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European Battery Manufacturing - Feasibility and Profitability

Market Development, Cell Technologies and European Competitiveness

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Summary

This paper discusses the competitiveness of a European battery production. While in the past the relatively low market demand for batteries could not justify the high development cost that are needed for the European market to compete with the established Asian producers, the demand in 2025 will be 30 times providing a chance for European producers to enter the market. Especially if factors like non-automotive market potentials for batteries, change to customer driven production location, new technologies and employment potential are considered, a European battery production is recommended.

Keywords: Lithium battery, market development, strategy, EV, PHEV

1 Market Development

The first Lithium-Ion cell was produced by Sony in 1990 for the consumer electronics industry. Today the worldwide battery market of 30 GWh installed capacity is dominated by Asian companies like LG Chem, Samsung SDI and Panasonic as shown in figures 1 and 2.

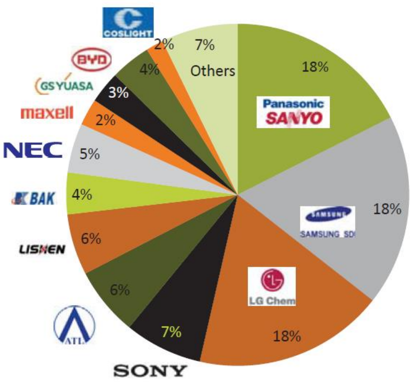

Figure 1: Market Share [1]

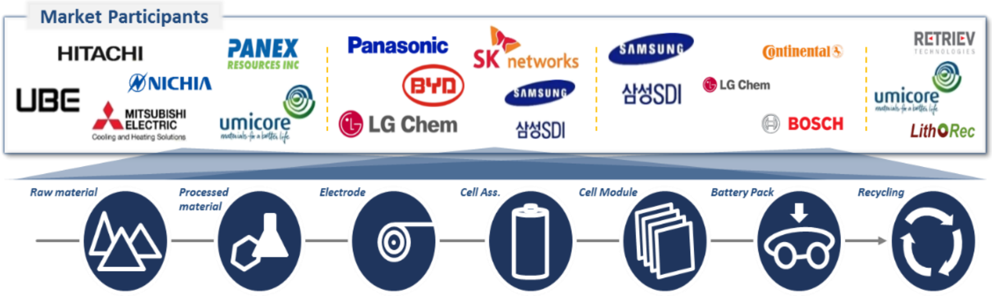

Figure 2: Supply Chain Participants [2]

Asian companies invested large sums in battery production facilities and can now use economies of scale from the consumer industry for automotive application. This is also supported by the figure below that shows the cell producers of electrical vehicles currently in the market.

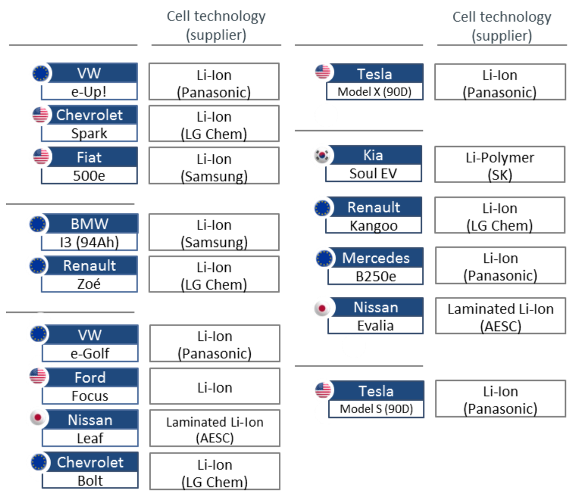

Figure 3: Cell-producers of current electric vehicles [3]

Due to those advantages and a rapid industrialization, they can offer their battery cells at competitive prices and satisfy the market demand from a strong market position while European companies must catch up considering the time needed from the first prototype to a high-volume production.

Especially cells are currently produced in Asian countries while other battery components like cooling and battery management systems are already developed and produced worldwide.

In this competitive environment, a European cell production was so far not feasible due to cost and technology advantages of Asian competitors for the current Lithium-Ion technology although the European market of electric vehicles is mainly dominated by European car manufacturers (see figure 4).

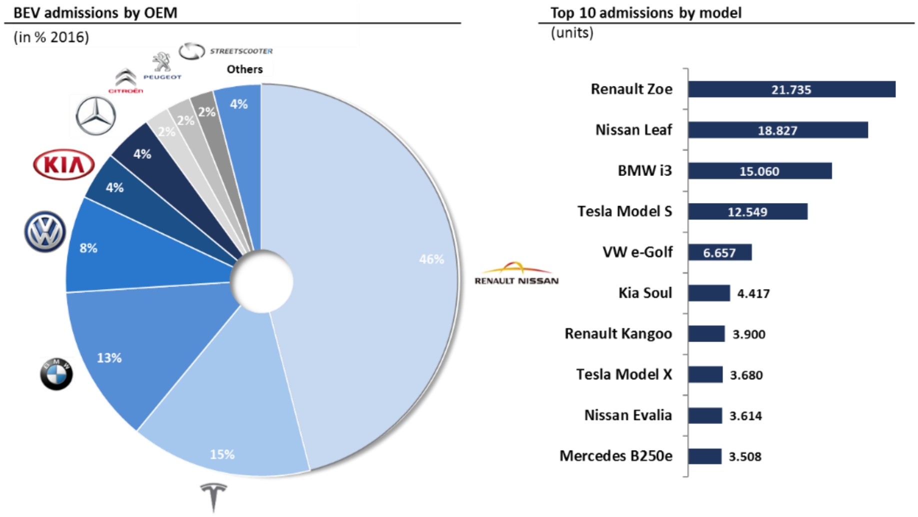

Figure 4: Sales and market share of BEVs in the European market [4]

The replacement of the predominant Li-Ion technology could however provide a chance for European manufacturers to enter the battery market as explained further in chapter 3.

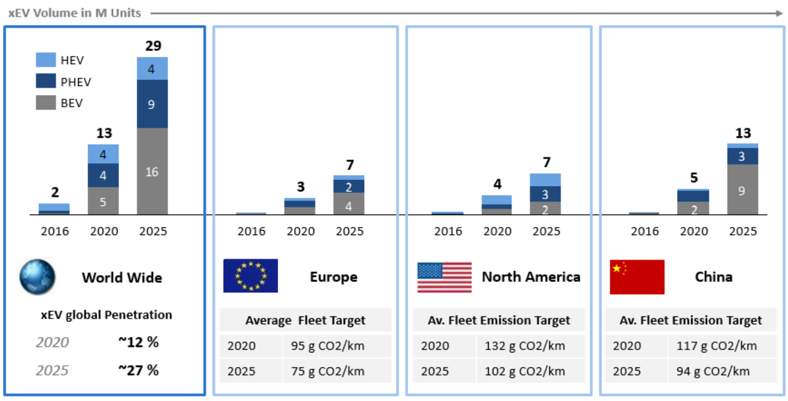

Figure 5: CO_2 fleet target & Market development [5]

Against the background of stricter CO_2-regulations shown in figure 5 it is expected, that the currently installed capacity of 30 GWh equals only 20% of the capacity in 2020. That means, that the market demand of batteries will be six times higher in 2020 and even 30 times higher in 2025 compared to the battery demand today.
Globally a sale of 29 million electric vehicles in 2025 and a EV-penetration of approximately 27% in 2025 is projected.

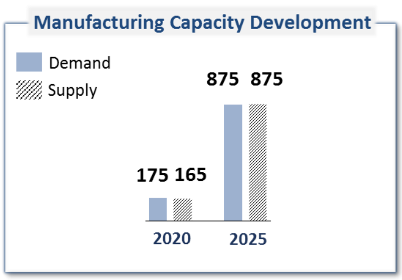

Figure 6: Manufacturing Capacity Development [6]

Compared to established technologies, battery innovations resulted so far in high development costs and, due to the small number of units, very high production costs. The expected market growth can therefore be a chance to enter the market and maintain important value added in Europe.
The figure below shows todays and future production locations of LG Chem and Samsung SDI worldwide. Especially in eastern Europe production facilities are already built up (see figure 7).

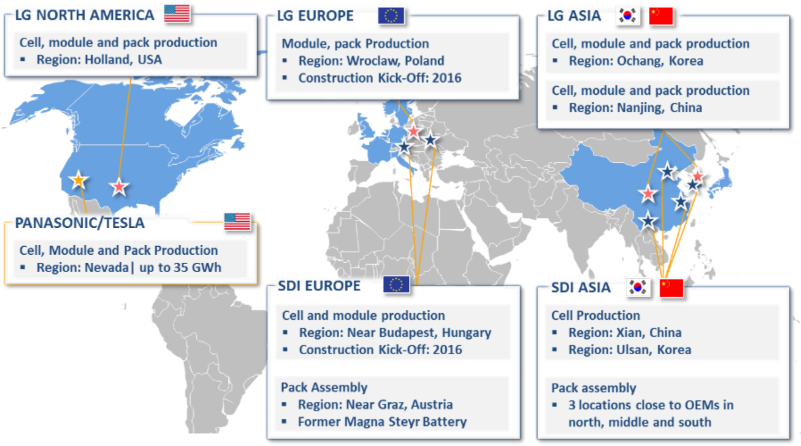

Figure 7: Worldwide production locations of LG Chem and Samsung SDI

Besides the automotive industry other technologies like power tools, home energy storages combined with PV systems, commercial transport and finally electric public transportation have a rising demand for batteries as shown in figure 8.

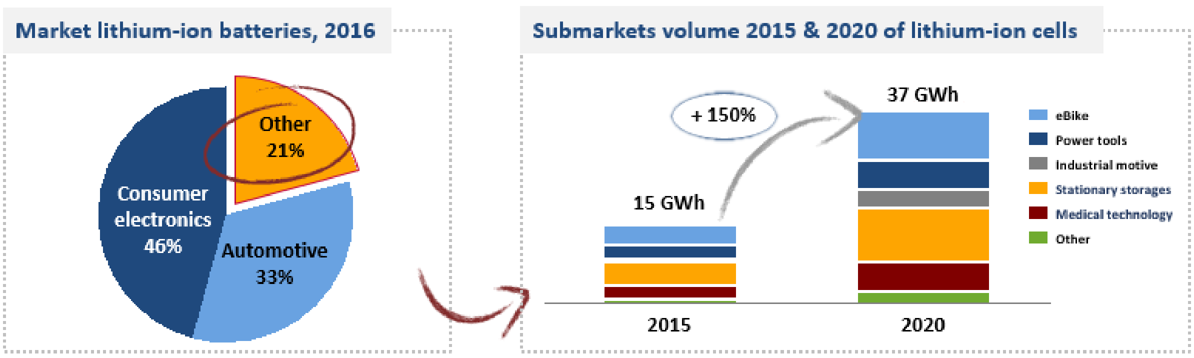

Figure 8: Potential of industry [7]

Overall it can be stated, that a market demand for additional production capacity is clearly felt.

2 Feasibility Analysis

It is certain, that battery systems must be further developed during the next years. Targets are:

- Increase of energy and power density for a range of up to 600 km
- The cost of ownership must be reduced by technological development and scale effects to the extent that they are at the same level as the costs for a vehicle with conventional drive technology
- Maximization of safety and reliability
- Minimization of quality fluctuations in cell production
- Increase of the usable capacity range with a long service life

To meet the high requirements, some factors should be considered, e.g

- Cell monitoring and control is necessary for safe and long-term use
- New developments in housings and thermal management can contribute to higher safety

The following paragraphs explain two aspects why a European battery production can be feasibly in this context according to P3 analysis:

First, the evaluation of the supply chain and depth of value added through various market stakeholders shows that Asian companies are specialized in the production of battery cells und strive to forward integrate their value added to module and pack assembly while European companies have a strong advantage in assembling battery systems and their corresponding components. Moreover, measures to optimize the production could be identified, shown in figure 9, which can bring costs down.

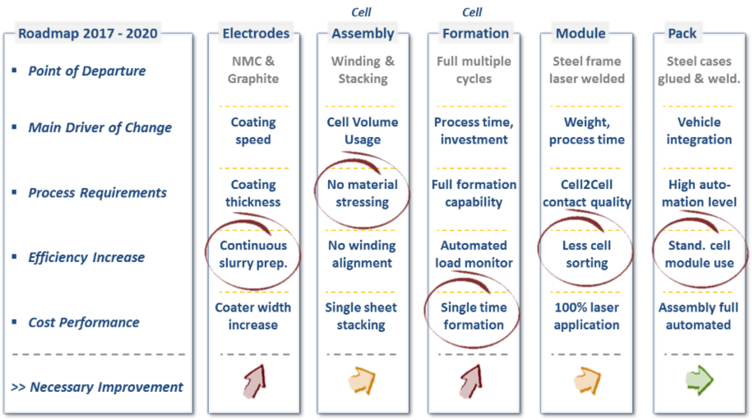

Figure 9: Improvement of battery factories

Nevertheless, the battery cell is the elementary component of the battery system. The cell accounts for about 2/3 of the costs and must be optimally integrated into the system.

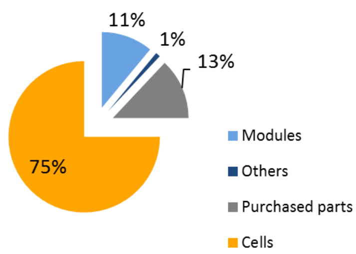

Figure 10: Cost break down battery system [8]

Second, the current and future battery technologies should be investigated. The development of the cell is proceeding rapidly: For example, Samsung developed a 64 Ah battery a few years ago, now a 95 Ah battery with the same weight and price is on the market and a 120 Ah cell is expected to be sold from next year.

Now the Li-Ion technology is at a significant and ground-breaking point, at which different development trajectories emerge. Besides the conventional approach, Li-Sulfur and All-Solid-State technologies are most promising to master upcoming challenges and to leverage the electromobility on a broad basis.

Especially in the development phase the availability of qualified personnel and the proximity to research centres is decisive. Further factors for a found decision among others are energy costs and state subsidies.

3 Profitability Check and Cost Comparison

To evaluate battery costs, P3 has set up a reversed engineering cost model for battery cells and battery systems. Within this model cell technologies including the necessary manufacturing technologies can be investigated. Based on these calculations and different cell- and battery concepts current and future battery cost can be determined. This results in a validated opportunity to define battery industry cost.

The cost model [9] shows that the cost of Lithium-Ion battery cells will be reduced from over 150 Euro per kWh in 2015 to 100 Euro per kWh in 2020 which is by far not marking the end of cost down potential. While learning curve effects and constant production optimizations are improving the cost position of a specific cell composition, the switch in cell compositions from NMC111 to NMC622 and further to NMC811 soon results in a notable drop in cost per kWh due to higher energy densities.

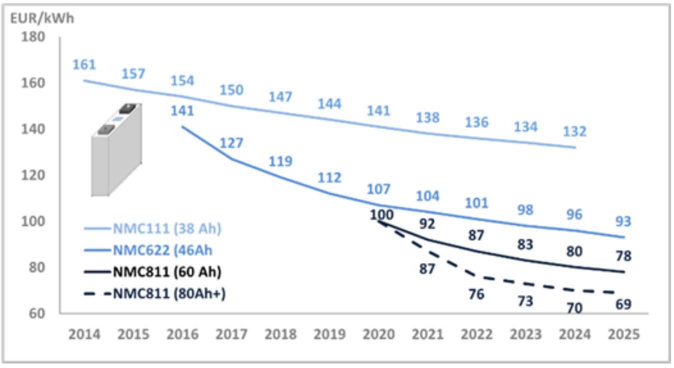

Figure 11: Cost development of battery cells

In the given example, the battery system reflects an automotive system cost structure of a 90 kWh battery. With this capacity, the battery cell is the major cost driver with an 80% share of the battery system. The battery cell cost structure [10] in figure 12 shows that the major cost factor is production costs.

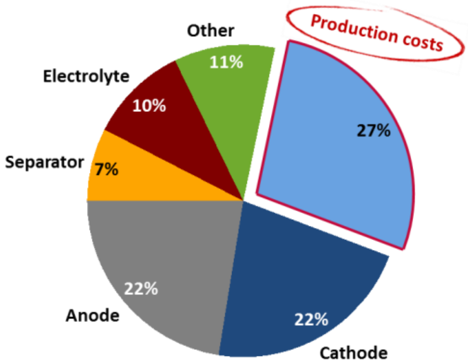

Figure 12: Cost structure: Lithium-Ion cell, 2016

When assessing the impact of location, the product cost should be adjusted according to country specific cost factors as labour, energy and space cost. There are also further factors that highly influence the attractiveness of a location like state subsidies and cooperation possibilities with local research institutes. The latter shall not be valued in the cost evaluation of Germany.

When reading in the press about Samsung planning on building a battery factory in Hungary [11] and LG Chem building a battery plant in Poland [12] the question arises whether there is a cost advantage in producing in Europe. In the following total cost for battery cell production for Germany, Eastern Europe and South Korea shall be compared. Learning curves are not reflected in this calculation step and will be discussed later. The cost categories are divided into material and scrap, depreciation, staff, buildings and energy. While material and Scrap and depreciation is equal in each of the location, Germany has a significant cost disadvantage caused by a higher national wage level as well as construction, site and pre-product logistic costs. Considering that labour cost only account for around 12% of the production cost for cells, the wage difference becomes less significant. [13] In terms of energy cost Germany and Korea are comparable while eastern Europe offers a notable cost advantage.

Cost components		E-EU	
Material & scrap	100%	100%	100%
Depreciation	100%	100%	100%
Staff	100%	20%	48%
Buildings	100%	51%	56%
Energy	100%	72%	90%

Figure 13: Regional influence on cost components of battery cells [14]

Aggregating this results to the total cost of a battery cells shows that Germany has a cost disadvantages of 5% to South Korea and 7% to Eastern Europe.

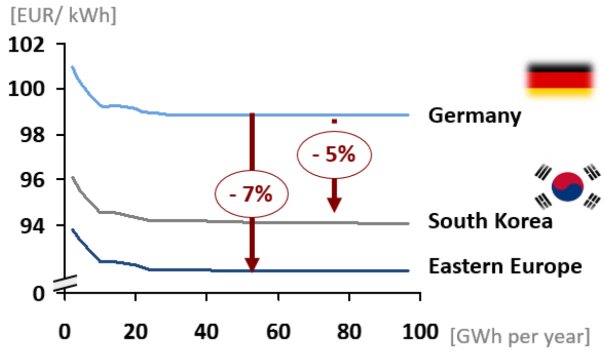

Figure 14: Total battery cell cost depending on production site [15]

Reasons why a German battery production can still be attractive are found when looking in other application of lithium-ion batteries. Applications other than automotive and consumer electronics like power tools account for around 21% of the lithium ion market (figure 8). The cost impact of battery cells to the final product in those applications are significantly lower than in the automotive application. The effect of a battery system cost increase in an automotive application is four times higher than for example in a power tool application. [16] The initial cost disadvantage of Germany can be compensated in parts by process flexibility which allows a wider range of battery systems. Furthermore, qualitative reasons for a battery production in Germany exists like the guarantee of product quality by “Made in Germany” processes. Several other qualitative reasons for a battery production exists. Bringing battery production to Germany and thereby also building the basis to extent production of battery systems and adjacent systems like cooling will create new jobs in Germany that would otherwise disappear in the shift from conventional power train to electric power train. [17]

The last factor that have not been evaluated yet, but has to be considered is the learning curve of battery cell production. It is empirically proven that there is an exponential correlation between product cost and cumulated product volume. The price experience factor (PEF) indicates the achievable cost reduction when doubling the cumulated production volume. While the factor is 25% for the established customer electronic batteries [18], the calculations in figure 11 in combination with the underlying market forecast in chapter 1 shows that the PEF in the automotive market is just at the beginning of the development with a factor of around 10%. Additionally, to this long term learning curve, a ramp up learning curve for a first-time cell production needs to be considered (figure 15). It takes up to 16 month of production until the initial scrap rate of 60% falls below 5%. With these two learning curve factors the advantages of established Asian battery cell suppliers is a hurdle that requires a Germany battery production to start with a new battery cell technology which is not established yet on the market and where the learning curve achievements by Asian competitors are limited. Another option for a Germany battery production would be a partnering with a leading technology provider which would allow to directly implement the learning effects.

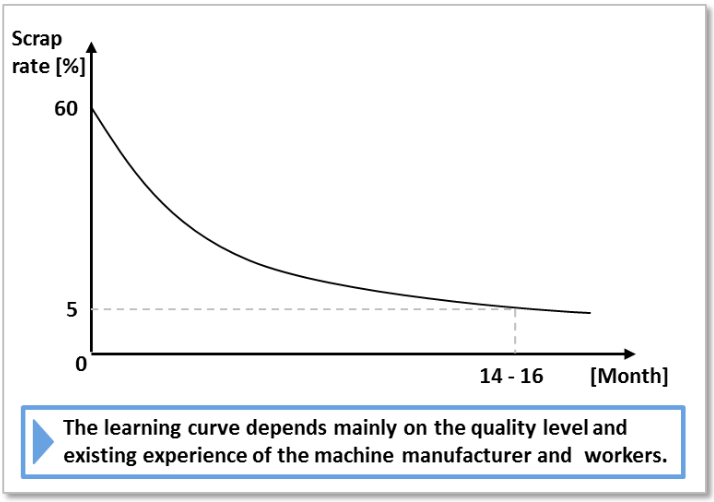

Figure 15: The scrap rate follows a 14 to 16 months learning curve [19]

Summing up the previously discussed points of a battery production and setting a new technology without significant influence of learning curves in the market a minimum size for a battery production factory in Germany can be calculated. P3 calculation indicate a minimum factory size of approximately 4,4 GWh to be competitive as of 2019. [20]

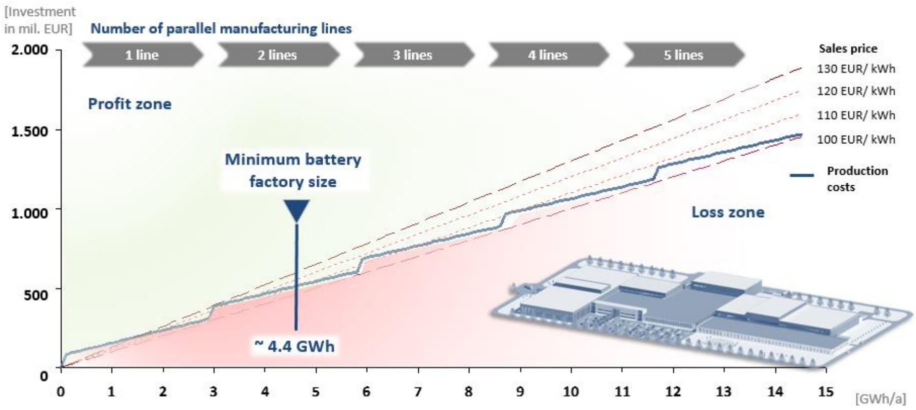

Figure 16: P3 calculation for the minimum battery factory size in Germany to be competitive

The NPE states a 13 GWh factory in 2021 as minimum requirement for a competitive Germany battery production. [21]

For the required investments per annual GWh output P3 calculations indicate 121 Mio. EUR for investments in equipment and 45 Mio. EUR for investments in buildings. [22]

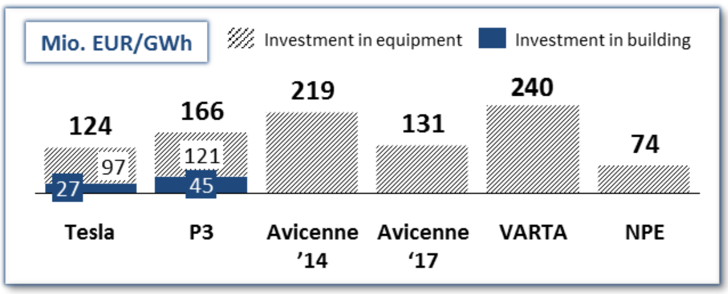

Figure 17: Statements regarding investment needs for battery factory per annual GWh output [23] [24] [25] [26] [27]

4 Summary & Outlook

Overall, it is crucial for the European market to compete with Asian companies in the field of battery cells and batteries.

Entering the battery market and building up a production leads to challenges as well as opportunities. For example, the steep rising demand due to CO_2 regulations and the expected peak demand of 875 GWh in 2025 can lead to both - a strong competition for raw materials and a high automation and flexibility grade.

Comparing state of the art manufacturing setup with the future strategy, it can be pointed out, that

- The preferred location will change from Asian countries to customer driven locations as manufacturers will reach higher integration levels
- the optimum size of production sites will be five times higher than today
- new technologies will enter the market
- production costs will come down to approximately 100 USD/kWh in 2020.

The main advantages of a European cell production are:

- the market, as submarkets show great potential, especially for expensive and high tech products and new cell technologies
- costs, as the cost disadvantage of 5% compared to Asia can be compensated by process flexibility
- product, as Germany is known for its R&D activities and product improvements are required to successfully increase the market share of EV
- Investments, as building up a battery production will lead to great employment potential

To further examine the possibility of a European battery production P3 already published and is doing further research on the market, competitors involved, top down calculations of battery systems and sensitivity checks of those analysis and business cases.

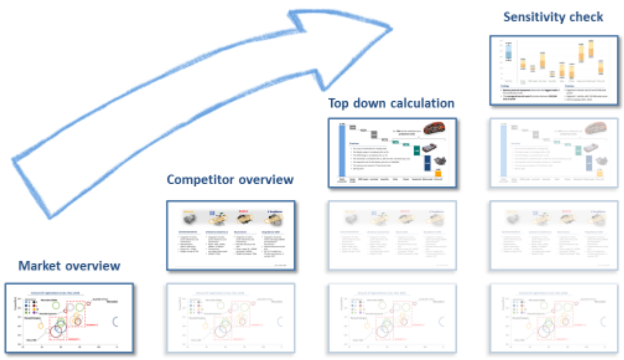

Figure 18: P3 analysis in the field of battery production

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