which represents a year on year increase of 14.5%. Thereof, 24.421 million produced vehicles were passenger cars, 24.377 million of them were sold.[88] This makes China the biggest automobile market in the world.[89]
Figure 9 shows the development of the Chinese passenger car market since 2010, including a distinction between the segments SUV, MPV, Minivan, NEV and the residual car types.

[84] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 11)
[85] Cf. (Dr. Sikora, Westliche Marken verlieren Anschluss, 2017)
[86] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 12)
[87] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 13)
[88] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[89] Cf. (Hu, 2010)

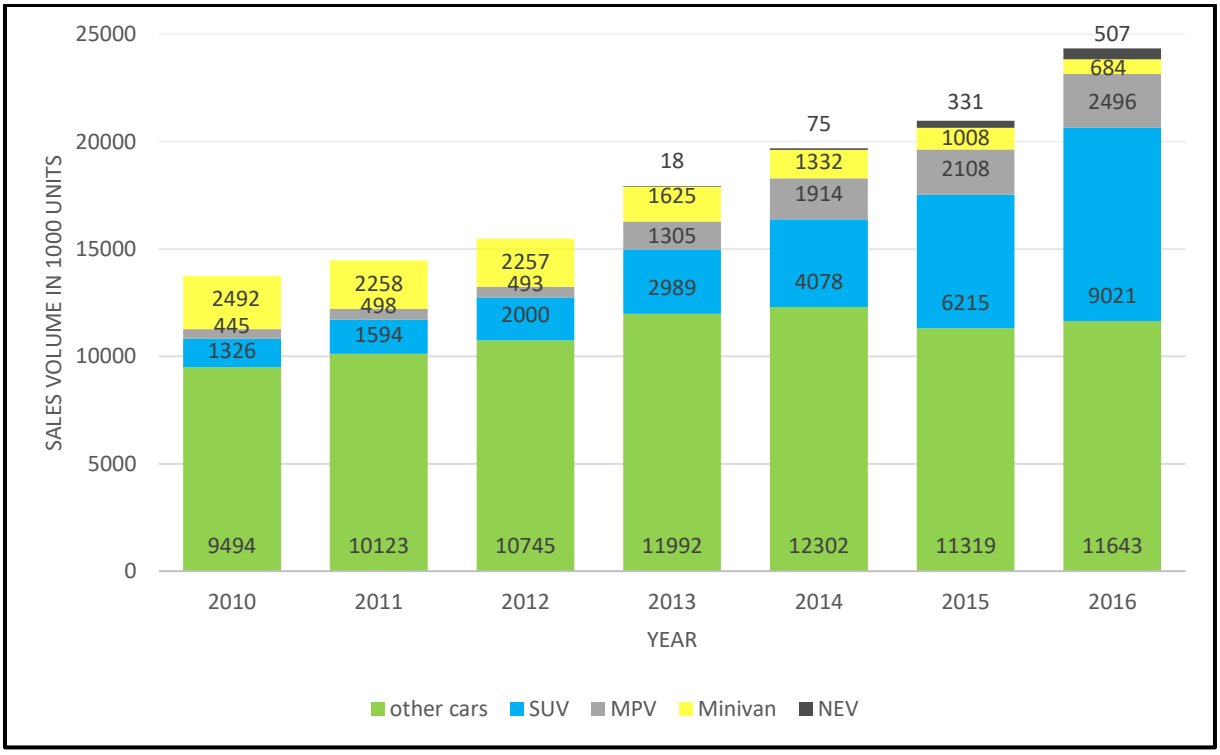


Figure 9: Chinese passenger car market development [90]

The SUV, MPV and NEV segments have witnessed huge growth rates in the last years, while the importance of the Minivan segment vanishes. This development becomes more obvious when looking at the relative market share provided by Figure 10.

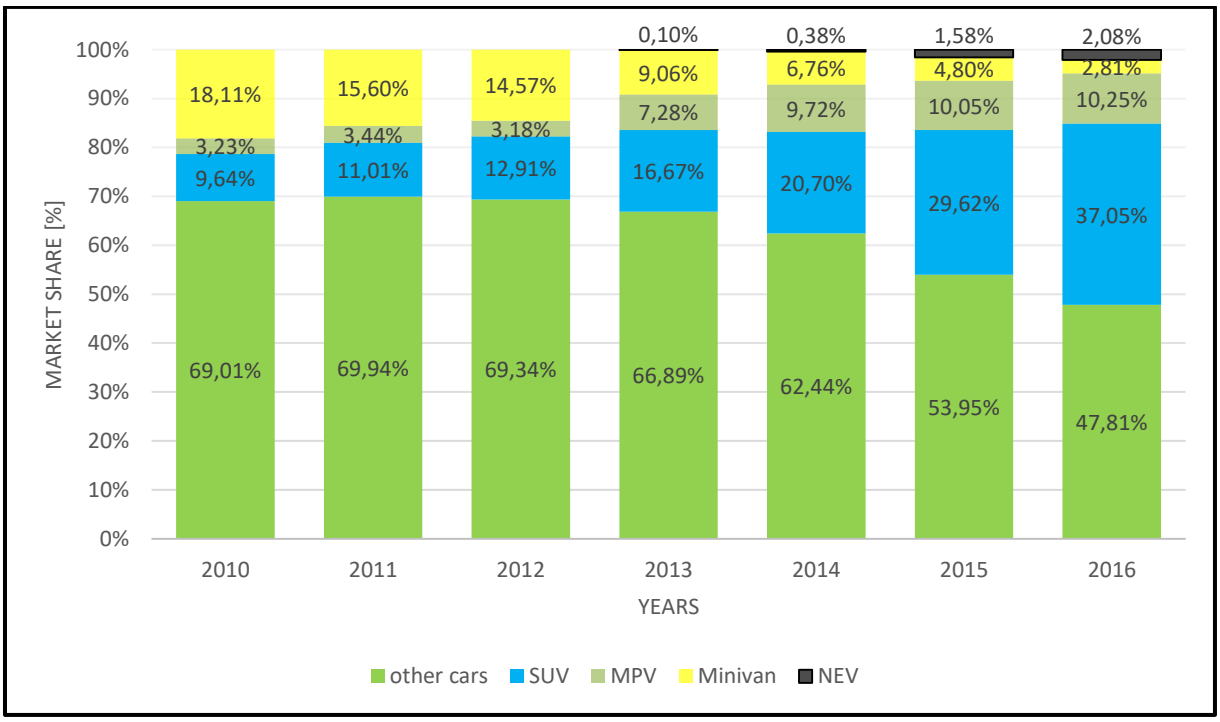


Figure 10: Market share development of SUV, MPV, Minivan, NEV segments [91]

[90] Cf. (CAAM - China Association of Automobile Manufacturers, 2017), (statista, 2017)
[91] Cf. (CAAM - China Association of Automobile Manufacturers, 2017), (statista, 2017)

2.496 million cars were sold in the MPV segment in 2016, representing a market share of around 10%. SUVs accounted for a market share of 37%, which is slightly more than 9 million units. In the first half of 2017 the SUV segment grew again with a rate of 16.8%.[92]

With nearly 75 thousand sold NEVs, this segment made a noteworthy breakthrough in 2014, followed by a rapid growth until 2016, when 507 thousand cars with electric engine were sold, representing more than 2% market share. This is nearly a sevenfold increase from 2014 to 2016! The NEVs also kept further growth in the first half of 2017 with a plus of 14.7% compared to the same period in 2016.[92]

Sections 3.3.3.3 and 3.3.3.4 will deal more closely with these three interesting segments. Before that the market share of Chinese brands will be analysed in section 3.3.3.2.

3.3.3.2 Market share of Chinese brand passenger cars and German OEMs

Figure 11 shows a correlation between the development of the NEV+MPV+SUV segment and the market share of Chinese brands as well as a negative correlation with the market share of German brands.

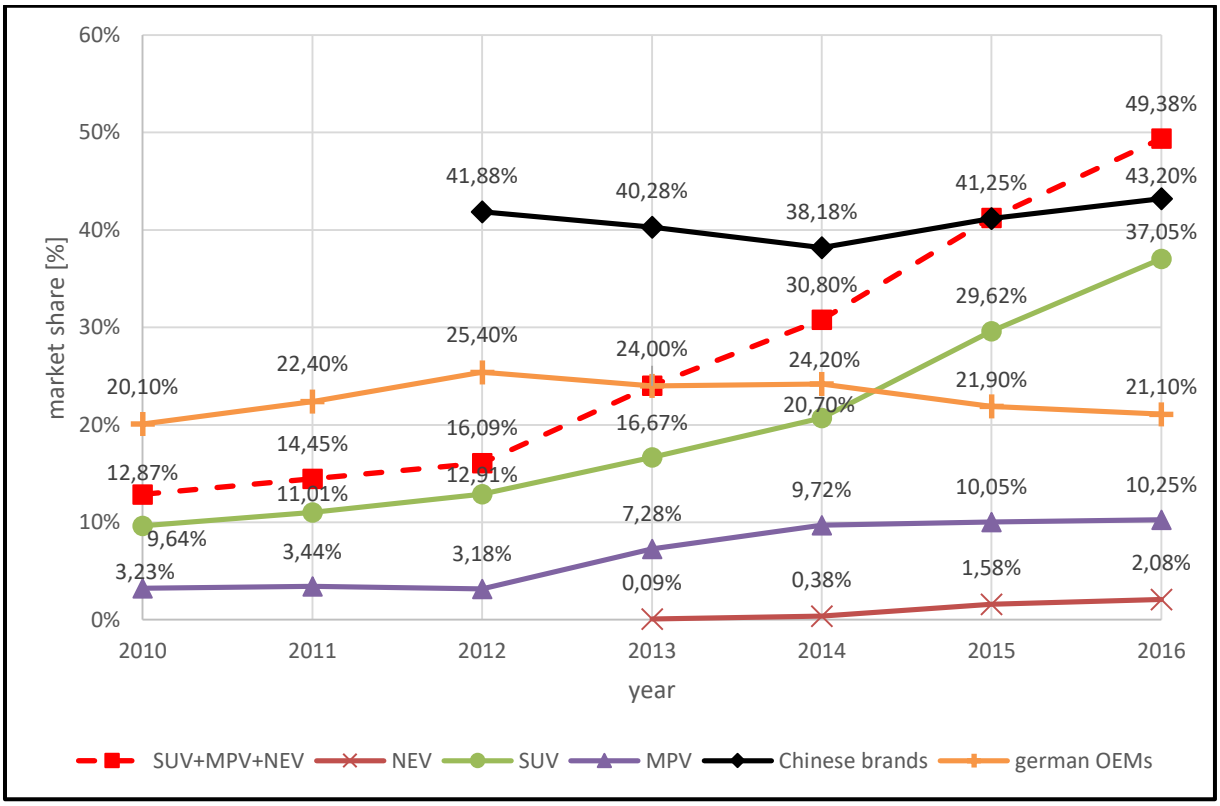


Figure 11: Market share comparison of German OEMs, Chinese brands, SUV, MPV and NEV segments [93]

Chinese brands gained a lot of market share in the decade from 2000 until around 2010, followed by some years of decline. The turnaround happened in 2014 again, since then their

[92] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[93] Cf. (CAAM - China Association of Automobile Manufacturers, 2017), (Deutsche Mittelstands Nachrichten, 2017)

home market share has grown fast and reached 45.7% in the first quarter of 2017. Still, the 50% target of the 2009 automotive industry revitalisation plan has not been fulfilled yet, but the trend promises that this might happen with some years of delay.
Simultaneously, German OEMs have lost market share although their sales rate has increased[94].

The reasons for this development are to be found in the SUV, MPV and NEV market segment. The share of Chinese brands on the SUV segment grew from 53.4% in 2015 to 58.2% in 2016 and from 88% to 89.2% on the MPV segment.[95] With a market share of 94.5%, the NEV segment is practically fully dominated by domestic brands.[96] The correlation between the dashed line in Figure 11, which shows the development of the combined SUV+MPV+NEV market share, and the market share of Chinese OEMs indicates that they are fully in line with the market trend.

Note: Referring to 3.3.2.3, it must be mentioned again that the definition of “Chinese brand” is vague. CAAM does not provide an explanation how the data are accumulated either. Hence, it is assumed that also brands like “Volvo”, “Wuling” or “Baojun” (both JV brands of SAIC-GM-Wuling) are considered as “Chinese brands”.
In general, CAAM seems to be the most reliable automotive statistic data source, as the sales figures from the manufacturers are matched with the certification data from the MIIT.[97] Most secondary sources also use CAAM as data source. Still, the interpretation of the data is sometimes difficult and confusing. For that reason, all data provided in this thesis have been verified with several sources.

3.3.3.3 NEV segment

The number of NEV manufacturers (with sales volume higher than 100 vehicles p.a.) has grown by 50% to 21 since the breakthrough in 2014 and the number of models available has more than doubled to 68 (reference date: end of 2016).[98]
The next figures analyse the composition of the NEV sales volume of the last years. Figure 12 distinguishes between passenger and commercial NEVs whereas Figure 13 shows the sales volume of BEV and PHEV.

[94] Cf. (Deutsche Mittelstands Nachrichten, 2017)
[95] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[96] Cf. (EVVolumes.com, 2017)
[97] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[98] Cf. (EVVolumes.com, 2017)

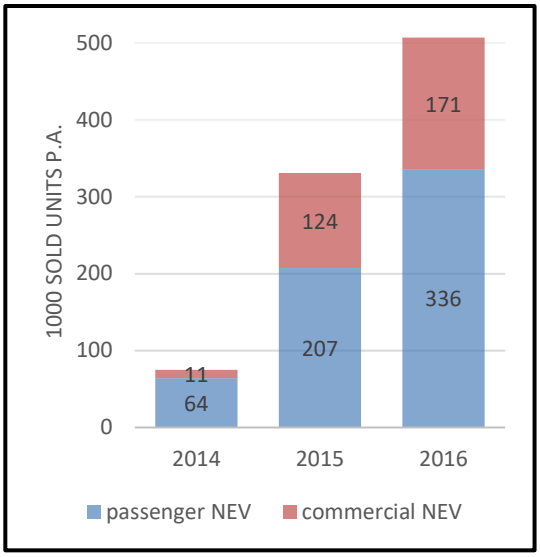


Figure 12: Commercial/passenger NEV [99]

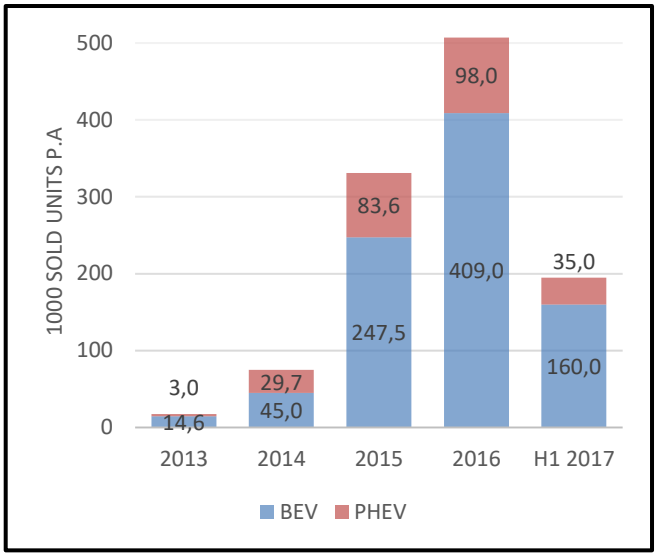


Figure 13: Sales distribution BEV/PHEV [100]

Figure 13 clearly shows that the PHEV technology is of subordinate importance in China compared to BEV. The relative depiction in Figure 14 suggests the assumption that PHEV have played an important role for opening the NEV market in 2014, but since then the proportion of PHEV has dropped sharply below 20%.

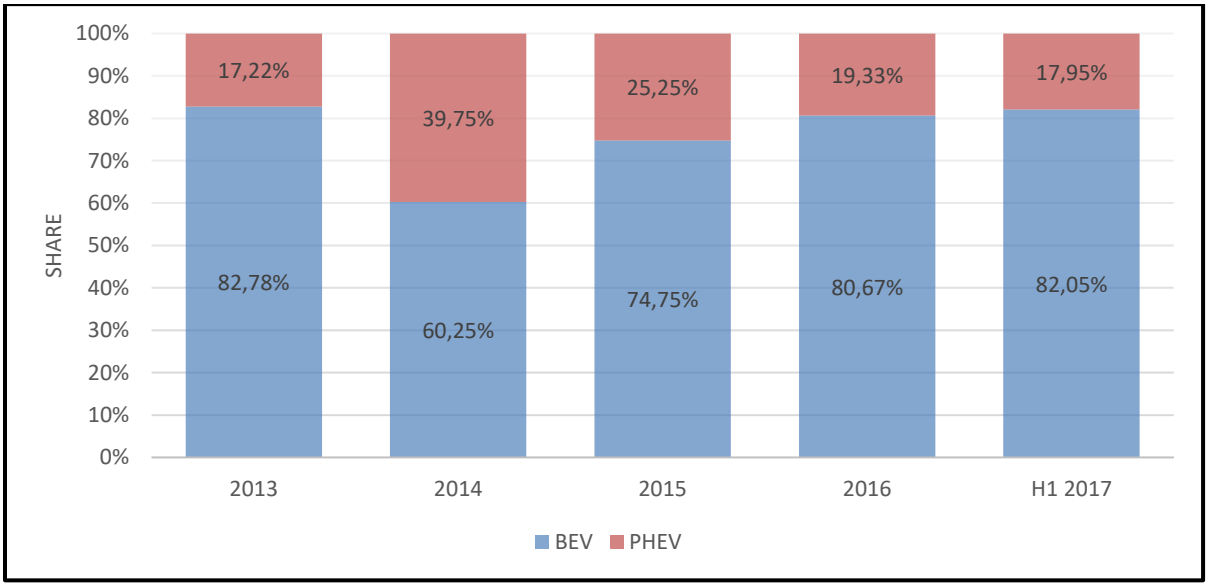


Figure 14: BEV and PHEV share on NEV sales volume [101]

The commercial vehicle market is comprised of 80% big buses, which are mostly fully electric. The Chinese electric bus market leader is “Yutong”. The biggest exporter is “BYD”, but China accounts for 98% of the global market anyway.[102]

[99] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[100] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[101] Cf. (CAAM - China Association of Automobile Manufacturers, 2017)
[102] Cf. (EVVolumes.com, 2017)

Considering the passenger NEV market, a list with the 30 most successful models of the year 2016 can be found in the appendix Table 28. Those 30 models account for more than 97% of the market volume. Hence, it can be considered as representative. The market share of the most important brands was calculated from this list (small blur possible). The results including the sold units are shown in Table 6 and the relative share is visualised in Figure 15.

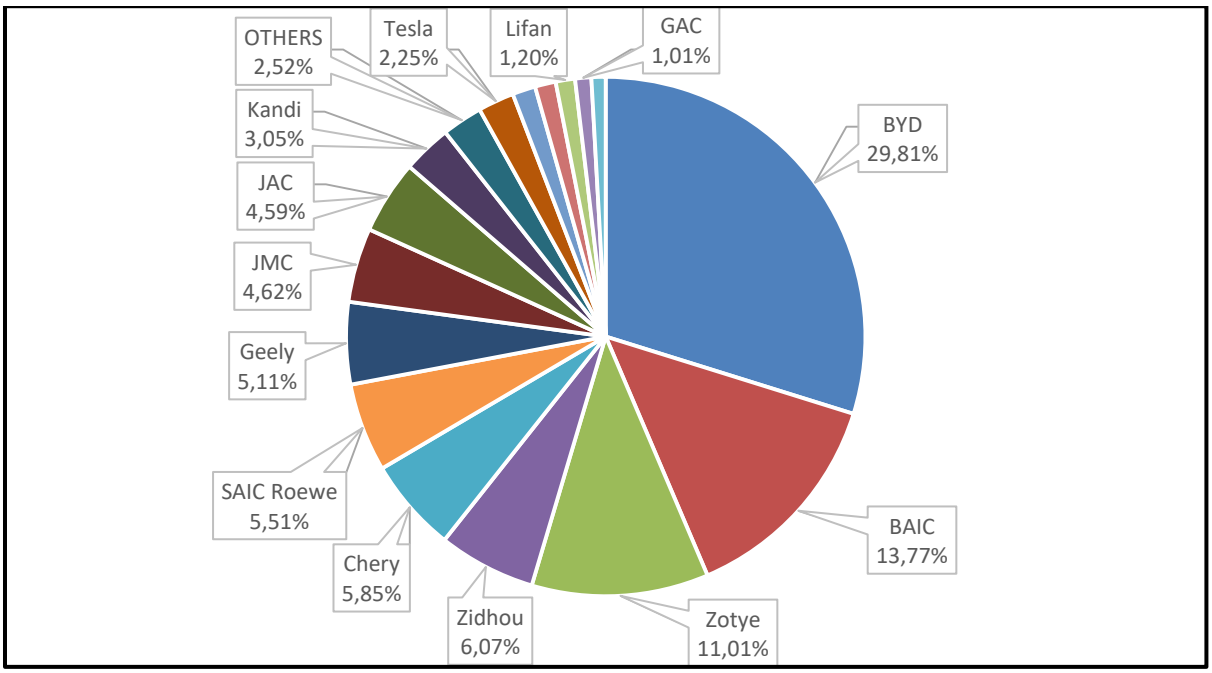


Figure 15: NEV market shares by brand [103]

Table 6: Top selling passenger NEV brands 2016 [103]

Rank	Brand	Accumulated sales volume 2016 [#]	Accumulated share on PNEV 2016
1	BYD	100,173	29,81%
2	BAIC	46,281	13,77%
3	Zotye	36,999	11,01%
4	Zidhou	20,392	6,07%
5	Chery	19,660	5,85%
6	SAIC Roewe	18,522	5,51%
7	Geely	17,181	5,11%
8	JMC	15,535	4,62%
9	JAC	15,409	4,59%
10	Kandi	10,246	3,05%
11	Tesla	7,548	2,25%
12	Changan	4,839	1,44%
13	Dongfeng	4,347	1,29%
14	Lifan	4,047	1,20%
15	GAC	3,378	1,01%
16	Porsche	2,963	0,88%

[103] Cf. (EVVolumes.com, 2017)

BYD is the clear leader in the NEV segment. With more than 100 thousand sold units, BYD is the biggest manufacturer of NEV on the world. Just when considering BEV only, Tesla leads the global market with 83922 produced vehicles in 2016 (BYD: around 50 thousand).[104] With slightly more than 2% market share, Tesla also covers the biggest fraction of NEV imports to China.[105]

The NEV division of BAIC is called BJEV and has grown fast, being second in 2016 narrowly followed by Zotye.

The power of these NEV varies from very low (around 10kW) up to 160kW per electric engine, whereby it is conspicuous that the best selling cars tend to have higher power around 100kW.

There is an interesting fact concerning HEV (non-plug-in) which shall be mentioned as a side note. The HEV whole sales volume in China in 2016 was just 85 thousand units and Toyota sold the bulk of them.[106]

Concluding this chapter, a comparison of the Chinese- with the European NEV market shall be provided. In 2016, 222 200 BEV and PHEV were sold in whole Europe, whereby the ration between them was approximately 1:1. This represents a 1.3% market share. The growth rate was just 15% compared to 2015. This means the European NEV market is not even half times as big as China's with 507 thousand units in 2016 and when considering BEV only, China's market is around four times bigger. The growth rate was also not comparable. HEVs and PHEVs are more important, BEVs are less important in Europe compared to China.[107]

3.3.3.4 SUV+MPV segment

SUVs are very popular in China in general. Besides the fact that Chinese cars become more and more competitive considering quality, they are also cheaper than international brands. Most importantly, Chinese OEMs have created the right combination, namely SUVs with small engines below 1.6 litres engine displacement. As an additional advantage, the purchase tax for new cars with engines below this size was cut by 50% on October 1st 2015. A new 7.5% tax has been introduced by 31st of December 2016, which is still significantly lower than the 10% tax of the next engine class with more than 1.6 litres. Overall, passenger cars with engines below 1.6 litres displacement accounted for 72% of the sales volume in 2016.[108]
This tax cut policy may have given an additional boost to the automotive market, preferred to domestic OEMs, but as Figure 11 shows, there was also a strong and domestic OEM dominated growth in the SUV and MPV market before October 2015.

Table 7 shows the top 10 selling SUV models in 2016. Great Wall leads the ranks with its Haval H6, but with the Haval H2 (rank 8), H1 (rank 48), H7 (rank 61) and H5 (rank 95) Great Wall

[104] Cf. (Zeitonline, 2017)
[105] Cf. (EVVolumes.com, 2017)
[106] Cf. (EVVolumes.com, 2017)
[107] Cf. (EV-Volumes, 2017)
[108] Cf. (Automotive Analysts, 2017)

has four more SUVs under the top 100 sold SUV models, which accumulates to 919 044 sold Great Wall SUVs.

Table 7: Top 10 selling SUVs in 2016[109]

Rank	Models	Manufacturers	2016 Sales [#]
1	Haval H6	Great Wall	580,683
2	GAC Trumpchi GS4	GAC	326,906
3	Baojun 560	SAIC-GM-Wuling	321,555
4	Buick Envision	SAIC-GM	275,383
5	VW Tiguan	SAIC-VW	240,510
6	Changan CS75	Changan	209,353
7	JAC Refine S3	JAC	197,947
8	Haval H2	Great Wall	196,926
9	Honda CR-V	Dongfeng-Honda	180,319
10	Nissan X-Trail	Dongfeng-Nissan	180,202

As Table 8 shows, seven models out of the 2014 top ten carried foreign brands, whereas the opposite was the case already in 2016 (Table 7).

Table 8: Top 10 selling SUVs in 2014, comparison with 2016 rank[110]

Models	Manufacturers	Rank	2014 Sales [#]	2016 Sales [#]	Rank
Haval H6	Great Wall	1	315,878	580,683	1
Volkswagen Tiguan	SAIC-VW	2	246,418	240,510	5
Honda CR-V	Dongfeng-Honda	3	168,179	180,319	9
Hyundai ix35	Beijing-Hyundai	4	145,304	71,938	46
Ford Kuga	Changan-Ford	5	135,998	115,083	20
Toyota RAV4	FAW-Toyota	6	124,680	116,389	19
Nissan X-Trail	Dongfeng-Nissan	7	114,459	180,202	10
Audi Q5	FAW-FW	8	109,709	129,453	16
Chery Tiggo3	Chery	9	104,064	118,414	18
Chang'an CS35	Chang'an	10	100,571		

All successful foreign branded SUVs from 2014 have dropped back significantly in the ranking of 2016.

[109] Cf. (ChinaAutoWeb, 2017)
[110] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 33), (ChinaAutoWeb, 2017)

3.3.3.5 Overall best performing manufacturers, brands and models

This chapter provides an overview of the most important manufacturers, brands and models measured by all units sold in 2016.
Starting with the most successful models, Table 9 shows the top ten ranking.

Table 9: Top 10 selling car models 2016[111]

Rank	Model	2016 sales [#]
1	Wuling Hongguang	650,018
2	Great Wall Haval H6	580,683
3	VW Lavida	478,699
4	Buick Excelle GT	370,370
5	Baojun 730	370,000
6	Nissan Sylphy	367,979
7	VW Jetta	348,437
8	VW Sagitar	341,331
9	GAC Trumpchi GS4	326,906
10	Baojun 560	321,555

It is noticeable, that also in this ranking with Wuling, Haval, Baojun and GAC five out of 10 models are Chinese branded. Certainly, behind the brands Wuling and Baojun is the JV SAIC-GM-Wuling.
Figure 16 shows the top ten automotive manufacturing enterprises, which accounted for a market share of approximately 88% in 2016. In comparison with the year before, Brilliance dropped back behind Great Wall and Geely, Chery is new on place ten and has kicked out JAC.

[111] Cf. (Haj-Assaad, 2017)

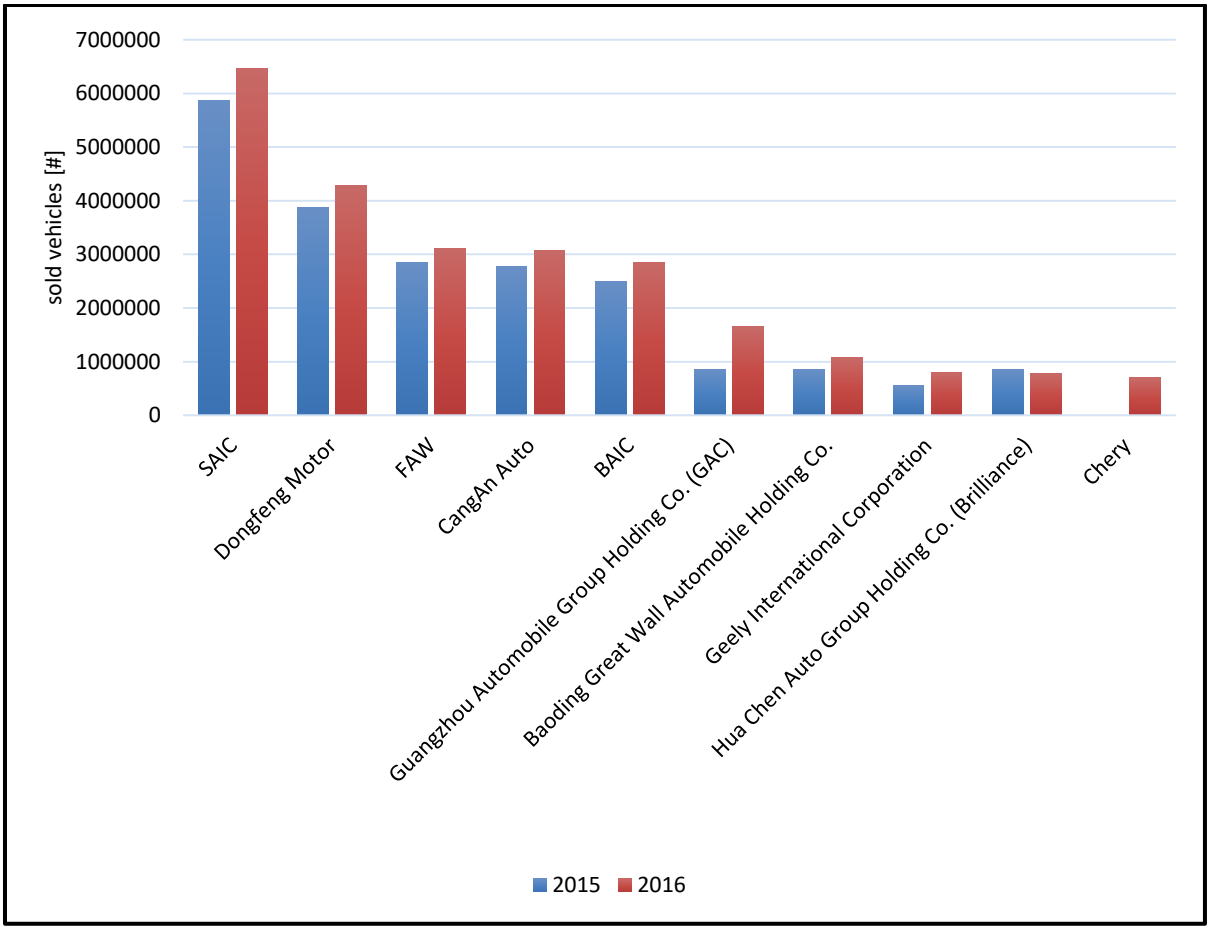


Figure 16: 2016 ranking (with 2015 comparison) of Chinese OEMs due to sold vehicles (JVs included) [112]

Finally, Figure 17 shows the 2016 market share of 22 important brands with VW unchallenged on top, although its market share has declined from 14.2% in 2014. Compared with a market share ranking out of 2014, other losers are Hyundai (-1.1%), Wuling (-1.1%) or Chevrolet (-1.7%).
Buik (+0.35%), Honda (+0.91%), Changan (+1.1%) or Great Wall have won market share.[113]

[112] Cf. (statista, 2017)
[113] Cf. (Aussenwirtschaftscenter Shanghai, 2015, S. 24)

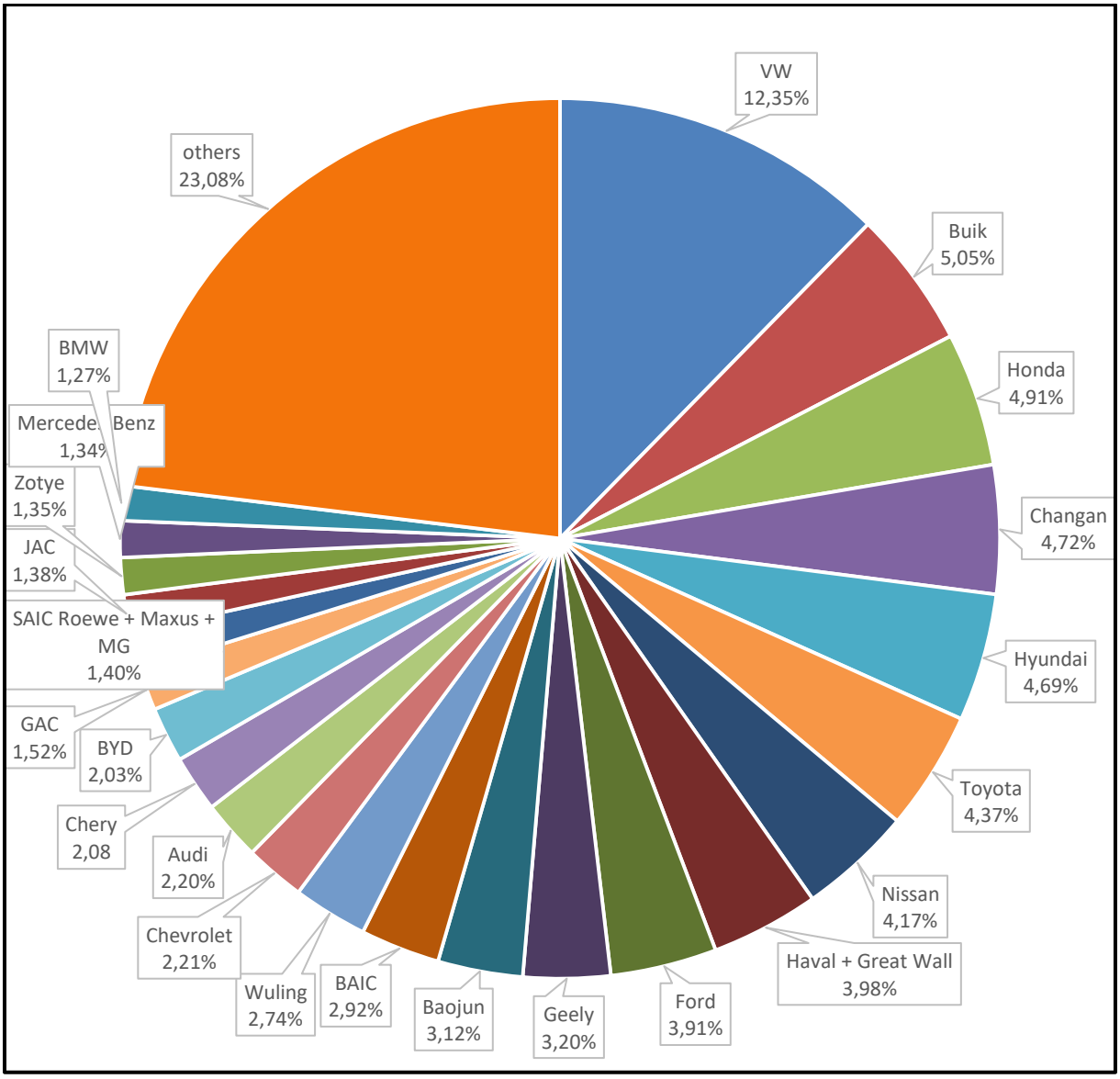


Figure 17: Market share of top brands in 2016 [114]

These data only consider locally produced vehicles, imports are neglected.

The next chapter deals with the future plans of Chinas government for the automotive industry.

[114] Cf. (Carsalesbase.com, 2017)

3.3.4 Analysis of the 13th Chinese five-year plan

The Communist Party of China (CPC) publishes strategic development plans in a five year interval. The current 13th five-year plan is valid from 2016 until 2020 and it "sets forth China's strategic intentions and defines its major objectives, tasks, and measures for economic and social development. This plan is to serve as a guide to action for market entities, an important basis for government in performing its duties, and a common vision to be shared among the people of China."[115]

Following a top-down approach as explicitly wished by AB-Mikroelektronik, this chapter analyses the 13th five-year plan concerning potential effects on the future business opportunities of AB-Mikroelektronik in China. The first section gives an executive summary of relevant content. Thereby, it must be clarified that this plan can be seen as a trend-setter, sparely providing hard facts. The summary starts with general trends and turns to the industrial part in the end.
Concerning industry, the 13th five-year plan is strongly linked with the "Made in China 2025" plan. Hence, there will be some anticipations on this plan in the following summary before there will be a several chapter 3.3.4.2 on it.

3.3.4.1 Executive Summary of relevant content

Due to its combination of coordinated, innovative, green and open development targets, the government perceives the current five year-plan as a significant change in its development efforts.[116]
The most important objectives have been selected and serve as the structural elements for this summary.

3.3.4.1.1 Innovation

Innovation is announced as a major objective. This comprises that business start-ups, productivity, but first and foremost science and technology shall be improved and become a driving factor for economy. Essential achievements in key technologies are striven for. The necessary resources and prerequisites for those goals will be allocated.[117]

Considering technological innovation, China's own capacities on basic research, primary innovation and innovation through integration of existing technologies shall be improved, but innovation based on import and assimilation is forced too. To support this, a network that connects the innovation activities of government, enterprises, universities, research institutes and end-users will be realized.
National innovation centres are planned which have got the assignment to support the development of corporate technology centres. Systematic reforms will be implemented to

[115] (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 6)
[116] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 21)
[117] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016)

support comprehensive innovation. Institutional barriers to innovation shall be removed and financing models be created. Innovation rewards are planned and resources will be allocated to innovation leaders. International competitive enterprises concerning innovation shall be developed, which explicitly includes the fostering of small and medium high tech enterprises.[118]

Human resources shall become internationally competitive with respect to education, skills and competence. Talents will be fostered according to this. The organisational, geographical, and social mobility of such talents will be improved. International talents, students as well as skilled professionals shall be attracted and their permanent residence will be made easier. The international exchange of personnel will be strengthened and incentives for their return established. [118]

Beijing and Shanghai are designated hot spots for scientific and technological innovation and will be fostered the most.[118]

3.3.4.1.2 Intellectual Property Rights (IPR)

The Intellectual Property Rights (IPR) system shall be improved; clear ownership, rights and protection be ensured. The IPR protection shall be independent from the type of enterprise ownership. This is also seen as a prerequisite for more innovation. China wants to become a country with strong IPR. That also entails that it will fight against the production and sales of counterfeit products.[119]

3.3.4.1.3 State Owned Enterprises (SOE) versus Private Owned Enterprises (POE)

China does not intend to let off their SOEs. Quite the opposite is the case! Under the headline "upholding and improve China's basic economic system", the 13th five-year plan contains the commitment that SOEs will be supported with the aim that they increase their innovation capacities and reach the international competitive level. Several mechanisms are planned which should make sure that the state capital is used in a more effective way. Furthermore, mixed ownership shall be introduced and encouraged.
Additionally, the non-public sector shall be supported either. Equal development chances, access to markets and resources will be ensured. Legal protection will be established and hidden barriers be removed.[120]

3.3.4.1.4 Opening up

An opening-up strategy towards the rest of the world will be followed further on. Besides an import-export balance, this strategy explicitly aims to get higher attraction of foreign investments, advanced technologies and equipment, talents and high quality consumer goods. Investments are preferentially desired in the fields of advanced manufacturing, new and green

[118] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 15-30)
[119] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 37)
[120] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 34-36)

technologies and environmental protection. To support this, the legal protection system for foreign companies and investors shall be strengthened and unified with the regulations for domestic capital.[121]

The export rate should be increased through a better competitiveness in technology, standards, brand names and quality.[122]

However, globalization is not a one way street and so the Chinese "opening up" strategy also is not. Hence, China will encourage domestic enterprises to go abroad. This means global investments in international cooperation as well as merging and acquisition and localization in foreign countries with R&D, marketing and service centres but also manufacturing sites. In this context, the automotive industry is explicitly mentioned as candidate for "going out" in both the 13th five-year plan and in the "Made in China 2025" plan as well.[123]

3.3.4.1.5 Carbon emission reduction and energy conservation

Another core topic is the reduction of carbon emissions through efficient resource extraction and use, in order to improve the quality of the environment.[124] Quotations, for example, that China wants to "implement the strictest possible environmental protection system"[125] and that it will "fully participate in global climate governance"[126] make clear how serious the environment pollution and global climate change topic is taken. The policy that the top 100 energy consuming enterprises will be taken under national regulation and the next 1000 and 10000 under supervision of the next lower governmental levels respectively is just one example of action.[127]

A comprehensive approach is followed:
On the side of supply, this goal shall be reached through an intensification of hydropower, wind-and photovoltaic-power, nuclear power (30GW under construction!) without neglecting adequate safety measures, solar-, thermal-, biomass- and tidal energy. The use of coal will be restricted, cleaner and its efficiency improved.[128]

On the side of the consumer, environmentally friendly products and technologies will be promoted in general.[129] The industry and thereby especially the automotive industry will be heavily affected as the next sections show.

[121] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 143)
[122] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 33)
[123] Cf. (State Council, 2015, S. 31 et seqq.), (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 142)
[124] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 17)
[125] (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 127)
[126] (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 132)
[127] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 122)
[128] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 84)
[129] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 139)

Three essential measures are:

- The new emission regulation standard China 6 and also national standards for fuel products will be implemented.
- Old vehicles and such with high-emissions shall be taken off the streets.[130]
- Research and development concerning exhaust purification systems for vehicles will be intensified.[131]

3.3.4.1.6 Transportation in general

Ambitious projects in high-speed rail, road and expressway construction as well as harbours and airports are planned. Considering vehicles, it is aimed to improve transportation efficiency through vehicle automation and the internet of vehicles.[132]
In this context, it may also be noteworthy that the government wants to bring more people from rural into urban areas. The specific target is that 60% of the population shall live in cities by 2020.[133]

3.3.4.1.7 Strategic emerging industries

The following industries are defined as “strategic emerging industries”: next generation information technology, biotech industry, intelligent perception of spatial information, Energy storage and distribution energy, advanced materials and **New-Energy Vehicles**. The overall target is that all of these strategic emerging industries together reach 15% of the GDP.

Industrial innovation and new technology promotion centres will be fostered, but also not only on a national level. Companies will be encouraged to spread their innovation, research and development centres internationally as also mentioned in the opening-up section.

Industrial policies, regulatory rules, and standard systems as well as market access requirements will be adopted in a way that they favour the development and competition within these emerging industries. Furthermore, a national development fund will be created and the “National Venture Capital Guide Fund” will be advised to preferably support innovative enterprises which are in an early stage of development and coming from these industries.

As a remark for other TT Electronics business units it shall be mentioned that advanced sensors will be promoted as a part of the next generation information technology industry.
Fuel cells are a key part of the energy storage and distribution industry, but it is assumed that with this, stationary units are addressed.[134]

[130] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 131)
[131] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 140)
[132] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 83)
[133] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 92)
[134] Cf. (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 65-67)

Considering NEV, the 13th five-year plan as well as the “Made in China 2025 plan”, which will be introduced in the next section, both reveal actions and targets the government has scheduled. In order to maintain legibility, they will be listed together in 3.3.4.3 “Targets effecting the automotive industry”.

3.3.4.1.8 Modern industrial system

In this case the 13th five year plan explicitly refers to the “Made in China 2025 action plan”, which has been issued one year earlier in 2015. This plan can be seen as an answer to Germanys “Industry 4.0”. In fact, Germany and China signed a memorandum of understanding about a cooperation concerning intelligent manufacturing. A high-tech manufacturing industrial park in Chinese-German cooperation is planned and communication channels for “Industry 4.0” topics have been established between four German and Chinese ministries.[135]

The following section provides a summary of relevant content taken from “Made in China 2025”, which is not only linked but also heavily repeated in the 13th five-year plan.

3.3.4.2 Executive Summary “Made in China 2025”

Concerning its situation in the global industrial competition, China sees itself in a “two-way squeeze” between developed and developing countries. Developed countries are pursuing “Manufacturing Renaissance” strategies like the German “Industry 4.0” with key pillars like new manufacturing process technologies (e.g. 3D printing), big data, new energy resources, new materials or intelligent manufacturing with plants utilizing cyber-physical systems. Simultaneously, developing countries increasingly rely on industrial labour.
Furthermore, China is facing resource and environmental constraints, rising labour costs and slowing export growth. Therefore, China must change its resource and investment intensive development model and determined manufacturing as a key driver of its economy future.[136]

On this path, the current gap compared to developed economies is described in one sentence: “Chinese manufacturing is large but not yet strong.”[137] In detail, a lack of innovation capability and key technologies, low resource efficiency, high environmental pollution, few internationally known brands and an unsatisfying product quality are stated to be key problems.[138]

The target of the “Made in China 2025” strategy is a transformation from “Chinese products to Chinese brands”.[139] Its “guiding principles” are manufacturing innovation, improving quality and performance, integration of next generation IT in manufacturing and intelligent manufacturing combined with service orientation and green development.
In a first step, the strategic goals are a significantly increased digitalization of manufacturing, progress with core technologies, far better product quality and a drastic decrease of pollution

[135] Cf. (Chao, 2016)
[136] Cf. (State Council, 2015, S. 3ff)
[137] (State Council, 2015, S. 4)
[138] Cf. (State Council, 2015, S. 4)
[139] (State Council, 2015, S. 4)

by 2020. By 2025 the resource efficiency shall be at the level of developed economies.[140] In figures, the innovation capability of manufacturing companies shall rise from 0.95% internal R&D costs in percent of revenue to 1.68% by 2025.[141]

The following strategic tasks and key points directly affect considerations about business opportunities for AB-Mikroelektronik:

Among other measures with the aim to support innovation, foreign OEMs are motivated to build R&D centers in order to enable a knowledge transfer to domestic brands. Innovation and design centers and clusters with international collaboration are planned and direct financial support is foreseen.[142]

The government strives for a major leap in product quality as a prerequisite for the subsequently desired strong and world-famous Chinese branded products and an overall better image of “Made in China”. Thereby, the automotive and the electronic components industries are explicitly prioritized. Amongst other measures, product quality standards and planning systems, quality management laws and regulations as well as compulsory and voluntary product certifications will be set in place. Producers of poor quality or counterfeit products will be penalized.

Weaknesses in four primary industrial capabilities, namely essential spare parts and components, advanced techniques, key materials and industrial technologies shall be eliminated so that by 2020 40% and by 2025 already 70% of all spare parts and components can be produced in China.

Carbon and pollutant emission reduction and all other green aspects are repeatedly mentioned requirements. The focus is not only on production, but on the whole product life-cycle. Specifically mentioned and relevant measures are the efficiency enhancement of electrical machines and combustion engines and a faster elimination of non-complying products. Enterprises which develop green products and/or underlie a green production will be supported.[143]

3.3.4.3 Targets effecting the automotive industry

There are several technological fields listed in “Made in China 2025” in which major breakthroughs are striven for. One of them is energy efficient and New-Energy-Vehicles.
The following planned actions shall be directly quoted out of the 13th five-year plan and “Made in China 2025”:

[140] Cf. (State Council, 2015, S. 7)
[141] Cf. (State Council, 2015, S. 9)
[142] Cf. (State Council, 2015, S. 11)
[143] Cf. (State Council, 2015, S. 17-21)

- “Continue to support electric automobiles and fuel cell vehicles;
- Master core automobile technologies for low carbon, informatization and intelligence;
- Improve engineering and industrialization capability of core technology like batteries, driving motors, efficient combustion engines, advanced derailleurs, lightweight materials and intelligent controls;
- Build a complete industrial system and an innovation system ranging from essential spare parts to complete automobiles;
- Promote energy-savings and new energy automobiles with independent brands to match advanced international levels.”[144]
- “Encourage the use of new-energy vehicles for urban public transport and taxi services;
- Develop all-electric vehicles and hybrid electric vehicles with a focus on making advancements in key technological areas such as battery energy density and battery temperature adaptability;
- Facilitate the development of a network of charging facilities and services that are compatible with each other and come under unified standards;
- Improve policies to provide continuous support in this regard;
- Ensure the cumulative total production and sales figures for new-energy vehicles in China reach **five million**.”[145]

A designated goal is to lower the dependency on foreign core technology in these fields and to replace it with own intellectual property high-technologies to a high extend by 2025. Independent research capabilities shall be realized by 2020 in order to reach that goal.[146]
shows an overview about the targets for the automotive industry in figures.

[144] (State Council, 2015, S. 25)
[145] (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 68)
[146] Cf. (State Council, 2015, S. 27)

Table 10: Overview about targets for the automotive industry in figures [147]

Status 2014	
Fuel efficient passenger cars	• Average fuel consumption 7.33l/100km
NEV	• Sales volume p.a. 74763 units
Targets 2020	
Fuel efficient passenger cars	• Average fuel consumption ≤ 5l/100km. • Market share of such fuel efficient cars ≥ 30% • Five efficient Chinese branded cars in the top ten. • Quality level of Chinese brands same as JV brands.
NEV (BEV and PHEV)	• Sales volume p.a. ≥ 1 million units. • ≥ 5 million units on the market. • Two models ranking in the global top ten. • 80% market share and world leading level with core systems, including electric engines and batteries. • Exporting core systems
NEV (FCEV)	• Production volume p.a. ≥ 1000 units.
Targets 2025	
Fuel efficient passenger cars	• Average fuel consumption ≤ 4l/100km. • Market share of such fuel efficient cars ≥40% • Three efficient Chinese branded cars in the top five. • Reputation of Chinese brands surpasses JV brands. • Commercial efficient vehicles on advanced level in international comparison.
NEV (BEV and PHEV)	• Sales volume p.a. ≥ 3 million units. • Two car makes ranking in the global top ten measured by their sales volume. • 10% overseas exports.
NEV (FCEV)	• Hydrogen infrastructure completed. • Small-scale regional operation of FCEV.
Intelligent connected cars	• 30% less traffic accidents • 10% less fatalities • Autonomous driving speed 120km/h • 10% less energy consumption • 20% emission reduction

[147] Cf. (Ministry of Industry and Information Technology (China), 2015), (U.S. Chamber of Commerce, 2015), (China Automotive Engineering Institute, 2016)

Actually, an older “Energy-saving and New Energy Automobile Industry Development Plan (2012-2020)” exists which basically is comprised of the same targets, but tells a little bit more about how they shall be reached. The next section provides a very brief insight into this plan.

3.3.4.4 “Energy-saving and New Energy Automobile Industry Development Plan (2012-2020)”

This plan makes clear that at the moment all types of NEV and more efficient conventional cars are promoted, but that **“pure electric mode will be the main strategic orientation for the development of new energy vehicles and the transformation of automobile industry”**[148].

The targets of 500 thousand NEV on the streets by 2015 and 5 million by 2020 have already been announced in 2012. The 2015 target was nearly fulfilled, although when the plan was issued, there were hardly any NEV on the market. This is evidence for the power of implementation by the state council’s plans.

Different than the other plans, this plan also specifies more technical objectives for example that the speed of NEV must be at least 100km/h and their range at least 150km for BEVs and 50km for PHEV by 2015. As the market overview 3.3.3 shows, these targets have also been reached. Interesting are the targets directly affecting the batteries, namely that the energy density of battery packs shall reach 300Wh/kg at maximum costs of 1.5RMB/Wh by 2020. According to primary sources, those are ambitious targets and they would, if reached, surely give a supply side push to the NEV market.[149]

Some measures how those targets can be reached are already familiar from the other plans, like accelerating research at all relevant technological levels, establishing R&D centres, international cooperation and fostering innovation by promotion of talents amongst others. But some elements of the plan for the industrial structure are new:[150]

1. When having expansion plans, existing OEMs “shall overall consider developing new-energy automobiles production capacity”[151]. That sounds like a required prerequisite for expansion approvals.
2. Large scale battery manufacturing capacities are planned and thereby it is aimed to establish two or three major enterprises, which should account for a production rate of at least ten billion watt hours. The same target is valid for key battery materials.
3. Also two-three leading enterprise for key components like electric engines, electronics or transmissions shall be raised.[150]

[148] (State Council, 2012)
[149] Cf. (State Council, 2012)
[150] Cf. (State Council, 2012)
[151] (State Council, 2012)

Planned measures concerning the promotion of NEVs on the market are:

1. Comprehensive NEV promotion projects in public areas and cities, aiming to boost private purchases. Thereby FCEV are explicitly included.
2. A plan for fuel consumption regulations favouring NEV has already been outlined in this plan. The next chapter 3.3.5 will explain the current development stage, which basically follows this draft. Even annual supply side requirements have been scheduled for the period of 2016-2020, chapter 3.3.5.3.3 will show the current status.
3. Subsidies for private consumers and the public sector, licencing- and traffic-restrictions as well as tax policies to the benefit of NEVs are foreseen. Chapter 3.3.5.3 will show the degree of conversion.[152]

A comprehensive approach is followed and hence, also plans for electric-charging and hydrogen-filling infrastructure are not missing.[153]

The main responsibility for the introduction of this plan is assigned to the Ministry of Industry and Information Technology with some other affected ministries in a cooperative role. They have the task to make appropriate policies and action plans in order to ensure the target compliance. Regional governments are also taken into responsibility for their sphere of influence and they are advised to immediately report emerging problems and changing situations to higher governmental levels.[153]

The following chapter introduces the current and future regulations affecting the automotive industry. Thereby, it becomes obvious that the instructions of this plan have been executed up to now.

[152] Cf. (State Council, 2012)
[153] Cf. (State Council, 2012)

3.3.5 Overview of regulation and policy development

This chapter provides an overview of regulations and policies affecting the automotive sector in the next years.

3.3.5.1 Corporate Fuel Consumption Regulation (CFCR) for passenger cars

The tightening of the CFCR is a contribution to China's ambitions for the reduction of the CO_2 emissions. It takes account of the fact that currently, automobiles consume 55% of the fossil fuel in China and it is predicted that this fraction will rise to 60% by 2020.[154] As Figure 18 shows, the CFCR will be nearly as strict as the EU regulations by 2019.

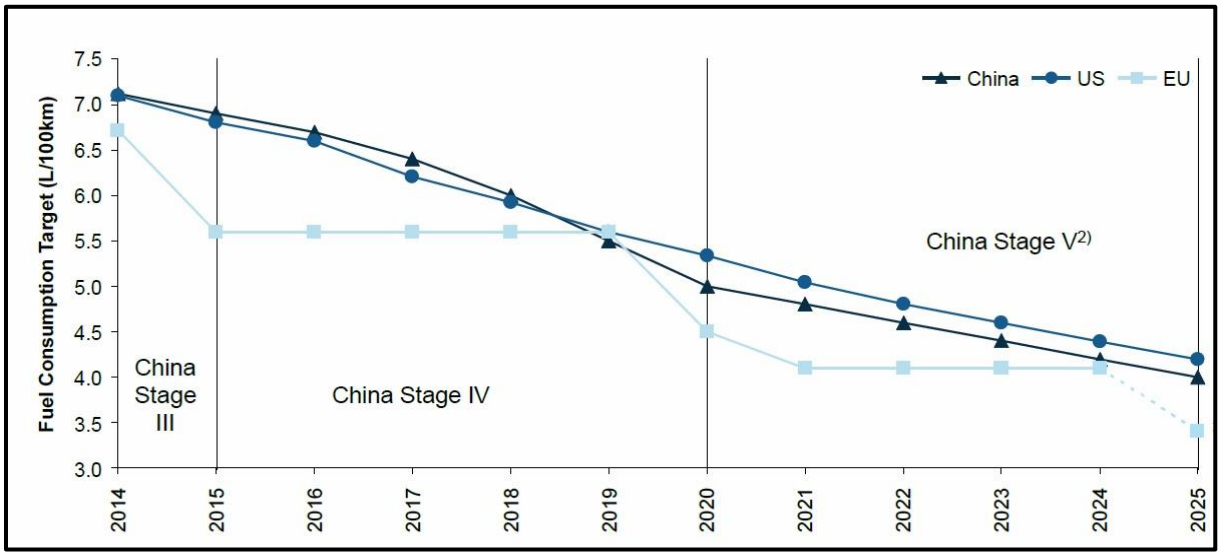


Figure 18: Comparison between the CFCRs of the US, EU and China[155]

Notes:

1. All values are based on the EU NEDC test cycle
2. Linear implementation of China Stage V assumed
3. EU limits for 2025 not clear yet

As Figure 19 shows on the example of the current valid CFCR-IV phase, the CFCR is mainly comprised of three mechanisms.

[154] Cf. (Dr. Jun Li, 2016)
[155] (Koehler & Gong, 2016)

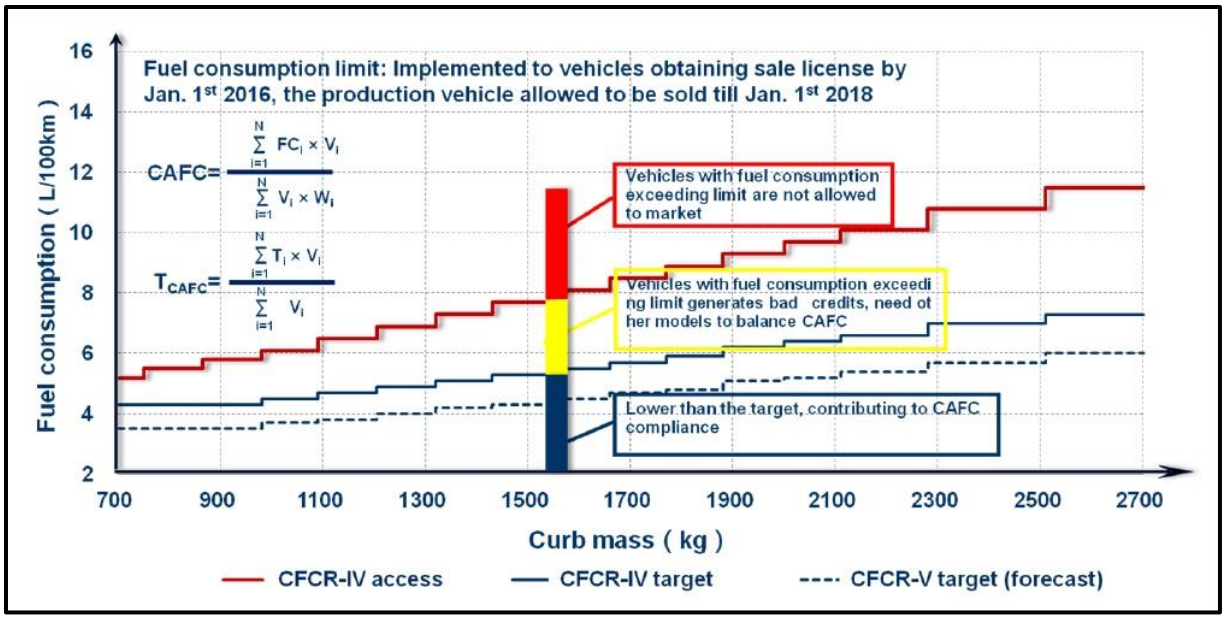


Figure 19: Example CFCR-IV in detail[156]

First, the CFCR sets mass-dependent threshold values for the fuel consumption by dividing the spectrum into 16 vehicle-mass classes. Surely, this is a measure which takes the high proportion of heavy weight SUVs and MPVs on the Chinese market into account, whereby the targets for heavy vehicles are still about 20% tougher than for sedans.[157] Due to that mass segmentation, a weight-reduction strategy has a limited effect on achieving the targets. As a consequence, the required efficiency gains must be mainly accomplished by powertrain related optimizations. According to an FAW survey, this means that engines in China must already be slightly more efficient than those from Europe in order to compensate for that.[158]

Second, the target for the Corporate Average Fuel Consumption (CAFC) is specified in a mass-dependent way. A crucial issue is that when failing these requirements, an OEM has to reduce its production on disadvantageous vehicles because there is no opportunity to buy out with penalties.[159]

Third, the regulation sets a mass-dependent threshold for the maximum fuel consumption of single vehicle models as a market approval criterion. The CFCR-IV access values are identical to the old CFCR-III target values.[160]

3.3.5.2 Emission regulations

Table 11 shows the introduction plan of new and stricter stages of emission regulations. China 6 shall start just two years later than Euro 6c, which is scheduled for 2018.

[156] (Dr. Jun Li, 2016)
[157] Cf. (Koehler & Gong, 2016)
[158] Cf. (Dr. Jun Li, 2016)
[159] Cf. (Dr. Jun Li, 2016)
[160] Cf. (Dr. Jun Li, 2016)

Table 11: Introduction plan for Emission regulations[161]

Stage	Date	Region	Reference
China 5	2013/02	Beijing	Euro 5
	2014/05	Shanghai	
	1016/04	All eastern	
	2018/01	Nationwide	
China 6a	2020/07	Nationwide	Euro 6
China 6b	2023/07	Nationwide	

With China 6 the Worldwide Harmonized Light Vehicles Test Cycle (WLTC) will be introduced.[162] Figure 20 shows a comparison between the EU, US and Chinese emission regulations and the development concerning the limits for the important emission components carbon monoxide (CO), hydrocarbons (HC), nitrous gases (NO_x) and particulate matter (PM).

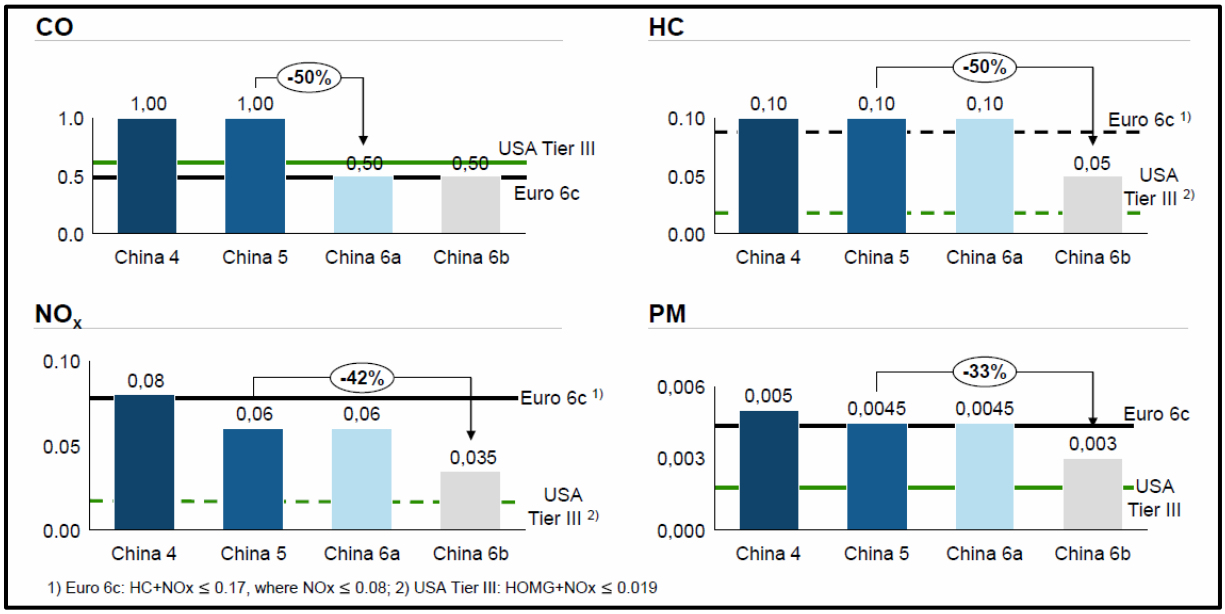


Figure 20: Comparison emission regulations[163]

Note that the Chinese regulations are the same for diesel and gasoline engines, whereas the EU regulations are fuel dependent. The Euro 6c limits in Figure 20 are for diesel engines. The Euro 6c NO_x limit for gasoline engines is 60mg/km, for CO it is 1000mg/km. Still, the China 6 emission regulations are stricter than the Euro 6 regulation.[164]
Another challenge is the distinctive tightening step from China 5 to China 6.

3.3.5.3 Policies promoting NEV

The following policies and incentives aim to promote NEV.

[161] Cf. (dieselnet.com, 2017)
[162] Cf. (dieselnet.com, 2017)
[163] (Koehler & Gong, 2016)
[164] Cf. (dieselnet.com, 2017)

3.3.5.3.1 Over proportional NEV benefit for CAFC

When calculating the CAFC, NEV with a pure electric range higher than 50km (BEV, FCEV and most PHEV) are not taken into account one by one. NEVs affect the CAFC with an additional weight factor W_i. W_i is zero for conventional cars, in 2016 and 2017 it is five for NEV with range >50km, 2018 and 2019 it will be three and from 2020 on still two.
Furthermore, there is an additional credit S_i for NEV which can be used to reduce the CAFC and it can also be sold to other OEMs. The credit variable S_i is zero for conventional cars, one for PHEV with a range >50km, up to three for BEV dependent on their range and five for FCEV with a range higher than 250km.[165]

Equation 1 shows how W_i and S_i influence the CAFC. The sum of fuel consumption of every sold vehicle is devided by the sum of the product of every sold vehicle with its weight factor W_i. Additionally, a bonus calculated out of of the sum of credits S_i in relation to the sales volume is substracted from the CAFC. Hence, every sold NEV over proportionally compensates for conventional cars with high fuel consumption.

$$CAFC_{nev-R+P} = \frac{\sum_{i=1}^{N} FC_i \times V_i}{\sum_{i=1}^{N} V_i \times W_i} - \frac{\sum_{i=1}^{N} S_i \times V_i}{\sum_{i=1}^{N} V_i}$$

Equation 1: Calculation of CAFC considering NEV[166]

3.3.5.3.2 Financial subsidies and licencing restrictions

Table 12 provides an overview of the national subsidies for NEV. In addition to that, there are no purchasing or running taxes on NEV. Moreover, some regional governments give additional subsidies: Shanghai and Beijing, for example, nearly double the subsidy of the central government.[167]
The cities Shanghai, Beijing, Guangzhou, Shenzhen, Tianjin, Hangzhou, Guiyang and Shijiazhuang have introduced limited contingents for conventional car licence plates which are given away in auctions or lottery and cost up to around 80kRMB. NEV are excluded from these constraints, Licence plates are for free.[168]

[165] Cf. (Dr. Jun Li, 2016)
[166] (Dr. Jun Li, 2016)
[167] (Christian Chapelle, 2016)
[168] (Aussenwirtschaftscenter Shanghai, 2015, S. 43)

Table 12: National financial NEV subsidies[169]

Years	100≤EV<150km	150≤EV<250km	EV≥250km	PHEV≥50km
2013-2015	32kRMB	45kRMB	55kRMB	32kRMB
2016	25kRMB	45kRMB	55kRMB	30kRMB
2017-2018	80% of 2016			
2019-2020	60% of 2016			
From 2020 on	Not announced yet			

Table 13 and Table 14 show examples of NEV models with list price, state and city subsidy for Shanghai and Beijing in 2016. The subsidies can account for up to around 50% of the list price depending on electrical range and the list price itself. Note that the subsidy percentage is calculated from the minimum list price representing the lowest possible equipment, but it does not include the savings on taxes and licence plate costs.

When including the savings on licence plate costs but without savings on taxes, the subsidies can add up to approximately 180 thousand RMB (~24 thousand EURO) in Shanghai.

Note that the shown subsidies have been cut by 20% considering national subsidies and by 50-60% on regional level with 2017. Instead, the battery supply is supported now.[170] Hence, also considering the plans for a quota (3.3.5.3.3), it seems that the promotion strategy is shifting from the demand to the supply side.

[169] (Christian Chapelle, 2016)
[170] (EVVolumes.com, 2017)

Table 13: NEV with subsidies in Shanghai, 2016[171]

Model	Weight [kg]	LIST PRICE [RMB]	EV Range [km]	SH subsidy [RMB]	state subsidy [RMB]	Consumer Price [RMB]	Consumer Price (lowest) [EUR]	max sub list [%]
JAC iEV 4	1200	157800-159800	**200**	30000	45000	82800-84800	€ 11.010,64	47,53%
JAC iEV 6 (new EV)	1310	194800	**250**	30000	55000	109800	€ 14.601,06	43,63%
BAIC E160 EV	1295	176900-188900	**200**	30000	45000	101900-113900	€ 13.550,53	42,40%
JAC iEV 5 (cheapest)	1635	179800	**200**	30000	45000	104800	€ 13.936,17	41,71%
GEELY Emgrand EV	1570	228800-249800	**253**	30000	55000	143800-164800	€ 19.122,34	37,15%
BAIC E150 EV	1370	220800-249800	150	30000	45000	145800-174800	€ 19.388,30	33,97%
CHANGAN EAODO EV	1610	234900-249900	**200**	30000	45000	159900-174900	€ 21.263,30	31,93%
SH GM SPRINGO	1385	258000	**200**	30000	45000	183000	€ 24.335,11	29,07%
Lifan 7002CEV	1490	267000	150	30000	45000	192000	€ 25.531,91	28,09%
NISSAN E30 Venucia (Leaf)	1530	267800-281800	175	30000	45000	192800-206800	€ 25.638,30	28,01%
BYD E6 EV	2020	309800-369800	**300**	30000	*55000*	234800-294800	€ 31.223,40	27,44%
DENZA EV	2090	369000	**300**	30000	55000	284000	€ 37.765,96	23,04%
CHERY eQ	1128	159900 – 164900	120	10000	25000	124400 – 129900	€ 16.542,55	21,89%
BYD QIN	1720	209800-219800	*70*	10000	30000	169800-179800	€ 22.579,79	19,07%
BMW I3 Imported (!) 2016	1310	458675	**300**	30000	55000	373675	€ 49.690,82	18,53%
ROEWE E50 (*SmartCar)*	1540	188900	120	10000	25000	153900	€ 20.465,43	18,53%
ROEWE 550 PLUG IN	1699	248800-259800	*58*	10000	30000	208800-219800	€ 27.765,96	16,08%
BYD TANG SUV	2220	251300-279800	*80*	10000	30000	211300-239800	€ 28.098,40	15,92%
VOLVO S60L 2.0T (PHEV)	1996	505900-559900	*53*	10000	30000	465900-519900	€ 61.954,79	7,91%

Note: RMB/EUR = 7.52 (3rd of May 2017)

[171] Cf. (Sikora, 2017)

Table 14: NEV with subsidies in Beijing, 2016[172]

Model	Weight [kg]	LIST PRICE [RMB]	EV Range [km]	SH subsidy [RMB]	state subsidy [RMB]	Consumer Price [RMB]	Consumer Price (lowest) [EUR]	max sub list [%]
JAC IEV 4	1200	157800-159800	**200**	45000	45000	67800-69800	€ 9.015,96	57,03%
ZD D2	690	158800	180	45000	45000	68800	€ 9.148,94	56,68%
BAIC EV160	1295	176900-188900	**200**	45000	45000	86900-98900	€ 11.555,85	50,88%
JAC IEV5	1635	179800	**200**	45000	45000	89800	€ 11.941,49	50,06%
BAIC EU 260	1295	254900	**350**	55000	55000	144900	€ 19.268,62	43,15%
BAIC EV200	1295	209900-246900	**200**	45000	45000	119900-156900	€ 15.944,15	42,88%
BAIC E150 EV	1370	220800-249800	150	45000	45000	130800-159800	€ 17.393,62	40,76%
CHANGAN Eaodo EV	1610	234900-249900	**200**	45000	45000	144900-159900	€ 19.268,62	38,31%
BYD E6	2020	309800-369800	**300**	55000	55000	199800-259800	€ 26.569,15	35,51%
启辰晨风	1494	267800-281800	175	45000	45000	177800-191800	€ 23.643,62	33,61%
CHERY eQ	1128	159900-164800	120	25000	25000	109900-114800	€ 14.614,36	31,27%
ROEWE E50	1540	188900	120	25000	25000	138900	€ 18.470,74	26,47%
DENZA EV	2090	415800	**300**	55000	55000	305800	€ 40.664,89	26,46%
BAIC ES210	1760	346900	210	45000	45000	256900	€ 34.162,23	25,94%

Note: RMB/EUR = 7.52 (3/5/2017)

[172] Cf. (Sikora, 2017)

3.3.5.3.3 Further Promotion initiatives

Some further promotion initiatives shall be mentioned:

- NEV targets were given to 88 selected pilot cities
- A quota of 30% NEV in the public sector
- Regulations for the use of electric power are adapted to the favour of NEV
- There are no limits for purchasing NEV and no traffic restrictions[173]
- The charging infrastructure will be extended to ≥ 4.8 million charging spots by 2020[174]

3.3.5.3.4 Outlook: NEV quota

There will be a quota regulation which is expected to become valid by 2019. It requires every OEM to fulfil an 8% sales rate on BEV or PHEV. Actually, the original plan of the central government was to bring this quota into action by 2018, although they have published the draft only in October 2016. An intervention of Chancellor Angela Merkel resulted in a one year postponement.[175]

OEMs who do not comply with this quota regulation will either have to buy credits from other OEMs or have to cut back their production of conventional cars. The details of the final regulation are not known at the moment, but it can be expected that this challenging quota will be further raised in the following years.[175]

The intention of this “New Energy Vehicles Credits Joint Management Method” is to decouple the NEV reward/penalty regulation from the CAFC system in order to make sure that efficient conventional cars cannot completely compensate for a lack of NEV models. Furthermore, it aims to create a supply-side push, because subsidies alone are perceived as insufficient to create a new market. The inspiring example for this idea is the Californian ZEV (Zero Emission Vehicle) credit program, in which besides California nine other US states participate.
Note that according to published drafts, the quota is not measured one to one out of the sales rate. The higher the electric range, the higher the credits one sold vehicle gains. E.g. a BEV or FCEV with a range higher than 350km shall account for five vehicles, this is the maximum multiplier.[176]

A shift from subsidies to regulations affecting the supply side may even have a greater impact on the NEV market. Due to a regulation similar to the ZEV credit program, no OEM can effort to neglect NEVs without financial drawbacks. Hence, a growing variety of models and subsequently stronger competition and decreasing prices can be expected. OEMs will be interested in selling NEVs, which is for sure more sustainable than direct purchasing subsidies.

[173] Cf. (Dr. Jun Li, 2016)
[174] Cf. (Dr. An, 2016)
[175] Cf. (Graser, 2017)
[176] Cf. (Innovation Center for Energy and Transportation, 2016)

3.3.6 Evaluation of the 13th five year plans' impact on the development of China's automotive industry, using 3rd parties' perspective

Also the German chamber of foreign trade (Außenhandelskammer – AHK) perceives the 13th five year plan as a blue print without much detail but as important for the general alignment of China's economy. Subsequently, it sees cooperation opportunities in the branches robotics, high-tech mechanical engineering and plant manufacturing, bio-tech, aviation, aeronautics and **electro mobility** because the five-year plan defines them as strategic industries with growth potential. The AHK also points at the Chinese ambitions of transforming their economy with structural reforms, environmental protection, technological progress and an upgrade of the industrial manufacturing sector.[177]

In an analysis of the 13th five year plan with focus on the automotive industry, the US ministry of commerce found that there are **opportunities for automobile manufacturers and supplier companies**. Not only in general because of the growing Chinese market, but they also attest **"best prospects" in the NEV market** segment due to supportive policies and active promotion by the government. As a risk, they mention a remaining lack of intellectual property rights, especially for the auto parts sector and when establishing JVs with Chinese partners.[178]

Dr. Crystal Chang, Lecturer at the Berkeley University of California, gave a testimony in front of the "U.S.-China Economic and Security Review Commission" about the effects of China's 13th five year plan on the automotive industry.[179] This testimony is critical but also a little bit inconsistent. After an executive summary, this paper will show why it is still interesting.

In the beginning Dr. Chang states that the plan must be "understood as the Chinese government's long-winded wish list of what they would like to see happen in the economy"[180]. She also finds that a central "wish" of the five-year plan is innovative Chinese brands, which are leading the NEV market. But her perception of the NEV market in the beginning of 2016 is that there are mainly low-cost models utilizing simple technologies, which prevalently have been bought by local governments. Besides that, she thinks that the greater part of the future automotive market will be comprised of foreign branded gasoline cars anyway.

A big weakness of the Chinese automobile market is that, except "Chang'an", all Chinese brands have failed. As reasons why there are no strong local brands she declares the fragmentation of the automotive industry and the JV policy, which made SOEs rich but weakened their ambitions of developing own cars. The typical organisation of JVs is that the domestic partner produces the vehicles, while the foreign partner takes responsibility for the design and branding. Now, Dr. Chang also claims that the government puts more pressure on

[177] Cf. (AHK-China, 2016)
[178] Cf. (U.S. embassies abroad, 2016)
[179] Cf. (Dr. Chang, 2016)
[180] (Dr. Chang, 2016, S. 1)

foreign companies to help their JV partners developing cars with own brands and mentions "Baojun" as such an example.
Talking about Baojun, Dr.Chang points out that GM follows an unusual JV strategy, because they decided to share technology with SAIC when founding the joint research and development centre "Pan-Asia Technical Automotive Center" (PATC), which is designing car models for the Chinese market. GM even sold 1% of its JV share to SAIC and, hence, gave the majority to SAIC. These decisions may be a reason for the success of the JV SAIC-GM.

Independent car makers like Chery (local government owned), BYD or Geely on the other hand were discriminated by industrial policies. They had were allowed to create JVs for example. They emerged with copied designs, later they started working with global part suppliers. In Dr. Chang's point of view they all have somehow struggled and remained at the low-end market.

Since the 11th five-year plan the central government has given more freedom to the self-regulation capability of the markets. Hence, the "plans" have changed to "guidelines" and lost some influence in Dr.Chang's opinion. Still, she admits that the 13th five year plan will most likely have an influence on the NEV sector.
Although Dr. Chang is doubts the influence and success of the 13th five-year plan in the beginning of her testimony, at the end she suggests to the congress to introduce stricter emission regulations in the US in order to make US cars more competitive internationally. Furthermore, she suggests to support and promote the development and production of NEVs in the US as well, with the argument that the US should not allow China to become a leader in the growing electric car market segment.[181]

This critical perspective, which has been published in April 2016, is interesting because it shows how fast the Chinese automotive market is changing.
Dr. Chang attests to the most local brands that they have struggled. When now looking back at the market situation by the end of 2016, displayed in Figure 17 in chapter 3.3.3.5, Chang'an has risen to the 4th place in the brand ranking. Great Wall, Geely, Baojun, Wuling, Chery, BYD, GAC and other local brands are following with market shares of 4% downwards after all. A reason for the sudden success of the POEs, which is not limited to the low-end of the market anymore, may be found in the 13th five-year plan, which foresees equal policy treatment for POEs and SOEs. Refering to Baojun or Wuling, also the policy of forcing JVs to create Chinese brands seems to have an effect.
Concerning NEV, the argument that most of them are low-tech and were purchased by officials can hardly be sustained now, after the NEV market segment saw another significant growth in the year 2016. Furthermore, when looking at Table 13, Table 14 and Table 28, there are a number of local NEVs covering the SUV, D and E segment with respectable power and range (e.g. the brands BYD, BAIC, Geely or Changan), some of them top sellers in the year 2016.
The envisaged shift from a subsidy policy to a supply side quota regulation as described in chapter 3.3.5.3.3 can also be interpreted as a sign that the government pursues the goals of the 13th five-year plan and the "Made in China 2025" strategy persistently.

[181] Cf. (Dr. Chang, 2016)

3.3.7 Latest market predictions

In October 2016 a new “Technology Roadmap for Energy-Saving and New Energy Vehicles” based on “Made in China 2025” has been released. It was elaborated by experts from the Chinese Society of Automotive Engineers (SAE) on behalf of the MIIT.[182] Table 15 shows the up-to-date predictions of this roadmap. According to this, the total annual vehicle sales rate is expected to increase up to about 30 million units by 2020 but not any further.

Table 15: Market share prediction out of Roadmap for Energy Saving and NEV[183]

	2020	2025	2030
Sales units p.a.	30 million	30 million	30 million
Energy-saving vehicles*	30%	40%	50%
NEV	**7-10%**	**15-20%**	**40-50%**
FCEV units	5000	50 000	1 million

*) Energy-saving vehicles are powered by an ICE, but fulfil the requirements of future emission and consumption standards.[184]

The prediction for the market share of NEVs exceeds the targets set by the government (refer 3.3.4.3) by far. When assuming the lower end of the prediction for 2020 it would mean a sales volume of 2 million NEVs – the double of the target value the government set in 2015. According to I reports, minister Miao Wei from the MIIT confirmed these predictions in January 2017.[185]

3.3.8 Results of primary data analysis

This chapter analysis the opinion of the interview partners (3.1.2) concerning the governmental plans, regulations and market trends.

3.3.8.1 Influence of the governmental strategic plans on the real economy

The experts unanimously describe the Chinese government as very strong in realising its targets with reference to former five-year plans. Although the implementation of changes is mainly up to enterprises nowadays, the government does not hesitate to take drastic reform measures in order to support the desired progress.
Also in the perception of the experts, the general industrial policy guided by the “Made in China 2025” plan is to elevate the level of industrial manufacturing in the style of the German “Industrie 4.0”. They all believe that the targets affecting the automotive industry (3.3.4.3) are realistic. A specific central concern of the government is to push technology and market share of NEV. In line with the latest roadmap prediction (3.3.7), the experts expect the yardsticks of

[182] Cf. (Chinese Society of Automotive Engineers (SAE), 2016)
[183] Cf. (Chinese Society of Automotive Engineers (SAE), 2016)
[184] Cf. (MarkLines, 2017)
[185] Cf. (IHS Automotive Supplier Insight, 2017)

1 and 3 million NEV being sold in the years 2020 and 2025, respectively, to be exceeded. Thereby, the focus of the government is clearly on pure electric vehicles and not on HEV or PHEVs, because PHEVs sometimes are misused to bypass the licence limitations for conventional cars.
Arguments which were often used to reinforce these optimistic expectations are the Chinese consumers (see next paragraph), that China has been a NEV pioneer since many years and the rapid development of this market. In that context there was also the remark that statistics are not 100% reliable because some OEMs faked their NEV sales data. Anyway, these offences were penalized by the government.
As reasons for this strategic focus on NEV, the environmental problems and the lack of competence in the ICE technology of Chinese OEMs were mentioned. The government and the OEMs hope to gain competitiveness with battery electric propulsion systems.

As an example of how persistent the government pursues its targets, the high speed train network was mentioned repeatedly. Nobody had believed that China would be able to accomplish this ambitious target when it was announced in former five-year plans. Now China has the world's longest high speed train network available and the majority of components are produced locally, hardly anything is imported.

3.3.8.2 Consumer Base

Experts who live in Shanghai confirm that the big middle class population of such Tier-1 cities desires environmental improvements and is therefore willing to support clean mobility. The situation cannot be compared with Europe where people can see a blue sky every day.
Furthermore, the consumer base is perceived as very open to new technologies. To give an example, in China it is more common to pay everything electronically without cash than it is in Europe.
These statements correlate with the results of a recent survey conducted by Roland Berger shown in Figure 21 in which people from different countries were asked: "Are you considering buying a battery electric vehicle as your next car?"[186]

[186] (Roland Berger GmbH, April 2017)

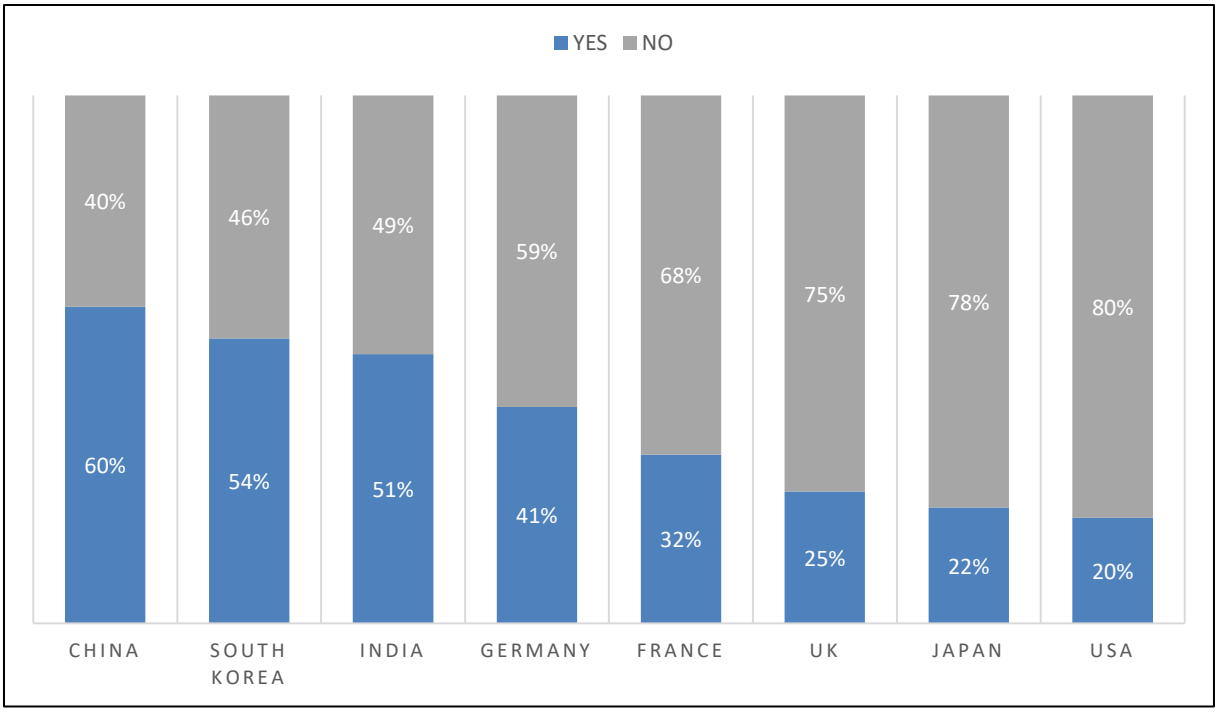


Figure 21: Share of potential EV consumers[187]

The majority of Chinese people already considers buying an electric car.

3.3.8.3 Most important legislation changes for the automotive industry over the next years

Experts think that two policy changes will have the most severe impact on the automotive industry to the benefit of NEVs:

1. Since recently, NEV received a green licence plate. Certain areas in Tier-1 cities already exist into which the entrance with private ICE vehicles is prohibited. It is foreseeable that these areas will be enlarged and that there will be further restrictions to conventional cars which do not affect NEV with green licence plates.
2. The shift from demand side subsidies to a supply side NEV quota regulation, forcing OEMs to sell NEVs.

The emission and fuel consumption regulations are not unique in China. The political trend is the same for all important automotive markets with just small differences and introduction time deviations. The difference is that China (and California) will implement more measures directly promoting NEV, while other markets like the EU will just regulate the average consumption (CAFC) and emissions.
It is also important to mention that quality and functional security standards like ISO26262 will become stricter in China. Concerning quality standards, this is already happening in cooperation between (mainly local) enterprises and universities with the participation of the government. The introduction time of functional security requirements depends on the competitiveness of Chinese OEMs, which will be considered.

[187] (Roland Berger GmbH, April 2017)

Considering subsidies, all OEMs independent from private or state ownership are treated fairly by the government according to Chinese experts. Subsidies provided by province and city governments surely are preferably given to their local OEMs.
Top POEs are BYD, Geely and GWM. It was mentioned before that also BYD and Geely received a large sum of money from governments. The capital Geely used to buy Volvo was provided by the government. GWM is the most independent POE in that context, but is respected by the government.

Except for policies affecting the propulsion system, also autonomous driving and connected vehicles are big trends in China. A lot of internet and communication enterprises like Huawei or Alibaba enter JVs with automotive OEMs. This topic is not of interest for AB-Mikroelektronik and therefore not further investigated.

3.3.8.4 Incentives for foreign companies

There are three categories of foreign investments depending on the branch: prohibited, limited and promoted investments.
If promoted, there are incentives for foreign companies, but they mostly apply to first settlement. Once in China, foreign companies are welcome to transfer know-how and technologies but will not receive subsidies. It is more likely that the Chinese government or companies try to buy foreign companies and personnel.

Considering patents, there is a so called “patent high-way” between Austria and China, making the registration of patents in China easier and the WKO provides consulting and subsidies as well.

3.4 Technological trends and OEM strategies

As analysed in the previous chapter 3.3.5, the fuel consumption regulation trend is very similar in the most important global automotive markets. Although this thesis is about business opportunities in China, AB-Mikroelektronik has (as every business enterprise) limited resources and cannot afford to fully neglect other markets when making a product strategy decision for China. Potential synergies must be kept in mind.
Therefore, this chapter examines which technological strategies some selected important European and Chinese OEMs follow in order to cope with that trend and if there are market specific trends e.g. considering the electrification strategy in China and elsewhere.
This chapter serves as a preparation for the assessment of market potentials for the products of AB-Mikroelektronik in chapter 3.6.

Both will be used, information gathered from primary and secondary sources (see 3.1).

3.4.1 VW and Audi

Confirming the introductory statement, Dr. Korman from AUDI said that the technological strategy of the VW group is not particularly China specific. There are considerations that by 2021 every 4th car that AUDI sells must be a BEV in order to comply with the upcoming CAFC regulations. This is one reason why the VW group states a clear commitment to high voltage Evs. Malicious gossip has it that the “Diesel-Gate” scandal may also have played a role when this decision was made. PHEVs are considered as the best hybrid concept but still an interim solution, as they neither can take full advantage of the BEV nor of the conventional technology. Insiders expect a distinctive turnaround of market share towards BEV by 2021. At least by 2025 the BEV share must be high because another tightening of regulations will have been set in place then.
Actually, VW has announced a massive electro mobility offensive within its “Transform 2025+” strategy. The declared goal is to reach a sales volume of one million electric vehicles in the year 2025. The technological base will be an own electro platform “MEB” which will be utilized by several group brands as usual. The first car based on this platform will be introduced to the market by 2020.[188]
For China, VW plans to strengthen its portfolio with NEVs and SUVs in its JV with FAW. Two new JV plants are planned to start operation in 2017 and 2018. Overall, VW plans to introduce 15 NEV models on the Chinese market within the next 4 years and wants to achieve a NEV sales volume of 400 thousand units by 2020.[189]

According to interviewees, the VW group and AUDI are busily working on FCEV in their R&D centre Osnabrück. The first vehicle shall be introduced to the market around 2020+.

[188] Cf. (Elektroauto-News.net, 2017)
[189] Cf. (IHS Automotive Supplier Insight, 2017)

CNG (natural gas), combined with the promise to produce it out of renewable energy (e-gas), is another core strategy followed by VW.[190]

3.4.2 PSA

The PSA group follows a strategy with four main pillars. The first is the introduction of new, downsized 1.2 and 1.6 litre gasoline engines which comply with China 6b and Euro 6d. The second strategy is a set of new manual and automatic transmissions.
Another key approach will be the launch of seven PHEV models with a pure electric range of 60km (NEDC) by 2021 in Europe and China, whereby the first DS models will be available in 2019. A similar roadmap is followed for pure BEVs, which will be based on a dedicated platform. The first BEV models with a range of around 450km are planned for 2019, four models shall be on the market by 2021.[191]

3.4.3 FAW

According to a paper by Dr. Jun Li from FAW in 2016, Chinese OEMs basically just have two possible strategies they can follow in order to get along with the CAFC regulations:[192]

1. Optimize conventional vehicles to such an extent that they fulfil the model specific market access limits. Focus on NEV as they must compensate for the CAFC transgression of the ICE fleet.
2. A majority of the conventional vehicles must be optimized to such an extent that they comply with the target values of the CAFC regulation. This strategy still makes the development of NEVs necessary but reduces the dependency from NEV sales volume and subsidies.[192]

FAW decided on the second strategy and thereby came to hold the opinion that 48V hybridisation would be a technological demand to attract customer excitement.[193]

Note that this is a decision that had been made early in 2016, before the government announced its plans for a NEV quota requirement (3.3.5.3.4). Due to this new development, it is possible that FAW has reconsidered this decision meanwhile.

3.4.4 SAIC

Ingo Scholten, executive director for powertrains at SAIC, clearly confirmed SAICs focus on PHEVs and BEVs at the concluding panel discussion of the 29th AVL “Engine & Environment” conference. Mr. Scholten mentioned that some other OEMs in China think about the 48V technology, but he definitely doesn’t see a trend towards that in China.

[190] (Dr. Demmelbauer-Ebner, 2017)
[191] (Christian Chapelle, 2016)
[192] (Dr. Jun Li, 2016)
[193] (Dr. Jun Li, 2016)

3.4.5 GM

According to Mark Reuss, board member responsible for product development, GM wants to be the first manufacturer that is able to sell affordable electric cars with profit margin. In order to make that possible, the main development goal is to make batteries more effective and to reduce their weight. The production rate of NEV shall be significantly increased. Thereby, the priority will be the Chinese market for which ten new NEV models are planned by 2020.[194] They shall be sold under the brand names Chevrolet, Buick, Cadillac and Baojun.[195]

GM has underlined the credibility of these ambitions with the Chevrolet Bolt EV, which is the first vehicle with an EPA (Environmental Protection Agency) range of 380km that is affordable for the mass consumer.[196]

3.4.6 Toyota

The strategy of Toyota is very clear and can easily be explained in a few sentences. Toyota has been very successful with its hybrid powertrain systems. The share on sold vehicles in Europe equipped with such a powertrain was higher than 30% in 2016. Costs and CO2 emissions have been drastically reduced since the first Prius generation in 1997.
Hence, Toyota continues to focus on its high voltage HEV and PHEV. In the long term, Toyota expects a high potential in FCEV for long range driving usage and develops this technology with the same conviction as they did with the Hybrids.[197]
Reliable primary sources confirmed Toyota's full commitment towards these two technologies, whereas electrification with 48V systems is no topic.

3.4.7 Volvo

The Chinese owned "Volvo cars" has announced that from 2019 on every new model will have an electric engine. Those will be different hybrid types and pure electric vehicles, but no more pure ICE vehicle will be developed. According to Volvo boss Hakan Samuelsson, the target is to sell one million electric cars until 2025. Volvo and its electro brand "Polestar" will launch five BEV models in between 2019 and 2021 together.
Volvo has already announced to stop all investments into diesel-engines before.[198]

3.4.8 Further OEMs

ChangAn plans to have 27 different NEV in its portfolio by 2025.[199]

[194] Cf. (SN-gk, dpa, 2017)
[195] Cf. (IHS Automotive Supplier Insight, 2017)
[196] Cf. (Harpster, 2017)
[197] Cf. (Killmann, 2017)
[198] Cf. (manager magazin, 2017)
[199] Cf. (IHS Automotive Supplier Insight, 2017)

According to interview partners, Daimler and BMW aim to have NEV sales rates of 25% by 2025. This recalls the assumption of Audi that they will have to sell 25% NEVs in order to comply with the upcoming corporate fuel consumption regulations.

3.4.9 Market specific electrification trends

Due to several experts, 48V supply systems as a low electrification compromise with around 20kW mainly finds acceptance by European and Korean OEMs. Big international Tier-1s like AVL or Continental promote 48V systems as a cheap electrification approach for ICE efficiency optimisation purposes. Apparently, 48V systems are broadly introduced to new platforms at the moment.

Considering Chinese OEMs none of the consulted experts have recognised a trend towards 48V systems. This is consistent due to several reasons:

- Chinese OEMs are described as venturesome towards the newest technology; they do not make compromises like Europeans.
- They have a lack of know-how with ICE technology, whereby 48V's main purpose is to increase the efficiency of ICE systems.
- The regulations in China are stricter with emissions than with fuel consumption.
- 48V vehicles are not emission free and will not help to fulfil the upcoming NEV quota.
- There will be no preferential treatment for non-plug-in vehicles by the Chinese government[200].

Analysts from Roland Berger draw a different picture. They expect a high acceptance in China, but with 1.5 million 48V vehicles in 2020 and 6 million in 2025 still less than the latest prediction for HV NEV (refer 3.3.7). Their main argument is that due to a negligible diesel share, Chinese OEMs are forced to optimize gasoline engines in order to reach the CAFC regulation targets. When reading this study and considering the sources as well as the preceding interviews in the publishing ATZ-magazine, it becomes quite clear that the most eager suppliers for this technology are international Tier-1s like Valeo, Continental or Delphi.[201] Hence, if Chinese OEMs will introduce 48V systems (FAW and Geely have announced to do so) they will purchase them from their international suppliers.

However, the OEMs in China clearly follow the push of the government towards PHEV and BEV with high-voltage supply systems. Even PHEVs are just considered as an interim solution which will be promoted as long as the charging infrastructure is weak. SAIC as the biggest Chinese automobile manufacturer confirms this strategy for themselves and also as a general trend in China (refer 3.4.4). They believe that Chinese OEMs could gain a competitive advantage with high-voltage Evs. If so, they will also be able to reduce their dependency from international suppliers.

[200] Cf. (Michael Carman, 2016)
[201] Cf. (Dr. Bernhart & Riederle, 2017)

The most important HV systems operate at around 400V. This standard is broadly taking root at the moment. In China 200V low-cost systems may also become relevant.
800V systems are interesting for the premium and luxury segment. The VW group has allocated this technological approach to Porsche exclusively.

3.4.10 Fuel-Cell Electric Vehicle development stage

This chapter provides results taken from primary and secondary data analysis (see 3.1 and 3.2) concerning the development stage of FCEV. This is not a market specific perspective.

Enormous progress has been made with FCs for mobility applications since 2000. The volume and the weight of a representative 100kW FC stack have been reduced from 200 to 32 litres and from 250kg to 35kg, respectively. The lifetime has been increased from 50 thousand to 200 thousand kilometres. Primary sources and also BMW specify the efficiency of state of the art FC systems with up to 65% for part load operation.[202]
Thereby, also the costs have been cut by approximately 95%. Nowadays, the platinum content in a FCEV and a modern diesel car catalyst are comparable.

Toyota has achieved such cost reductions with its “Mirai” series FCEV, which has been released in 2014, compared to its first SUV based FCEV, the “FCHV-adv” from 2008, amongst others due to several key measures:[203]

- Utilization of electric powertrain system and battery from mass produced Hybrids.
- External air humidifier substituted by internal water circulation in FC stack.
- Reduction of the FC electrolyte area by 59%.
- Less cells in the stack, due to improved boost converter.
- Thickness of membranes and thereby platinum content reduced by two-thirds.
- Improved lamination structure of carbon fibre hybrid tanks enabled 20% material saving.[203]

Toyota is convinced that it is possible to make FCEV mass competitive. Furthermore, FCEV are considered to be better than BEVs from an environmental lifecycle perspective, mainly due to the impact of the battery production and recycling itself.
Experts referred to an AVL study which came to the result that FCEV will be cheaper than BEV for driving ranges longer than 300km. This calculation was done with very optimistic battery prices that are not predictable at the moment. Also, OEMs say that FCEV have reached the cost level of HEVs.
An additional incentive is that with FCEV even higher ranges are conceivable than with conventional cars.

[202] (Dr. Jung, 2017)
[203] (Killmann, 2017)

A remaining limitation of the FC technology is the high cooling effort. Different than ICEs, heat cannot be dissipated from a FC-stack with the exhaust gas. Furthermore, the operating temperature of the FC is limited to about 85°C at the moment. Hence, the radiator area is the main constraining factor for the output-power of FCs. Even if the operation temperature can be increased, the power limit for FCs in passenger cars is estimated roughly around 150-200kW.

3.5 Analysis of the product and technology portfolio of AB-Mikroelektronik

This chapter provides an overview of the technological possibilities of AB-Mikroelektronik. The core competence of the enterprise will be elaborated and some remarkable product examples will be shown.

3.5.1 Technologies

This subchapter introduces some core technologies.

3.5.1.1 Substrate technologies

AB-Mikroelektronik has its origins in the thick-film technology branch. Different than the printed circuit board technology, where the desired layout is produced with a subtractive process through etching unneeded copper surfaces away, the thick-film technology is an additive process. A typical substrate material for this process is Al_2O_3 ceramics (Figure 22). The circuit is built on the substrate layer by layer with alternating conductive metal and isolating materials in a repeating paste-print, dry and sinter/burning process. Double sided substrates are possible and on each side multi-conductive-layers can be built to a limited extend.
The enterprise has enlarged its thick-film portfolio with the capability of printing thick-film-copper (TFC) and thick-film-silver (TFS) circuits with extended conductor layer thicknesses (10µm up to 300µm) on AlN-ceramic substrates and on metallic Aluminium-substrates as well. The Aluminium-thick-film substrate technology is patented under the trademarks “Anotherm” and “Anotherm Plus”.[204]

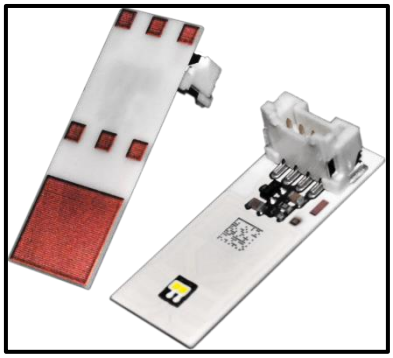


Figure 22: LED application on Al_2O_3 substrate[204]

Figure 23 shows a comparison between the different ceramic thick-film substrates made by AB-Mikroelektronik with the high-performance Insulated Metal Substrate (IMS) material “HPL” made by “Bergquist” as a reference. It shows that depending on the price, comparable up to far better thermal conductivity performance can be achieved. [204]

[204] (AB-Mikroelektronik GmbH)

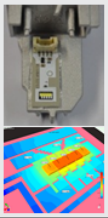
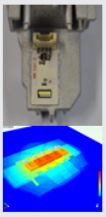
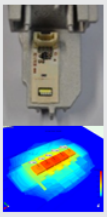
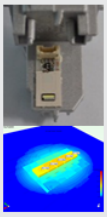
Substrate	HPL-Bergquist front 70µm Cu Diel. 38µm	Ceramic with T. front 60µm Cu back 150µm Cu	Ceramic with H. front 100µm Cu back 200µm Cu	Aluminium-Nitride Ceramic front 45µm Cu back 35µm Cu
Approx. relative costs for substrate	100%	-30%	-4%	+67%
Measurement results (LED-Case to glue bottom for OBF 1x5), thermal conductivity of glue 1,7W/mK	**100%**	**88%**	**120%**	**167%**
Rth [K/W]	3,00	3,40	2,50	1,80
Delta-T [K] (Led-Case to glue bottom)	35,00	40,00	30,00	21,00
LED Junction Temperature *	67°C	72°C	62°C	53°C
* measurement @ 25°C heat sink temperature, OSRAM OBF1x5 @1A, 11,6W with 30% efficiency				

Figure 23: Comparison of substrate materials utilized in an LED-application.[205]

Besides the self-produced circuit boards, AB-Mikroelektronik also works with semi-finished products that are available on the market. Such are various Printed Circuit Boards (PCB), Insulated Metal Substrates (IMS) or Direct Copper Bonded (DCB) substrates.[206]

3.5.1.2 Connection and assemble technologies

As an electronic manufacturing enterprise, AB-Mikroelektronik of course is equipped with Pick & Place lines and widely uses vacuum soldering processes with state of the art process supervision systems like X-ray, 3D-Automatic Optic Inspection (AOI) and so on.[207]

Concerning the connection and assembling of components and circuit boards to modules, a big basket of technologies is available, just to mention some of them:

- Ribbon and wire bonding (Figure 24)
- Die bonding (see Figure 25)
- Base plate soldering
- Vapour phase soldering
- Different gluing technologies
- Lead frame technology
- Potting
- Resistance welding[207]

Figure 24: Ribbon/wire bonding[207]

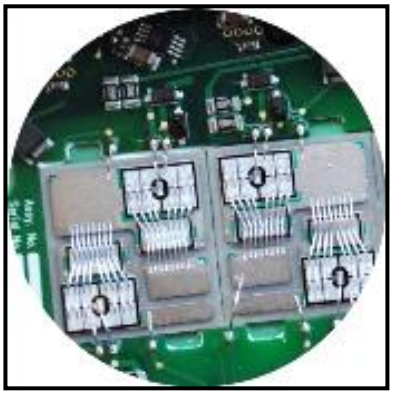


Figure 25: Die bonding[208]

[205] (AB-Mikroelektronik GmbH)
[206] (AB-Mikroelektronik GmbH)
[207] (AB-Mikroelektronik GmbH)
[208] (AB-Mikroelektronik GmbH)

Figure 26 illustrates some of these technologies in a schematic way.

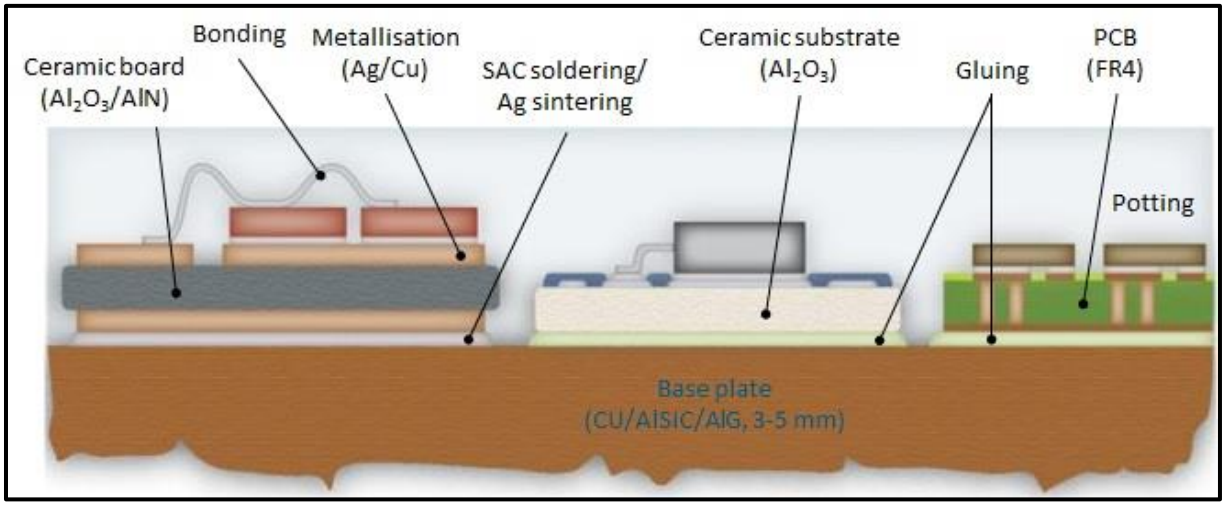


Figure 26: Illustration of connection and assembly technologies[209]

Thereby, a high automatization grade can be realized for all connection and assembly processes.

Recently, AB-Mikroelektronik has developed and patented a special technology which allows double-sided cooling and extra compact construction of the electronic power module. This technology is called “Chip Stacking” and utilizes “Anotherm Plus” substrates.[210]

Figure 27 shows a B6-inverter-bridge as a possible application, whereby this is just one high-side/low-side switch combination of which three are needed for a full B6-bridge circuit.

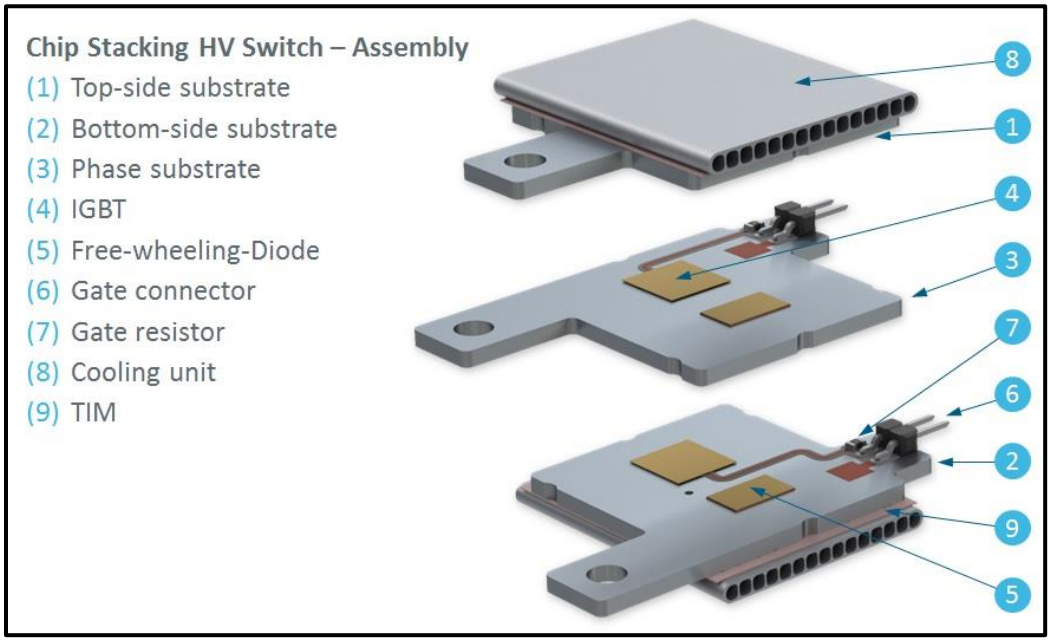


Figure 27: “Chip Stacking” technology in a HV half-bridge application[211]

[209] (AB-Mikroelektronik GmbH)
[210] (AB-Mikroelektronik GmbH)
[211] (AB-Mikroelektronik GmbH)

The low-side IGBT and a free-wheeling-diode are built in between two “Anotherm Plus” substrates and soldered on both sides. The same happens with the high-side IGBT + free-wheeling-diode between the phase- and top-side Anotherm substrate. The collector and emitter of both IGBTs are thereby directly soldered onto the aluminium plates without any isolating layer in between, resulting in an excellent thermal interface. The DC potential is directly applied to the top- and bottom-side substrate, the phase connects the phase-substrate in the middle. That means the substrate-plates serve as current bus-bars simultaneously. Only the gate connectors are isolated and must be connected via separate control pins.
The top- and bottom-side substrates must be connected to a water cooling unit in a thermal conductive, but electrically isolating way. A thermal interface material (TIM) could be used.[211]

This Chip Stacking Technology has the following advantages:

1. Extreme good thermal conductivity.
2. Double-sided cooling possible.
3. 3D-assabling of chips – “Chip stacking”.
4. Advantages 1, 2 and 3 enable high packing and power density.
5. No bond connections are needed.
6. Low parasitic inductivity → this entails reduction of power loss and lowers the requirements for other electronic components such as gate driver and capacitors.
7. Advantages 4 and 6 are also advantageous for electromagnetic compliance (EMC).
8. The technology is not susceptible to mechanical shock and vibration exposure. [211]

3.5.2 Engineering services, business model and core competencies

Objective of this chapter is to find out which services AB-Mikro offers, which business model is followed and which core competencies could be formulated.

On the strengths side of a SWOT analysis (explained in 2.3.2) in its strategy plan, AB-Mikroelektronik lists the market leadership for electric water pump controllers, know-how regarding motor control units, the integration competence of such controllers into the engine units, a lean organisation of the operations and thermal performance as well as weight reduction solutions referring to its substrate technologies.[212]

The comprehensive system development service of electronic modules starts with the project management and includes mechanical design, electronic Hard- and Software design, simulation, testing and measurement as well as final automotive validation infrastructure and capabilities. Concerning Hard- and Software development for motor control units, it must be mentioned that AB-Mikroelektronik has developed a special Field Orientated Control (FOC) algorithm which allows a motor operation without rotor position sensor and only one current shunt. This enables additional cost and space advantages.[213]

[212] (AB-Mikroelektronik GmbH, 2016)
[213] (AB-Mikroelektronik GmbH)

Thereby, AB-Mikroelektronik has basic resources in all those fields and the opportunity to take advantage of sister enterprise resources and several long lasting cooperation's with external development service contractors.

But AB-Mikroelektronik is not a pure development service provider. Key part of its business model is that all developments are done for their own manufacturing facilities. As the chapter 3.5.1 shows, special manufacturing process know-how is necessary to produce those products.
Hence, the business model is defined by the synergies between development and manufacturing capabilities with a focus on customer specific electronic modules. As the company acts nearly exclusively on the automotive market, of course all processes are ISO9001, ISO14001 and TS16949 certified.[214]

Finally, after gathering information on the technologies, business model and strengths of AB-Mikroelektronik in this chapter 3.5, an attempt to formulate a main core competence of the electronic power modules product line has been done:

A main core competence of AB-Mikroelektronik is the integration of customized power electronic modules into limited construction space under elevated thermal and mechanical requirements. High integration- and power density with excellent thermal features are made possible by a combination of several high-technology materials and processes with experienced engineering.

As the next chapter will show, this core competence can be leveraged for several applications and markets. It is also difficult for competitors to imitate this constellation and it clearly provides value benefits for the customer. Therefore, the definition of a core competence according to chapter 2.1 is fulfilled.

3.5.3 Applications and product examples

The current product portfolio of AB-Mikroelektronik's power-modules product line basically can be divided into a "lower-power" group with up to 1kW and a "high-power" group with a magnitude of 50kW control unit output power.

The "lower-power" group covers several products all somehow dealing with the electrification of ancillary units such as water pumps for ICE cooling applications, oil- or vacuum pumps, air pumps e.g. for exhaust gas treatment applications or centrifuges. More than 2.5 million units per year of those units are produced for series applications of customers like BMW, Ford, Volvo or Daimler. A platform strategy for 12V, 24V and 48V/HV applications is leveraged, which enables a faster development of such motor control units. Exemplary, section 3.5.3.1

[214] (AB-Mikroelektronik GmbH)

introduces a high-end 1kW HV water pump which is currently in the final development stage. Its application is a cooling unit of a series FCEV.[215]

Electronic control units for traction engines are the main products of the “higher-power” group; section 3.5.3.2 presents two examples of these. [215]

Another application, a current project in the initial development stage, involves a power module comprising the electronic switches for a stack-scalable central DC/DC converter with 50kW continuous power per module for FCEV. [215]

It must be mentioned that at the moment the comprehensive development capabilities of AB-Mikroelektronik are limited to the “lower-power” product group. The experience level with electronics hard- and software design for “higher-power” applications is quite low in house at the moment. Hereby, the company mainly relies on external development partners and focuses on the thermal management and the industrialization itself.[215]

3.5.3.1 Example electrified ancillary aggregates: High voltage Motor Control Units (MCU) for FC cooling water pump

AB-Mikroelektronik has MCUs for pump products in a power range from 35W up to 1kW in its portfolio but the higher power, temperature and supply voltage, the higher the advantage which can be achieved with the described core competence. In the HV derivate with 1kW two main advantages of the ceramic thick-film substrate technology can be leveraged at the same time: high thermal conductivity and electrical isolation strength. [215]

[215] (AB-Mikroelektronik GmbH)

Figure 28 shows the ceramic substrate which is assembled into the head of the pump housing. It carries the digital electronic part (microprocessor etc., white circle) as well as the DC/AC inverter (green circle) on the high voltage part. There is a galvanic separation between the high-voltage part and the low-voltage CAN-interface (marked with a red arrow).
The EMC filter parts (big capacitors and inductors) are mounted in an additional level as shown in Figure 29. They are situated in the HV supply path with its supply connector on the left side. The connection between the HV connector and the lower electronic level is established by resistance welding of lead contacts (white arrows). [215]

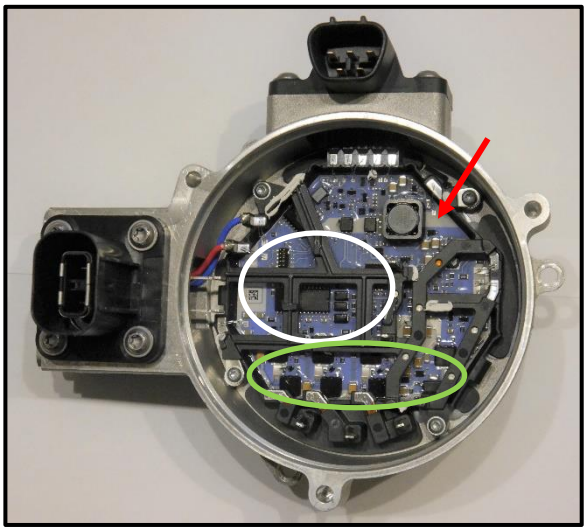


Figure 28: MCU excl. filter elements[216]

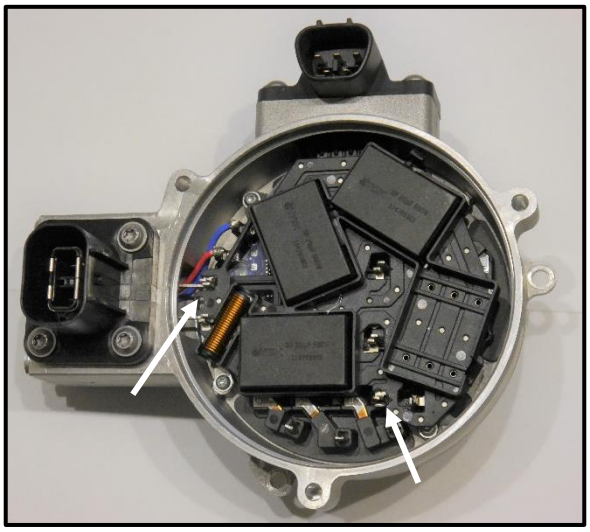


Figure 29: MCU incl. filter elements[217]

This control unit performs with 700W output power at its continuous nominal operating point, which corresponds to a volume flow rate of 200l/min with a pressure difference of 1.2bar in the 100kW FC-stack system. The maximum continuous output power is 1kW up to an operating temperature of 135°C.
Another key feature is that this control unit can cope with voltage fluctuation rates up to 1500V/s in a range between 200 and 500V (600V peak) without operation mode interferences.[218]

As far as AB-Mikroelektronik knows, this integrated control unit is currently unique at the market. AVL has been won as a potential customer for this pump in course of this thesis and the responsible AVL-engineer has confirmed that he currently is not aware of a similar product on the market. It is an excellent application example for the core competence of AB-Mikroelektronik. Upscale concepts of integrated MCUs with the same architecture up to an output power of more than 10kW and just approximately 150% of that size are ready. Conceivable applications are e.g. air compressors for FCEV.[218]

[216] (AB-Mikroelektronik GmbH)
[217] (AB-Mikroelektronik GmbH)
[218] (AB-Mikroelektronik GmbH)

3.5.3.2 Electric Control Units (ECU) for traction engines

Figure 30 shows the construction of an electric control unit (ECU) for an all-electric motorcycle.

It comprises all voltage sources for low- and high-voltage consumers including the traction engine and thereby complies with functional security requirements according to ISO26262 ASIL level C. The continuous supply current is 39.4A_{eff} in a voltage range of 200-300V. Peak currents up to 137.9A_{eff} are possible.

The resulting specific power density is 11.7kW/kg.[219]

Figure 30: ECU for an all-electric motorcycle[219]

Another traction engine controls example is the Intelligent Power Module (IPM) for an in-wheel powertrain system (refer Figure 31). The IPMs as shown in Figure 32 include the power switches (Figure 33) as well as the related control elements including gate drivers and protection circuits.
One in-wheel engine system, equipped with two IPMs, can perform with up to 65kW continuous and 80kW peak power. The power density of the IPMs is 108kW/l, again made possible due to the core competencies of AB-Mikroelektronik.
The reliability requirements the IPMs have to comply with are extreme; 400 thousand active power cycles have been tested and approved. Functional security according to ISO26262/ASIL-D is also implemented.[221]

Figure 31: In-wheel system[220]

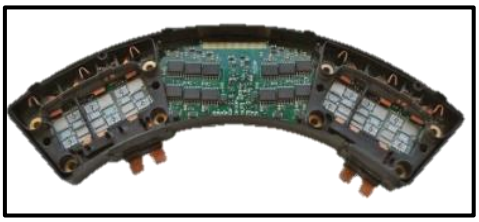


Figure 32: IPM by AB-Mikro[221]

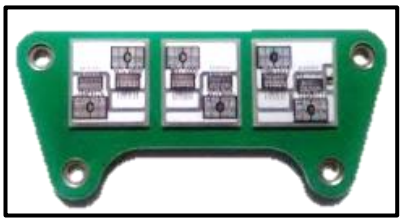


Figure 33: Detail view – Inverter bridge by AB-Mikro[222]

The whole series volume of those IPMs will be manufactured in China. Start of production will be by the end of 2017. [221]

[219] (AB-Mikroelektronik GmbH)
[220] (AB-Mikroelektronik GmbH)
[221] (AB-Mikroelektronik GmbH)
[222] (AB-Mikroelektronik GmbH)

3.5.3.3 Intelligent electronic relay for Lithium-Ion battery protection

The intelligent electronic relay is a protection switch for Lithium-Ion batteries in 12V hybrid vehicles. The standard condition of the switch is “on” with a specified continuous current flow of 200A. The principle is illustrated in Figure 34, it has two main functions:

- Disconnection of the Lithium-Ion Battery in case of short circuit. In that case, the current surges within 50µs from 500 to 1000A. The circuit must be interrupted at ~ 580A.
- Enables charge balance control between Lead-Acid and Lithium-Ion batteries as well as disconnection of the Lithium-Ion battery in case of low voltage.

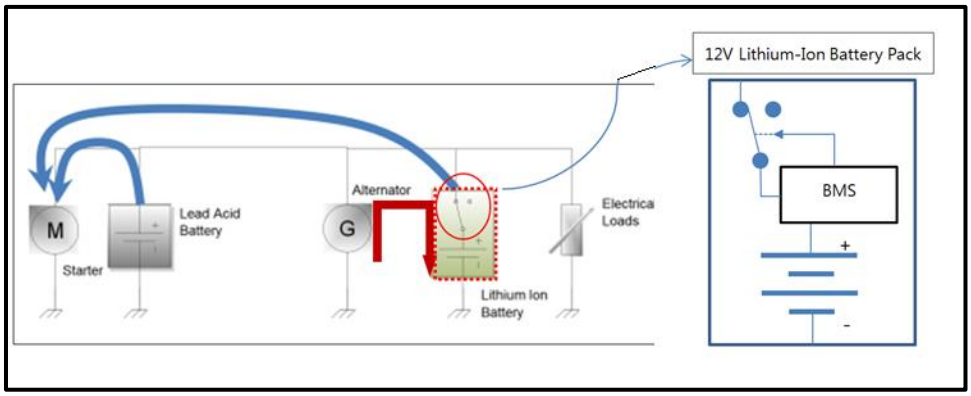


Figure 34: Function principle of the intelligent electronic relay[223]

Figure 35 and Figure 36 show a block diagram and a picture of the intelligent electronic relay.

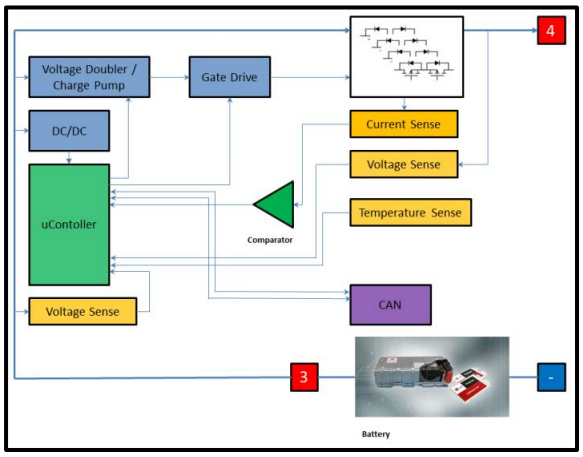


Figure 35: Block diagram[224]

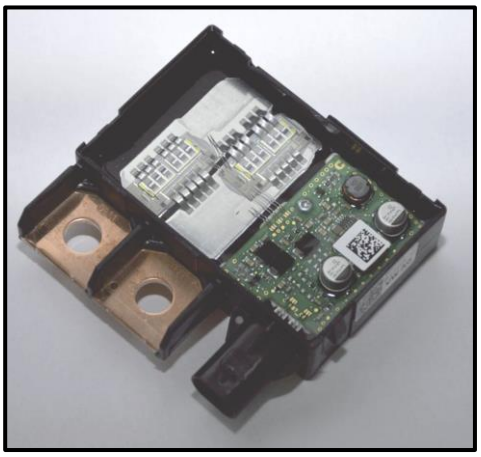


Figure 36: Intelligent Electronic Relay[225]

The diagnoses, current sense and the driver units for the MOSFET switches as well as the Controller unit with a communication interface to the battery management system (BMS) are integrated in the module and located on a PCB. The power semi-conductors (MOSFETs and free-wheel diodes) are mounted on a thermal conductive substrate. Depending on the current requirements, several MOSFETs are switched in parallel configuration. Moreover, bidirectional and unidirectional configurations are possible.

[223] (AB-Mikroelektronik GmbH)
[224] (AB-Mikroelektronik GmbH)
[225] (AB-Mikroelektronik GmbH)

3.6 Market potential and potential customers

The main goal of this chapter is to provide an overview of market potential and potential customers for products and technologies of AB-Mikroelektronik with reference to the goals two and three (see 1.2). Thereby, results from primary and secondary data analysis (see 3.1 and 3.2) are mixed up in order to keep a common thread in the context.
The field of competitors is explicitly excluded from the region under examination in this thesis (refer 1.4), but it is related to the potential customers. Due to the business model and core competences of AB-Mikroelektronik, some customers are competitors at the same time. A competing manufacturer of whole inverter units for example could still be interested in power modules as a customer.

As the task for this thesis was to follow a top-down approach, the results mainly cover OEM customers. To get a deeper insight into the Tier-1 and Tier-2 supplier level, a follow-up study has to be done. Experts suggested that such a study should be conducted by an institution located in China involving Chinese researchers because otherwise it is difficult to get the desired information.

The market overview chapter 3.3.3 anticipates essential information for this chapter as well. All the listed OEMs with their strengths and market shares are potential customers.

3.6.1 Market potential for electrification of ancillary ICE aggregates

According to the consulted experts, there is a potential for the optimisation of ICEs in China as they will be still necessary and must comply with future consumption and emission regulations. But the competence of Chinese OEMs on the field of ICEs is described as still low and not competitive. For that reason, state and private owned Chinese OEMs rely on ICE development services and purchase complete propulsion systems and components from big international Tier-1 suppliers like AVL, Bosch, Continental and so on. The only chance to get business in that market segment is seen in having a good USP, very low price and standardised products. Chinese OEMs are not willing to pay for development costs, therefore, the business model of customer specific development is difficult, especially in the field of ICE applications.

AB-Mikroelektronik has already experienced that most enquiries for ancillary aggregate motor control units are for lower-power applications around 50W. This is a high competitive market which big players can satisfy. As chapter 3.5.3 explains, the core competence of AB-Mikroelektronik shows the advantage of ancillary aggregates with several hundred watts and more. Such applications are to be found in big engines. Now, Chinese people may prefer big cars but not necessarily big engines as chapter 3.3.3 showed.

The booming SUV and MPV market in China also is not a promising enabler for higher power combustion engine applications. As shown in 3.3.3.4 the star in this segment is GWM, but part of its success recipe was the equipment of SUVs with small engines. Furthermore, this OEM

has especially strong ties to selected international suppliers. It is said that Bosch, Delphi and Valeo have long term contracts with GWM and have built factory sites next to GWM. Other suppliers, even Continental, will have nearly no chance to achieve business. GWM talks with a lot of suppliers, but in the end the primary partners get the business. The only chance again is with an outstanding USP and very low prices. GWM doesn't pay development costs at all.
Another topic is NEV SUVs, which GWM doesn't have yet. One expert said that he would know the reason for that first hand: Due to the very high work load GWM hasn't had the resources for the development of NEVs so far, but this will change.

3.6.2 Potential customers for electrification of ancillary ICE aggregates

As a matter of fact, the interview partners confirmed a prevalent position of big international Tier-1 supplier companies and they were not aware of important Chinese suppliers which are active in that field of application. The experts recommend focusing on international Tier-1 suppliers (Bosch, Continental, Borgwarner, Magna, Johnson Controls, a.s.o.). The focus should lie on existing customers and competitors of AB-Mikroelektronik.

According to TT-Electronic internal sources, a market survey on Chinese pump suppliers exists and some of them have already been visited. The problem was that if they had a demand for electrification of pumps, these were low power units with around 50W. This confirms the described situation.

Concerning the competitors, a reference to chapter four of the dissertation from Johann Maier (AB-Mikroelektronik) is made. According to this, the most important competitors are Continental, Bosch, Aisin, Denso, Myunghwa and EMS with AB-Mikroelektronik in a leading position concerning the product complexity/performance portfolio.[226]

3.6.3 Market potential for NEV applications

As mentioned in chapter 3.3.8, all interviewed experts expect a high growth of NEV market share and thereby consider NEVs as particularly important for Chinese OEMs. A high market potential is assumed for technologies and applications that AB-Mikroelektronik can offer as there are clear technological advantages compared with manufacturers in China.
This not only applies to cars and commercial vehicles. The electric motorcycle market may be huge and mature, but those are mainly cheap and low-tech purpose-machines with low life time, not comparable with the European market. There may be limited potential for a new sportive and prestige electric motor cycle market.

The following sections provide market potential assessments for the key applications traction inverters, battery protection switches and DC/DC-converters as well as some information on technical success-requirements. Further conceivable applications for NEVs are ceramic-heaters or air conditioning compressors.

[226] (Dr. Dipl.-Ing. Johann Maier, 2014)

3.6.3.1 Traction inverter

Every NEV needs an inverter to transform the DC supply to an AC for the traction engine. It must be distinguished between the whole inverter and the power module, which can be seen as its core part. AB-Mikroelektronik has a product concept for the MOSFET/IGBT power module (refer Chip-Stacking in 3.5.1.2) but can develop and produce whole customer specific inverters as well (refer 3.5.3.2).

Considering the chip-stacking inverter power module concept, the experts from ISLE evaluated the low parasitic inductivity as the biggest advantage. This is especially beneficial for applications with high currents like in 48V but also high-power HV applications. A crucial feature in that context is how the DC-link capacitors are connected with the power-module. Therefore, ISLE strongly recommended including these capacitors into the project scope.

For whole inverter units it has been common to install them as a separate module in the car until now. This solution has significant disadvantages considering EMC, space, power losses and material costs (copper). Because of that, there is a clear trend of fully integrating them into the electric power train or at least to directly attach them onto the engine. This will be state of art. Actually, this is a problem for established system suppliers like Bosch, Conti and co, because they strive for standardised solutions which they can sell to every OEM. Furthermore, the OEMs try to keep the inverter know-how in house and are searching for partners who do the customer specific industrialization.
This is seen as a clear chance for AB-Mikroelektronik with its customization business model.

At the moment the prevailing electric machine type is the permanent magnetic synchronous machine (PSM). Only Tesla and partly Audi and Daimler use asynchronous machines, although this type has advantages and therefore could gain importance in future.

According to Helen Xu, vice president of Infineon's automotive devision in China, Infineon is the clear market leader on semi-conductors for NEVs and makes half of its revenue in China. Infineon considers itself as the only big vendor of power-semiconductors for electric vehicles, except from some Japanese competitors.[227] It can be assumed that with these statements mainly semi-conductors for inverter power modules are addressed. Of course, also other power module suppliers use Infineon semi-conductors (AB-Mikroelektronik does not).
Chapter 3.6.4 provides more information on the field of customers and competitors. This information has been anticipated here because Infineon states further that they expect over proportional growth potential in that sector.[228]

[227] (Kordik, 2017)
[228] (Kordik, 2017)

3.6.3.2 Electronic battery protection switch

An insight out of the primary research is that relay solutions are state of the art in battery disconnect units. A main disadvantage is, that such relays are just capable of a few short current switching cycles. The idea to substitute the relays with electronic semiconductor switches is promising according to experts. Potential customers showed high interest too. Experts added for consideration that NEV for the Chinese market are kept as simple as possible, especially by Chinese OEMs. This is why it is assumed that they will use relay-switches as long as they are cheaper and security standards do not force the application of electronic switches.

A workshop with ISLE and a visit at Samsung SDI have been done on this topic. Furthermore, existing meeting minutes from sales engineers have been analysed. The results are presented hereafter.

Results from the workshop with ISLE

ISLE is already working on a 480V battery protection switch solution in an early development stage. They think that there is a strong demand for such applications but that there is still no satisfying supplier market.

A technological requirement according to the LV123 standard is that it must be possible to disconnect the battery in both directions in case of over current. The ISLE concept solves this requirement via an unidirectional electronic switch as a replacement for the high side main and pre-charge relays, but with a remaining mechanical relay on the low side. The load requirements to the low-side relay are low, because it is only switched current-less except in case of a leakage current on the ground potential (short cut with the chassis).

Another insight gained from attending the workshop was that for a standardized solution it makes sense to integrate the whole intelligence inclusive current sensing and maybe even the control circuit for the remaining relay into one encapsulated module. Otherwise, with the measurement logic in the BMS, it may be difficult to realize the fast reaction times and a standardized interface seems to be unrealistic.

Low- and high-voltage versions based on the same concept should be foreseen. In a high-voltage solution, HV-MOSFETs have power loss advantages compared to IGBTs.

Outcome from the visit at Samsung SDI, Premstätten, Austria:

Currently, Samsung SDI has just HV-battery packages in series production, but 48V projects with ten times higher quantity (around 500 thousand vehicles p.a. per project) are in ramp-up phase. According to Samsung, semiconductor disconnect switches are allowed but not required in OEM specifications. Hence, there is no clear market potential seen at the moment. However, such a solution is from high strategic relevance for Samsung SDI. The key enabler requirement is economic competitiveness with relay solutions. The target price for a 48V power-switch exclusive control electronics is about 4.50 EUR.

Samsung SDI expressed clear interest in a development cooperation and was very keen for the chip-stacking technology. Their approach would be to start with a bidirectional 48V pure power switch, probably based on chip-stacking technology, which would be controlled by their own battery management system. The continuous current load is up to about 200A, whereby the only cooling possibility is via the current bus-bars.
In contrast to HV systems, for 48V batteries there is no galvanic isolation requirement and there is no low-side relay (common ground with 12V system). The pre-charge function is often realized by the DC/DC-converter. Subsequently, just the main relay must be replaced. Furthermore, there are more sophisticated semiconductors available.

Due to different OEM requirements and vehicle concepts, Samsung SDI cannot conceive of a standard solution for a 48V semiconductor protection switch. Additionally, the BMS consists out of just one PCB and it does not make sense to outsource parts of it. Hence, just a pure power switch is from interest. The BMS of HV battery packs on the other hand consist of several modules. Here it could make sense to use an intelligent protection switch on a modular base.

Summarized, the considerations at Samsung concerning semiconductor substitutes for relay switches are in a conceptual phase. Development and series production cooperation as well as the chip-stacking technology are from interest.
For this application it must be considered that semiconductor also entail disadvantages, namely costs, higher power loss under high load and the risk of a failure with shortcut.

Outcome from AB-Mikroelektronik visits and correspondence with LG Chem (Germany) in the middle of 2016:
LG Chem tried persistently to get access to AB-Mikroelektroniks related product designs (refer 3.5.3.3) and was interested in the chip-stacking technology, but no business relation has been achieved. The main reason was that LG Chem is not interested in technology and customer specific development. They want to have a finished, encapsulated and validated product with specified functionality. This is valid for LG in Germany and Korea. LG decided to source bidirectional standard switches on the market but they are committed to continue using relays and to start developing an electronic substitute themselves if they cannot find an appropriate product.
Except for products from *Eberspächer* and *AUTO-KABEL*, there seems to be a lack of free available standard products on the market. According to LG, due to different setups and hybrid strategies it is difficult to supply different OEMs with a standard solution. Stand-alone protection modules are an option but an interesting alternative solution for LG would be to integrate the intelligence into the BMS system and to attach a power module comprising the power semi-conductors and thermal sensors in a chip-stack solution. Such a power module could directly be connected to the bus-bars. Target price for a 12V or 48V bidirectional MOSFET solution would be around 9.20EUR.

Key Features:
12V: 200A continuous and 500A peak for several seconds
48V: 100A continuous and 350A peak for several seconds[229]

Other manufacturers like CATL and Power Whise have expressed similar demands and key features, see 3.6.4.3.

3.6.3.3 DC/DC-Converters

All types of electrified vehicles with an elevated supply voltage grid (48V and higher) utilize DC/DC for transferring electric energy between those voltage levels and also for charging applications. This market has just been touched on in this research project, because Marcus Auer from AB-Mikroelektronik has already gathered information about competitors on that field. He found that this market is already well occupied. Other interview partners confirmed this perception. They think that it is too late for AB-Mikroelektronik to enter this market.
This view also became prevailing during the workshop with ISLE. The electronic experts from ISLE unanimously reported that this is a very complex application, because there are a lot of different topologies, different vehicle architectures and OEM standards. Also, the charging interfaces are still far from unified as the German AHK reports[230] and the grid operators are becoming stricter and stricter through regulations. Hence, they expect very high development efforts. The feasibility of a standard solution applicable in several vehicles is not conceivable in their opinion. Furthermore, the efficiency of existing solutions has already reached very high levels of around 96% and it is difficult to improve them further.

Possible applications for technologies from AB-Mikroelektronik are assumed in fast charging solutions with 20kW and more, but it is also expected that such converters will mainly be situated in the charging station itself and not in the cars.

The situation for DC/DC boost converters in FCEV is slightly different, see chapter 3.6.5.

3.6.4 Potential customers and competitors for NEV applications

This chapter provides lists with potential customers for NEV applications and some initial information about them.

3.6.4.1 NEV-manufacturing license owners

OEMs need to have a licence for the production of cars in China and this licence can also be used for the production of NEVs. According to primary sources, practically every existing OEM has such a licence (which is not self-evident, there are also uncertified small OEMs). It is said that more than 200 such licences have been approved.
Boosted by the enormous subsidy programs, a huge number of NEV start-ups (more than 20) have emerged, some delivering vehicles with low-tech, poor quality and security standards. In

[229] (AB-Mikroelektronik GmbH)
[230] (Hecker, 2015)

order to counteract that and to ensure a strong, qualitative and cost efficient NEV development competition, the government has announced to approve a limited number of ten production licences. Special is that these are licences exclusively for NEV production. This means they are preliminary assigned to non-conventional carmakers.[231]

Table 16 provides the entire list of companies which have received a NEV production licence in the sequence of approval. In addition to the existing NEV producing OEMs, which were already gathered in chapter 3.3.3.3, these are potential customers in an earlier development stage.

Table 16: List of OEMs which have received an NEV production license[232]

	Company	Website	Comments
1	BJEV	http://www.bjev.com.cn/	By BAIC
2	Changjiang EV	http://www.changjiangev.com	
3	Chery New Energy	http://www.cherynewenergy.com/	Chery aims at 200 000 NEV units sales p.a. in 2020.[233]
4	Qiantu Motor	http://www.qiantumotor.com	By "CH Auto Technology", wants to debut in USA
5	Min An Auto (Jiangsu Minan)	http://www.jsminan.com/en/	Subsidiary of **Minth Group**, link to Cleanwave USA
6	Wanxiang Group	http://www.wanxiang.com.cn	Part supplier, but now also has permission to produce NEV, owns A123 USA and Fisker USA.
7	JMEV	http://www.jmev.com/	By JMC
8	Chongqing Sokon Industry Group	http://www.sokon.com/	
9	NEVS	https://www.nevs.com/en/	National Electric Vehicle Sweden, got NEV licence for its plant in Tianjin.
10	Yudo Auto	http://www.yudoauto.com/	Link to Kandi?

NEV start-ups which have not got a licence do not have good chances for success anymore.

[231] (Spring, 2016), (IHS Automotive SupplierInsight, 2015)
[232] Provided by primary sources, verified by internet recherché
[233] (IHS Automotive Supplier Insight, 2017)

Table 17 shows further promising companies which are striving for a NEV production license or to get the permission on alternative paths.

Table 17: Other companies planning to open NEV manufacturing[234]

Company	Comments
Thunder Power	Located in Hong Kong, plans to start NEV manufacturing in Ganzhou by the end of 2018
NextEV	http://www.nio.com/ According to primary sources, NextEV (Nio) shall also have a NEV production license but this could not be confirmed and the announced contingent of 10 licenses is exhausted. According to Reuters, NextEV is in production cooperation with JAC.[235]
New JV between JAC and VW	Exclusively for NEV, they shall be in the final stage of NEV licence approval procedure. Own NEV brand shall be created.
Kaiyun Motors	NEV start-up that wants to avoid the NEV licence costs via buying a conventional OEM together with its licence instead.
Foton AUV Bus Company	Has won an order over 100 NEV buses by the end of 2016.

3.6.4.2 Electric powertrains, inverters and power modules

As mentioned before, the most established Tier-1 powertrain suppliers (Magna, Bosch, Continental, ZF, Magneti Marelli, etc.) offer electric powertrains and inverter solutions but strive for standard modules, which contradicts the integration trend. An exception is AVL, who has shown demonstrator projects with integrated inverters on its conference exhibition at the 29th AVL conference. OEMs try to keep the inverter know-how in-house. Hence, the well-known powertrain Tier-1 as well as OEMs are all potential customers as they need power modules and manufacturing partners for integrated inverter systems.

Newer interesting suppliers with China relation are:

- **Tianjin Santroll Electric Automobile Technology Co., Ltd.**
  Chinese supplier of electric-powertrains including power-electronics for the use in hybrid- and full-electric vehicles.
- **Cleanwave**
  Is a Californian supplier owned by Chinese **MINTH Group** and through them has access to a NEV production license. Cleanwave itself has developed electric powertrains including the inverter and may be interested in manufacturing partners in China and in power module solutions.
- **Elaphe**
  In-Wheel drive systems including inverter, owned by a Chinese company **APG**.

[234] (IHS Automotive Supplier Insight, 2017)
[235] (Spring, 2016)

- **Protean**
  In-Wheel drive systems including inverter, owned by a Chinese company. They are already a customer of AB-Mikroelektronik.
- **GKN with JV GKN Huayu Driveline Systems (SDS)**
  GKN starts producing electric-powertrain components in China by 2018 in a JV. With a predicted production rate of one million e-drive units in the year 2025, they strive for market leadership. They will also start producing a complete system consisting of engine, inverter and a gearbox in one encapsulated case.[236]

At this level, a follow-up study involving Chinese researchers could be useful.

The number of competitors in the field of power modules for inverters seems to be moderate at the moment. Table 18 shows some important vendors. But as a matter of fact, experts say that several new providers are in the starting blocks at the moment.

Table 18: Power module suppliers (for traction inverter and DC/DC-converter)

Company	Comments
Infineon	http://www.infineon.com/cms/de/product/power/igbt/automotive-igbts/automotive-igbt-module/channel.html?channel=db3a30432ba3fa6f012be33e87b75915 Market leader with NEV semi-conductors, supplier of power modules. E.g. BYD uses power modules from Infineon for their own inverter system. Melecs as an Inverter developer (competitor) also uses Infineon.
Denso	http://denso-europe.com/products/powertrain/ Has developed the first inverter power module with double sided semi-conductor cooling, similar to the Chip-Stacking concept of AB-Mikroelektronik.
Delphi	http://www.delphi.com/manufacturers/auto/hevevproducts/inverters/ Inverter and power module: Delphi has a so called Viper switch, which allows double sided cooling of semi-conductors similar to AB-Mikroelektronik's Chip Stacking
Mitsubishielectric	Power modules: http://www.mitsubishielectric.com/semiconductors/
Starpower	http://www.starpowereurope.com/en/news-records/new-subsidiary-for-e-vehicle-applications-in-shanghai Has a new automotive TS16949 certified site in Shanghai, focusing on IGBT power modules for traction inverter and DCDC applications.
Fuji Electric	Power modules: http://www.fujielectric-europe.com/de/leistungshalbleiter/automotive_products/igbt_modules
Semikron	Doesn't have automotive products at the moment, but has ambitions towards automotive according to ISLE.
KEBODA	Is a big direct competitor on the fields of customer specific development of LED and power applications like MCUs or traction inverters.

[236] Cf. (Auerbach, 2017)

For a detailed competitor analysis a reference to the dissertation of Johann Maier[237], chapter four is made again.

3.6.4.3 Battery system and electronic suppliers

According to insiders from the battery and automotive branch, the battery cells market is dominated by a few manufacturers. They are convinced that the market in Europe will be controlled by the three big players Panasonic (supplier of Tesla), Samsung SDI and LG Chem. These three are also active in China, but the local manufacturers BYD and CATL are bigger and deliver competitive products. Some interview partners have visited CATL plants in China recently and report that this company, which didn't exist ten years ago now has 30 thousand qualified employees and top state of the art and highly automated production equipment. Samsung SDI currently doesn't have a cell production allowance in China and is considering to use CATL cells for its battery pack production in China.
CATL is currently the third biggest global battery manufacturer and is expanding in Europe with Sales and R&D offices in Germany and a share on the Finnish supplier company "*Valmet Automotive*". China considers limiting NEV subsidies to models which are equipped with batteries form a supplier that has production capacity of more than 8GWh. At the moment, only BYD and CATL would be prepared to fulfil such a requirement in China.[238]

Those five manufacturers also assemble complete battery package systems for NEVs. Some OEMs are deeply involved in R&D on batteries and have their own affiliated battery pack assembling companies (e.g. Daimler, Tesla). Table 19 and Table 20 provide an overview about some battery-pack manufacturers.

Table 19: Battery-pack suppliers (1/2)[239]

Company	Country	Comments
CATL	China, expanding	Known European customers in China: NEVS (9-3 EV), BMW (X1 xDrive25Le), PSA (DS7) First visit: interested in 48V switches with 350A and 600A for several seconds, shut off between 500 and 1000A @ 105°C busbar/air cooling
BYD	China	First visit: interested in battery heating system, 20A continuous and 40A peak @ 105°C
Lishen	China	
Power Whise	China	First visit: interested in 48V switches with 300A for several seconds and 100A average @ 85°C busbar/air cooling
Guoxuan	China	
CALB	China	
Panasonic	International	One of the international big three. Supplier of Tesla.

[237] Cf. (Dr. Dipl.-Ing. Johann Maier, 2014)
[238] Cf. (Flörecke, 2017)
[239] (AB-Mikroelektronik GmbH) and primary sources

Table 20: Battery-pack suppliers (2/2)[240]

Company	Country	Comments
LG Chem	International	One of the international big three. Provides battery cells, stacks and complete battery systems. Visit results see 3.6.3.2; interested in 48V switch with 100A continuous and 350A peak.
Samsung SDI	International (incl. Austria)	One of the international big three cell manufacturers. Currently, the only battery pack manufacturing and R&D site is situated in Premstätten, Austria. Electronics development for the global market is done there. In China, Samsung is not on the "white list" for battery cell production and is even considering to use CATL cells if no production allowance can be achieved. **First visit has been done in course of this work, results see 3.6.3.2.**
A123	USA	Owned by Wanxiang, design and manufacturing of battery systems.
Kreisel Electric	Austria	Battery system manufacturer with innovative cooling and joining technologies. Currently expanding, but still a small player.

Besides the battery manufacturers, also cable harness manufacturers like Dräxlmaier (already customer) or Leoni are potential customers as they must prevent cable fire. Leoni doesn't have own electronic development capabilities.

Battery management systems are developed by the mentioned battery system manufacturers themselves, but further by NBT, Wanxiang, Joyson, Continental, Hella and Guoxuan.

Internationally known vendors for electronic battery switches are: Dräxlmaier (customer from AB-Mikroelektronik), Lear, Autokabel, Panasonic and Eberspächer. Also Infineon has a prototype for such applications, which must be considered as a demonstrator for its semi-conductors. AB-Mikroelektronik's state of knowledge is that Infineon does not further pursue an own product due to a clash of interest with its customers like Dräxlmaier.

3.6.5 Market potential for FCEV applications

The Fuel Cell R&D manager of AVL, Mr. Rechberger in his OEVK speech said that all market potential studies on FCEV have one common message: FCEV will be part of the future mobility. This is an opinion that Mr. Rechberger himself and other experts share. Naturally, predictions of sales figures are still uncertain.

[240] (AB-Mikroelektronik GmbH) and primary sources

The technical reasons for this prediction have been explained in chapter 3.4.10. The Fuel Cell technology is mature and FCEV are competitive when in series production. The reason why they are still not in big series production is the lack of infrastructure, but according to Mr. Rechberger the governments of three core regions have announced roadmaps with the goal of eliminating that obstacle:

- Japan currently has about 100 hydrogen filling stations available and plans to increase this number to 1000 by 2025. The island is a hydrogen pioneer in general, as it wants to decrease its dependency on energy imports and strives for a “hydrogen society” as a solution. Stationary fuel cells for local electricity production are already well distributed.
- Central Europe, especially Germany plans to have 400 hydrogen filling stations ready by 2023 (today: 20) and France aims to have 300 stations by 2025. Also the UK and Austria are to mention as public hydrogen filling stations have been opened in Graz, Linz, Innsbruck and Vienna since 2012.
- California wants to expand its hydrogen network from currently 25 filling stations to 100 by 2023.

Interview partners reported that the Chinese government has pivoted towards FCEV just recently and has increased subsidies significantly. An evidence for that is that the target of 1000 FCEV by 2020, which has been announced in five year plans from 2015 (see 3.3.4.3), has increased fivefold in the newest predictions and is now 50 thousand FCEV for 2025 after all.
An assumed reason for this distinctive shift is the problem of charging a huge fleet of BEVs in a big city. Not only because of the charging infrastructure, but also due to the tremendous power that would be needed for that. This is a global argument for hydrogen as it will be necessary as an energy carrier for the transport of electricity and especially for the storage of renewable energy. Experts strongly doubt that it will be possible to serve the electric power demand for huge EV fleets fully through electricity grids. And by 2050, nobody can imagine that a lot of ICEs will remain.

On the Chinese market features like comfort, NVH (noise, vibration and harshness) or space are more important than engine power. Hence, the characteristics of FC powertrains are beneficial for the Chinese market. The power limitation is not a crucial constraint.

The FC technology will be introduced to the markets in the commercial sector first. Experts say that they experience a strong push for light, medium and heavy duty applications at the moment. An explanation is that the infrastructure problem can be solved easiest on predefined routes for trucks or with few central stations for fuelling buses in city operation. Especially in the US, trucks are always operating on the same track with high frequency. In China, cities are eager to substitute diesel buses in cities either with BEV or FCEV buses.

Possible applications for technologies from AB-Mikroelektronik in FCEV are:

- **Air supply path:** Typical components in the air supply path are air filter, compressor, cooling unit, humidifier and water separator.
  Electrified HV centrifugal compressors are utilized for compressing the air up to a pressure of 3bar. Thereby, the air on the output side reaches temperatures of up to 150° Celsius and electric MCUs with up to 20kW are necessary.
- **Hydrogen path:** Depending on the system concept, an electrified hydrogen blower unit may be used.
- **Cooling unit:** As mentioned in chapter 3.4.10, FCs have a high cooling demand. Therefore, electrified HV water pumps with a power of approximately 2kW enabling a flow rate of around 200l/min at pressure differences up to 3.5bar are necessary.
  A responsible AVL-engineer has confirmed the perception of AB-Mikroelektronik, that currently they are not aware of a similar product like the water pump with the integrated HV-MCU (refer 3.5.3.1) on the market.
- **DC/DC boost converters** are a central component of FC powertrains. Depending on the concept, a very high amount of power (up to the whole traction power) has to be transferred. This is an interesting application for power modules.

According to experts, a 100kW FC system would cost about 6000EUR in a series production with 100 thousand units per year as a calculation basis. Thereby the assembly groups ancillary units (comprised of boost converter, compressors, pumps, valves, humidifier, etc.), hydrogen tanks and the FC stack itself account for about one-third each.

3.6.6 Potential customers and competitors for FCEV applications

Table 21 - Table 23 show a list of potential customers for FC applications that resulted out of the primary research. It starts with OEMs who already have series FCEV on the market, followed by OEMs which have announced models as well as interesting suppliers. Although AB-Mikroelektronik acts as a Tier-2 for most FC applications, still the OEMs are particularly interesting customers because they have developed most components for their first models themselves (e.g. Toyota). Their next step will be to find development and supplier partners.

Table 21: Potential customers for FC applications (1/3)

Company	Comments
Toyota	Released Toyota “Mirai” (= Zukunft) 100kW FCEV in 2014. Developed components themselves, follows a FCEV strategy. Announced a FC bus utilizing two Mirai FC systems for Olympia.
Hyundai	Series car “Tucson ix35” FCEV with 100kW, announced a follow up model, **is already indirect customer** of AB-Mikroelektronik.
Honda	Honda “FCX Clarity” series car with 100kW
GM	series car GM “HydroGen 4”

Table 22: Potential customers for FC applications (2/3)

Company	Comments
Daimler with NUCELLSYS	Announced a “GLC” Plug-in F-Cell for 09/2017 and a bus, also utilizing two passenger car FC systems. The related enterprise NUCELLSYS is development expert for the FC and tank systems. Both are members of the AFCC (automotive FC cooperation).
BMW	Announced the BMW FC Hybrid electric 1-Series for 2020, has a FC-cooperation with Toyota.
Ford	Announced the Ford HySeries Edge for 2020. Member of AFCC, hence partner of Daimler.
Nissan	Announced the Nissan X-Trail for 2020 and also a light duty vehicle.
VW/Audi	Enormous activity in R&D on FC in Osnabrück, announced a series FCEV for 2020.
SCANIA	Is developing a FC truck.
NikolaMotor (USA)	Announced a heavy duty truck for 2021. All-in business model: offers the trucks for a per mile price that is lower than with diesel trucks.
Kenworth (USA)	Announced a FC truck project in the harbour area of Los Angeles.
SAIC with Sunrise Power (CHINA)	Presented a FC concept car at the Beijing motor show, but still cannot state a series production date. Related company “Sunrise Power Co., Ltd” is developing the FC.
Ballard (CANADA)	**A leading development partner and supplier of FC stack systems.**
Re-Fire (CHINA)	**First contact with the CEO and the oversea manager of Re-Fire has been made in course of this work. A company presentation of AB-Mikroelektronik and its products was done. Follow-up meeting of AB-Mikro top-management was done in Shanghai. Further meetings are planned.** Re-Fire was established in 2014 in Shanghai. Core business is FC system integration, FC powertrain integration and vehicle development service as a supplier for OEMs. Re-Fire cooperates with Ballard and is seeking cooperation in Graz (TU, AVL, Magna). Re-Fire is highly interested in the following products of AB-Mirko: • HV water pumps • HV air compressors • DC/DC boost converters • The chip-stacking technology
Shen-li High Tech Co., Ltd (CHINA)	R&D on FC, no further information.

Table 23: Potential customers for FC applications (3/3)

Company	Comments
AVL	Has a FC team with 110 engineers, still expanding. Is building a new FC laboratory. Is developing a FC concept car with 6 associated OEM partners, which will receive the results. **Contact has been revitalized in course of this work. AVL is interested in the HV pump and DCDC converters. Discussions about small modifications on the pump for the application of AVL are ongoing.**
ElringKlinger	Supplier of FC stacks, also supplier for the AVL concept car.
Other active suppliers	Viessmann, Vaillant (both stationar heating systems), GE, LG, Mitsubishi, Cummins, Bosch

The "Global and China Fuel Cell Industry Chain report (2014-2016)" attests that the FC industry in China is far behind in international comparison. Just a few small enterprises were active in that field and there were no component suppliers for ancillary units like compressors, humidifiers and so on in China in 2014.[241] Experts say that at the moment just SAIC and Chang'an have FC concept cars, but it is assumed that most Chinese OEMs have started FCEV activities at least recently. Again, the dependency on international supplier companies is high. Ballard and some Japanese suppliers (names not known) are considered as the most important ones. The increased predictions for FCEV and the emergence of new enterprises like Re-Fire are indicators that FCs have gained importance in China too.

Another very interesting opportunity for AB-Mikroelektronik would be the participation in a FC research centre which shall be established at the TU Graz in cooperation with Re-Fire, AVL, Magna and some institutions of the TU under the leadership of Prof. Su Zhou from the Tongji University Shanghai. First contact with responsible Professors at the TU Graz, Prof. Su Zhou and Re-Fire was made in the course of this work.

3.6.7 Experts perception about Chinese OEMs and suppliers

Throughout, experts give positive predictions considering the potential of Chinese brands and OEMs. The talent fostering programs of the government seem to be successful, because the local enterprises have more and more high skilled and innovative employees available who got their education and experience abroad or in education establishments with international participation. The competitiveness of local brands is continuously rising and in segments like SUV and NEV they have already overtaken JV brands. However, there is still a quality gap and they are still no threat for foreign brands in the premium segment.
NEVs also seem to bear the highest competitiveness and most sustainable chances for Chinese OEMs. In the subjective perception of several experts, certainly BYD is the most important passenger NEV-OEM at the moment, not to forget its strength with buses.

[241] (ResearchInChina, 2014)

Nevertheless, business with BYD is difficult for suppliers due to the high vertical integration. The NEV brands of SAIC, JAC (NEV-JV with VW planed!), Chery, BAIC and Chang'an are also credited with good chances. Geely with Kandi is interesting for small cars.
Considering ICE technology, Chinese OEMs are not expected to become competitive with JV brands and their foreign technology in the future either.

Considering the supplier branch, the data density is not very high. As mentioned before, a follow up study is suggested. Experts know that, unlike for ICEs, there are Chinese suppliers for electric powertrains. Also, a lot of mergings and acquisitions with/of foreign enterprises are done in that sector. Chinese Tier-1 of course enjoy the same support from international Tier-2 and 3 as international ones and therefore have access to the same sophisticated technology.

3.7 How to achieve business relations in China

The results presented in this chapter cover goal four; how to initiate business and how to achieve consistent business relationships with Chinese companies.

3.7.1 Business relevant cultural aspects about China

This chapter gives a brief insight into the most important characteristics of the Chinese culture from a Europeans view, whereby the focus is on how to deal with Chinese business partners. For specifics considering qualitative research see chapter 2.2.3.4.

Due to an isolated historical culture development there are some significant differences considering the basic mind-set/way of thinking between European and Chinese people.

3.7.1.1 Basic differences in cultural mind-set

Table 24 shows a comparison between some fundamental differences in cultural mind-set.

Table 24: Comparison of fundamental differences in mind-set[242]

European	Chinese
Individualists	Collectivists
Egalitarian (equality)	Hierarchical
Information and fact-oriented	Relationship-oriented
Reductionists (solve one problem after the other), sequential way of thinking	Holistic view (hole package must be solved), circular way of thinking
seek for results	Seek the way and the means
Argument culture: open debate, striving for consensus, quick meetings	Bargaining culture: durability in long lasting back-and-forth bargaining processes
Forging a “good deal”	Forging a long-term relationship

As a conclusion, a European needs to be very patient when negotiating with Chinese business partners. This starts with the introduction in which Chinese people like to do a lot of non-business small-talk and remains necessary all over the negotiation process. Chinese people follow an indirect approach which means that they want to discuss the context first. Furthermore, it is very common that the participants are not fully authorized. Overall, a reason for those characteristics is that Chinese strive for long-lasting business relations.[243]

The next section provides some specifics of how to initiate business contacts.

[242] Cf. (EU SME Centre, 2013, S. 5)
[243] Cf. (EU SME Centre, 2013, S. 5)

3.7.1.2 Personal relationships (guanxi) as a prerequisite for business

The best way to initially approach a potential Chinese business partner is through a trusted person who manages the introduction.
Alternatively, direct first contact e.g. via calling or a very brief introduction mail is also possible, but a relationship has to be established and in this way it will take much longer. A first contact should not go too much into business. It should rather aim to be an initial relationship-building meeting. Thereby, communication in Chinese language is not compulsory but may be necessary especially when dealing with smaller companies.[244]

Thus, a personal network is far more important when doing business in China than it is in Europe. Such personal relationships (guanxi) must be mutually beneficial friendships. It takes high time efforts to create and nurture them. There are a lot of networking events which can be used to makec ontacts. During such events it is absolutely appropriate to introduce one self. Once personal relationships are won, they have to be maintained. In this context there are no special criteria or topics to be aware of. It is about a respectful contact with at least as much giving as taking as in every other country. Regular social contact may be more important and time consuming in China compared to other cultures.[245]
Invitations for meals, drinks and entertainment activities through business partners are common. It is important to show interest and to participate in such events in order to strengthen the relationship. When conducting small-talk one should avoid political sensitive topics like the “One-China politics”, human rights or the communist party.
Chinese people are patriotic. Therefore, it is beneficial to know something about the country’s history, winning sports teams or big Chinese events. Furthermore, things such as family, which is considered to be a private topic in Europe, will be openly addressed in China. Experiences from abroad are also a welcome topic. Regarding that, invitations to one’s home country are highly appreciated.[246]
Small gifts, especially from the home country, are especially appreciated in Asian cultures. Clocks and everything related to the number four should be avoided, because Chinese people tend to superstitious and such things represent bad fortune. It should be redundant to mention that expensive gifts are not acceptable for compliance reasons.[247]

As a conclusion, building trust is a necessary prerequisite when striving for long-term business relationships. Therefore, it is essential to show commitment in personal meetings – hence, to go to China.[248] Experts have also highlighted the importance of patience, personal relationships, B2B networking events, business lunch and dinners and provided the additional hint that it is very important to be recognized as competent and hard working for building trust.

[244] Cf. (EU SME Centre, 2013, S. 7 et seqq.)
[245] Cf. (EU SME Centre, 2013, S. 7 et seqq.)
[246] Cf. (EU SME Centre, 2013, S. 16)
[247] Cf. (EU SME Centre, 2013, S. 15)
[248] Cf. (EU SME Centre, 2013, S. 6)

3.7.1.3 Maintain the “face” (mianzi)

In the Chinese culture, “face” (mianzi) is of crucial importance. “Face” includes factors like prestige, social standing, reputation, integrity, morality, respect and personal honour. It can be influenced through wealth, intelligence, attractiveness, skills, position and good personal relationships, as described in the last chapter.[249]

Another prerequisite for business, therefore, is for all business partners to be able to preserve their face. Thus, a good personal image is a key success factor for business in China.
Causing a loss of face to a Chinese on the other hand would be catastrophic for every business negotiation. Doing so could also result in damaged personal relationships or even an enmity.
In order to avoid this, the hierarchical structure must be respected. Junior delegation members must be very cautious when arguing with senior members of the opposing delegation. The primary communication channel is from seniors to seniors. In general, breaking promises, showing impoliteness, impatience, anger, frustration or even worse aggression in negotiations is detrimental.[250]

3.7.1.4 The negotiation process

Negotiations have a major cultural status in China. As mentioned before, the negotiation process can be very exhausting and unfamiliar for foreigners.

Once again, a Chinese rule is “friendship first, business later”[251]. Negotiation processes start slowly, meaning that the initial meetings are mainly off topic. A lot of small talk has the purpose to form personal connections as mentioned in 3.7.1.2.[252]

A challenge for foreigners is the correct interpretation of the communicated content, as Chinese people use a lot of indirect communication. Therefore, people who are qualified to interpret communication should be members of every delegation.[253]
An example for this difficulty is the Chinese use of “yes” and “no”. A “yes” does not necessarily mean an “OK”. It is rather used as an expression to maintain the communication flow or as a confirmation that one understands what was said. An interview partner described this circumstance with the sentence “in China, there are ten levels of yes”.
As abundantly Chinese people use a “yes”, as reluctantly they are with a “no”. A “no” may really imply that the negotiations have failed and is therefore often replaced with a phrase like “we will consider” or even with a “yes”.[254] Consequently, also the western partner should avoid a “no” in negotiations and rather replace it with “we will see” or “maybe” out of politeness.[255]

[249] Cf. (EU SME Centre, 2013, S. 10)
[250] Cf. (EU SME Centre, 2013, S. 10)
[251] Cf. (EU SME Centre, 2013, S. 12)
[252] Cf. (EU SME Centre, 2013, S. 12)
[253] Cf. (EU SME Centre, 2013, S. 11)
[254] Cf. (EU SME Centre, 2013, S. 15)
[255] Cf. (Berkemeier, 2005, S. 6)

Furthermore, jokes and idioms as well as emotional presentations should be avoided as they can be misinterpreted easily.[256] Long phases of silence during negotiations are usual in Asia. Such phases should not be interrupted.[257]
It is also recommended to establish more than one communication channel. This can also entail the necessity of more than one Chinese speaking team member. A multi-channel approach has the advantage that it creates a multi-perspectival view on the negotiations and it also helps to prevent communication problems due to personal conflicts.[258]

Regarding the strong hierarchy, it is crucial to get access to high-level persons in an early negotiation stage (B2B networking events), because they set the direction. Certainly, they also make the final decisions at the end of the process. In between a lower level team works on the details. As a consequence, it should be mentioned that there is little chance to accelerate a negotiation process through the attendance of the leading negotiator due to the lack of decision-competence in such a Chinese team.[259]
The person with the highest rank usually enters the room first and greets a delegation.[260]

The holistic perspective of Chinese people also applies to the negotiation process. That means one should not get stuck with single details as long as the whole package is not roughly completed. It is always possible and also common to go back to a detail, even if it was already finalized.[261]

3.7.1.5 Contracts

In China, conflicts are seldom brought to court. Among other reasons, this is because Chinese people strive to maintain their face as explained before. Bringing their problems to the public is not beneficial in that context. It is also in the interest of the foreign partner to avoid litigations in China because the outcome will be often disappointing.
Still, one has to be prepared for that case and therefore it is absolutely necessary to build contracts on a legal base including a clause of arbitration. Although the legal system in China is still under development, it is also recommended to be in contact with a Chinese lawyer to approve contracts from a legal point of view.[262] This was also confirmed by interview partners, who further recommended to involve Chinese colleagues. They also strongly recommended to register IP in China before bringing it to the market, whereby the WKO can assist. Also the usage rights for patents which may be created during a development project should be regulated in contracts. This makes sense, as the IPR system in China is definitely becoming better and better.
In general, interview partners have not made bad experiences with their Chinese business partners.

[256] Cf. (EU SME Centre, 2013, S. 11)
[257] Cf. (Berkemeier, 2005, S. 7)
[258] Cf. (EU SME Centre, 2013, S. 11)
[259] Cf. (EU SME Centre, 2013, S. 12)
[260] Cf. (Berkemeier, 2005, S. 6)
[261] Cf. (EU SME Centre, 2013, S. 12)
[262] Cf. (EU SME Centre, 2013)

3.7.1.6 Etiquette in business

Doing business with Chinese business partners is not a cultural one way street. Chinese business people are also adapting to western culture. For example, a handshake mostly has replaced the traditional bow for greetings.[263] Also the presentation of a business card with both hands is not obligatory anymore.[264] These assessments can be personally confirmed from the experience gathered through the conduction of interviews for this thesis during a one week business trip to China.

Still, one should be aware of some basic Chinese etiquette as this can be very helpful to show commitment and, hence, to build up "face" and personal relationships. Also the 13th five year plan reveals China's intention to "expand the influence of Chinese culture"[265] as a major objective. Therefore, this chapter provides some further information on how to behave on several specific occasions.

The greeting

As mentioned, a handshake is OK nowadays, whereby a weak handshake is considered as friendly and does not imply a shy character as in Europe. One should consider that Chinese people do not feel comfortable with long and deep eye contact.

It may happen that there is applause during a greeting. In that case one should just participate. Presenting business cards with both hands may still be appreciated. It is also suggested to focus attention on these received business cards. A no go is to just put them into a pocket or to write something on them.

The Chinese surname is mostly monosyllabic and written before the first name, but younger Chinese people often choose an English name anyway. Titles and positions are important in China and should not be neglected when addressing somebody.[266]

Business dinner

At business dinner a lot of alcohol is consumed and business partners are also expected to participate in every toast. It is common to refill the glass of the neighbour instead of one's own and one should never refuse the refill.

The sticks should never point into a rice bowl, but should be placed on top of it instead.

Small talk is preferred over business talk.[267]

[263] Cf. (Berkemeier, 2005, S. 4)
[264] Cf. (Kleedorfer, 2014)
[265] (Compilation and Translation Bureau, Central Committee of the Communist Party of China, 2016, S. 16)
[266] Cf. (Berkemeier, 2005, S. 4)
[267] Cf. (Berkemeier, 2005, S. 10)

Gerneral hints for everyday life

- Chinese people behave distanced considering body contact.
- Blowing one's nose is considered as ugly. Reusing a handkerchief as a no go, it should be thrown away immediately.
- Similar to a "yes", also nodding does not mean an approval. It just means that somebody can understand you acoustically.
- Asian people in general show a minimum of gestures and countenance. That means also a foreigner should not exaggerate gestures.
- Talking and making noise during presentations is opposed to Austria not considered as impolite. [268]

3.7.2 Key-success factors and common problems for foreign enterprises

This chapter presents the results out of the expert interviews (see 3.1.2 and 3.2) concerning important factors that should be considered when doing business in China.

Except the cultural aspects, experts have not experienced crucial differences in international comparison when doing business in China. High quality is expected in the same way as in Europe and one should not make promises which cannot be accomplished afterwards. Trust, references and reputation are of crucial importance and such misdoings would be detrimental for maintaining "face".
Another cultural identity of Chinese enterprises is that they strive for a very high proportion of added value. They want to do everything themselves. Hence, legal protection of IP and technical protection of software are of essential importance.

According to several interview partners, alongside a production in China an important prerequisite is to have Chinese people on all customer interfaces to be perceived as a Chinese enterprise and hence, for successful business in China. This requirement also seems to be necessary for the satisfiability of key-success factors like short response times, low price and obviously frequent visits as well as cultural understanding to build relationships.
The foreign team can take care of a USP in terms of technology and quality, but there must be competent Chinese employees for the first technical questions. Hence, a Chinese sales, field-application and at least an adaption development team are of vital importance. The participation of senior managers, coming in from Austria, at customer visits is appreciated because it shows additional commitment. Overall, relationships are an important prerequisite but are not sufficient if the technical competence is missing at the negotiation table.
In one sentence, AB-Mikroelektronik should work like a European enterprise but the appearance should be Chinese.

[268] Cf. (Berkemeier, 2005, S. 8, 9)

A hint which may be worth considering is to situate the sales, field application and maybe even the R&D team in Shanghai instead of Suzhou. First, it easier to find qualified people in Shanghai and second, it is where the customers are. Shanghai is considered to be the Chinese Detroit. Even OEMs like GWM who don't have their production sites in Shanghai often have R&D centres there.

A crucial point is how to find and hold good Chinese employees. This is, amongst other causes, due to a rising attractiveness of Chinese enterprises and subsequently an increasing competition for hiring university graduates. For sales people it is beneficial if they have some experience in big companies because they may bring a network with them, but they must learn to act without a big brand at hand. Once engaged, the knowledge drain due to fluctuation of employees is a problem. To avoid this, it is important to gain loyalty. In that context, payment is a factor of overproportional importance in China.

3.7.3 Establishing contact

The interviewed experts (3.1.2.1) think that it is very promising for European technology enterprises like AB-Mikroelektronik to seek business relations with Chinese companies. Thereby it does not make a difference if POE or SOEs are addressed as long as the requirements referred to in chapter 3.7.2 are fulfilled. Leading Chinese enterprises tend to be very self-confident and have contracts with big supplier enterprises which makes it difficult for new suppliers to gain contracts. It may be more promising to approach OEMs with lower market shares that still need support. Another typical way for suppliers to enter the market is via the commercial vehicle sector.
Simultaneously, orders from international customers are precious references.

Some interview partners made the experience that cold calls are not working in China, because nobody will be forwarded to be decision makers. Instead, they suggest employing business consulters because they have existing networks at hand and participation on specialized fairs (there are subsidies given by the WKO for the participation on fairs or the conduction of market surveys) and cooperation with universities for getting first contacts. The Universities in China shall have very good contacts and cooperation with enterprises. The potential of the students and with them the influence of the universities is growing. One reason for the improving level of the universities is a cooperation with foreign universities. The Tongji University in Shanghai, for example, operates the CDHK (chinesisches deutsches Hochschulkolleg) and cooperates with the TU Graz. Also, the fact that a lot of Chinese professors have made experience abroad is beneficial for the education level and the network intensity as well.
However, research cooperation with universities also has the drawback of knowledge and IP drain in all directions. It shall be mentioned that competitors like Infineon and KEBODA or potential customers like AVL and Re-Fire are also working with the Tongji University.

People who invite somebody to a business dinner are quite likely decision makers. It is very important to know such people, but also to get in contact with the operating technicians in order to ensure progress in a quotation of project process.

4 Conclusion and Suggestions

In this chapter, conclusions of this qualitative research project will be stated. The last sub-chapter provides a strategic product prioritization which has been elaborated in a workshop subsequently to the final thesis presentation at AB-Mikroelektronik GmbH.

4.1 Conclusions

Conclusion on five-year plan

The Chinese government is very powerful in realizing its plans. The targets must be taken seriously. The ambitions set by the 13th five-year plan and “Made in China 2025” contain many chances but also threats for AB-Mikroelektronik. The competition in China itself will become tougher, as the innovation strength and quality level especially in the automotive and electronics sector will increase. If China is successful with its opening up ambitions as stated in chapter 3.3.4.1.4, entailing increasing exports on high technology and enterprises establishing subsidiaries abroad, this can even be dangerous for the established home markets.

Conclusion on market development speed

The Chinese automotive market is developing incredibly fast. Newest information must be gathered as a basis for decisions. Just two year old reports are completely outdated and not reliable anymore. This problem could be solved by employing business consultants or by assigning further master thesis to students in the future.

Conclusion on market potential for ICE applications

The electrification of small cooling pumps for ICEs is a market segment with strong competition which AB-Mikroelektronik doesn’t have a clear USP for. At the moment, there is no market for water pumps in higher power classes around 500W where AB-Mikroelektronik could take advantage of its core competence.

Also, no trend is predictable that such a market might emerge. Chinese people may prefer big cars, but not necessarily big engines. As the market overview in 3.3.3.4 shows, 72% of all vehicles sold in 2016 have an engine displacement lower than 1.6 litres. Small engines are also a main ingredient for the success recipe of Chinese OEMs on the booming SUV market, as GWM has shown.

E-booster applications, on the other hand, have international market potential resulting out of the down-sizing trend. As this is a high-power application, the core competences of AB-Mikroelektronik are advantageous.

The market of ICE powertrains and components is in the hand of big and strong international Tier-1 suppliers. Therefore, AB-Mikroelektronik should continue focusing on them.

Conclusion concerning NEV market potential

The market share of NEV has grown rapidly from zero to more than two percent in just three years in China. Legislations, regulations and restrictions with significant impact to the benefit of NEV are on the horizon. The majority of the Chinese consumer base already considers to buy a NEV as their next car. Experts confirm the conviction and strength of the government to realise the ambitious NEV sales volume targets guided by its strategic plans and think that they will be exceeded. Hence, the latest prediction given in Table 15 which states that the market share of NEV could reach 10% by 2020 and 50% by the end of the next decade is not unrealistic. This represents market potentials of up to two, six and 15 million NEVs in the years 2020, 2025 and 2030, respectively. Opposed to Europe, hybridisation and PHEVs will play a subordinate role compared to BEVs in China.

Globally, a distinctive shift towards NEV is to be expected around 2020. Several major OEMs like the VW group, GM or PSA have announced a NEV model offensive for this time. The Chinese market is prioritised; the models will be released there first.

Conclusion concerning NEV market share of Chinese OEMs

The NEV market is nearly fully dominated by Chinese OEMs at the moment, but foreign OEMs will enter amongst others due to the upcoming quota regulation. OEM announcements, interviews and guest lectures also suggest this assumption. Hence, it is possible that Chinese OEMs will heavily lose market share in the next years.

Conclusion concerning FCEV

According to experts, the government has set a stronger focus on FCEV just recently. The latest prediction given in Table 15 shows sales expectations that are much higher than the “Made in China 2025” targets. Still, at the moment the regions Japan and EU are ahead with their infrastructure, technology and car development progress. Because of that, it may be wiser for AB-Mikroelektronik to focus on these markets first. The FC powertrain bears good applications for the core competences of AB-Mikroelektronik, but when entering the Chinese market too early, the risk of being imitated before gaining significant sales rates is high.

The commercial vehicle sector is highly interesting for FC powertrains, especially in the technology introduction phase. This market should not be neglected.

Conclusion 48V vs HV systems

The trend towards high voltage systems in China is stronger than the one to 48V electrification. This is due to the following reasons:

- Chinese OEMs are not competitive in ICE technology.
- OEMs and government see a chance to gain a competitive advantage with HV systems.
- NEV and thereby mainly BEV are not just promoted by the government, OEMs will be forced to fulfil a rising quota on zero emission vehicles.
- 48V Hybrids will not get preferential treatment like NEV concerning licence plates, tax reductions, subsidies, entrance allowances and so on.
- Chinese customers a more willing to buy NEV than others.

- High demand on city vehicles, short range is sufficient.
- A lot of small cars in the cities, small engines are dominating the market. It is easier to substitute them with electric traction engines, but 48V traction engines are still too weak except for micro cars.
- The government itself has already defined pure electric vehicles openly and clearly as the intended future of mobility in the year 2012 (refer 3.3.4.4).

In Europe, the opposite is the case for most of these points. European manufacturers try to extend the lifetime of ICEs and, therefore, follow an electrification strategy with the centre of gravity on the ICE side: 48V systems.
Certainly, there will also be a 48V market in China, but it will be mainly satisfied by the same international Tier-1 powertrain suppliers with long lasting contracts, which also deliver the conventional powertrains at the moment.
Vice versa, the potential for high voltage EV in Europe shall not be underestimated either, as OEMs are forced to develop this technology for the Chinese market and also in order to comply with the upcoming strict CAFC regulations in the EU.

Summarized, both systems will be relevant in the future. Considering powertrain applications, AB-Mikroelektronik may have better chances in HV systems due to less competition (Note: applications for batteries are excluded from this statement). Furthermore, as mentioned before a global distinctive shift towards HV-EV is expected by around 2020.

Conclusion concerning traction inverter
Integration of the inverter into the engine/powertrain is the clear trend. Simultaneously, OEMs want to keep the know-how in house and Tier-1 suppliers strive for standard solutions. This could be a chance for AB-Mikroelektronik as a manufacturing partner. An own power module product for such inverters could be leveraged as a “door opener”.
The first approach should be a 400V power module, scalable in a power range of 40-100kW.

Conclusion concerning semiconductor battery protection switch
Market potential can only by enabled in case of economic competitiveness with mechanical relays. The technology is from strategic relevance for battery pack manufacturers, but considerations are in a conceptual phase. According to LG and Samsung SDI, the first approach should be a 48V pure power switch without integrated control electronics.
An intelligent power switch may be interesting for HV systems.

Conclusion on DC/DC converters
Experts clearly stated that it is too late for AB-Mikroelektronik to enter the market of complete DC/DC converters. This is a very complex but mature technology and the density of competitors is high. The know-how level at AB-Mikroelektronik is low.
On subcomponent level, power modules for FC DC/DC converters fit to the core competence of AB-Mikroelektronik. The market potential for this application becomes interesting by 2025.

Conclusion about market consolidation

The Chinese government is striving for market consolidation towards a few big, strong and international competitive manufacturers of core technologies. This is valid for existing OEMs, but especially for emerging pure NEV-OEMs and for manufacturers of key NEV components such as battery system and electric powertrains.
Therefore, the government has set policies to the benefit of the strongest players in place. This strategy has brought forth two of the five biggest battery suppliers of the world: BYD and CATL.

Conclusion about potential customers

Historic policies have forced foreign OEMs to engage JV but haven't done so with supplier companies. For that reason, foreign Tier-1 suppliers are still dominating the Chinese market. There are numerous Chinese lower Tier suppliers for simple components, but on Tier-1 level the development has started just recently with a focus on key components for NEVs. For battery systems, with BYD and CATL strong enterprises have already been established. Concerning electric powertrain suppliers, this is not clear so far. The MINTH or APG group or Santroll may develop into such strategic suppliers.

That means, except for those few local Tier-1s, the majority of potential customers for AB-Mikroelektronik in China are the OEMs themselves and the international Tier-1 suppliers. Hence, the product level must be elevated towards Tier-1 level in order to gain attractiveness for OEMs.

Conclusion about business network

Personal networks are important prerequisites for business in China, but the creation of such networks takes a lot of time. Engaging local business agents with existing networks at hand could help short cutting the market entrance efforts.

Conclusion about corporate appearance

Chinese employees on every customer interface are important. This is a prerequisite for being perceived as a Chinese company, but also to make frequent visits and the establishment of personal relationships possible and of course to prevent cultural misunderstandings in negotiation processes. Hence, a Chinese sales, field-application, but also at least an adaption development team are of vital importance, because good personal relationships are not sufficient if the technical competence is missing at the negotiation table.

Conclusion about the importance of cooperation with universities

Chinese Universities are heavily interconnected with the economy. The government wants to deepen cooperation between universities and enterprises in order to achieve innovative progress. Establishing contact to universities could be very beneficial to create business relationships and also to stay informed about technological and market trends.

A good opportunity would be to take advantage of the cooperation between the TU Graz and the Tongji University in Shanghai. Bachelor- or Master Thesis in various constellations, with

participation of Chinese students or dispatching Austrian students, are possible. Suppliers, competitors and potential customers like Infineon, KEBODA, AVL and Re-Fire are cooperating with the Tongji University as well.

Conclusion concerning customer specific development business model

Chinese OEMs are not willing to pay for development costs, especially foreign costs are not competitive. The business model of customer specific development is difficult; standardized products have better chances for success. AB-Mikroelektronik has experienced that and experts have confirmed the same.

For that reason, the decision has been made that an own standard product shall be developed during the work on this thesis. The next chapter will support the decision process.

4.2 Product strategy

In conclusion, the strategic decision process for the development of a new product is supported until process step two (selection of alternatives), according to the theory provided in chapter 2.3.

According to the conclusion about potential customers in chapter 4.1, a requirement to an own product is that it must be a component on module level that provides a functionality which is interesting for a broad, high-level customer base such as OEMs and big-player Tier-1s.

Although integrated HV-MCUs for ancillary units in FC applications have a high potential in the long term, such products do not fulfil the described requirement because a pump-manufacturer is needed in order to reach such a functionality level. The same applies to power modules for FC boost converters. The know-how to build whole boost converters is too low at AB-Mikroelektronik. However, following the hypothesis, own products for FCEV have been eliminated in the preselection because it is too early. The market potential is not interesting at the moment. For such applications, the existing business model shall be pursued. A strong promotion focusing on European, Korean and Japanese customers is suggested.

The following alternatives have been defined as possible own products:

- Bidirectional electronic battery protection switch for 48V systems (pure switch without current measurement), substitute for main relay (refer Samsung SDI, LG, CATL, Power Whise in chapter 3.6.4.3)
- Intelligent electronic battery protection switch for HV systems, unidirectional, substitute for pre-charge and main relay, inclusive current measurement (refer ISLE in 3.6.4.3)
- 48V traction inverter power module, optional with DC-link capacitors
- HV traction inverter power module, optional with DC-link capacitors

The basic requirements, namely USP and customer value for those products are fulfilled.

Traction inverter power modules already exist on the market, AB-Mikroelektronik would imitate the functionality. Hence, there is customer value as long as the price is competitive. Integrated DC-link capacitors enable further customer value and USP.
The customer value concerning electronic battery protection solutions is justified through:

- Electronic (solid state) switches allow far more switching cycles (practically unlimited) compared to mechanical relays (~two short current switching cycles). That enables security improvements and maintenance advantages, because worn relays do not have to be replaced anymore.
- This enables the integration of further functionalities such as charge balancing with a secondary battery or pre-charging with pulse-width-modulation
- Through that, the pre-charge relay can be eliminated in HV systems
- Weight reduction
- Potential customers have shown interest

Clear USP can be realized for each alternative through utilization of the core competence of AB-Mikroelektronik. Advantages are for example (values depending on the application):

- Better thermal conductivity than known competitive technologies
- Current surge capability due to high thermal capacity (Chip-Stacking)
- High power- and packaging density possible
- Low parasitic inductivity and more

Prioritization of the alternatives
All decision tools which were introduced in chapter 2.3 have to be conducted in a group of experts and authorized decision makers. Therefore, the documents were prepared as far as possible, but were elaborated in a workshop on the 1st of August 2017 at AB-Mikroelektronik.

Moderator: Philipp Höller
Participants: Hermann Hauser (General Manager)
Johann Maier (Director of product line power modules and control units)
Marcus Auer (Director Field Application)
Gerhard Köck (Manager new product introduction power modules)
Timo Huemer (SW/HW development engineering supervisor)

The main method for comparing the alternatives is the value-benefit-analysis (see 2.3.1). In order to keep the effort low and the result clear and comprehensible, it was decided to integrate the SWOT analysis (see 2.3.2) into the value-benefit-analysis. Following the suggestions of the theory chapter 2.3.2, the internal perspective is covered with a criteria checklist and “Porter’s Five-Forces” (2.3.3) are considered in the external environment assessment. Reference is made to the existing SWOT analyses in the strategy plan of AB-Mikroelektronik and to the core competences which have been examined in chapter 3.5.2.

Further, the decision was made to evaluate the alternatives regarding the global market potential. As argued in chapter 4.1, it can be assumed that the HV solutions have better chances in China whereas 48V applications are currently more interesting in Europe.

Objective of the decision process is to select a product with a high global sales potential that can be brought to market within reasonable time.

Table 25 shows the completed value-benefit-analysis according to the theory of chapter 2.3.1. Just even points were assigned in order to ensure a significant difference between the alternatives. The criteria group “market opportunities” was considered as the most important one, as it is the prerequisite for business opportunities.

Table 25: Value-benefit-analysis

					48V pure battery switch		Intelligent HV battery switch		48V inverter power module		HV inverter power module	
Criteria group	Group weight	Sub-criteria	Criteria weight	Resulting weight	Points [1-10]	Weighed points	Points [1-10]	Weighed points	Points [1-10]	Weighed points	Points [1-10]	Weighed points
Strength and weaknesses	25%	Know-How inhouse and ISLE	30%	8%	8	0,6	6	0,45	6	0,45	4	0,3
		Degree of specification awareness	25%	6%	8	0,5	6	0,375	8	0,5	6	0,375
		Degree of core competence utilization	5%	1%	8	0,1	10	0,125	8	0,1	10	0,125
		USP comparison (basic precondition)	5%	1%	10	0,125	6	0,075	10	0,125	8	0,1
		technological problems/risks	15%	4%	10	0,375	6	0,225	8	0,3	6	0,225
		possible production grade in China (market enabler)	15%	4%	6	0,225	6	0,225	6	0,225	8	0,3
		production capabilities and capacities available	5%	1%	6	0,075	6	0,075	6	0,075	6	0,075
Opportunities (market)	40%	market potential	35%	14%	10	1,4	10	1,4	6	0,84	10	1,4
		known (high) potential customers (entrance chances)	20%	8%	10	0,8	6	0,48	6	0,48	6	0,48
		standardisation opportunity	15%	6%	8	0,48	6	0,36	6	0,36	8	0,48
		unit price (* market potential ~ revenue)	10%	4%	4	0,16	8	0,32	6	0,24	8	0,32
		enabler of further orders	10%	4%	0	0	4	0,16	8	0,32	10	0,4
		profit margin	10%	4%	2	0,08	2	0,08	4	0,16	6	0,24
Threats (competitive environment)	20%	competitive rivalry	40%	8%	8	0,64	8	0,64	6	0,48	4	0,32
		Threats of new market entrants	10%	2%	2	0,04	2	0,04	2	0,04	6	0,12
		threats of new substitute products	10%	2%	2	0,04	2	0,04	10	0,2	10	0,2
		suppliers bargaining power	15%	3%	4	0,12	2	0,06	4	0,12	2	0,06
		customers bargaining power	15%	3%	8	0,24	8	0,24	4	0,12	4	0,12
		conflict with existing customers	10%	2%	10	0,2	10	0,2	8	0,16	8	0,16
Efforts/ Resource capacities	15%	time to market	90%	14%	10	1,35	8	1,08	8	1,08	6	0,81
		resource intensitiy	10%	2%	8	0,12	6	0,09	4	0,06	2	0,03
Result	**100%**		**400%**	**100%**		**7,67**		**6,74**		**6,435**		**6,64**

The realisation costs for a first prototype of these alternatives have been estimated separately by the same team. Table 26 shows a rough cost breakdown. The purpose is an estimation of the cost difference between the alternatives. There is no calculation behind, significant deviations are possible.

Table 26: Cost estimation

Cost estimation blocks	48V pure battery switch	Intelligent HV battery switch	48V inverter power module	HV inverter power module
Development costs	50000€	75000€	100000€	150000€
Invest costs (Tools)	10000€	20000€	20000€	30000€
Demonstrator costs	60000€	70000€	80000€	100000€
Sum Invest Costs	**120000**€	**165000**€	**200000**€	**280000**€

Figure 37 displays a visualisation of the value-benefit results on the y-axis combined with the rough invest cost estimation on the inverse x-axis. The ideal point would be in the top-right corner. It shows that a 48V battery switch has the most value-benefit points and the realisation costs are estimated lowest. A HV derivate could be considered subsequently, because the value-benefit is also high and the invest costs are second lowest. Furthermore, there are synergy-effects.
A power module for HV inverters would be interesting regarding the value-benefit points, but the realisation costs are high.

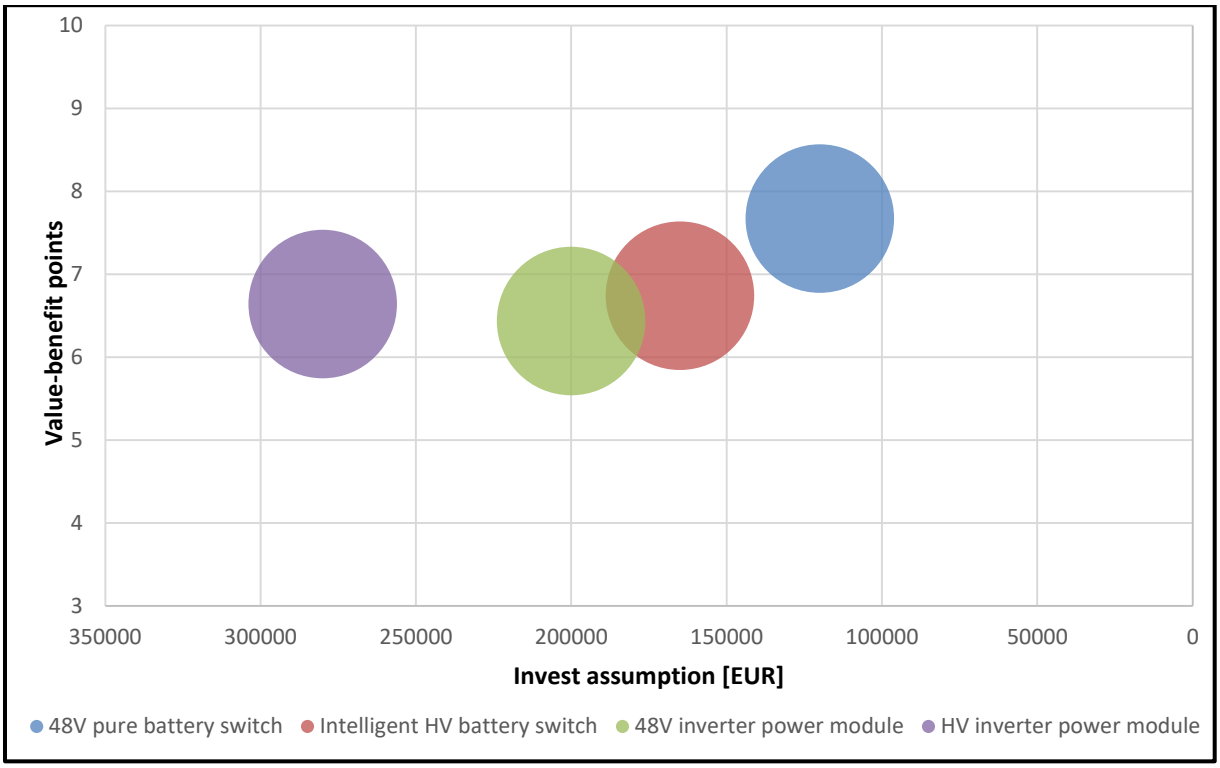


Figure 37: Visualisation of value-benefit results combined with invest cost assumption

4.3 Outlook

Chapter 4.1 provides the most important conclusions that have to be considered by AB-Mikroelektronik when doing business in China. The realisation of an own product will be decisive for the company as an entrance criterion for the Chinese market. Due to the results of chapter 4.2, a suggestion is to start with the development of a 48V battery switch. The contact to Samsung SDI, which has been established in terms of this thesis, should be used with the aim of a development cooperation.

The thesis shows that HV powertrains (BEV and FCEV) will gain importance quickly in China but also internationally with a few years delay. The enterprise has the right technology and product portfolio for this applications and should consequently focus on this emerging automotive market segments. Hence, a 48V battery protection switch should be leveraged for gaining application know-how and new customer relations with battery pack manufacturers. A HV derivate and maybe a HV inverter power module are the consequent next step.

Concerning the corporate appearance on the Chinese market, the company is on a good way. Chinese employees have been recruited for customer interface positions such as sales and field application in the last year. This teams should be promoted further on.
The creation of a business network could be accelerated by integration of local business consulters. In the long term a cooperation with local Universities such as the Tongji University in Shanghai may be beneficial. The connections of the TU-Graz to this University are a good opportunity and a further investigation on Chinese suppliers of NEV powertrain components would be an appropriate research topic.

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List of abbreviations

AC	Alternating Current
AHK	Außenhandelskammer (Deutschland)
Al_2O_3	Aluminium Oxide
AlN	Aluminium Nitride
BEV	Battery Electric Vehicle
BMS	Battery management system
BYD	Build Your Dreams (OEM brand)
CAAM	China Association of Automobile Manufacturers
CAFC	Corporate Average Fuel Consumption
CFCR	Corporate Fuel Consumption Regulation
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CPC	Communist Party of China
DC	Direct Current
DCB	Direct Copper Bonded
ECU	Electric Control Unit
EMC	Electro Magnetic Compliance
EPA	Environmental Protection Agency (USA)
EREV	Extended Range Electriv Vehicle
EV	Electric Vehicle
FC	Fuel Cell
FCEV	Fuel-Cell Electric Vehicle
FOC	Field Orientated Control
GDP	Gross Domestic Product
GM	General Motors (OEM brand)
GWM	Great Wall Motors (OEM brand)
HEV	Hybrid Electric Vehicle (comprises Micro, Mild- and Full Hybrid)
HV	High-Voltage

ICE	Internal combustion engine
IGBT	Insulatet-Gate Bipolar Transistor
IMS	Isolated Metal Substrate
IPM	Intelligent Power Module
IPR	Intellectual Property Rights
LV	Low-Voltage
MCU	Motor Controll Unit
MHEV	Mild Hybrid Electric Vehicle
MIIT	Ministry of Industry and Information Technology
MOSFET	Metal-oxide-semiconductor field-effect transistor
MPV	Multi Purpose Vehicle
NEDC	New European Driving Cycle
NEV	New-Energy-Vehicle
OEM	Original Equipment Manufacturer
ÖVK	Österreichischer Verein für Verbrennungskraftmaschinen
p.a.	Per annum
PATC	Pan-Asia Technical Automotive Center
PCB	Printed Circuit Board
PHEV	Plug-in Hybrid Electric Vehicle
PMSM	Permanent Magnetic Synchronous Machine
POE	Private Owned Enterprise
R&D	Research and Design
SAIC	Shanghai Automotive Industries Corporation (OEM brand)
SCM	Supply Chain Management
SOE	State Owned Enterprise
SUV	Sport-Utiliy-Vehicle
TFC	Thick-Film Copper
TFS	Thick-Film Silver
TIM	Thermal Interface Material

USP	Unique Selling Proposition
VW	Volkswagen (OEM brand)
WKO	Wirtschatskammer Österreich
WLTC	Worldwide Harmonized Light Vehicles Test Cycle
WTO	World Trade Organisation
ZEV	Zero Emission Vehicle
SW	Software
HW	Hardware

Appendix

Appendix 1: Interview Guideline

Table 27: Interview guideline

	primary questions	additional questions
goal 1	**The 13th five-year plan and the "made in china 2025" strategy both set ambitious targets for the automotive industry, but how do you think about the actual influence of those plans?**	**The main targets are a turnover of 1 Million NEV in 2020 and 3 Million in 2025, innovative and strong Chinese brands, increased export of cars and a world leading research level on key systems like batteries and electric engines with 80% market share. How realistic are those targets in your opinion?**
		What legislation changes will have the biggest impact on the automotive industry within the next 5 years?
		Do you know if there are any new or stricter quality- or security regulations with high cost impact to be introduced in the next years? Maybe something like functional security ISO 26262?
	According to the "Made in China 2025 strategy", the Government wants to foster all types of new energy vehicles. Except stricter emission regulations and admission restrictions for conventional cars, which other measures are planned by the government in order to reach that goal?	**Are there any OEMs and supplier companies, which are specifically promoted? For example with subsidies to NEVs?**
		According to the 5 year plan, small and medium high tech enterprises should be supported. Are there also subventions to foreign owned enterprises and how to get access?
		According to the "opening up" strategy, China wants to increase the import on advanced technologies and make the market access easier. Are there any opportunities or incentives for AB-Mikro resulting out of that?
goal 2/3	**A core competence of AB-Mikro is the integration of intelligent power electronic modules in very small space with excellent thermal management for extreme conditions.** **Running applications are for example cooling pumps, compressors, separators for exhaust gas treatment or crank case ventilation with integrated MCU up to 1kW power. In other words, everything around electrification of ancillary aggregates.** **Utilizing such systems, significant efficiency improvements and emission reductions can be achieved.** **AB-Mikro can act as a Tier 1 or Tier 2 development and supplier.** **How would you evaluate the market potential for the electrification of ancillary aggregates in China?**	**Do you know tier 1 supplier companies, which are active in that field of application in china?**
	Furthermore, AB-Mikro develops and produces high power DC/DC converters, electronic high current protection switches and Engine Control Units with outstanding power density and extreme operating condition capability up to in wheel drive applications for NEV. **How would you evaluate the current and future market potential for such technologies in China?**	Do you know established vendors for such technologies in China?
		Which supplier companies are producing battery management systems and which one are assembling complete battery systems?
	Which technological strategies are pursued by Chinese OEMs in order to cope with the upcoming emission restrictions? 48V Mild Hybrid, or high voltage full and plug in hybrid systems?	Are there any possible applications for technologies of AB-Mikro coming to your mind?
goal 3	According to the "made in China 2025 strategy", the reputation of Chinese brands should overtake Joint venture brands by 2025. **How would you evaluate the development potential of Chinese brands compared to foreign JV brands?**	**The sales figures of NEVs and the market share of Chinese brands on them is already impressive today. Considering NEVs, which OEMs are the most promising ones in your opinion?**
		From a technological point of view. Are Chinese NEV OEMs really so sophisticated that they could be dangerous for foreign JVs, or could that be an artificial hype?

	Do you think it is promising to aim for business relations with Chinese OEMs and supplier companies, or should an enterprise like AB-Mikro focus on JV and foreign suppliers?	If yes: Should it focus on private owned OEMs like Geely, GWM or BYD or own state owned ones like Chery?
		There should be a strong trend to SUVs and MPVs in China. Do you know where local SUVs manufacturers like GWM get their engines from and could those manufacturers be forced to cooperate with foreign suppliers like AB-Mikro in order to comply with the coming consumption and emission legislation?
	The "made in china 2025" strategy explicitly comprises fuel cell cars. Which OEMs are developing such vehicles?	**How do you evaluate the long term market potential of fuel cell cars on the Chinese market?**
	Are independent Chinese tier 1 suppliers capable of developing key components like high sophisticated inverters for modern NEV on their own today?	Which suppliers are the most important in your opinion?
goal 4	**How should an European supplier enterprise appear in order to have the best business chances in China? Do you think the TT Electronics site in Suzhou with factory, sales and engineering will be perceived as a Chinese enterprise or should a cooperation with a Chinese owned company be entered?** Henry, Leo: Are we perceived as a Chinese company?	**What is the best way to get contact with potential Chinese customers and how to find the decision makers?**
		How to initiate business in order to achieve contracts? What are the most common problems?
		What must be considered when negotiating contracts?
		What are the key-success factors for automotive suppliers in China?
		What are the most common problems occurring in business relations between Chinese and western companies?
Secondary goals	How would you evaluate the R&D competence and innovation capability of Chinese OEMs and Tier1? Is it still based on reverse engineering and merging and acquisition?	
	The government wants to introduce a modern intellectual property right system. How can technologies be protected in an effective way today and in future?	
	Do you know potential local competitors for technologies of AB-Mikro?	
	Well, now I am done with my questions. Do you have another important hint for me out of your experience?	

Appendix 2: Top 30 list of passenger NEV sold in 2016

Table 28: Top 30 list of passenger NEV sold in 2016[269]

Rank	Brand	model	E-grade	segment	max. electric power [kW]	2016	2016 share on PNEV
1	BYD	Tang	PHEV	SUV	2*110	31405	9,35%
2	BYD	Qin PHEV	PHEV	D	110	21868	6,51%
3	BYD	e6	BEV	MPV	90	20605	6,13%
4	Zhidhou	D1/D2	BEV	A		20392	6,07%
5	BAIC	E-Series	BEV	B	53	18814	5,60%
6	BAIC	EU 260	BEV	D	100	18805	5,60%
7	Geely	Emgrand	BEV	D	95	17181	5,11%
8	Zotye	Z100/Cloud	BEV	A	18	16417	4,89%
9	Chery	eQ	BEV	A		16017	4,77%
10	BYD	e5	BEV	D	41,8	15639	4,65%
11	JAC	J3 iev	BEV	B		15409	4,59%
12	SAIC Roewe	e550	PHEV	D	67	15145	4,51%
13	Zotye	E200	BEV	A	17,6	13154	3,91%
14	JMC	E100	BEV	A	7,5	10823	3,22%
15	BYD	Qin EV300	BEV	D	160	10656	3,17%
16	Tesla	Model S	BEV	E		7548	2,25%
17	Kandi	K17 Cyclone	BEV	B	35	6862	2,04%
18	Changan	Eado	BEV	D	90	4839	1,44%
19	JMC	E200	BEV	A	30	4712	1,40%
20	BAIC	EX200	BEV	SUV	53	4534	1,35%
21	Dongfeng Junfeng	ER30	BEV	MPV	58	4347	1,29%
22	BAIC	EC180	BEV	B	30	4128	1,23%
23	Lifan	330	BEV	B	30	4047	1,20%
24	Zotye	5008(T200)	BEV	SUV	27	3957	1,18%
25	Chery	Arrizo 7	PHEV	D	55	3643	1,08%
26	Zotye	E30	BEV	A	18	3471	1,03%
27	Kandi	K10 & K11	BEV	A		3384	1,01%
28	GAC	Trumpchi GA5	EREV	E	31	3378	1,01%
29	SAIC Roewe	e950	PHEV	E	60	3377	1,01%
30	Porsche	Cayenne	PHEV	SUV		2963	0,88%

[269] (EVVolumes.com, 2017), (ChinaAutoWeb, 2017)

Appendix 3: Primary data analysis procedure

Crossed out text in the second abstraction level is not irrelevant, but redundant. The abbreviation “n.a.” means not applicable.
The yellow bars indicate a new group of questions referring to the interview guideline.

Table 29: Primary data analysis procedure acc. to Mayring

P.	Paraphrasing (Z1)	Abstraction (Z2)	ref. Res.
	The 13th five-year plan and the "made in china 2025" strategy both set ambitious targets for the automotive industry, but how do you think about the actual influence of those plans?		
b	Chinesische Regierung kleckert nicht, sie klotzt. Es wird mit Zuckerbrot und Peitsche gearbeitet.	Chinesische Regierung kleckert nicht, sie klotzt. Es wird mit Zuckerbrot und Peitsche gearbeitet.	3.3
	Bei den letzten Jahresplänen gesehen, dass Chinese sehr stark in Umsetzung sind. Sagens nicht nur, die tuns.	Bei den letzten Jahresplänen gesehen, dass Chinese sehr stark in Umsetzung sind. Sagens nicht nur, die tuns.	
	Forderung nach gesünderer Umwelt für lokale Bevölkerung großes Thema. Luft und Lebensmittel sind größtes Thema. Mittelschicht in Shanghai sehr breit und die Wünscht das.	Große Mittelschicht in Shanghai erwartet bessere Luft	
	Saubere Mobilität wird daher gewünscht.	Saubere Mobilität gewünscht	
	In EU geht das alles schleppender weil man jeden Tag einen blauen Himmel sieht. Hier spürt jeder, dass sich was ändern muss.	In EU schleppender, weil jeden Tag blauer Himmel. In China spürt jeder, dass sich etwas ändern muss.	
c	Jahresplan nur generelle Ziele, Made in China 2025 eher techn. Leitfaden in Anlehnung an Industrie 4.0. Dann gibt es Durchführungsbestimmung. Gibt 13. automotive Jahresplan als ppt von CAAM, nur chinesisch, auch nicht konkreter als: NEV als besonders zu Fördernder Sektor, Fahrplan dass Konventionelle durch NEV ersetzt werden sollen. Auch smart connected cars. Umsetzung obliegt OEMs. Ziele aber realistisch.	Umsetzung obliegt der Wirtschaft, aber die Ziele sind realistisch.	
f	fördert NEV, aber geringe Effizienz der einesetzten Mittel, weil verteilt über so viele OEMs.	fördert NEV, aber geringe Effizienz der einesetzten Mittel, weil verteilt über so viele OEMs.	
g	Made in China 2025 ist mit Industrie 4.0 vergleichbar, das Ziel ist das Niveau der Industrie zu erhöhen, dabei speziell automotive und dabei NEV sektor	Made in China 2025 mit Industrie 4.0 vergleichbar, Industrielles Niveau soll erhöht werden. Schwerpunkt autotive NEV Sektor.	
	Deutsche und japanische Hersteller haben 100 Jahre Erfahung mit ICE, diese Länder wollen ICE am Leben halten, China hat das nicht! China kopiert das nur, jeder OEM macht das, abder die Kernkompetenz liegt bei den Tier 1. Daher verwenden alle chin. OEM mehr Ressourcen auf NEV. Die Regierung unterstützt das auf Cash und STeuer seite.	Anders als deutsche oder japnische Hersteller hat China nicht 100 Jahre Erfahrung mit ICE, chinesische OEMs kopieren hier und Kernkompetenz liegt bei Tier 1. Chinesische OEM setzen Ressourcen auf NEV, Regierung unterstützt mit Cash, Steuern und Gesetzgebung.	
	große Städt wie Shanghai und Beijing drücken sehr stark gegen konventionelle, Teure Lizenzen	große Städte zB mit teuren Lizenzen gegen konventionelle KFZ	
	The main targets are a turnover of 1 Million NEV in 2020 and 3 Million in 2025, innovative and strong Chinese brands, increased export of cars and a world leading research level on key systems like batteries and electric engines with 80% market share. How realistic are those targets in your opinion?		
a	Denke mit den NEV Lizenzen sind vielleicht Förderungen verbunden, Tier 1 bekommen sie vielleicht indirekt?	nicht relevant, reine Vermutung	3.3
b	erachte ich nicht für unwahrscheinlich	Realistisch	

	Strategie war in den letzten Jahrzehnten immer die gleiche: Man suchte sich Partner, saugte das Wissen ab und hat sich dann getrennt.	Strategie der letzten Jahrzehnte: Wissen von Partnern absaugen, dann Trennung	
	Beispiel Hochgeschwindigkeitszüge: Früher hat man gelacht, heute hat China längstes Netzwerk und alles wird im Land gebaut, nichts mehr importiert. Daher glaube ich, die werden 3 Millionen NEV 2025 bauen.	Bsp Hochgeschwindikeitszüge: China heute längstes Netz, alles lokale Herstellung, kaum import. Früher haben alle gelacht. Daher, die werden 3 Millionen NEV 2025 bauen.	
	Die Frage ist, gewinnt die BEV Technologie oder FC? Die nächsten 10 Jahre aber sicher BEV.	Die nächsten 10 Jahre BEV, dann kommt sicher FCEV	
c	Ziele realistisch. China schon seit Jahren Pionier in Elektromobilität. In Shanghai will jeder Auto, Elektroauto sind schon billiger wegen Förderung.	Ziele realistisch. China schon seit Jahren Pionier in Elektromobilität.	
d			
e	wenn man die Entwicklung in den letzten Jahren bedenkt, dann ist die Million NEV in 2020 sicher realistisch	Angesichts Entwicklung der letzen Jahre, 1 Mio NEV 2020 realistisch	
	Der Fokus der Regierung liegt definitv auf pure EV, nicht auf PHEV.	Regierung Fokus definitiv auf pure EV, nicht PHEV	
f	Es gab aber viele Fake-Verkäufe um die NEV Statistik zu schönen. Lifan oder auch Jinglung, der führende NEV Bus Hersteller hat betrogen, wurden bestraft. Man muss mit Statistik aufpassen.	Es gab aber viele Fake-Verkäufe um die NEV Statistik zu schönen. Lifan oder auch Jinglung, der führende NEV Bus Hersteller hat betrogen, wurden bestraft. Man muss mit Statistik aufpassen.	
	Man hat PHEV gefördert, aber Leute wollen die nicht wirklich, die wollen Lizenz. Die Elektrische Funktion wird gar nicht verwendet. Daher wird jetzt die PHEV Förderung stärker zurück gefahren und ein Fokus auf BEV gelegt, auch seit kurzem mehr Fokus auf FCEV. SAIC ist der einzige den ich bisher mit FCEV kenne, die besitzen Sunrise und die entwickeln FC.	Man hat PHEV gefördert, aber Leute wollen die nicht wirklich, die wollen Lizenz. Die Elektrische Funktion nicht verwendet. Daher wird jetzt die PHEV Förderung stärker zurück gefahren und ein Fokus auf BEV gelegt, auch seit kurzem mehr Fokus auf FCEV.	
	Ziele dennoch sehr realistisch.	Ziele dennoch sehr realistisch.	
g	Ja das wird kein Problem sein wenn die Regierung das sagt. Verweis auf das Beispiel Hochgeschwindigkeitszüge, das hat auch keine geglaubt. Außerdem wäre das immer noch ein kleiner Marktanteil.	Wird kein Problem sein, Regierung verlässlich, Beispiel Hochgeschwindigkeitszüge	
h	Realistisch, aber man muss genau schauen was sind alles NEV. Sind da Microcars und Dreiradler dabei? Wenn Gesamtumfang gemeint, dann hat man das bald erreicht! Wandel geht schnell, wie man bei Motorrädern gesehen hat.	Realistisch. Schnell erreicht wenn auch Microcars inbegriffen.	
i	Sehe starken NEV Trend in China	Starker NEV Trend	
	What legislation changes will have the biggest impact on the automotive industry within the next 5 years?		
a	Limitierung für Benziner Nummerntaferl haben wir schon.	Nummerntaferl Limitierung bei konventionellen	3.3
	Generelle Verbannung von ICE in Ballungsräumen wird sicher auch kommen. Diese Änderungen kommen in China sehr schnell.	Verbannung konventionelle aus Ballungsräumen absehbar, Änderungen kommen sehr schnell in China	
e	BYD Tang war das erfolgreichste PHEV Fahrzeug im letzten Jahr. Monster Sportwagen um nur 30k EUR wegen starker Subvention und gratis Nummerntafel. Letztes Jahr um 80k RMB für den Glücklichen, der eine Tafel für ein konventionelles Auto gewonnen hat. Diese Beschränkung gilt neben Shanghai auch in Guancho, Senzhen, etc. Dieses Subventionssystem wird aber jetzt zurück gefahren, dabei schneller für PHEV.	Nummerntaferl Limitierung bei konventionellen, massive Subventionen - die werden aber zurück gefahren	
	Gleichzeitig kommt ZEV Credit Programm, dadurch viel mehr Anreiz für OEMs zur NEV Produktion. Wenn zu wenig Absatz droht Produktionsdrosselung.	statt Subventionen kommt Credit Programm ähnlich ZEV - Produktionsdrosselung bei Nichterfüllung!	

	Förderung geht direkt an OEM, aber voll vom Kaufpreis abgezogen. Höhe siehe Excel Liste. Förderung nur für OEM mit Lizenz die ihr Modell auch vor produktion freigeben haben lassen, es gibt auch nicht lizenzierte OEM in den Provinzen.	Nur Modelle mit Marktfreigabe und OEM mit NEV Lizenz förderbar (gibt nicht lizenzierte OEM in Provinzen)	
	Ab heuer grüne Tafeln für NEV.	Grüne Taferl für NEV (Restriktionen für andere zu erwarten)	
f	Lizenz Limitierung für konventionelle Autos in großen Städten.	Lizenz Limitierung für konventionelle Autos in großen Städten.	
g	Endziel ist die Reduktion von Emissionen, das verfolgt die Regierung mit Nachdruck.	Endziel Emissionsreduktion, verfolgt von Regierung mit Nachdruck.	
	Autonomes Fahren und Fahrzeug Konnektivität ist auch ein großes Thema, das die Regierung starkt treibt. Internetunternehmen wie Huawei oder Alibaba sind da auch schon eingestiegen, teilweise auf Druck der Regierung.	Neben NEV sind autonomes Fahren, Fahrzeugkonnektivität große Themen. Internetunternehmen wie Huwawei und Alibaba in Kooperationen mit OEMs eingestiegen.	
k	NEV Strategie von Audi gar nicht so China spezifisch, weil die politischen Strömungen überall (Emission, Verbrauch) ähnlich sind.		
l	Europa: Bis 2030 wird ein Marktanteil von ca. 50% NEV notwendig um die CO2 Gesetzgebung einhalten zu können. Daimler und BMW wollen 2025 25% EV verkaufen.		
	Do you know if there are any new or stricter quality- or security regulations with high cost impact to be introduced in the next years? Maybe something like functional security ISO 26262?		
			3.3
a	ISO 26262 ist noch kein Thema, das ist alles billig. Wenn das kommt haben die ein Problem mit ihrer Technologie. Protean hat das System nicht umsonst komplex entwickelt.	ISO 26262 noch kein Thema. Wenn kommt haben lokale Problem, weil zZ alles so simpel wie möglich. Absehbar, Protean schon vorgesehen. CHANCE	
b	Schwierigkeiten zu Beurteilen. Aber heute kann man internationalen chin. Firmen wie Huawei keine minderwertige Qualität mehr liefern.	Internationalen chinesischen Unternehmen wie Huawei kann man heute keine mindwertige Qualität mehr liefern	
	Bzgl. Funktionaler Sicherheit wird China sicher den gleichen Weg gehen,wie EU. Zeit kann nicht abgeschätzt werden.	~~Bzgl. Funktionaler Sicherheit wird China sicher den gleichen Weg gehen,wie EU. Zeit kann nicht abgeschätzt werden.~~	
e	kein Wissen darüber		
f	ISO26262 ist sogar schon Thema, aber nicht für billige Autos	ISO26262 ist sogar schon Thema, aber nicht für billige Autos	
g	Ja es sollen Standards entwickelt werden, Universitäten und Unternehmen sollen diese gemeinsam unter Führung der Regierung erarbeiten. Es werden aber eher nur lokale Unternehmen eingebunden, weniger JV. Das läuft auch heute schon so. Funktionale Sicherheit wird als wichtig angesehen.	Ja, Standards werden von Universitäten gemeinsam mit vorwiegend lokalen Unternehmen unter Anleitung der Regierung erarbeitet. Funktionale Sicherheit wichtig.	
h	Ist ein Thema, weil sich Chinesen grundsätzlich an EU bei Gesetzgebung anlehnen. Noch gibt's das nicht, weil Know-How differenz zu groß, also Wirtschaftlicher Schaden befürchtet. Es ist ein Potenzial bzw. Vorteil nach ISO entwickeln zu können.	~~Wird Thema sein wenn Know-How Rückstand verkleinert. Daher Vorteil wenn man ISO beherrscht.~~	
	According to the "Made in China 2025 strategy", the Government wants to foster all types of new energy vehicles. Except stricter emission regulations and admission restrictions for conventional cars, which other measures are planned by the government in order to reach that goal?		
			3.3
b	Es gibt kein Land auf der Welt, das so technologiefreundlich ist wie China. Da bezahlt schon jeder Bargeldlos. Consumer Base ist neuer Technologie sehr aufgeschlossen.	Consumer Base in china ist neuer Technologie sehr aufgeschlossen, jeder bezahlt schon Bargeldlos in Shanghai.	
	Grüne Nummernschilder auf NEV seit ein paar Wochen auf den Straßen. Zumindest in Shanghai wird es Benutzungsbeschränkungen für andere KFZ geben, nicht aber für NEV.	~~Seit kurem grüne Nummernschilder für NEV, Benutzungsbeschränkungen für andere KFZ in Shanghai werden folgen.~~	

c	NEV bereits billiger wegen Förderungen: Jede Stadt hat Liste welche Modelle wie gefördert werden. Meist chinesische Marken, aber auch BMW, Tesla.	NEV wegen Förderungen bereits billiger als als konventionelle.	
	Lizenz für konventionelle Auto beschränkt, teuer, man wartet lange. Für Elektroauto nicht.	Lizenz für konventionelle Auto beschränkt, teuer, man wartet lange. Für Elektroauto nicht.	
h	Städte überlegen, dass konventionelle nicht mehr hinein fahren dürfen, Viertel (Shanghai) gibt es schon in denen Einfahrt für private ICE verboten	Bann konventioneller KFZ aus gewissen Städten überlegt. Zonenweise bereits Realität (ausgenommen Taxi)	
	ICE wird schnell aus gewissen Bereichen ausgeschlossen werden	~~Auschluss ICE aus gewissen Zonen~~	
	Are there any OEMs and supplier companies, which are specifically promoted? For example with subsidies to NEVs?		
a	Cleanwave sagt er hat die 5. NEV Lizenz bekommen.	Cleanwave behauptet 5. NEV Lizenz bekommen zu haben (Anm. von 10 seit 2016)	3.6
d	NEV Lizenzen: Fast jeder OEM hat NEV Lizenz, lt. Medienberichten sollen es mehr als 200 Lizenzen sein. 2016 haben Behörden angekündigt nur noch 10 neue NEV Produktionslizenzen zu vergeben um zu konsolidieren. Siehe Link welche das sind.	NEV Lizenzen: Fast jeder OEM hat NEV Lizenz, lt. Medienberichten sollen es mehr als 200 Lizenzen sein. 2016 haben Behörden angekündigt nur noch 10 neue NEV Produktionslizenzen zu vergeben um zu konsolidieren. Siehe Link welche das sind.	
e	Mein Wissen ist auf OEM Level. Nehme aber an, dass Zulieferer auch bevorzugte Behandlung genießen wenn sie qualitativ entsprechende NEV Komponenten liefern. Die Qualität wird überprüft, wenn nicht eingehalten kann aber auch die Produktion geschlossen werden.	Kann sein. Jedenfalls wird Qualitätsstandard geprüft, strafen bei nicht Einhaltung bis zu Schließung der Produktion.	
f	existierende OEMS werden fair behandelt	existierende OEMS werden fair behandelt	
	(vermutung: Existierende OEMs wie BYD, SAIC, etc. können EV produzieren auch wenn sie keine eigene EV Marke schaffen) Neue NEV Firmen benötigen Lizenz. Aus dem Kontingent von 10 neuen wurden vergeben: event, BJEV (BAIC), Changjiang EV, Cherynewenergy (Kandi?), Jiangsu mingan (MINTH group, link zu cleanwave), JMC EV, Wanxiang group (link zu A123 und karma USA)	(vermutung: Existierende OEMs können EV produzieren) Neue benötigen Lizenz. vergeben: event, BJEV (BAIC), Changjiang EV, Cherynewenergy (Kandi?), Jiangsu mingan (MINTH group, link zu cleanwave), JMC EV, Wanxiang group (link zu A123 und karma USA)	
g	Ob Changan, SAIC, BAIC, FAW, etc. das sind alles SOE. Es gibt nur zwei wirklich unabhängige OEM in den top ten, das sind GWM und Geely. Weiß nicht genau, aber denke Regierung oder lokale Regierung wird alle SOE unterstützen. Aber auch das Geld mit dem Geely Volvo gekauft hat kommt alles von der Regierung (indirket über Bank). Der Geely Eigentümer hat starke familiäre Beziehungen zur Zentralregierung. Anders GWM, verwendet seine Technologie, ist stark bei SUV und die Regierung respektiert die. BYD ist auch eigenständig, hat aber auch sehr viel Unterstützung von der Regierung bekommen.	Zentral oder Lokalregierungen unterstützen alle SOE wie Changan, SAIC, BAIC, FAW, etc. Top POEs sind nur BYD, GWM und Geely. Geely hat Geld für Volvo Kauf von Regierung bekommen, Eigentümer hat Familienbeziehnung zu Regierung. BYD auch stark unterstützt. GWM am wenigsten, setzt auf Technik und wird von Regierung respektiert.	
	Die Förderungen sind lokal sehr Unterschiedlich, Shanghai zB fördert SAIC doppelt so stark wie BYD.	Förderung lokal Unterschiedlich, Bsp Shanghai bevorzug SAIC stark.	
h	Lizenzen: ein Mittel um den Überblick zu bewahren wer was macht und um Kooperationen zu erwirken. Kein konkretes Wissen über Verteilungskriterien. China KEINE freie Marktwirtschaft (mehr schon)	Mittel zur Marktkontrolle, kein Wissen über Vergabekriterien	
	According to the 5 year plan, small and medium high tech enterprises should be supported. Are there also subventions to foreign owned enterprises and how to get access?		

b	Man kommt auch als ausländisches Unternehmen an die Fördertöpfe, aber nur wenn man R&D hier macht. WKO kann dabei helfen, wenn nicht, dann die deutsche Handelskammer weil die sind sehr groß in Shanghai.	~~Wenn R&D in China bekommt auch ausl. Unternehmen Förderung. WKO hilft.~~	
e	Ausländer sind hier um zu Investieren und Technologie zu bringen, Förderungen von der Regierung bekommt man sicher nicht.	Ausländer sind hier um zu Investieren und Technologie zu bringen, Förderungen von der Regierung bekommt man sicher nicht.	
f	da geht es hauptsächlich um die Zugang zu Krediten, das betrifft ausländische Unternehmen eher nicht.	da geht es hauptsächlich um die Zugang zu Krediten, das betrifft ausländische Unternehmen eher nicht.	
	According to the "opening up" strategy, China wants to increase the import on advanced technologies and make the market access easier. Are there any opportunities or incentives for AB-Mikro resulting out of that?		
a	Bezieht sich wahrscheinlich nur auf Firmengründungen.	Bei Neugründung evtl.	3.3
c	Ausländische Investitionen werden lt. Lenkungskatalog eingeteilt in gefördert, beschränkt und verboten. Wenn gefördert, bsp günstige Grundstücke. Das Aufstellen bzw. die Einfuhr neuer Produktionslinien in ein bestehendes Werk kann steuerfrei sein (aber nur Einmalig, bei Neuprodukt eher nicht mehr, prüfen).	Ausländische Investitionen werden lt. Lenkungskatalog eingeteilt in gefördert, beschränkt und verboten. Wenn gefördert, bsp günstige Grundstücke. Das Aufstellen bzw. die Einfuhr neuer Produktionslinien in ein bestehendes Werk kann steuerfrei sein (aber nur Einmalig, bei Neuprodukt eher nicht mehr, prüfen).	
	Bei Patentanmeldung: Es gibt Patenthighway zwischen Österreich und China. Es gibt dafür Förderung von WKO oder öterr. Patentamt. WKO berät auch.	Bei Patentanmeldung: Es gibt Patenthighway zwischen Österreich und China. Es gibt dafür Förderung von WKO oder öterr. Patentamt. WKO berät auch.	
e	Chinesische Investoren versuchen Europäische Unternehmen, Know How, Personal zu kaufen.	Chinesische Investoren versuchen ausländische Unternehmen, Know How, Personal zu kaufen.	
f	ja es gibt bestimmte Liste mit bevorzugten Produkten die Zoll und Steuervorteile haben.	ja es gibt bestimmte Liste mit bevorzugten Produkten die Zoll und Steuervorteile haben.	
	How would you evaluate the market potential for the electrification of ancillary aggregates in China?		
a	Werden wohl Optimieren müssen, kaufen aber eher Komplettsysteme von Bosch, Conti etc.	ICE müssen wohl optimiert werden, Chinesen kaufen aber Komplettsysteme von Bosch, Conti, etc.	3.6.1
b	Will China vorallem die Effizienz von ICE steigern oder NEV fördern? Zögerlich: Glaube man hat gute Chancen mit solchen Systemen.	Wenig Erfahrung: glaube gute Chance mit solchen Systemen in China	
	Aber, glaube man hat mit NEV mehr Chancen als mit Optimierung von ICE.	Bessere Chancen sicher mit NEV!	
c	Chinesische OEMs sind sehr schwach bei ICE Motorenentwicklung, Fahrzeugsicherheit, teilweise auch schwach bei Batterien bzw. auf ausländer angewiesen. AVL hat Fahrzeugsicherheitstest für Qoros gemacht und engineering auch. Stärke ist der Markt.	Chinesische OEM schwach bei ICE Entwicklung, angewiesen auf ausländische Entwicklungspartner wie AVL.	
e	Die Frage ist ob die USP groß genug ist für die chinesischen OEMs um sie zu kaufen. Weiß zwar nicht über diese Komponenten, die werden jetzt aber sicher in china zu Billigpreisen gekauft, wenn auch vielleicht nicht elektrisch.	Nur Chancen mit sehr guter USP und billigem Preis.	
f	Das Geschäftsmodell kundenspezifisch zu Entwickeln kommt nicht gut an, die Kunden bevorzugen fertige Produkte aus dem katalog.	Das Geschäftsmodell kundenspezifisch zu Entwickeln kommt nicht gut an, die Kunden bevorzugen fertige Produkte aus dem katalog.	

g	Es gibt eine Roadmap zur Effizienzsteiguerng von ICE, aber die ist nur auf 5 Jahre angelegt, langfristig werden die Resourcen sehr stark auf NEV gesetzt werden. Bei ICE werden Tier 1 wie zB AVL, Bosch oder Continental mit der Entwicklung beauftragt. Die Entscheidung macht zwar der OEM, aber die Tier 1 wird gefragt, auch welche Zulieferer empfohlen werden. Dh wir brauchen jemanden der den OEM für uns beeinflusst, das geht über die Tier 1.	Nur kurzfristige Roadmap zu Effizienzsteigerung von ICE. Know How aber von AVL, Bosch, Conti, etc. Geschäft am besten über diese ausländischen Tier 1 anbahnen. Resourcen chin. OEM werden stärker auf NEV gesetzt!	
h	Elektrifizierung von konventionellen KFZ wird voranschreiten, weil Gesetzgebung Richtung Emissionsreduktion, aber starker Trend zu Vollelektrifizierung.	Elektrifizierung konventioneller KFZ wird voranschreiten, aber starkter Trend zu Vollelektrifizierung.	
	Hybrid wird nicht so verbreitet kommen wie in EU	Hybrid wird nicht so verbreitet kommen wie in EU	
k	Beim FCEV sind die ganzen Nebenaggregate wie Pumpen aus Sicht von Audi heikel.		
l	Bei Brennstoffzellen großer Bedarf an Elektrifizierung von Nebenaggregaten. Jetzt sind das noch OEM Eigenentwicklungen, Toyota hat auch Luftverdichter und Boost Converter selbst entwickelt. Wir sehen schon, dass die Zulieferer solche Komponenten auf das Thema aufmerksam werden.	**Bei FC großer Bedarf Elektrifizierung Nebenaggregaten**. Jetzt noch OEM Eigenentwicklungen. Wir sehen schon, dass die Zulieferer solche Komponenten auf das Thema aufmerksam werden.	
	Do you know tier 1 supplier companies, which are active in that field of application in china?		
a	Henry hat Liste mit Pumpenherstellern in China (Lee Burtelson hat Marktstudie für Pumpen und LED gemacht vor 3 Jahren), zB Shisha(?) die machen auch elektrische Pumpen mit 30W und sind mit 400W konfrontiert. Bei Shisha war ich schon 2 mal. Es scheiterte am Preis und an den Entwicklungskosten, wurde selbst entwickelt, war aber sehr einfache niedrig temperatur 30W Pumpe. Bei 400W integriert wären wir wieder im Spiel. Andere sind Yamada in Japan, GMB immer die bei 400W Unterstützung brauchen, 30W kann jeder. Unser Vorteile beziehen sich wegen Hoch Temp und und HV durch TF Technologie wegen Isolationsfestigkeit und Wärmeleitung, sowie unsere fertigen Plattformen. Konkurrenten sind Bosch, Conti, Borgwarner (USA), Magna (aber alle eher niedrige Leistung).Noch ist der Bedarf für höhere Leistungen und HV nicht da, wenn der kommt können wir richtig einhaken. Melixis (liefert ICs) ist sehr aktiv am chinesischen Markt und kennt die auch alle, Melexis hat uns auch unterstützt.	TT hat schon Marktstudie zu Pumpen und LED Lighting Zulieferer durchgeführt! Henry hat Liste! Bsp Pumpen: Shisha (CN), Yamada (Japan), GMB (Korea)Gescheitert an: Noch keine >400W Anwendung, niedrige Leistung ca. 50W kann jeder und billig (Bosch, Conti, Borgwarner, Magna, auch Shisha, etc.). Melixis (ICs) sehr aktiv in China, kennt HerstellerBei größerer Leistung und HV haben wir große CHANCE	3.6.2
b	Kein Ahnung bei Pumpenherstellern		
	Unsere Kunden sind Stellmotorenhersteller (Sitzverstellung etc.), das sind vorallem Johnson Electric, Bosch und japanische Hersteller, kein einziger lokaler Hersteller.	Unsere Kunden sind Stellmotorhersteller bspws für Sitze: Johnson Control, Bosch, japanische Hersteller, aber kenne keinen einigen lokalen Hersteller	
	Wir Sind noch in engine cooling fan drinnen, aber keine Pumpen	Littelfuse macht was für Engine Cooling fan, nichts für Pumpen	
f	nicht für Pumpen	nicht für Pumpen	
g	Wasserpumpen weiß ich nicht so genau. Borgwarner, Continental, etc. machen das. Es wird für uns besser sein mit bestehenden ausländischen Tier 1 zu arbeiten, die müssen den chinesischen OEM Vorschlag unterbreiten. Kenne keine starkten chinesischen Zulieferer. Aber die OEMs denken die ausländischen Tier 1 sind außer Kontrolle, weil die black box liefern die die OEMs nicht verstehen.	Kenne keine starken chin. Zulieferer bekannt, hauptsächlich in Hand von ausländ. Tier 1 wie Borgwarner, Conti, Bosch, etc.	
h	Hybridisierung Technik eher von ausländern angeboten und Know How von ausländischen Tier 1.	Hybridtechnik Know-How hauptsächlich von ausl. Tier 1	

	Auch China POE haben JV, kaufen Technologie und Know How für ICE Optimierung zu. In China aufwand gering, wenn dann holen sie sich AVL, etc. Antriebsstrang wird im Ausland entwickelt, aber Local sourcing von Zulieferern (Gesamtpackage)	Auch POE kaufen Technik und Know-How für ICE Optimierung zu. Enwicklungspartner wie AVL, aber Local Sourcing der Lieferanten auf Gesamtpackage Ebene	
	How would you evaluate the current and future market potential for such technologies (higher power product group) in China?		
a	Jedes NEV braucht Inverter, China sicher am stärksten wachsender Markt.	China am stärksten Wachsender NEV Markt, jedes NEV brauch Inverter	3.6.3
e	Inverter: Da habe ich ein sehr gutes Gefühl, habe so etwas in China noch nicht gesehen. Hier vermute ich ein großes Marktpotenzial bei NEVs.	Inverter: Da habe ich ein sehr gutes Gefühl, habe so etwas in China noch nicht gesehen. Hier vermute ich ein großes Marktpotenzial bei NEVs.	
	Kurzschlussschalter: Little Fuse hat sowas aber für Mobile Geräte, nicht für NEV. Chinesen machen NEV so einfach wie möglich, ich weiß es zwar nicht aber gehe davon aus, die nehmen Relais und die brauchen auch keine elektronischen Schalter wenn die teurer sind.	Kurzschlussschalter: Chinesen halten NEV so simpel und billig wie möglich, vermutet verwendung von Relais und noch ausreichend.	
	Anders wenn sie anfangen nach Europa zu exportieren, dann könnten sie sowas brauche. Geely fängt nächstes Jahr an über das Volvo Netz nach Österreich Geelies zu exportieren. Weiß ich sicher weil der Importeur mein Kunde ist.	Anders wenn Export nach Europa, Geely exportiert ab 2018 nach AUT	
	Geely sollte man ernst nehmen.		
f	Wachsende Chancen, aber unser Problem ist wieder, dass wir keine Standardprodukte haben.	Wachsende Chancen, aber unser Problem ist wieder, dass wir keine Standardprodukte haben.	
g	NEV sind sehr wichtig für chinesische Unternehmen.	NEV sehr wichtig für chin. OEM	
h	Elektrifizierung in 2 Gruppen Teilbar. 1. Antriebsstrang (Batterie, Leistungselektronik, EM) Anwendungen genannt	wichtigeste Technologie Anwendungen schon genannt	
	Sensorik im Antriebsstrang könnte noch interessant für uns sein, Positionssensoren für EM. Großer Forschungsbedarf, Institut mach viel, man ist auch auf der Suche nach Zulieferern.	Sensorik im Antriebsstrang (Positionssensoren) hat Potenzial. TU Fahrzeugtechnik Institut forscht und sucht Zulieferer.	
	Inverter für EM. Bis vor kurzem Modulartige Sache (Wegbau), das dreht sich auf Maßgeschneiderte Lösungen! Klarer Trend zu integrierten Lösungen, das ist schon fast Stand der Technik. Es gibt Potenzial Wirkungsgrad zu heben! Andere Lösungen für 50kW als für 200kW. Platzbedarf, Kühlung, Effizienz ist Potenzial, in Europa aber auf jeden Fall auch in China.	Inverter für EM waren bisher oft Wegbaulösungen, jetzt kundenspezifische Integration und Anbaulösung klarer Trend bzw. fast Stand der Technik. Hohe Potenziale, verbesserung: Wirkungsgrad, Platzbedarf, Kühlung! In Europa und China! Unterschiedliche Lösungen 50kW und 200kW andenken.	
	EM Trends: PSM unangefochten bis vor 3 Jahren, dann mehr ASM aus Kostengründen (Tesla macht nur ASM, auch Daimler B Klasse). ZZ wieder Richtung PSM. Wird eine Mischung werden.	EM Trends: Bis vor 3 Jahren klar PSM, dann ASM (Tesla, B-Klasse), jetzt wieder PSM. Wird Mischung werden!	
	Zweirad: Zug für Europäer nicht abgefahren, weil ein billiges Zweck-Motorrad in China mit max um 5kW technologisch nicht vergleichbar mit den Sportgeräten aus EU ist. Markt als Statussymbol vorhanden, auch Stückzahlen, aber keine große Durchdringung.	Potenzial auch bei Sport-Motorrädern! Als Prestige, td Stückzahlen, aber keine Durchdringung. In China nur max. um 5kW Zweck-Geräte.	
	Große Stückzahlen werden die 50-80kW BEV sein.	Größte Stückzahlen 50-80kW erwartet (BEV)	
k	Audi hatte Probleme mit Leistungselektronik als Wegbaulösung in bisherigen NEVs. Riesen Nachteile EMV, Verluste. Daher in Zukunft integriert oder direkt am Motors angeflansht.	Leistungselektronik als Wegbaulösung bringt massive Nachteile Verluste und EMV. Zukünftig nur mehr integriert oder am EM angeflansht.	
	Do you know established vendors for such technologies in China?		

			3.6.4
a	Minth Gruppe hat Cleanwave in Californien gekauft: Hatte schon prototyp Autos, will E-Drivetrain (Motor + Inverter) der in Californien entwickelt wurde an Chinesische OEM verkaufen. 1. Schritt: Cleanwave braucht vielleicht Fertiger in China, hat nur Prototypen in Californien. 2. Schritt mineatursierung mit unserem Power Modul. APG (bremsenhersteller) hat ähnliches vor, hat in slowenien ELAPHE (macht Inverter für in wheel drive system aber nicht integriert) gekauft und will E-Drivetrain Systeme, Komponeten daraus oder Lizenzen verkaufen.	MINTH Group hat CLEANWAVE (Californien) gekauft: Die haben E-Drivetrain (EM+Inverter) entwickelt, soll an chinesische OEM verkauft werden. Brauchen evtl. Fertiger in China, evtl. an Mineaturisierung (Chip Stacking Inverter) interessiert. APG (Bremsenhersteller) hat ähnliches vor, hat ELAPHE (Slowenien, Inverter in-wheel drive aber nicht in Rad), will System, Komponenten und/oder Lizenzen an OEM verkaufen.	
	unser Kunde Protean: Engländer, aber Eigentümer und Kunden sind Chinesen, Steigt bei Kleinstransportern in den Markt ein (GS hat Liste). Will auch Lizenzen verkaufen.	Protean (bereits Kunde): Steigt über Kleintransporter in China ein, will auch tlws. Lizenzen verkaufen.	
	BYD macht Inverter selbst, nutzt Infineon Hybrid Pack	BYD macht Inverter selbst, nutzt Infineon Hybrid Pack.	
	Kleine Startups haben jetzt kaum mehr Chance, weil sie die NEV Lizenz nicht mehr bekommen und daher ein Geldproblem haben.	Startups jetzt kaum mehr Chance, weil keine NEV Lizenzen mehr.	
	Verweis auf Liste mit Kontakten von MA	Verweis Liste bisheriger Kontakte MA	
e	Grundsätzlich kommt die Elektronik der Welt aus China. Wer aber ähnliches macht müsste man in einer Marktstudie herausfinden.	~~Verweis auf eigene Marktstudie~~	
f	DC/DC: Hella, Conti, Valeo, BYD Battery Protection Switch: Littelfuse	DC/DC: Hella, Conti, Valeo, BYD Battery Protection Switch: Littelfuse	
g	OEM wollen Batterie inkl BMS und Zellen, Control Unit und den Drivtrain inkl. Motor kontrollieren.	Chin. OEM wollen Know-How über Batterie (inkl. BMS und Zellen), Drivetrain und Vehicle Control Unit selbst kontrollieren.	
h	Inverter Integration: in EU: Magna auch mit Converter aber die integrieren sie, Bosch, Continental und ein paar andere die Integrieren. Ganz klar auch OEMs selbst! Inverter lieferanten selbst nicht bekannt, das wären dann wir.	Inverter Integration in EU: Magna, Bosch, Continental, etc. Ganz klar auch OEMs selbst, wollen Inverter Know How halten!	
	Koopertion mit Tongji Universität - die Kennen markt Besser. Können Hersteller eroieren. Projekt, Bachelor-, eher Masterarbeit kann formuliert werden. Ohne Chinesen kommt man da nicht weiter!!!	China Hersteller nicht bekannt. Kann mit Projektkooperation mit Tongji Uni herausgefunden werden. Ohne Chinesen kommt man da nicht weiter!	
o	Global: Power Module für Inverter: Infineon, Simikron, Delphi, weitere noch nicht genannte betreten Markt	Global: Power Module für Inverter: Infineon, Simikron, Delphi, weitere noch nicht genannte betreten Markt	
	AVL verwendet nicht (immer) Infineon, sagt aber nicht wen.	AVL verwendet nicht (immer) Infineon, sagt aber nicht wen.	
	Melecs verwendet Infineon, bleibt auch dabei	Melecs verwendet Infineon, bleibt auch dabei	
	Which supplier companies are producing battery management systems and which one are assembling complete battery systems?		
			3.6.4.3
a	ATL (Amerikanische Firma), Chinesischer Ableger ist CATL. Wir haben zwar den CEO getroffen, aber keinen Zugang zur Technik gefunden.	CATL: AB hat schon CEO getroffen aber kein Zugang zu Technikern.	
	Samsung SDI hat in Klingenberg Temperatursensor angefragt, machen Batteriestack mit Elektronik.	Samsung SDI: Temp Sensor in Klingenberg angefragt. Liefern Batterie Gesamtsystem.	

	Batterieschutzschalter (haben wir ähnlich mit Drexelmaier für Audi: Quasidiode trennt die beiden Batterien wenn Hauptbatterie entladen, da schalten wir 300-400A). Hatten LG Anfrage: normal werden bei 400V so 240 gezogen, innerhalb von Nanosekunden Richtung kA. Derzeit mechanische Relais, können aber nur 3-4 mal geöffnet werden. Was sind die Anforderungen an einen Batterieschutzschalter? Was macht CATL wirklich, nur Zellen oder Komplettpacket? Wer liefert Komplettsysteme an Autohersteller?	el. Batterieschutzschalter statt Relais: Ähnlich Drexelmaier Projekt für Audi, der trennt zwei Batterien. Hier schon 3-400A geschalten. LG Anfrage: 240A bei 400V schnell auf kA Bereich hoch, Abschalten in ns.
	LG hat 3 Stufen die man kaufen kann: Zellen, Zellenstacks, Komplettsystem Batterie + BMS + Kühlung + Schutzschalter. Unser Ansatzpunkt ist nur der Schutzschalter.	LG bietet: Zellen, Zellenstack und Komplettsystem
b	CATL und BYD definitiv die größten am Batteriesektor. Dann Ableger von Japanern: Panasonic und STI aus Korea. Samsung hat Kooperation mit ATL	CATL und BYD definitiv die größten am Batteriesektor. Dann Ableger von Japanern: Panasonic und SDI aus Korea. Samsung hat Kooperation mit ATL
	War grad bei Batteriehersteller CATL, den hat es vor 10 Jahren nicht gegeben und heute 30k Mitarbeiter! Alle Fertigungseinrichtungen top modern und automatisiert, auch gute Leute.	CATL besucht: Vor 10 Jahren nicht existent, heute 30k gute Mitarbeiter, top moderne automatisierte Anlagen
e	Albert Fellner (Emporia) hat 2010 mit NEV in China begonnen, wir haben u.a. den 50kW Drivetrain von Bosch, die Batterie und das BMS gesourced. Allerdings hatte er zu wenig Geld für die Serienproduktoin.	n.a.
	Wenn wir ein Projekt machen, können wird dieses Markt Know-How über Batteriesystemlieferanten teilen.	n.a.
	EDAC war das deutsche Entwicklungsbüro für die Fahrzeugentwicklung.	n.a.
	Kreisel Elektrik ist hier ein Innovator, nutzen Lasergeschweißte Panasonic Zellen automatisiert, haben die Technologie an Chinesen verkauft. Markus Kreisel hat mir erzählt, da ist ein großes Potenzial die Kühlung des Batteriesystems zu verbessern. Kühlsystem für Batterien wäre also interessant.	Kreisel Electric ist Innovator: Markus Kreisel berichtet von Optimierungspotenzial bei Kühlsystemen.
f	BMS: NBT, Wanxiang, Joyson (for BMW?), BYD, Conti (for baic), LG, Hella, Guoxuan. Battery: BYD, CATL, Lishen, Guoxuan, CALB	BMS: NBT, Wanxiang, Joyson (for BMW?), BYD, Conti (for baic), LG, Hella, Guoxuan. Battery: BYD, CATL, Lishen, Guoxuan, CALB
g	BYD, andere müsst ich nachschauen. BYD macht aber alles selbst, vertikal integriert.	BYD macht aber alles selbst, vertikal integriert.
h	Flach zu halten, gibt nicht viele Batterie Hersteller, aber alle OEMs forschen stark.	EU: Wenige Hersteller, aber OEM Forschen stark.
	Zulieferer dünn gesäht: Samsung battery Systems in Zettling (nähe Graz stellen Packages her), produzieren für Daimler und i3 im 3 Schicht Betrieb mit Vollauslastung. Machen Batterie Energie, thermal, Crah, Sicherheitsmanagement.	Wenig Hersteller in EU: z.B. Samsung Battery Systems in Zettling bei Graz stellt Packages für Daimler und i3 her. Voll ausgelastet! Batterie Energie-, Thermal-, Crash-, Sicherheitsmanagement.
	Kreisel interessant, aber eher kleine Quetsche. Expandieren aber.	Kreisel interessant, expandiert, aber noch nicht groß.
	Asien unbekannt, könnte man Tongji Kontakte Nutzen.	Asien unbekannt, Verweis auf Tongji Kontakte.
m	Zellen: LG, Samsung und Panasonic werden Europa Markt kontrollieren, Tesla nur Panasonic	SEHR VERLÄSSLICHE QUELLE Zellen: LG, Samsung und Panasonic werden Europa Markt kontrollieren, Tesla nur Panasonic

	Zellen: BYD, CATL sind teilweise auf gutem Level, werden sich aber stärker auf China Markt beschränken. Zellchemie Lithium-Eisen-Phosphat, während Samsung und LG doch auf Materialen setzen die höhere Energiedichten ermöglichen aber auch kritischer sind.	Zellen: BYD, CATL sind teilweise auf gutem Level, werden sich aber stärker auf China Markt beschränken. Zellchemie Lithium-Eisen-Phosphat, während Samsung und LG doch auf Materialen setzen die höhere Energiedichten ermöglichen aber auch kritischer sind.	
	Bei Kurzschluss entstehen mehrere 100A in sehr kurzer Zeit. Energieeffizienz Thema in NEV wird zunehmen, auch Kosten Kosten Kosten. Das betrifft Leistungselektronik besonders.	Bei Kurzschluss entstehen mehrere 100A in sehr kurzer Zeit. Energieeffizienz Thema in NEV wird zunehmen, auch Kosten Kosten Kosten. Das betrifft Leistungselektronik besonders.	
	300km Reichweite sind wirtschaftliche Größenordnung von Li-ion BEV in absehbarer Zeit	300km Reichweite sind wirtschaftliche Größenordnung von Li-ion BEV in absehbarer Zeit	
	Which technological strategies are pursued by Chinese OEMs in order to cope with the upcoming emission restrictions? 48V Mild Hybrid, or high voltage full and plug in hybrid systems?		
a	Das ist die Frage und welche Systeme wollen sie auf HV Elektrifizieren?	n.a.	3.4.9
b	48V findet in China Akzeptanz, wird aber hauptächlich von Koreanern, VW und anderen betrieben. Das ist die nächste Stufe.	48V findet akzeptanz als nächste Stufe, aber hauptsächlich von Koreanern und VW betrieben.	
	Aber die Regierung treibt ganz klar in Richtung NEV mit HV	Aber die Regierung treibt ganz klar in Richtung NEV mit HV	
c	Ladestationen sind noch ausbaubedürftig, wird auch gemacht, aber daher sind im Moment noch PHEV wichtig.	Ladestationen sind noch ausbaubedürftig, wird auch gemacht, aber daher sind im Moment noch PHEV wichtig.	
e	Gehen sicher auf HV, Chinesen machen keine Kompromisse wie die Deutschen. All die deutschen Kompromiss Modelle wie der BMW X1 elektisch, Denza, etc. sind fehlgeschlagen. Chinesen nehmen Risiko und gehen auf die neueste Technologie.	Chinesen machen keine Kompromisse wie Deutsche, deren Denza, BMW X1 elektrisch etc. gescheitert! Chinesen nehmen Risiko und neueste Technologie --> sicher HV	
f	kurzfristig PHEV, langfristig BEV	kurzfristig PHEV, langfristig BEV	
g	Langfristig HV, selbst PHEV ist nur Übergangslösung (auf die zB BYD stark setzt) um CAFC Ziele zu erfüllen	Langfristig HV, selbst PHEV ist nur Übergangslösung (auf die zB BYD stark setzt) um CAFC Ziele zu erfüllen	
h	48V nur um Mild Hybrid (20-30kW), das wird in China zugekauft. Nur zur Effizienzsteigerung. Auch in EU.	48V: Nur um Mild Hybrid 20-30kW. Wird in China zugekauft. Auch in EU nur zu Effizienzsteigerung.	
	Effizienzthema nicht ganz so streng wie bei uns, es geht eher um Emissionen. Daher kein großer 48V Markt gesehen.	China: Weniger Effizienz, mehr Emissions-Thema. Daher kein großer 48V Markt gesehen!	
	Leistungsstarke Hybridkonzepte Plug in ja.	Eher Leistungsstarke PHEV!	
	800V ist Thema in EU (VW, Porsche) für Luxusfahrzeuge	800V nur Luxusfahzeugthema in EU (VW, Porsche)	
	400V ist Standardthema, etabliert sich breit. 600V nicht gesehen. In China könnte man sogar über 200V nachdenken.	400V ist Standard, etabliert sich breit.	
		200V könnte in China kommen (low-end)	
		600V nicht gesehen.	
k	Aus Sicht von Audi sind PHEV zwar die sinnvollsten Hybride, aber nur Übergangslösung weil sie weder die BEV noch die konventionelle Welt erreichen können (Tank/Batterie balance)	PHEV Übergangslösung, können weder BEV noch konventionelle Welt erreichen. (nicht China bezogen)	

	NEV Strategie von Audi gar nicht so China spezifisch, weil die politischen Strömungen überall (Emission, Verbrauch) ähnlich sind. Vielleicht 1-2 Jahre differenz. 2021: **Auf 3 konventionelle Fahrzeuge muss ein BEV verkauft werden damit die Flottenverbräuche eingehalten werden**. BEV Strategie von **Audi: 2021 sollen 800000 BEV verkauft werden, elektrische A3 und A4 werden 2021 kommen. 2021 wird markanter Trendwechsel erwartet.** Risiko ist, dass sich der Umstieg dann abschwecht weil Elektromobilität durch Besteuerung teurer und konventionelle Kraftstoffe billiger werden könnten. 2025 noch Verschärfungen, spätestens dann muss NEV Anteil hoch sein.		
o	SAIC als größter Chinesischer Autobauer fokusiert sich auf BEV und PHEV, 48V ist kein Thema. In CN generell wird 48V auch überlegt, ist aber nicht als Trend ersichtlich. SAIC glaubt an Wettbewerbsvorteil für CN Hersteller bei BEV.	In CN kein 48V Trend gesehen. SAIC fokusiert auf BEV/PHEV. SAIC glaubt an Wettbewerbsvorteil von CN-OEM mit BEV.	
	VW kommt mit eigener EV Plattform um 2020 auf den Markt, klares Bekenntnis zu hochvolt EV.	VW führt 2020 eigene EV Plattform in Markt ein, klares Bekenntnis zu hochvolt EV.	
	Toyota: Full Hybrid mit Hochvolt Technologie, langfristig FCEV. Kein 48V.	Toyota: Full Hybrid hoch volt, 48V kein Thema. Langfristig FCEV.	
	Andere große Europäische OEM und Zulieferer wie AVL, PSA, Conti, etc. tendieren zu 48V als günstigen Elektrifizierungsansatz. Derzeit breite Einführung in vielen Plattformen.	Andere EU OEM und Tier 1 (AVL, Conti, PSA, etc.) tentieren zu 48V als günstige Elektrifizierung. Derzeit breite Einführung in vielen Plattformen.	
	800V ist Trend bei Premiumfahrzeugen. VW Konzern hat 800V exklusiv für Porsche beschlossen.	800V Trend nur bei Premium. VW exklusiv für Porsche beschlossen.	
	Are there any possible applications for technologies of AB-Mikro coming to your mind?		
a	Andere Applikationen denkbar: Heizer für NEV, Fahrwerksstellmotoren, Klimakompressor. etc	Andere Applikationen denkbar: Heizer für NEV (BHTC Projekt), Fahrwerksstellmotoren, Klimakompressor. etc	3.6.3.3
f	Nein. Es ist zu spät für DCDC (natürlich nicht die für FCEV) oder Wasserpumpen. EM Powerelektronik noch Chance, aber wir müssen schneller entwickeln.	Nein. Es ist zu spät für DCDC (natürlich nicht die für FCEV) oder Wasserpumpen. EM Powerelektronik noch Chance, aber wir müssen schneller entwickeln.	
	How would you evaluate the development potential of Chinese brands compared to foreign JV brands?		
a	Die Masterminds die wirklich gut drauf sind, die ich bisher getroffen habe, haben im Ausland Studiert und gearbeitet. Auch die Kindererziehung ändert sicht, Henry schickt Kinder in Lego Kurs. Also ich glaube das wird schon. Wenn ich mit Henry diskutiere, früher waren nur BMW, VW, etc. Die chinesischen Marken gewinnen jetzt an Marktanteilen. Sind mit Qualität am besten weg.	Die guten Leute, die Masterminds, immer im ausland studiert/gearbeitet. Kindererziehung heute auch schon anders. Henry sagt früher nur ausländische Marken, heute viele chinesische Marken auf Straßen --> chinesische Marken sind auf gutem Weg.	3.6.7
b	Glaube nicht das chinesen es schaffen werden internationale Marken bei ICE in den Schatten zu stellen.	Chinesen Marken werden internationelen Marken bei ICE nicht gefährlich	
	Aber NEV, da traue ich ihnen zu eine wesentliche Markposition bis 2025 einzunehmen. Der herkömmliche Powertrain ist das Know How bedürftigste im Auto, hat aber keine Bedeutung im NEV. Beim neuen Powertrain werden die chinesen eine Rolle spielen.	Aber wesentliche Marktposition für chin. Marken bei NEV bis 2025 wahrscheinlich. Bei NEV Powertrain werden chinesen Rolle spielen, konventionell nicht.	
c	Export bisher Afrika und Südamerika weil dort Markenschutz nicht so stark, daher dort Image recht gut. In den chinesischen Städten sind heimische Marken schwach, keine BYD oder GWM in Shanghai, aber in den Provinzen sehr viele.	Regional unterschiedlich: Kaum BYD oder GWM in Shanghai, aber in den Provinzen stark. Export Chancen nach Afrika, Südamerika.	
e	Das passiert bereits, die chinesischen marken holen die JVs ein. Der schnellste wachsende Marktsement im letzten Jahr waren SUV, Chinesen lieben SUVs weil die eine Waffe im verrückten Verkehr sind, Chinesische Marken haben internationale Marken bei SUVs (56%) und MPVs (90%) überholt. Internationale sind nur mehr im Hochpreissegment stark.	passiert schon, chinesische marken holen JVs ein. Vor allen bei SUV (56%) und MPV (90%) segmenten schon überholt, hier internationale marken nur mehr bei Hochpreis stark.	
f	Gute Chancen bei BEV, ziehen auch viel Kapital an.	Gute Chancen bei BEV, ziehen auch viel Kapital an.	

g	Für JV wird es schwieriger werden. In den letzten Jahren ist der Marktanteil chinesischer Marken von 10 auf Rund 40% angestiegen, eine besondere Stärke sind dabei SUV und NEV.	Für JV wird es schwieriger. Marktanteil chinesischer Marken von 10 auf ca. 40% angestiegen, besondere Stärke SUV und NEV.	
	The sales figures of NEVs and the market share of Chinese brands on them is already impressive today. Considering NEVs, which OEMs are the most promising ones in your opinion?		
a	schwierig zu sagen.	n.a.	3.6.7
b	BYD wird eine wesentliche Rolle, sonst kann ich wenig sagen.	BYD wesentliche Rolle, sonst zu wenig Erfahrung.	
c	JAC (demnächst NEV-JV mit VW), BYD, Geely	JAC (demnächst NEV-JV mit VW), BYD, Geely	
e	BYD ist klar die Nummer 1, aber die haben ihre Ursprünge als batterielieferant. Dann ging es weiter mit Bussen, da sind sie Exportführer bei Bussen (10 Modelle in Europa, nicht in D oder AUT). 2004 haben sie die Lizenz eines bankroten OEM gekauft und bauen seither auch passenger cars. Die haben sogar Lithium Minen, produzieren Elektronik, Airbags, alles. Die sind voll vertikal integriert. Viele meiner Kunden waren nicht erfolgreich einen Kontrakt mit BYD zu bekommen. Da kommt man nur mit einem Nieschenprodukt rein.	BYD Nr. 1, auch bei Bus Exporten. Sind aber völlig vertikal integriert über Batterie bis Minen. Schwer hinein zu kommen, nur mit Nieschenprodukt.	
	Andere erfolgreiche Hersteller kenne ich aber gebe ich nur in einem Projekt frei.	n.a.	
f	Aktuell BYD, aber ich glaube da werden noch andere bedeutend werden.	Aktuell BYD, aber ich glaube da werden noch andere bedeutend werden.	
g	Neben BYD ist als erstes SAIC zu nennen. Auch JAC, Chery, BAIC und Changan, alle haben lokale Marken. Die Geely NEV Marke ist Kandi, die machen aber nur sehr kleine Autos für speziellen Markt. Bei Hybriden ist BYD erster, dann die japaner mit Toyota, dritter ist SAIC, dann BAIC, JAC, Changan am gleichen Level. BYD ist auch stark mit Bussen.	BYD, dann SAIC, dann JAC, Chery, BAIC, Changan, alle mit Eigenmarken! Geely mit Kandi, aber nur Kleinstfahrzeuge. Hybrid: BYD, dann Toyota u.a. Japaner, dritter SAIC, dann BAIC, JAC, Changan. BYD ist auch stark bei Bussen!	
	From a technological point of view. Are Chinese NEV OEMs really so sophisticated that they could be dangerous for foreign JVs, or could that be an artificial hype?		
b	Konsumverhalten chin. Konsumenten kaufen entweder High End Produkt aus dem Ausland, aber für Mid und Low End produkte wird es schwieriger, da werden sie Lokal kaufen. Meine Mitarbeiter kaufen bspws nie und nimmer Iphone, die kaufen Huawei.	Konsumentenverhalten: high End produkte aus Auland wegen Status, bei low- und mid end werden Chinesen anteile gewinnen. Kein Mitarbeiter kauft mehr iphone, alle Huawei.	3.6.7
c	Ja, könnten Konkurrenzfähig werden. NEV Hype eher nicht gesehen. Auch Korruptionsregeln werden strenger und chinesische Marken könnten Alternative zu bsp Audi sein.	Ja, könnten Konkurrenzfähig werden. NEV Hype eher nicht gesehen. Antikorruptionsregeln nachteilig zb für Audi.	
e	Bzgl. Qualität ist schon noch unterschied auf internationale Marken, solange die Funktionalität und Sicherheit nicht gefährdet ist sind sie zufrieden. Aber genügend für den lokalen Markt und die Behörden, weil jeder braucht Lizenz.	schon noch Qualitätsunterschied zu internationalen Marken, aber ausreichend für Markt und Behörden.	
	Aber als Ausländer darf man absolut keine schlechte Qualität liefern, man wird bestraft und der Ruf auf medial ruiniert. Das ist sogar den Deutschen schon passiert. In der Öffentlichkeit ist das sogar schlimmer als in Europa.	ABER für ausländische OEM und Zulieferer ist Qualität MUSS!	
	Die deutschen sind Premium und dieses Segment ist immer noch stark. Audi verliert zwar Marktanteil, aber nur wegen eines Händlerproblems.	Premium noch schwer für Chinesen	
	Die Chinesen greifen den Markt über SUV und NEV Segmente an. Das SUV Segment schmerzt die Ausländer besonders. VW hat mit Q3, Q5 und Tiguan nur 3 Modelle, GWM hat 8 Modelle und die sind gut. Bei NEV haben die westlichen Hersteller gar nichts.	Chinesen greifen Markt über SUV und NEV an.	
f	bei BEV ja, konkurrenzfähig	bei BEV ja, konkurrenzfähig	

	Do you think it is promising to aim for business relations with Chinese OEMs and supplier companies, or should an enterprise like AB-Mikro focus on JV and foreign suppliers?		
a	Kernfrage ist ob uns die als chinesischen oder Europäoschen Lieferanten sehen.	n.a.	3.6.7
b	Indirekt geantwortet: Markpotenzial in China ist riesig, jeder möchte mitnaschen. Man wird langfristig in den Regionen für die Regionen produzieren, China ist von den Herstellkosten überhaupt nicht mehr billig. Man kommer her um den Marktzutritt zu haben. Man hat Null Chancen ins Geschäft zu kommen wenn man das über Salzburg macht, das muss in China gemacht werden. Es ist auch schwierig in Englisch zu kommunizieren außerhalb von Shanghai, auch der Internetzugang ist eingeschränkt. Man hat Potenzial, aber man braucht lokale chinesische Leute die mit lokalen chinesischen Firmen arbeiten. Das ist sehr wichtig für chinesische Firmen. Ob POE oder SOE ist dann egal.	Null Chance von Salzburg aus! Sehr wichtig: lokale chinesische Leute an Kundenschnittstellen! Dann egal ob POE oder SOE.	
c	macht keinen Unterschied, solange alles in China produziert wird.	macht keinen Unterschied, solange alles in China produziert wird.	
e	Tipp: Mit den bestehenden internationalen Kunden weiter arbeiten und versuchen über diese Referenzen in China zu bekommen. Im nächsten Schritt erst die lokalen angreifen. Die großen chinesischen OEMs sind arrogant, die wollen das beste und zwar umsonst. Man sollte also nicht die großen Namen wie GWM zuerst angehen, bei den kleineren Starten die noch froh sind um uns.	1. mit bestehenden internationalen Kunden weiter arbeiten, so China Referenzen sammeln 2. Erfolgreiche chinesische OEM sind arrogant, haben viel Support, wollen das beste und umsonst, schwer hinein zu kommen. Auf solche konzentrieren die noch froh um Unterstützung sind (kleinere).	
f	wir fokusieren auf beide.	wir fokusieren auf beide.	
h	Aussichtsreich! Man ist in China als Europäer schon gern gesehen wenn es um know-how geht.	Aussichtsreich! Europäer mit Know How gerne gesehen in China!	
	If yes: Should it focus on private owned OEMs like Geely, GWM or BYD or own state owned ones like Chery?		
f	wir sollten nach dem Marktanteil gehen, nicht nach POE oder SOE	wir sollten nach dem Marktanteil gehen, nicht nach POE oder SOE	3.6.7
	There should be a strong trend to SUVs and MPVs in China. Do you know where local SUVs manufacturers like GWM get their engines from and could those manufacturers be forced to cooperate with foreign suppliers like AB-Mikro in order to comply with the coming consumption and emission legislation?		
a	Kaufen Kernsysteme von Conti, Bosch, zusammenbau vielleicht selbst. Mit leistungsstärkeren Pumpen haben wir vielleicht eine Chance wenn deutlich billiger.	Kaufen Kernsysteme von großen Tier 1 wie Bosch, Conti, montieren vielleicht selbst. Mit Leistungsstarken Pumpen haben wir CHANCE wenn billig genug.	3.6.7
c	Kann mir langfristig keinen SUV Trend in den Städten vorstellen, eher kleinere NEV.	Kann mir langfristig keinen SUV Trend in den Städten vorstellen, eher kleinere NEV.	
e	GWM macht noch keine elektrifizierten SUVs, habe GWM gefragt warum. Die Antwort war, weil sie so viel zu produzieren hatten dass schlicht keine Resourcen dafür übrig waren. Aber das wird sich ändern, spätestens mit dem ZEV Programm.	GWM hat noch nicht elektrifiziert, Grund: keine Resourcen wegen hoher Auslastung. Das wird sich ändern, spätestens wegen ZEV; arbeiten sicher daran.	
	Bosch, Conti, TGTruck sind die Lieferanten bester Technologie für GWM. Außerdem ist GWM sehr attraktiv für alle Zulieferer. Die haben Parnter die High Tech liefern können, wird also schwierig für AB da rein zu kommen. Großer Preiswettbewerb. GWM zahlt auch keine Entwicklungskosten, die wollen nur die Stückpreis zahlen. Die wollen fertige Module kaufen die für wen anderen entwickelt wurden und sagen, hat ja schon zB Chery gezahlt. Die Erfahrung haben schon einige österreichische LIeferanten gemacht.	Bosch, Conti, TGTruck sind die Lieferanten bester Technologie für GWM, GWM sehr attraktiv für alle Zulieferer. Die haben Parnter die High Tech liefern können, schwierig für AB. Großer Preiswettbewerb. GWM zahlt keine Entwicklungskosten, nur Stückpreis.	
f	Wir waren schon oft bei GWM. Die wollen alles im Haus machen, da müssen wir mit den Kosten mit kommen.	Wir waren schon oft bei GWM. Die wollen alles im Haus machen, da müssen wir mit den Kosten mit kommen.	

g	GWM hat starke Langzeit Kooperationen und Verträge mit Bosch, Delphi, Valeo. Die haben auch alle Werke neben GWM gebaut. Andere Zulieferer haben es sehr schwer mit GWM, selbst Continental hat keine Verträge und kommt nur ins Geschäft wenn die Vertragsparnter nicht helfen können. GWM diskutiert mit vielen Lieferanten, aber am Ende bekommt Bosch das Geschäft.	GWM hat starke Langzeit Kooperationen (JV) und Verträge mit Bosch, Delphi, Valeo. Die haben Werke neben GWM gebaut. Andere Zulieferer haben es sehr schwer mit GWM, selbst Continental hat keine Verträge und kommt nur ins Geschäft wenn die Vertragsparnter nicht helfen können. GWM diskutiert mit vielen Lieferanten, aber am Ende bekommt Bosch das Geschäft.	
	The "made in china 2025" strategy explicitly comprises fuel cell cars. Which OEMs are developing such vehicles?		
a	Weiß nicht wer.		3.6.6
	Umwelteinfluss und Sicherheit sind bei BEV schließlich problematisch.	n.a.	
	Kenne keine Hersteller in China	n.a.	
f	bisher nur SAIC mit Subunternehmen sunrise bekannt	bisher nur SAIC mit Subunternehmen sunrise bekannt	
g	Es gibt Ziele für 2025, aber nicht kurzfristig. Im commercial sector ist das aber schon Thema, Changan und SAIC haben FC commercial vehicle. Im passenger vehicle sektor wird noch nicht viel gemacht.	Zuerst commercial sector (Busse), changan und SAIC haben FCEV. Noch nicht viel im passanger sektor.	
h	Toyota, Hyundai sind in Serie. Japaner sind generell gut aufgestellt, weil FC sehr breit für private Haushalte eingesetzt. EU eher zögerlicher, einige Jahre delay. China Hersteller kaufen Know How zu.	Toyota, Hyundai in Serie!	
		Chinesen kaufen Know how und Hardware zu. Z.B. von kandanadischen (Ballard?) und japanischen Herstellern.	
	Zulieferer von Know How und Hardware sind zB kanadischer Hersteller (Ballard?) und japanische	Japan Markt generell Voraus, weil stationäre FC verbreitet!	
j	International, in serie top down bedeutung: Toyota Mirai, Hyundai Tucson Ix35 FCEV, Honda FCX Clarity (alle mit ca. 100kW, 1kWh Batterie und >>500km NEDC Reichweite), GM HydroGen 4 2017: Daimler B-Klasse F-Cell und GLC F-Cell, Ford HySeries Edge, Nissan X-Trail, BMW FC hybrid electric 1-Series	International, in serie top down bedeutung: Toyota Mirai, Hyundai Tucson Ix35 FCEV, Honda FCX Clarity (alle mit ca. 100kW, 1kWh Batterie und >>500km NEDC Reichweite), GM HydroGen 4 2017: Daimler B-Klasse F-Cell und GLC F-Cell, Ford HySeries Edge, Nissan X-Trail, BMW FC hybrid electric 1-Series	
	Das sind Manufacturen, kaum Automatisierung	Das sind Manufacturen, kaum Automatisierung	
	Viele Komponenten selbst entwickelt, bei Toyota alle Kernkomponenten.	~~Viele Komponenten selbst entwickelt, bei Toyota alle Kernkomponenten.~~	
	Kooperationen: AFCC (Automotive Fuel Cell Cooperation), Daimler, Ford, Nucellsys	Kooperationen: AFCC (Automotive Fuel Cell Cooperation), Daimler, Ford, Nucellsys	
	Truck: Toyota (2 mal 114kW), Nikolamotor (USA; wollen eigene Strecken betreiben)	~~Truck: Toyota (2 mal 114kW), Nikolamotor (USA; wollen eigene Strecken betreiben)~~	
k	VW Konzern und Audi Forschen sehr stark an FCEV in Osnabrück, dort ist ein eigenes Entwicklungszentrum.	VW Konzern und Audi Forschen sehr stark an FCEV in Osnabrück, dort ist ein eigenes Entwicklungszentrum.	
l	Hyundai iX 35. Toyota Mirai am leichtesten erhältlich aber vorwiegend in Californien und Japan. Honda Clarity gibt es seit einem halben ja, hat bessere Performance als Toyota. Ab Septemper Plug in FC Daimler GLC. Angekündigt für die nächsten 2 Jahre: Toyota und Hyundai nachfolgemodelle, Lexus, Nissan. Ab 2020-2022 Audi und BMW, hier sehen wir gerade wahnsinnig viel Aktivität, die sind auch AVL Kunden.	Serie: Hyundai ix35, Toyota Mirai (am leichtesten erhältlich), Honda Clarity 09/2017: Daimler GLC Plug in FC bis 2020: Toyota und Hyundai Nachfolgemodelle, Lexus, Nissan 2020+: Audi und BMW, sind AVL Kunden, wahsinnig viel Aktivität	

	China Markt: Sehr interessant für AVL, **alle lokalen OEMs haben vor ca. 1-2 Jahren FC Aktivität gestartet** und Regierung hat vor kurzem darauf eingeschwenkt weil erkannt dass Batterieladung in riesigen Städten nicht funktioniert. Praktisch alle lokalen passenger OEM entwickeln FC!	**Praktisch alle chinesischen passener car OEMs**, aber erst seit ca. 1-2 Jahren. Regierung kürlich auf FC geschwenkt, weil BEV Ladung in Städten problematisch.	
	Wahnisnnig viel Aktivität im commercial Bereich. LKW macht Geld mit Transport von Masse, kann daher nicht Batterien schultern.	Wahnsinnig viel Aktivität commercial Bereich.	
	Busse sind am nähesten an der Markteinführung, Toyota ist dran für Olympiade. Olympiade wird FC Showcase. Daimler hat auch einen Bus für 2019 angekündigt. In beiden Fahzeugen sind jeweils zwei passenger car systeme eingebaut.	Busse nahe an Markteinführung: Toyota (Olympia), Daimler (2019), jeweils 2 passenver car systeme verbaut.	
	heavy duty: 2021 will Nikolamotor auf den Markt kommen. Sehr interessant wegen All in Business Modell, kostet 75 Cent pro Meile. Das ist 30-40% als ein heutiger Diesel Truck. Die bauen auch die Tankstellen dazu selbst an der US Westküste auf vordefinierten Routen, wo viele Trucks immer die gleiche Route fahren. Toyota hat auch kürzlich Heavy Duty Truck mit zwei Mirai Systemen vorgestellt Kürzliche Erklärung: Kenworth entwickelt Truck für Hafen von Los Angeles.	Heavy duty: Nikolamotor 2021 - sehr interessant weil All In Business Model pro Meile günstiger als Diesel! Toyota: Truck mit mit zwei Mirai Systemen Kenworth für Hafen Los Angeles	
	Light duty: Nissan, Renault, Hyundai Medium duty: Scania baut Truck Flotte, UPS führt Zulieferfahrzeuge ein	Light duty: Nissan, Renault, Hyundai Medium duty: Scania baut Truck Flotte, UPS führt Zulieferfahrzeuge ein	
	Hersteller die bei FC generell sehr aktiv sind: Bosch, Viessmann, Weiland, GE, LG, Mitsubishi, Honda, Cummins, AVL und mehr.	Aktive FC Hersteller (inkl. Stationäre Systeme): Viessmann, Vaillant (beide Heizer), GE, LG, Mitsubishi, honda, Cummins, Bosch, AVL und weitere.	
	AVL beschäftigt sich intensiv mit FC, hat schon 110 Entwickler, baut Personal und Laborfläche aus, FC Concept Car bei dem 6 OEM Partner sind	AVL beschäftigt sich intensiv mit FC, hat schon 110 Entwickler, baut Personal und Laborfläche aus, FC Concept Car bei dem 6 OEM Partner sind	
	ElringKlinger liefert FC Stack, auch für AVL	ElringKlinger liefert FC Stacks, auch an AVL	
	How do you evaluate the long term market potential of fuel cell cars on the Chinese market?		
b	Erster Schwung NEV sicher BEV, aber dann kommen sicher auch FCEV dazu.	~~Erster Schwung BEV, aber dann kommen sicher auch FCEV dazu.~~	3.6.5
e	Keine Erfahrung, habe nur eines von SAIC auf der Beijing Motorshow gesehen. Die konnten aber keine Auskunft über Serienproduktion geben.	Keine Erfahrung, nur 1 Modell von SAIC auf der Beijing Motorshow gesehen. Die konnten aber keine Auskunft über Serienproduktion geben.	
f	Auf lange Sicht interessant: die Regierung hat vor kurzem FCEV in den Fokus genommen, Förderungen stark angestiegen.	Auf lange Sicht interessant: die Regierung hat vor kurzem FCEV in den Fokus genommen, Förderungen stark angestiegen.	
h	FCEV werden zZ recht stark gepusht in China.	~~FCEV in China zZ stark gepusht!~~	
	REFIRE hat Auftrag 1000 Busse mit Brennstoffzellen zu bauen. TU, AVL, Magna werden evtl. unterstützen.	REFIRE hat Auftrag über 1000 FC Busse. TU, AVL, Magna kooperation angedacht.	
	Es werden eher mehr als 1000 FCEV in China 2020 sein.	Es werden 2020 eher mehr als 1000 FCEV in China sein.	
	Stadtregierungen werden ganz konkret Dieselbusse raus schmeissen, BEV und FCEV Busse sind Ersatzthema	Konkret: Stadtregierungen werden Diesel-Busse raus schmeissen. BEV und FCEV sind Substitutionskandidaten!	

	FCEV wird zuerst im kommerziellen Bereich kommen, weil die sich mit der Infrastruktur leichter tun. Wird noch dauern bei privaten.	FCEV zuerst im kommerziellen Bereich da Infrastruktur leichter managbar. Privat später.	
i			
j	Im Moment sehr starker Push bei commercial Vehicles wie Trucks und Busse für FC	Im Moment sehr starker Push bei commercial Vehicles wie Trucks und Busse für FC	
	Mit FC sind sogar deutlich größere Reichweiten als mit Diesel/Benzin denkbar	Mit FC sind sogar deutlich größere Reichweiten als mit Diesel/Benzin denkbar	
	Deutschland will 2023 400 H2 Tankstellen haben, heute 20	~~Deutschland will 2023 400 H2 Tankstellen haben, heute 20~~	
k	FCEV Wirkungsgrad 60%	~~FCEV Wirkungsgrad 60%~~	
	FCEV wird es geben aber wahrscheinlich mit begrenztem Anwendungsbereich. Problem ist, dass keine hohen Leistungen realisiert werden können (Grenze ca. 150kW bei Audi A7)	~~FCEV wird es geben, Anwendungsbereich beschränkt weil Leistung mit ca. 150kW (in Audi A7) beschränkt.~~	
	China ist Schwerpunktmarkt von Audi, dort wird der höchste Absatz gesehen. China ist gar nicht Leistungsafin. Dort geht es um komfort, Akustik, Innenraumgefühl. Dort kann FCEV Chance haben.	China ist Schwerpunktmarkt von Audi, dort wird der höchste Absatz gesehen. China ist gar nicht Leistungsafin! Dort geht es um komfort, Akustik, Innenraumgefühl. Dort kann FCEV Chance haben.	
l	Enorme Fortschritte in den letzten 15 Jahren: Kosten um 95% reduziert, Volumen und Gewicht eines 100kW Stack von 200l auf 32l und 250kg auf 35kg. Lebensdauer von 50000 auf 200000 km erhöht (Platin auf dem Niveau wie in einem Diesel Kat). Gesamtwirkungsgrad FCEV bei 60%.	Generell enorme Fortschritte FC seit 2000: Kosten um 95% reduziert, Volumen und Gewicht eines 100kW Stack von 200l auf 32l und 250kg auf 35kg. Lebensdauer von 50000 auf 200000 km erhöht (Platinmenge wie Diesel Kat). Gesamtwirkungsgrad FCEV bei 60%.	
	Systemkosten 100kW FC inkl. Nebenaggregaten, Boost Converter und H2 Tanks in automotive Serienproduktion >100k#pa ca. 6000EUR. 1/3 davon fallen auf Komponenten wie Boost Converter, Befeuchter, Verdichter etc. 1/3 auf die FC selbst. 1/3 ist der Kohlefaser Tank, das ist das teuerste.	Systemkosten 100kW FC inkl. Nebenaggregaten, Boost Converter und H2 Tanks in automotive Serienproduktion >100k#pa ca. 6000EUR. 1/3 davon fallen auf Komponenten wie Boost Converter, Befeuchter, Verdichter etc. 1/3 auf die FC selbst. 1/3 ist der Kohlefaser Tank, das ist das teuerste.	
	FCEV, das sagen auch die meisten OEM, haben das Kostenniveau von Hybridfahrzeugen. FCEV sind ab ungefähr 300km Reichweite billiger als BEV (mit best case Batterie Kosten). Bei BEV skaliert die ganze Batterie mit Reichweite, bei FCEV nur Tank. In Regionen wo es kein H2 gibt kann mit SOFC gearbeitet werden, die arbeiten mit Biobrennstoffen.	FCEV, das sagen auch die meisten OEM, haben das Kostenniveau von Hybridfahrzeugen. FCEV ab ca 300km Reichweite billiger als BEV (mit best case Batterie Kosten).	
	Halte wenig von Marktanteil studien, aber die Message von allen Studien ist dass FCEV Teil des zukünftigen Antriebsportfolios sein. Shell sagt ab 2025 größere Stückzahlen voraus, Grund ist dass es erst dann die Infrastruktur geben wird. Die Frage ist nicht die Fahrzeugtechnologie, die ist reif und Wettbewerbsfähig, sondern wie man den H2 ins Auto bekommt.	Message von allen Studien ist dass FCEV Teil des zukünftigen Antriebsportfolios sein. Shell sagt ab 2025 größere Stückzahlen voraus, Grund ist dass es erst dann die Infrastruktur geben wird. Die Frage ist nicht die Fahrzeugtechnologie, die ist reif und Wettbewerbsfähig, sondern wie man den H2 ins Auto bekommt.	

	Infrastruktur (Tankstellen) Kernregionen: Japan von 100 bis 2025 auf 1000, Japan setzt strategisch stark auf H2. Mitteleuropa speziell Deutschland (400 bis 2023), Frankreich (300 bis 2025), England, Österreich. Californien von 25 auf 100 bis 2023.	3 Infrastruktur (Tankstellen) Kernregionen: Japan von 100 bis 2025 auf 1000. Mitteleuropa speziell Deutschland (400 bis 2023), Frankreich (300 bis 2025), England, Österreich. Californien von 25 auf 100 bis 2023.	
	Japan ist weiter, da sind auch schon 200000 stationäre Systeme (Heizgeräte und Energieversorung) zu kosten von 11k EUR am Markt. Die werden auch in Europa eingeführt und stark gefördert (30% in Deutschland).	Japan setzt Strategisch auf H2 wegen Energieimport, schon 200000 stationäre Systeme zu Kosten von 11k EUR am Markt. Die werden auch in Europa eingeführt und stark gefördert (30% in Deutschland).	
	Chinesische Regierung kürzlich auf FC geschwenkt, weil BEV Ladung in Städten problematisch.	**Chinesische Regierung** kürlich auf FC geschwenkt, weil BEV Ladung in Städten problematisch.	
	H2 wird auch als Energieträger notwendig sein, man kann nicht alle NEV aus dem Stromnetz laden.	H2 wird auch als Energieträger notwendig sein, man kann nicht alle NEV aus dem Stromnetz laden.	
	2050 wahrscheinlich nicht mehr viele ICE	2050 wahrscheinlich nicht mehr viele ICE	
o	Toyota believes it is possible to make FCEV mass competitive	Toyota believes it is possible to make FCEV mass competitive	
	Toyota believes FVEV is better than BEV, because of the battery production	Toyota believes FVEV is better than BEV, because of the battery production	
	Toyota is convinced, that FCEV will complement BEVs for for long driving use in future.	Toyota is convinced, that FCEV will complement BEVs for for long driving use in future.	
	Are independent Chinese tier 1 suppliers capable of developing key components like high sophisticated inverters for modern NEV on their own today?		
a	Hauptsächlich durch zukauf von internationalen Firmen ja. Es gibt aber dienstleister Entwickler die zB 30W Pumpen Elektronik aus dem Ärmel schütteln.	Durch zukauf ausländischer Zuflieferer ja. Entwicklungsdienstleister gibt es aber auch.	3.6.4
b	Jeder Tier 1 wird von jedem Tier 2 oder 3 unterstützt. Chinesische Tier 1 haben also gleichen Support Zugang. Also klares ja, ist für chinesische Hersteller nicht schwieriger als andere.	Klares JA! Weil alle ausländischen Tier 2 und 3 auch alle lokalen Tier 1 unterstützen.	
e	Man müsste einen Benchmark über hidden purchasing durchführen.	Benchmark über hidden purchasing notwendig.	
f	ja: APG, Santroll, BYD	ja: APG, Santroll, BYD	
h	Anders bei ICE, schon viele Hersteller kompletter rein elektrischer Antriebsstränge (inkl. Inverter, Batterie) in China die auch entwickeln! Zwar lower standard, aber dennoch	Anders als bei ICE in China viele komplett NEV-Antriebsstrang Hersteller, auch Entwicklung in China! Obwohl lower-tech standard.	
	How should an European supplier enterprise appear in order to have the best business chances in China? Do you think the TT Electronics site in Suzhou with factory, sales and engineering will be perceived as a Chinese enterprise or should a cooperation with a Chinese owned company be entered?		
a	Wir sind damit konfrontiert, dass Entwicklung in China sein muss. Die sind nicht bereit unsere Entwicklungskosten zu zahlen.	Entwicklung muss nach China, unsere Kosten zu hoch.	3.7
b	R&D und Sales, Customer Interface muss chinesisch in China sein. Problem ist gute Leute zu finden die Loyal ist. Die Lösung ist man muss gut bezahlen, chinesen sind sehr geldgetriebene Menschen.	Sehr wichtig: lokale chinesische Leute an Kundenschnittstellen! Loyalität ist Problem! Lösung: gut zahlen, Chinesen sind geldgetrieben!	
	Chin. Sind pragamatisch. Wenn man was gutes hat was sie brauchen kaufen sie es.	Chin. Sind pragamatisch. Wenn man was gutes hat was sie brauchen kaufen sie es.	
	Lokalisation ist wichtig	~~Lokalisierung ist wichtig~~	

	Kopiert werden ist gefährlich, man muss sich überlegen wie man die Software schützt!	Kopiert werden gefährlicht! Software schützen!	
c	Ja, wir werden als chinesisches Unternehmen wahr genommen. Bsp Nissan: wenn sie mehr als 200km weit weg von uns sind machen die kein Geschäft. Lokal Content ist teilweise sogar auf Provinz bezogen, alles muss in China produziert werden.	Wenn wir in china produzieren und chinesische Ansprechpartner haben, werden wir als chinesisches Unternehmen wahrgenommen.	
	Entwicklung muss nicht in China sein, es kann sogar besser sein in Europa zu entwickeln. Aber produziert muss in China werden, die Kosten müssen niedrig sein.	Entwicklung muss nicht in China sein, es kann sogar besser sein in Europa zu entwickeln. Aber produziert muss in China werden, die Kosten müssen niedrig sein.	
	Chinesisch sprachige technisch Kompetente Mitarbeiter braucht man aber. Bei JAC zB kommt man mit Englisch überhaupt nicht weiter.	Chinesisch sprachige technisch Kompetente Mitarbeiter braucht man aber. Bei JAC zB kommt man mit Englisch überhaupt nicht weiter.	
d	Es kommt gut an wenn jemand extra aus Österreich anreist, aber kompetente Ansprechpartner müssen in China sein.	Es kommt gut an wenn jemand extra aus Österreich anreist, aber kompetente Ansprechpartner müssen in China sein bzw. aufgebaut werden.	
e	Suzhou Struktur ist OK, aber das Sales und FAE Team sollte in Shanghai sein. In Suzhou bekommen wir keine guten Leute. Shanghai ist das Detroit von China. Qoros, SAIC, VW, GWM, GM, Geely haben alle Engineering Center in Shanghai. Die brauchen smarte Leute, die finden sie nicht in Baoding (GWM). Außerdem brauchen wir R&D lokalisierung. Wir sollten auch ein bisschen unabhängig von TT werden, weil wir können nicht sicher sein ob der Sales man jetzt für uns oder den größeren Boss arbeitet.	Suzhou OK, ABER: Sales und FAE nach Shanghai, weil Entwicklungszentren Qoros, SAIC, VW, GWM, GM, Geely alle dort. Shanghai ist Detroit von CN. Brauchen gute Leute, findet man nur dort. R&D muss nach CN.	
	Man braucht chinesischen Sales Leute wenn man mit chinesen Geschäft machen will, selbst wenn man chinesisch kann. Aber es ist schwierig loyale gute Leute zu bekommen. Wenn man Geschäft mit Ausländern machen will, dann westlicher sales mann.	~~Man braucht chinesischen Sales Leute, selbst wenn man chinesisch kann. Schwierig loyale gute Leute zu bekommen.~~	
f	Die Produktkompetenz muss stimmen und der Preis muss runter. Also wir müssen wie ein Europäische Unternehmen arbeiten aber die Geschäftshandhabung und das Auftreten muss chinesisch sein.	Produktkompetenz muss stimmen und Preis muss runter. Wir müssen wie Europäische Unternehmen arbeiten aber Geschäftshandhabung und Auftreten muss chinesisch sein.	
g	Der Markt ist da, zwei Dinge sind Grundvoraussetzung um erfolgreich teilnehmen zu können: Technologie und zuverlässige Performance und Qualität. Chinesische Tier 1 haben Technologie Probleme, am meisten Defizite haben sie mit Spezifikationen - sie können zwar etwas machen, es aber nicht validieren und spezifizieren. Die suchen nach Kooperationen mit europäischen, japanischen oder amerikanischen Technologieträgern. Strategie chinesischer Tier 1: 1. Technologie, 2. mach es billiger, 3. international werden.	Grundvoraussetzungen: Technologie, zuverlässige Qualität und muss billig sein.	
	OEM seite: Die müssen dich kennen lernen, das geht am besten über persönliche Beziehungen und Netzwerke. Der andere Weg ist, sie fragen den größten wie zB Bosch wer ihr Wettbewerber ist.	Zuliefermarkt heute sehr stabil: persönliche Beziehungen und Netzwerk oder langfristige Kooperationen (JV) wichtig um hinein zu kommen.	
	Heute ist der Zulieferermarkt sehr stabil, man braucht JV um hinein zu kommen, selbst wenn man gut ist. Man muss sich um den chinesischen Markt kümmern, sonst wird man verlieren selbst wenn man der beste ist.		
	Auch bei den lang eingesessenen ausländischen Partner Zulieferern hat man heute ein chinesisches Gesicht als Ansprechpartner!	Chinesen an Kundenschnittstellen! Ausländer können und sollen diese begleiten und kontrollieren (als Vorgesetzte), verstehen aber kultur und Bedeutung des Gesprochenen nicht!	

	Ausländer kennen die chinesische Kultur nicht, man erkennt die echte Bedeutung des Gesprochenen nicht. Ausländer können nur Führungspositionen einnehmen, aber man braucht Chinesen am Verhandlungstisch. Man kann die chinesischen Verhandler begleiten und kontrollieren, aber muss ihnen Spielraum und Resourcen in der Verhandlung geben. Schlüsselproblem ist loyale Personen zu finden. Der beste Weg dazu wäre, dass das Unternehmen etwas mit den chinesischen Sales Leuten teilt. Sales Leute von großen Zulieferern sind ein Problem, weil die es gewohnt sind die große Marke Bosch im Hintergrund haben. Man sollte erfahrende Sales Leute von kleineren Unternehmen nehmen, es ist gut wenn sie bei großen Marken waren um dort ein Netzwerk aufzubauen das sie als Türöffner verwenden können, aber nicht zu lange, max 5 Jahre.	Loyale und richtige chinesische Sales Leute wichtig. Richtig: Sales Leute dürfen nicht zu lange bei großen Unternehmen gewesen sein, da diese nur mit großer Marke auftreten können. Kurz OK, wegen Netzwerk. Loyalität: Etwas mit den Sales Leuten teilen.	
	Wir müssen in China produzieren und zumindest auch in China adaptieren. Nicht einfach nur Europäische Produkte für China adaptieren, der Preis MUSS niedrig sein.	In China produzieren und zumindest Adaptierung lokal durchführen.	
	Man braucht zumindes Applikations Ingenieure in China. Die müssen technisches Wissen haben, mit dem sie die Sales Leute unterstützen können. Wenn man das technische Wissen nicht auf den Verhandlungstisch bringen kann, hilft auch die persönliche Beziehung nichts, beides muss man haben. 1. Persönliche beziehung, 2. Verlässlichkeit, 3. Technische Kompetenz	Mindestens Applikations Ingenieur mit technischem Wissen in China. Technisches Verständnis muss an Verhandlungstisch, sonst nutzt auch persönliche Beziehung nicht.	
	What is the best way to get contact with potential Chinese customers and how to find the decision makers?		
a	Denke am besten von ganz oben nach unten, mit dem Eigentümer Golfen gehen und dann die Zuständigen Kontakte besorgen.	Von oben nach unten, braucht aber auch zuständigen techn. Ansprechpartner.	3.7
b	Meine Erfahrung: Wenn dich jemand zum Essen einlädt, dann hast du jemanden gefunden der in einer Schlüsselposition ist. Wenn man beim Meeting einfach so wieder raus geht, dann nicht. Essen ist das um und auf in China, es wird sehr viel beim Essen ausgemacht.	Derjenige der zum essen einlädt ist in Schlüsselposition.	
	Wenn du jemanden einladest geht jeder mit dir essen. Mittagessen kann dazu ausgenutzt werden.	Essen wichtig, Einladung zum Mittagessen kann genutzt werden!	
	Habe auch sehr viele Kontakte über Universitäten aufgebaut! Lokale chin Unis sind sehr starkt mit lok. Chin. Firmen vernetzt. Wenn man da irgendwie hinein kommt und den richtigen Prof hat, dann stellt der wunderbar Kontakte zu den richtigen Leuten her.	Kontakte über Universitäten knüpfen! Sehr gut vernetzt, stellen richtige Kontakte her!	
	Kehrseite: Beim Forschen muss man aufpassen dass das erlangte Wissen nicht überall hin wandert.	Kehrseite: Beim Forschen aufpassen, Wissen difundiert überall hin.	
c	Fachmessen sind sehr wichtig! ZB WKO automotive Marktsondierungsreise jährlich um März. Cold calling funktioniert nicht.	Fachmessen wichtig, bsps Austrian Business Show case jährlich um März. Man muss Image pflegen und Kontakte sammeln.	
	In China wird keiner weitergeleitet, daher ist wichtig sein Image zu promoten. Man bekommt Kontakte durch Messen.	Cold call funktioniert nicht, in China wird keiner weitergeleitet.	
d	Es gibt ein Förderprogramm der WKO "Export Check", mit dem Messeteilnahmen und Marktstudien gefördert werden können.	Es gibt ein Förderprogramm der WKO "Export Check", mit dem Messeteilnahmen und Marktstudien gefördert werden können.	
e	Chinesischer Weg ist Netzwerk und Empfehlungen. Oder Partner die bereits eines haben, die können das Klinkenputzen abkürzen.	Netzwerk und Empehlungen. Oder Partner (Consulter) nutzen die das haben.	
f	Konferenzen, EXPO, Freunde und Kunden die einen Vorstellen. Entscheidungsträger: wir müssen die Kundenorgansiation verstehen.	Konferenzen, EXPO, Freunde und Kunden die einen Vorstellen. Entscheidungsträger: wir müssen die Kundenorgansiation verstehen.	

g	OEMs konzentrieren sich auf Archtitektur und Software in den 3 Kernfeldern Batterie, Drivetrain und Vehicle Control Unit, für die Hardware setzen sie auf zulieferer. Für Tier 2 Zulieferer ist ein typischer Weg über die commercial Vehicle (vorwiegend Bus) in die passenger Vehicle einzusteigen.	OEMs konzentrieren sich auf Archtitektur und Software in den 3 Kernfeldern Batterie, Drivetrain und Vehicle Control Unit, Hardware von Zulieferer. Für Tier 2 Zulieferer ist ein typischer Weg über die commercial Vehicle (vorwiegend Bus) in die passenger Vehicle einzusteigen.	
h	Einfluss chinesischer Unis aus Wirtschaft groß. Unis haben großen Schritt gemacht. Studenten haben hohes Potenzial! An Tongji: CDHK - Chinesisch Deutsches Hochschul Kolleg, dort unterrichten Deutsche Profs seit Jahren.	Einfluss chin. Unis auf Wirtschaft groß und wachsend! Studenten hohes Potenzial!	
	Langfristiges Ziel der Regierung ist Bildungssektor.	Fokus und Ziel der Regierung Bildungskooperation, BSP: Tongji CDHK - chinesisch Deutsches Hochschul Kolleg, deutsche Prof unterrichten seit jahren	
	Viele chinesische Profs waren Jahre lang im Westen	Viele chin. Prof waren lange im Ausland	
	Es werden bereits Entwicklungsaufträge vom Westen nach China vergeben! BMW hat Entwicklungszentrum mit 240 Leute in Peking, 50:50 Chinesen:Europäer. Wechselseitig muss die Sprache gelernt werden.	Wirtschaft wandelt sich starkt von Produktion zu Dienstleistung. Entwicklungsaufträge werden bereits vom Westen nach China gegeben! Bsp. BMW hat Entwicklungszentrum mit 240 Leute in Peking, 50:50 Chinesen:Europäer. Wechselseitig muss die Sprache gelernt werden.	
	How to initiate business in order to achieve contracts? What are the most common problems?		
a	Wichtig ist regelmäßiger Kontakt. Auch bei GMB in Korea müssen wir ständig sein.	~~Regelmäßiger Kontakt~~	3.7
b	Man muss persönliche Beziehung aufbauen. Essen und Regelmäßige besuche.	Persönliche Beziehung aufbauen! Essen und regelmäßige Besuche!	
c	Bei B2B Treffen (bsp WKO Reise) herausfinden welcher Einkäufer für unsere Produkte zuständig ist, dann ein Folgemeeting vereinbaren. Techn. Details immer mit zuständigem Einkäufer und nicht mit Einkaufsleiter abstimmen.	Bei B2B Treffen (bsp WKO Reise) herausfinden welcher Einkäufer für Produkte zuständig ist, dann Folgemeeting vereinbaren. Techn. Details mit zuständigem Einkäufer nicht mit Einkaufsleiter abstimmen.	
e	Sehr harte Arbeit, man muss als smart und fleißig wahr genommen werden. Wenn man Wissen hat fangen Sie an einem zu Vertrauen, das ist Voraussetzung.	Man muss als fleißig und kompetent wahrgenommen werden, Voraussetzung für Vertrauen.	
g	Allgemeiner Tipp um mit lokalen OEM ins Geschäft zu kommen: Man braucht eine Beziehung, die müssen uns kennen. Das kann über Verträge oder persönliche Beziehung gehen, das ist sehr wichtig in China. Hella oder Valeo haben zB schlechte Chancen in China, weil sie keine Langzeitkontrakte (JV) haben, so wie Bosch mit GWM oder Kyudo (?) im Lighting Bereich mit SAIC.	OEM muss einen kennen: geht über Beziehung oder Verträge. Beispiel Valeo oder Hella schlecht positioniert in China, weil keine Langzeitkontrakte oder JV.	
	Auch die best verkauften JV Marken in China, sind solche in die China designed wurden. Z.B. der VW Lavida. Also werden chinesische Zulieferer immer wichtiger.	OEM Design verstärkt in China, daher chinesische Zulieferer immer wichtiger.	
h	Man kann nicht schnelle Erfolge erwarten, man muss Chinesen verstehen.	Man kann keine schnellen Erfolge erwarten, man muss Chinesen verstehen.	
i	Freundschafts Beziehung ist Voraussetzung, wobei damit nicht die gleiche Tiefe wie bei uns gemeint ist. Essen und Trinken ist wichtig.	Freundschaft eingehen, Essen Trinken. Wobei nicht gleiche Tiefe wie bei uns gemeint.	
	What must be considered when negotiating contracts?		
a	Chinesen wollen am Anfang immer das beste, dann aber den Preis nicht zahlen. (evlt. Viel Optional anbieten)	Chinesen wollen das beste aber gratis (evtl. viel Optional anbieten)	3.7
b	Keine schlechten Erfahrungen mit chinesischen Vertragspartnern gemacht.	Keine schlechten Erfahrungen mit chinesischen Vertragspartnern gemacht.	

c	vorher unbedingt IP schützen lassen (Patent in China). Dann: Beilegung von Streitigkeiten, Geheimhaltungsklausel mit Bezug auf Patente. WKO hat Reports zu Verhandlung mich Chinesen und Schutz geistigen Eigentums, kann auch Patentanwälte vermitteln.	vorher unbedingt IP schützen lassen (Patent in China). Dann: Beilegung von Streitigkeiten, Geheimhaltungsklausel mit Bezug auf Patente. WKO hat Reports zu Verhandlung mich Chinesen und Schutz geistigen Eigentums, kann auch Patentanwälte vermitteln.	
	sonst muss man sich nicht viele Sorgen machen.	sonst muss man sich nicht viele Sorgen machen.	
f	Preis, Zahlungskonditionen, Lieferbedingungen, Garantie, Kompensation und TT Regeln	Preis, Zahlungskonditionen, Lieferbedingungen, Garantie, Kompensation und TT Regeln	
i	Nutzungsrechte für Patente vor Erfindung Regeln, Verträge von Anwälten prüfen lassen	Nutzungsrechte für Patente vor Erfindung Regeln, Verträge von Anwälten prüfen lassen	
	Dolmetscher (chin. Kollegen) müssen dabei sein	Dolmetscher (chin. Kollegen) müssen dabei sein	
	rechtliche Unterstützung speziell am Anfang sehr wichtig	rechtliche Unterstützung speziell am Anfang sehr wichtig	
	What are the key-success factors for automotive suppliers in China?		
a	Schnelle Reaktionszeit und Preis, beides können wir nur lokal lösen.	Schnelle Reaktionszeit und Preis, beides können wir nur lokal lösen.	3.7
b	Abgesehen von der sozialen Komponente keine besonderheiten, der Rest ist wie anderswo auf der Welt auch.	Abgesehen von sozialer Komponente keine Besonderenheiten im int. Vergleich	
	Nicht Sachen versprechen die man nicht halten kann	Nicht Sachen versprechen die man nicht halten kann	
	Ausländischen Unternehmen wird hohe Qualität zugebilligt, aber die erwartet man auch, die muss man liefern. Entwicklung Richtung 0ppm ist ein muss.	Qualität wird von ausl. Unternehmen vorausgesetzt!	
c	Man muss die Zielkunden kennen lernen, Schutz geistigen Eigentums, andere Qualitätsstandards, Geschäftsgewohnheiten im Land.	Man muss die Zielkunden kennen lernen, Schutz geistigen Eigentums, andere Qualitätsstandards, Geschäftsgewohnheiten im Land.	
e	Vertrauen, Referenzen, Reputation, Erfahrung, Kulturverständnis	Vertrauen, Referenzen, Reputation, Erfahrung, Kulturverständnis	
f	Markt Applikation vorhersehen, Vorentwickeln, Wettbewerbsfähigkeit	Markt Applikation vorhersehen, Vorentwickeln, Wettbewerbsfähigkeit	
	What are the most common problems occurring in business relations between Chinese and western companies?		
a	Chinesen wollen alles selber machen. APG, Johnson Control, die machen bis zur Platine alles selber. Ist wohl kulturell verankert.	Chinesen wollen alles selber machen. APG, Johnson Control, die machen bis zur Platine alles selber. Ist wohl kulturell verankert.	3.7
	Momentan: Wir haben die Kontakte zu höhren ebenen nicht, und wir sind zu wenig präsent im Sinne regelmäßiger Besuche.	AB Problem zZ: Fehlende Top Level Kontakte, mangelnde Kontakthäufigkeit	
	Asiatische Kunden haben die Erwartungshaltung am nächsten Tag nach Anfrage ein Angebot zu erhalten. Daher brauchen wir FAE in China, der muss den Großteil abdecken können.	Asiaten wollen sofort Angebot, daher brauchen wir FAE in China, der Großteil machen kann.	
b	Ganz klar: Das JA sagen in China hat 8 verschiedene Level. Das kann heißen ich hab dich gehört bis ja ich hab dich auch verstanden. Man muss sich vergewissern, dass mit JA zumindest level 7 gemeint ist. Dazu kann man schon auch nachfragen.	JA ist nicht JA, 8 Level von JA! Man muss sicher sein mindestens auf Level 7 zu sein, dazu auch nachfragen!	
	Wenn man JV gründen will oder so unbedingt auf Leute zurück greifen, die sowas schon öfter gemacht haben. Da gibt es Beratungsunternehmen.	Bei JV oder Firmengründung über Berater machen, die Erfahrung haben.	
e	Wenn die Technologie einzigartig und schwer zu kopieren ist muss man sich keine großen Sorgen machen. Das Feld der Mitbewerber muss dazu genau analysiert werden. Kann man die schlagen oder sollte man mit Ihnen zusammen arbeiten?	Mitbewerberfeld genau analysieren	
f	Preis, Zahlungsbedingungen, Entwicklungskosten, Werkzeugkosten	Preis, Zahlungsbedingungen, Entwicklungskosten, Werkzeugkosten	

h	Vorallem bei Elektronik ist die Gefahr groß, dass Know How schnell übernommen wird. Wenn man keinen großen Namen hat ist die Gefahr groß über den Tisch gezogen zu werden.	Vorallem bei Elektronik ist die Gefahr groß, dass Know How schnell übernommen wird. Wenn man keinen großen Namen hat ist die Gefahr groß über den Tisch gezogen zu werden.	
	How would you evaluate the R&D competence and innovation capability of Chinese OEMs and Tier1? Is it still based on reverse engineering and merging and acquisition?		
b	Sieht heute bei Universitäten dass wir in intensiver Konkurrenz mit heimischen Unternehmen stehen um die wirklich guten Absolventen zu bekommen.	Chinesische Unternehmen sind attraktiv geworden: starkter Wettbewerb um Uni Absolventen	3.7
	Arbeitsweise eines chin. Ingenieurs ist im Problemfall zu schauen was die Konkurrenz macht. Das ist aber nicht Reverse Engineering, man appliziert etwas von anderen aber verbessert es auch. Das Verbessern machen sie aber ganz gut. Man kann schon Leute finden die auch Innovativ sind. Wir machen hier jedes Jahr 15 Patente.	Benchmarking und Verbessern, das machen sie gut. Ist aber nicht Reverse Engineering i.S.v. kopieren. Machen viele Patente.	
f	Die Marktführer arbeiten immer mehr mit Eigeninnovation und Ideen, benchmarking wird natürlich eingesetzt. In der unteren Schicht noch reverse engineering.	Die Marktführer arbeiten immer mehr mit Eigeninnovation und Ideen, benchmarking wird natürlich eingesetzt. In der unteren Schicht noch reverse engineering.	
h	nicht mehr so schlecht	nicht mehr so schlecht	
i	werden zunehmend Innovativ. Auch Ausbildung wird besser, orientierung am Westen. Auch enorm viele Austauschprogramme. Nach Würzburg kamen 40-60 Chinese p.a. an Uni.	werden zunehmend Innovativ. Auch Ausbildung wird besser, orientierung am Westen. Auch enorm viele Austauschprogramme. Nach Würzburg kamen 40-60 Chinese p.a. an Uni.	
	The government wants to introduce a modern intellectual property right system. How can technologies be protected in an effective way today and in future?		
b	Knowledge drain ist problematisch. Mitarbeiter werden ausgebildet und hauen dann ab. IP schützen ist eines der schwierigsten Themen.	Problem ist knowledge drain über Mitarbeiter Abwanderung. Gut bezahlen ist einzige Lösung.	3.7
	Hatten jetzt Situationen wo wir IP eingeklagt und gewonnen haben, das ist nicht mehr unmöglich. Man muss bei Patenten aber aufpassen nicht in nachbars garten zu treten, weil schon dicht besetzt. Es stimmt aber das schutz von IP besser geworden ist und sich das auch weiter verbessern wird. Das machen sie aber nicht für die Ausländer, sondern weil auch die chin Unternehmen mehr IP generieren die geschützt werden muss.	IPR ist besser geworden und wird noch besser werden! Haben jetzt mehrmals erfolgreich eingeklagt. Wird zum Schutz von Innovationen chinesischer Unternehmen verstärkt.	
f	Ja Patentgesetze werden strenger in Zukunft	Ja Patentgesetze werden strenger in Zukunft	
h	Patente müssen unbedingt in China angemeldet werden.	Patente müssen unbedingt in China angemeldet werden.	
i	Bisher keine Probleme die man nicht in EU auch hätte. Schützen von Software wichtig.	Bisher keine Probleme die man nicht in EU auch hätte. Schützen von Software wichtig.	
	Do you know potential local competitors for technologies of AB-Mikro?		
a	Star Power für Standard Leistungsmodule (Heatsink mit DCB, Chip and Wire), Infineon mit Hybrid Pack 2, TF gibt es noch ein paar - Verweis Rehrl, Leiterplatte kann jeder. sonst kenne ich automotive kaum welche. Pumpen: Shisha, Borgwarner, Bosch, Conti bei niedriger Leistung	Star Power für Standard Leistungsmodule (Heatsink mit DCB, Chip and Wire), Infineon mit Hybrid Pack 2, TF gibt es noch ein paar - Verweis Rehrl, Leiterplatte kann jeder. sonst kenne ich automotive kaum welche. Pumpen: Shisha, Borgwarner, Bosch, Conti bei niedriger Leistung	

b	Abgesehen von Conti, Bosch wahrscheinlich Johnson Controls, Nasmo (japanisch), aber kenne keine Lokalen	Abgesehen von Conti, Bosch wahrscheinlich Johnson Controls, Nasmo (japanisch), aber kenne keine Lokalen	
c	Melex		
f	Hauptsächlich die In Haus Fertigung der OEM. Xingyu macht LED Module. Wir müssen Kosten und Technologievorteil zeigen.	Hauptsächlich die In Haus Fertigung der OEM. Xingyu macht LED Module. Wir müssen Kosten und Technologievorteil zeigen.	
g	Flextronics ist ein Wettbewerber für usnere Lighting sparte, weil da macht TT fast nur manufacturing.	Lighting: Flextronics	
	MCU/ECU: Keboda, auch lighting. Kenne aber keinen großen. Das ist kein Typisches Tier 1 produkt. Kenne diesen Markt nicht so. Aber wenn wir mit dem Preis den Mitbewerb unterbieten können haben wir gute Chancen - Lokalisierung - Preis runter!	MCU/ECU/Lighting: Keboda Sonst gute Chancen wenn niedriger Preis!	
	Well, now I am done with my questions. Do you have another important hint for me out of your experience?		
b	Nein, schon ziemlich alles erfahren. Aber persönlich: Wenn du den Job machst und für Fernost zuständig bist, überleg dir gut ob du nicht 1-2 Jahre herkommen willst, wenn die Firma bereits ist das zu tragen. War vorher bis zu 6 Monate immer wieder hier, aber habe viel mehr kapiert wie ich fix da war. Es kommt aber darauf an wo man hin gehen soll, bei Shanghai und Suzhou keine bedenken, sonst schon.	1-2 Jahre nach China ziehen stark empfohlen	div.
c	GWM ist sehr wichtig für Österreichische Firmen, da einziger chin OEM der derzeit in Europa produzieren darf.	GWM ist sehr wichtig für Österreichische Firmen, da einziger chin OEM der derzeit in Europa produzieren darf.	
l	FC Auto Konzept: Luftversorgung: Luftfilter - Luftverdichter auf 2.5 bis 3 bar elektrische angetriebene radialverdichter - Kühler von 150°C auf 70°C - dann Befeuchter (Membran muss feucht sein, Toyota hat den eliminiert) - dann flüssig Wasser abscheider - diese Luft mit ca. 70°C in die ZelleWasserstoffversorgung: Tank - Druckregelventile, Toyota hat auch ein Gebläse drin, AVL macht das mit Venturi Prinzip - Kreislauft braucht Purge Leitung um Stickstoff und Flüssigwasser auszublasen (unter 4% H2 wegen Zündgrenze)Kühlkreislauf: konventionell aufgebaut mit Radiator, Ladeluftkühler, Kühlkanäle in Brennstoffzelle. Großer Unterschied ist Austrittstemperatur max 85°C. Zudem gibt es keine Wärmeabfuhr über das Abgas. Deshalb haben FCEV ein Kühlproblem und deutlich größere Radiatoren wie ICE (bei Nutzfahrzeugen Faktor 3). bei Nutzfahrzeugen ist das ein noch größeres Problem. Daher Leistung im passenger car beschränkt, grob 200kW. Tanks: Industriestandard sind 700 bar Gastanks mit 4-6kg, die sind absolut dicht. FC ist über Boost Converter an HV System angekoppelt. Luftverdichter braucht 15-20kW Leistung, hängt direkt HV System oder direkt an FCPEM für Mobilität und SOFC (hohe Temp!) für multi fuel capability, als Range Extender und für stationäre Anwendungen Brennstoffzellen haben größtes Marktpotenzial.		
n	Heute ca. 80% PSM Maschinen in NEV. Forschund bei Bordnetz geht Richtung kV Bereich bis zu 3,3kV!	Heute ca. 80% PSM Maschinen in NEV. Forschung an ASM/PSM Mischung, ändert aber Stator Ansteuerung nicht. Forschung zumindest bei Ladespannung geht Richtung kV Bereich bis zu 3,3kV! Batterie wird dann gepulst.	

Appendix 4: ISLE workshop report

TT Electronics	Workshop Protokoll/Workshop Report AB Mikroelektronik GmbH	Datum/Date: 23.06.2017

Von/*From:*	Firma/*Company:*		
Philipp Höller	ISLE		
Besuch am/*Date of visit:*			
	Ort des Besuchs/*Place of visit:*	Premstätten	
Weitere Anwesende von AB/ *Further participants of AB :*	**Gesprochen mit:** *Spoken with:*		Verteiler/ *Mailing list:*
Timo Huemer Marcus Auer Johann Maier	Herr Reimann (Geschäftsführer) Herr Scherf (Leistungselektronik Entwicklung) Herr ???		
Besprechungspunkte/*Items:*			

Batterieschutzschalter

Schaltung innerhalb von 50µs ist mit mechanischem Relais generell schwer vorstellbar, das ist eine Eigenheit der elektronischen Schalter.
Wir wissen, dass Relais im Batterypack integriert sind (Bsp gesehen bei Mitsubishi Outlander PHEV auf AVL Kongress), schwer zu tauschen. Hier gab es zwar eine Serviceklappe, bei anderen aber komplett eingebaut.

Schutzfunktion (Intelligenz) muss eher integriert sein.
Galvanische Trennung?

ISLE: Haben die Forderung gesehen, einen elektronischen Schalter extern, hochvoltgesichert anzubringen.
ISLE: Sieht es auch so, dass die Ströme und die Funktionalität bei 48V und HV sehr ähnlich sind. Das heißt es würde Sinn machen eine Architektur so zu gestalten, dass sie sowohl HV als auch 48V tauglich ist.

ISLE entwickelt gerade einen elektronischen Schalter für eine Hochvolt Batterie (anderer Kunde). Dabei sollen nur die high side Schalter S2 und S4 ersetzt werden, nicht der low side S1. S1 kann galvanische Trennung auf - Seite darstellen. S1 ist ein billigers Relais, weil nur leistungslose Schaltung (bzw. muss nur einmal schalten können, wenn Elektronik versagt). S2 und S4 werden durch einen elektronischen Schalter ersetzt (derzeit Hochvolt MOSFET Lösung). Kostenvorgabe war 20EUR für HV System.
Bei 480V max. Batteriespannung würde ISLE noch 650V MOSFETs einsetzen, IGBTs zu viel Verlustleistung. Mosfets werden über integrierte Highside Ansteuerung geschaltet, nicht Ladungspumpe (bei HV nicht mehr günstig).

ISLE: Stand der Technik ist Relais, elektronische Schalter sind in Konzeptphase. Aber man will die Relais absolut raus haben. ISLE hat auch den Eindruck, dass hier viele entwickeln aber keine fertigen Produkte existieren.

SiC Ansatz ZUKUNFT: Niedrige Rdson bei Hochvolt, nicht schnelles Schalten. GaN schaltet schneller. Es gibt keinen Grund bei 600V Sic einzusetzen, bei 1200V ist der SIC MOSFET Konkurrenz zu IGBT. GaN hat kostenmäßig das Potenzial an Silizium heran zu kommen, SiC aber nicht.

LV123 ist die Basis für HV Systeme, darauf muss ein Konzept ausgelegt sein, Zitat: "Im Falle ein Überstromes muss die Batterie vom Bordnetz in beiden Richtungen trennbar sein".

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Neben Batterieherstellern sind Kabelbaumhersteller wie **Dräxlmaier und Leoni** (hat selbst keine Elektronik!) potenzielle Kunden zur Vermeidung von Kabelbränden.

Welche Fragen müssen wir mit Samsung klären?

- Integrationsumfang? Aus unserer Sicht macht es Sinn die Abschaltlogik inkl. Strommessung zu integrieren, um schnelle Abschaltung sicherstellen zu können. Um einen Vorladepfad ersetzen zu können ist es Voraussetzung. Gibt es auch Bedarf an reinen Leistungsschaltern bzw. einen Teil der Logik im BMS zu realisieren?
- Muss ein ggf. verbleibendes Relais von unserem Modul oder vom BMS geschalten werden? Macht Sinn auch dessen Ansteuerung zu integrieren, da es immer nur nach dem elektronischen Schalter abgeschaltet werden kann.
- 12V Anschluss verfügbar oder nicht?
- Reicht Unidirektional schaltbar um nur externen Kurzschluss schalten zu können (das ist immer noch bidirektional leitfähig!) in Kombination mit einem kleinen Relais, oder muss es Bidirektional sein?
- Welche hochohmigkeit muss im ausgeschalteten Zustand sichergestellt werden?
- Lastprofil (Strom).
- Mögliche Kühlkonzepte? Je nach Halbleiterkosten Verlustleistung in Größenordnung 300-500W.
- Von welchen min. und max. Induktivitäten im System vor und hinter dem Schalter muss ausgegangen werden? (Einschalt- und Ausschaltstrompeaks). **(AB Technologien bieten das Potenzial die interne Induktivität zu reduzieren!)** Größenordnung 27µH dahinter und 10µH davor.
  Es gibt mehrere Möglichkeiten den Abschaltpeak abzufangen:

1. Avalanche und active clamping mit den Schaltern sind beide zu Riskant speziell im Hochvoltbereich.
2. Fraulaufdiode kann nur die Induktivität hinter dem Schalter klemmen. + Snubber für die interne induktivität.
3. Freilaufdiode für L2 und separaten active clamp (Zenerdiodenfunktion) für L1

--> Man muss sehr oft schalten können, speziell wenn man das Hochfahren über eine PWM-Strombegrenzung realisiert. Daher fällt Option 1 aus, diesen Betrieb kann man nicht garantiert spezifizieren (parallele Mosfets und auch wo der Hot spot am Chip selbst entsteht) Selbst wenn Avalanche spezifiziert ist, ist das nur Marketing - da ist ISLE schon eingefahren. Die Option 2 ist aus Kostengründen ausgefallen, die Bauteile müssen relativ viel Leistung können und sind teuer.
Variante 2 mit Snubber für L1 und Freilaufdiode L2 wurde als Kompromiss und technisch zuverlässig gewählt.

Ca. 100kEUR Entwicklungsaufwand für ersten Prototypen.

DCDC-Converter

Auer: Bei den 1-2kW DCDCs von HV oder 48V runter auf 12V sehen wir uns nicht. Aber bei den Hochleistungs-Onboard chargern. Es tummeln sich aber sehr viele Hersteller auf dem Markt.
PH: Bei Schnellladung 35kW ist die Frage ob nicht bereits direkt DC aus der Ladestation kommt.

ISLE: Viel Erfahrung im Flurförderbereich mit 1-2 Ladeprojekten pro Jahr, aber keine Anfragen automotive. Allerdings: Jeder hat seine eigenen Schnittstellen und Protokolle, verschiedenste Systeme und Batterien. Einheitliche Lösung für Charger kaum möglich. Riesige Topologievielfalt.
Regelung sehr komplex, vor allem wenn Netze nicht stabil. "DA EINEN STANDARD ZU KREIEREN KANN ICH MIR NICHT VORSTELLEN"

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ISLE: Die jetzigen Lösungen sind schon sehr gut und sind bei 96% Wirkungsgrad.

Konsens: bei Hochleistungs-Ladestationen(30kW) wird die Wandlereinheit zudem nicht im Auto sein, sondern in der Ladestation.
PH: Zudem verschiedene Ladestation-Standards (siehe http://china.ahk.de/services/carbon-market/articles/energy/single-article/artikel/herausforderungen-und-loesungsansaetze-fuer-den-aufbau-einer-ladeinfrastruktur-fuer-elektrofahrzeuge-in-peking/?cHash=35ea1bf91a7cd5e226513cf113300572)

ISLE: komplexere Inverter Topologien (siehe DCAC Inverter) werden zukünftig notwendig, weil auch Netzbetreiber strenger werden.

Es ist viel möglich, aber man braucht vorher die Spezifikation um ein Optimum einstellen/entwickeln zu können.

Entwicklungsaufwand viel höher als für Batterieschutzschalter. Richtung 400kEUR für ein A-Muster

DCAC Inverter
ISLE: B6 Brücken sind als Topologie gesetzt, es werden aber versetzte Topologien eingesetzt, d.h. Parallelschaltung mehrerer B6-Brücken.
Klassische B6-Brücke ist bidirektional, kann beide Energieflussrichtungen. IGBTs haben den Vorteil kommutierungsfeste antiparallele Diode. Derzeit Umbruch zu SiC MOSFETs. Mit heutigen hochvolt MOSFETs kann man so einen B6-Brücken nicht realisieren, die Dioden reichen nicht.

ISLE sieht auch eher eine voll integrierte B6 Brücke als am sinnvollsten an.

Anbindung des Zwischenkreiskondensators ist kritisch, die Leitungen müssen kurz sein vor allem bei 48V. Die DC Abstützung muss sitzen. Das ist immer die zentrale Frage: wie bekommt man die DC Kondensatoren niederinduktiv dran.
Im Hochvoltbereich ist der Kommutierungskreis weniger kritisch als im Niedervoltbereich. Bei Hochvolt ist die kapazitive Verkopplung mit Kühlkörper ein Schwachpunkt der Chip-Stacking Lösung - das kann zu massiven Problemen führen. Vorteil bei Chip-Stacking Invert Powermodul wird daher eher für Niedervolt Anwendung gesehen. Noch interessanter wenn Zwischenkreiskondensatoren zumindest zum Teil noch integriert werden könnten.

Ein sinnvolles Demonstratorprojekt wäre ein Kommutierungskreisprojekt, also das 48V Powerstack inkl. dem Zwischenkreiskondensator möglichst niederinduktiv aufgebaut.

Entwicklungsaufwand für einen vollständigen Inverter Demonstrator ähnlich DCDC.

AT&S und Schweizer machen angeblich ein Stack mit eingebetteten Chips in Platinen mit Kupferinlays. Das ist aber auch in Konzeptphase.

Appendix 5: Visit report Samsung SDI

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Von/*From:*	Firma/*Company:*		
Philipp Höller	Samsung SDI		
Besuch am/*Date of visit:*			
	Ort des Besuchs/*Place of visit:*	Premstätten	
Weitere Anwesende von AB/ *Further participants of AB :*	**Gesprochen mit:** ***Spoken with:***		Verteiler/ *Mailing list:*
Timo Huemer Marcus Auer	Jürgen Luef (Deputy Head of Purchasing) Dr. Maximilian Hofer (Lead Engineer Electronic Hardware) Jürgen Fritz (Electronic Hardware Engineering)		
Besprechungspunkte/*Items:*			**zuständig/ *responsible:***

<u>Zuerst Firmenpräsentation Samsung SDI, wichtige Punkte:</u>

Kernkompetenz:

- Zellmanagement (BMS) für 12V, 48V, und HV Batterypacks, Packs werden auch gefertigt
- Elektronikentwicklung ist in Premstätten, aber Produktion vergeben. Entwicklung mit 200 Leuten, es wird nicht Marktspezifisch sondern nach Kompetenz verteilt entwickelt. Leistungselektronik wird eher Thema für Premstätten.
- Derzeit kommen Zellen aus Korea, in Zukunft von Ungarn.
- Derzeit einziges Werk in Europa, Göd in Ungarn kommt dazu (für Zellen und Packs, großes Gebäude)

Pack: Gehäuse ist gekühlt, Kühlleitungen integriert

In China nicht auf Whitelist (5 Hersteller die Batterien fertigen dürfen), weil Zellen aus Korea. Man versucht aber wieder in das Geschäft zu kommen, auch Kooperation wie mit CATL wird angedacht, also andere Zellen. DZ nur 1 Serienlinie PHEV für Audi in China.

DZ nur HV Systeme in Serienproduktion, 48V Projekte sind aber im Kommen. Akquise für 48V läuft. SOP 48V 2018.

<u>Dann Firmenpräsentation AB-Mikroelektronik.</u>

<u>Zu Solid State Battery Switch:</u>

- Keine OEM Anforderung bisher, OEM LH sagt: "darf elektronisch ausgeführt werden".
- Halbleiter bringt Vorteile, aber auch Nachteile. Oftmaliges Abschalten ist keine drängende Anforderung, kommt nicht vor. --> Marktpotential kann nur gehoben werden preislich mit mechanischem Relais wettbewerbsfähig. Relais liegt bei 4,5EUR für Einfachausführung in 48V System.
- Elektronischer Schalter ist strategische Überlegung, Start mit 48V Systemen sinnvoll:
  - Bei 48V keine galvanische Trennung notwendig, gemeinsame Masse mit 12V. Precharge wird im DCDC oder Inverter gelöst. DCDC kann auch in Batterypack

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sein. Jedenfalls steht nur das Hauptschalterrelais als zur Substitution zur Debatte.
  - Bidirektional muss sein
  - Fehlerfall darf nicht Kurzschluss sein. Absicherung muss überzeugend sein.
  - Stückzahlen bei künftigen 48V Projekten ca. 10 mal größer als HV (500k)
  - Kühlung nur über Busbar möglich, da in 48V Systemen teilweise gar keine Kühlung vorhanden
  - Ströme bis 200A Dauer
  - Integrationsumfang zuerst nur Leistungsschalter, ohne Gateansteuerung
  - ECE-R100 ist die Gesetzeslage für Batteriefahrzeuge

- Bei 48V ist die BMS Elektronik nur eine Platte, hier ist Elektronik Auslagerung fraglich.
- Generell ist Standardmodul nur schwer vorstellbar - wenn dann Modullösung, aufgrund unterschiedlicher OEM Anforderungen und verschiedenster Fahrzeugsysteme. Elektronik wird bevorzugt immer in DCDC oder BMS sitzen.
- Bei HV ist Elektronik modular aufgebaut, da wäre denkbar auch die Elektronik in den Schalter unterzubringen. Zudem könnte sich aus ISO26262 die Anforderung ergeben, dass die Strommessung ohnehin doppelt ausgeführt werden muss.
- Chip-Stacking ist sehr interessante Technologie, vor allem thermische Kapazität und damit höhere Pulsbelastbarkeit wird als Vorteil gesehen.

Abschluss

Samsung SDI wird weitere Vorgehensweise intern besprechen und ggf. auf AB-Mikroelektronik zukommen.