STRATEGIC ADVISORY | MANAGEMENT CONSULTING | DIGITAL SOLUTIONS

DESIGN OF BUSINESS MODELS FOR THE OPERATION OF THE CHARGING INFRASTRUCTURE ACCORDING TO THE GERMAN CALIBRATION CONFORMITY - DEVELOPMENT OF A TCO-TOOL

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P3

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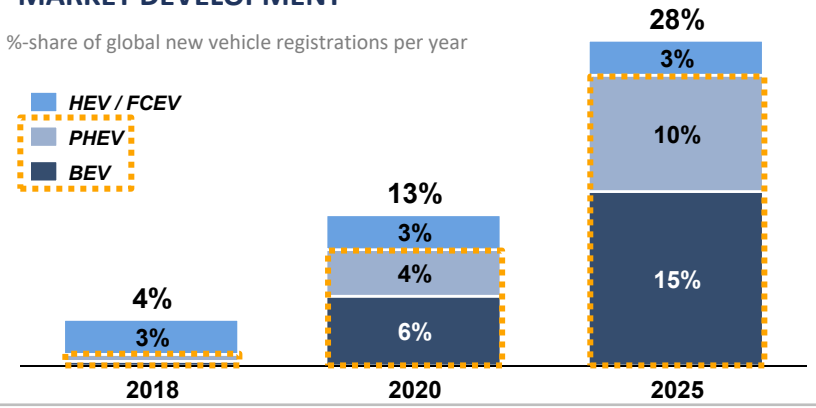
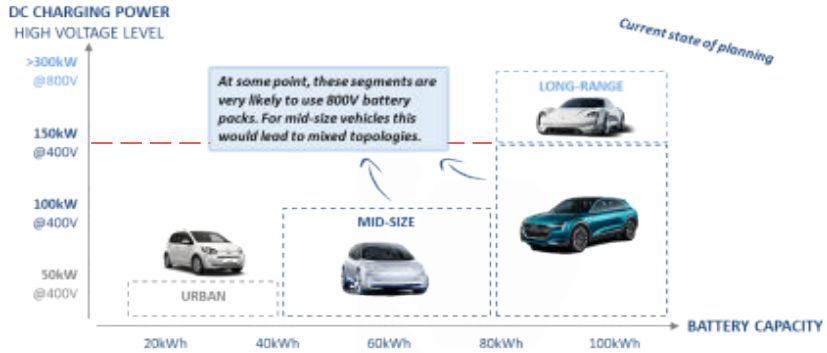
CURRENT MARKET & TECHNOLOGY SITUATION

The strongly rising sales volumes of electric vehicles (incl. a steady increase of driving range and applications) lead to a higher demand for charging infrastructure and electricity.

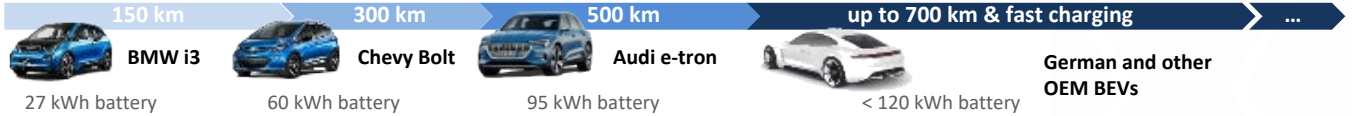
MARKET DEVELOPMENT[1]



FAST CHARGING STRATEGIES OF THE OEM



BEV ROADMAP

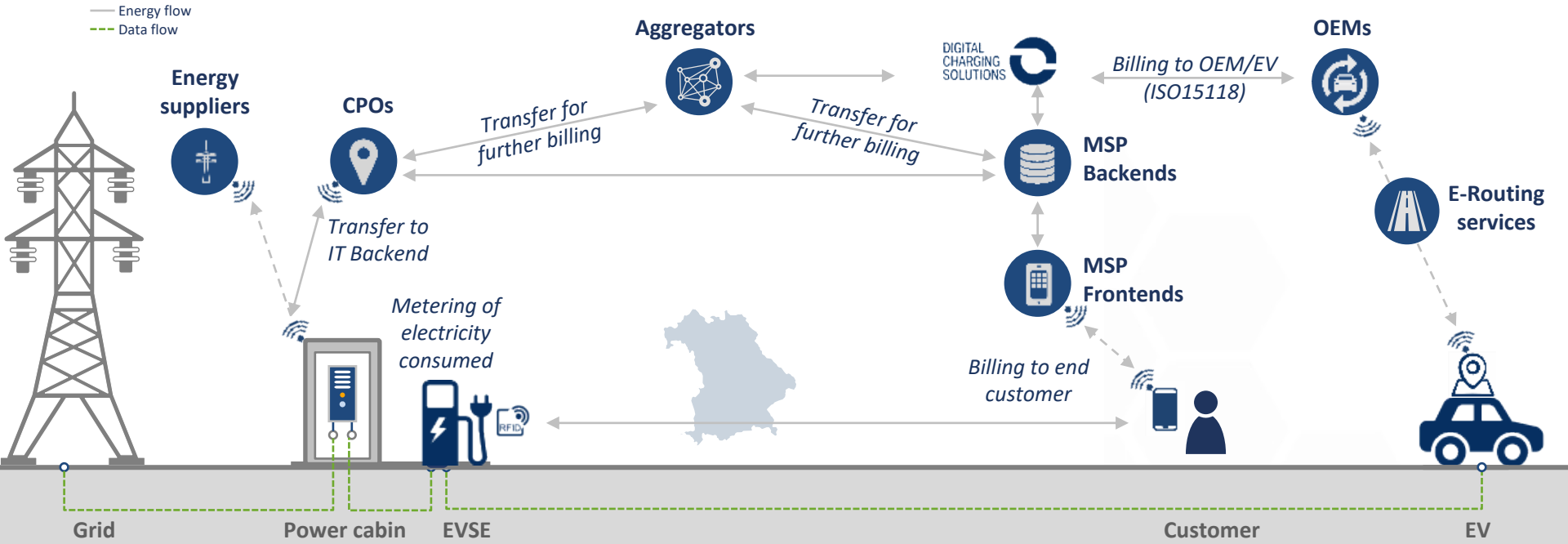


- Over the next few years, more and more BEVs and PHEVs will be entering the European and German markets
- The charging capacity of most vehicles will be up to 100-150kW, only a few will go beyond that (e.g. Porsche Taycan)

[1]Source: P3 vehicle-ramp up tool

EXEMPLARY ROLES AND MARKET MODEL GERMANY

The market landscape in Germany is divided into a heterogeneous market with many different players. From the measuring instrument to the accounting, however, the measurement and calibration law must be implemented.



- The overview shows that the processing of the measured values not only takes place in the CPO backend, but can also be continued at the aggregator/ MSP or even OEM (e.g. collective invoice)
- Within the framework of the German measuring & calibration law, e.g. signed values must ensure unadulterated forwarding.
- Every change (even one settlement) requires a “calibration conform IT-Backend/ chain”

GERMAN MEASUREMENT AND CALIBRATION LAW

The German measurement and calibration law defines different requirements for hardware and software. The installation of an appropriate meter alone is not everything.

Technical requirements

Hardware

- Calibration-compliant **meter** (with high accuracy)
- **Signature** device / encryption of CDR[1]
- **Storage** of measurement data for >90 days

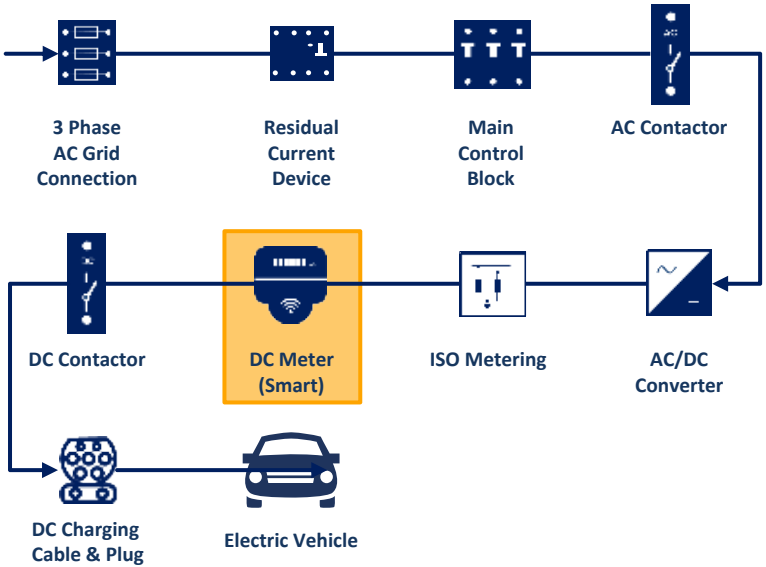
Software

- *Additional equipment may be legally relevant for calibration if measurement data is processed in the **backend** (e.g. billing)*
- ***Public key** infrastructure for verifiability of CDR*
- ***Transparency software** (customer can proof CDR)*

Key elements

- Measurement signing
- Conformity assessed measurements
- Consistency required
- Local measurement display
- Detached display and validation software
- Permanent and authentic storage

Typical setup of a DC charging station



- Conversion of most charging systems is possible
- The first conform DC meters conforming are available
- Costs of a conversion approx. 1.000€ per station

PARAMETERS TAKEN INTO ACCOUNT: HPC150 AS AN EXAMPLE

The tool was designed in such a way that all variables for the operation of the infrastructure are defined as input parameters and can be adapted at any time.

The tool maps a variety of costs that an operator of charging systems must take into account:

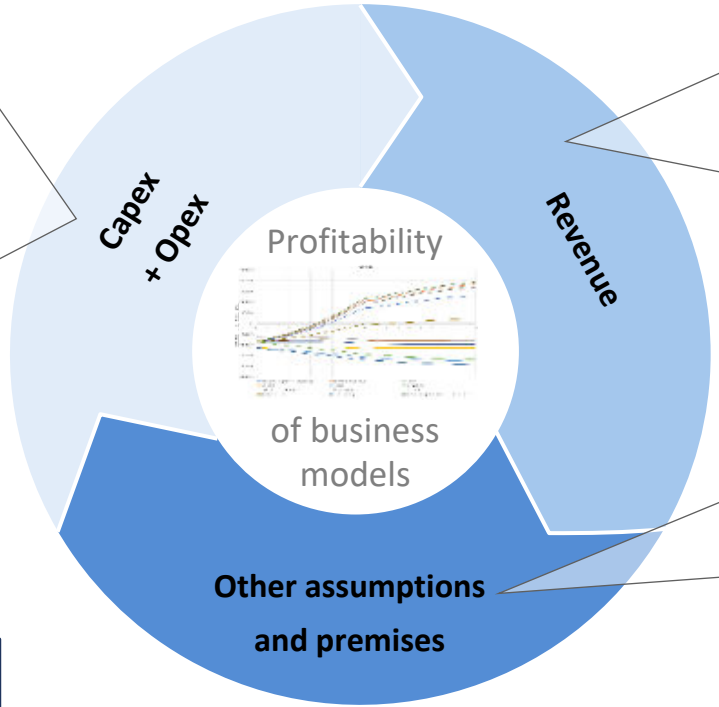
<u>Investment costs:</u>

- Hardware costs (incl. meters)
- Grid connection costs
- Approval, planning, location search
- Assembly, signage and other construction costs

<u>Annual operating costs:</u>

- Maintenance (service, hotline etc.)
- Communication costs
- IT/ backend system
- Contract management/ billing
- Parking rental fees

The tool forms the basis for further consideration, e.g. from an MSP perspective.



There are many different revenue models on the market, the tool can map them all (not only in Germany)

- Basic charge and amount of energy charged [per kWh]
- Parking fees and charging time [per min]
- Volume packages [per kWh/min]
- Credit note [per kWh]
- Packages [€/charge]
- Combined tariffs [per kWh/min]
- and much more

Further assumptions and premises guarantee the validity of the results:

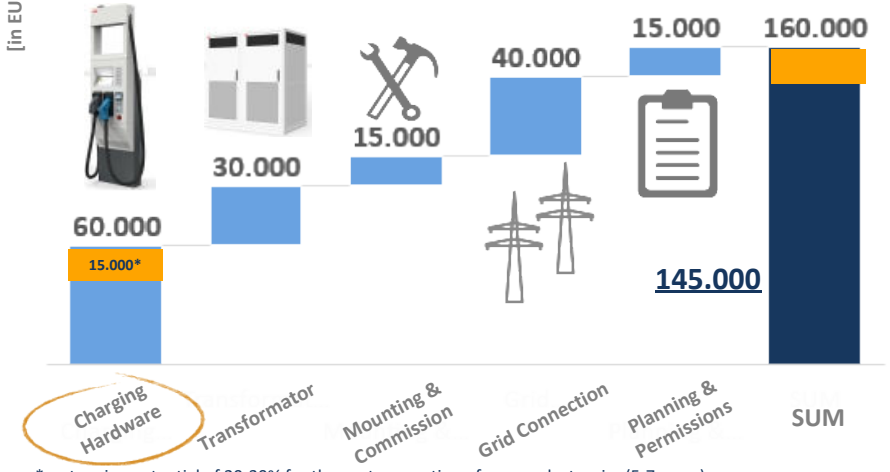
- Utilization of a charging station
- Average charging capacity per charging system and charging losses
- Funding quotas and calibration conformity
- and more than 50 other parameters

TOTAL COST STRUCTURE: HPC150 AS AN EXAMPLE

Offering charging infrastructure is a complex business with several issues – from grid connection to efficient operation.

CAPEX

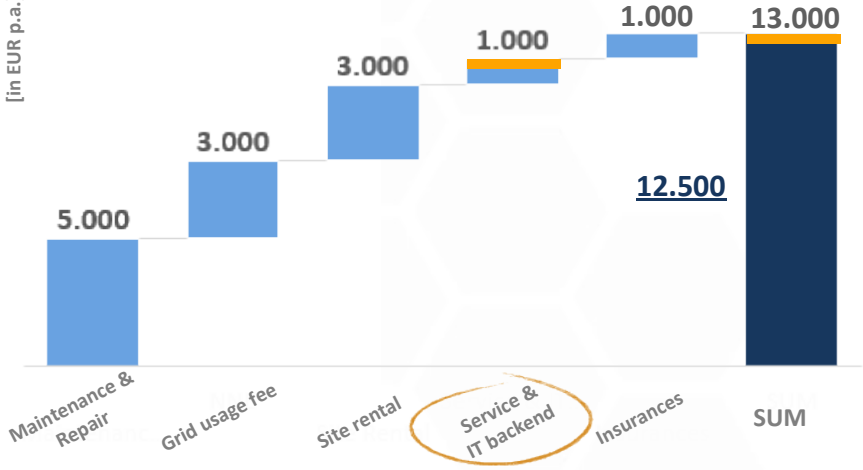
- Fix costs for installation and **set-up of HPC 150 kW with 2 charging points**
- Cost savings can be achieved by optimizing the **handling of load peaks** to reduce the **performance price impact.**
- **Economies of scale** are achievable in the area of Planning & Permissions as well as mounting.



*cost saving potential of 20-30% for the next generation of power electronics (5-7 years)

OPEX

- The **operating costs** are comparably high with ~10% of the initial invest – most important cost drivers are **maintenance & repair and site rental**
- For the backend connection a high cost degression can be expected



** Depreciation and energy costs not considered

PARAMETERS TAKEN INTO ACCOUNT: HPC150 AS AN EXAMPLE

An extract of the corresponding parameters for calculation is shown here. Well over 100 other parameters are taken into account in the tool.

General assumptions for 2018

- **Perspective:**
  CPO
- **Considered points in time:**
  2018 & 2025 & 2030
- **Period of depreciation:**
  10 years
- **Billing:**
  Every possibility known so far in Germany and other EU markets (see analysis)
- **Average charging power per event:**
  35 kW (80kW in 2025)
- **Average consumption per charging event:**
  40kWh (50kWh in 2025)
- **Charging station utilization:**
  5% (10% in 2025)
- **Electricity price:**
  Use of industrial tariff for HPC

Pricing model for calculations:

- **Basic charge + amount of electricity charged [per kWh]:**
  4,95€ + 0,30€/kWh AC or 0,50€/kWh DC
- **Parking fees + charging time [per min]**
  0,033€ + 0,04-0,30€/min (based on kW)
- **Volume packages [per kWh/min]**
  60min AC charging 5€ or DC for 30€
- **Sessions fees [€/charge]**
  6€ AC session or 8€ DC session
- **Combined tariffs [per kWh and min]**
  0,0144-0,1642€/kWh + 0,20-0,2€/min
- **and much more**

Adaptions in 2025

Technology improvements

Technological developments and economy of scale effects in power electronics shrink costs of the charging equipment.

Charging capabilities

EVs in 2025 are capable of **charging with higher power** raising the average charging power per event.

BEV sales

In 2025 the share of new BEV registrations per year is about 34% eventually leading to a **higher charging station utilization.**

TOTAL COSTS OF OWNERSHIP: HPC150 AS AN EXAMPLE

According to current pricing, the billing models permitted in Germany on the basis of kWh are profitable even after 7-8 years with an increasing utilization of the infrastructure due to the vehicle ramp-up.

- A kWh-based billing system can best take into account and bill the average charging capacity
- Uncertainties with minute billing or session fees lead to significantly lower revenues with higher charging capacities
- Flat rates or no billing at all lead to a highly unprofitable business model, unless revenue can be generated through side business models

CONCLUSIONS

Key take-aways from today's presentation:

1. The EV market is growing consistently **within the next decade**. In 2025 about **25% of European new vehicle registrations will be Battery Electric Vehicles** (BEVs) and **Plug-in Hybrid Electric Vehicles** (PHEV).

2. The **German calibration law** does **not only** include a compliant design of the **meter**, but also the **IT backend must be implemented in conformity** with the calibration if necessary.

3. In order to be **able to bill charging infrastructure in Germany** in accordance with the law, billing must be **based on kilowatt hours**. **Parking time** can also be **billed per minute.**

4. **With today's prices, kilowatt-hour-based billing is already the most profitable business model for HPC150+**. A comparable profit with a session fee can only be achieved from 27€ upwards per charging session.

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