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New business models for electric cars – a holistic approach

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Abstract

Climate change and global resource shortages lead to a rethinking of classic individual mobility basing on combustion engines. As a result of technological improvements first electric vehicles are introduced and further market penetrations can be expected. But due to a possible wider implementation of battery-powered electrical propulsion systems in future, new challenges arise for both the classic automotive industry and further new players, e.g. battery manufacturers, the power supply industry or other service providers. Due to the various application cases of electric vehicles discussed topically, numerous business models can emerge leading to new shares in the value creation and involving new participating players. Consequently, the individual stakeholders are uncertain as to which business models are really effective with regard to targeting a profitable overall concept. Therefore, the aim of this contribution is to define a holistic approach to developing business models for electric mobility, regarding the holistic system on the one hand and giving decision support for concerning enterprises on the other hand. For this, the basic elements of electric mobility will be observed and topical approaches for business models for various stakeholders will be discussed. The paper closes with a systemic instrument for business models basing on morphological methods.

Keywords: Business models, electric vehicles, morphologic box

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1 Challenges and opportunities for new business models

As a consequence of climate change and increasing global resource shortages, alternative propulsion concepts are becoming ever more important. Due to rising oil and gas prices and the advances made in battery technologies, greater attention is now being directed at battery-powered electrical propulsion concepts (see Barkenbus 2009, Kalhammer/ Kopf 2007, MIT 2008). In spite of these developments, there are still obstacles to the wider introduction of electric vehicles. These include the long charging times, on the one hand, as well as the shorter driving range and the skepticism among potential end-users, which is currently being expressed in surveys (Tate, Harpster 2008). The major obstacle to rapid market penetration at the moment, however, is the higher initial investment required, when being compared to conventional combustion engine vehicles (Cheron/Zins 1997, Nemry/Leduc 2009, Brooker, Thornton 2010). On the other hand, the running costs of electric cars are actually lower, but these do not stand out sufficiently on a total cost basis (Biere et al. 2009). Against this background, new mobility concepts and business models are required which transform the technological advantages of electric vehicles into value added for the customers. New, promising approaches here tend to follow one of four main directions:

1. *Better utilization of the vehicle capacity:* New, innovative mobility concepts such as car-sharing or company vehicle fleets exploit the strategy of extending the user base at the lower operating costs of electric cars and in this way spreading the capital costs over a greater number of heads. The same thing applies to electric cars in multiple car households; due to its lower consumption, it makes sense to use the electric car more often and to save the combustion engine-powered car for other, less frequent trips. Instead of resorting to a vehicle with a conventional motor, electric mobility can also be integrated into public transport systems which are then used for longer journeys.
2. *Extended utilization concepts:* The attempt is made here to improve the economic efficiency of the overall system through new applications. For instance, batteries can be charged cheaply with energy during off-peak periods and can then feed power back to the grid during peak periods. Systems services such as load shifting or back-feeding energy reduce costs at the same time as helping to balance the grid load and increasing grid quality.
3. *Secondary usage:* Another possibility is to use components which are no longer being used in the vehicle, such as the battery, for other, secondary

applications in order to increase their residual value, i.e., batteries could be used as stationary energy storage and as such help to improve the vehicle's overall economic efficiency (see Williams, Lipmann 2010).

4. *Increasing acceptance:* Obstacles such as, e.g., a comparatively restricted driving range can be increased by offering so-called 'mobility guarantees'. For instance, when purchasing an electric car, the occasional use of a combustion vehicle could be offered for longer journeys, or a kind of pick-up service for the drivers of stranded vehicles. Customer-oriented infrastructure solutions offer customers a reasonably priced and reliable infrastructure through a sensible mix of services.

These approaches can indeed help to promote the market penetration of electric vehicles, but at the same time it becomes clear how complex these concepts are. For example, these would have to integrate completely new stakeholders, who have not been part of the value chain for combustion vehicles so far. Alongside car and battery makers, energy utilities would have to be integrated, for example, as well as new mobility service providers. The consequence is that a variety of potential business models result for the different application cases, for which the participating companies and their share in the value creation have to be newly defined. In addition, the individual stakeholders are uncertain as to which business models are really effective with regard to targeting a profitable overall concept and should therefore be pursued. This paper aims to take a holistic approach to developing business models for electric mobility.

2 Types of business models

In industry, suppliers have been using the principle of new business models on their clients for some time now (Wise/Baumgartner 1999, Fähnrich/Opitz 2006). These new business models try to utilize additional services to design the product in such a way that increases the benefits for the client and gives the supplier's product the competitive edge (Matzen et al. 2005). This basic idea can also be transferred to innovative business models for electric mobility. For example, Afuah (2004) cites the following definition: "A business model is the set of which activities a firm performs, how it performs them, and when it performs them as it uses its resources to perform activities, given its industry, to create superior customer value (low-cost or differentiated products) and put itself in a position to appropriate the value".

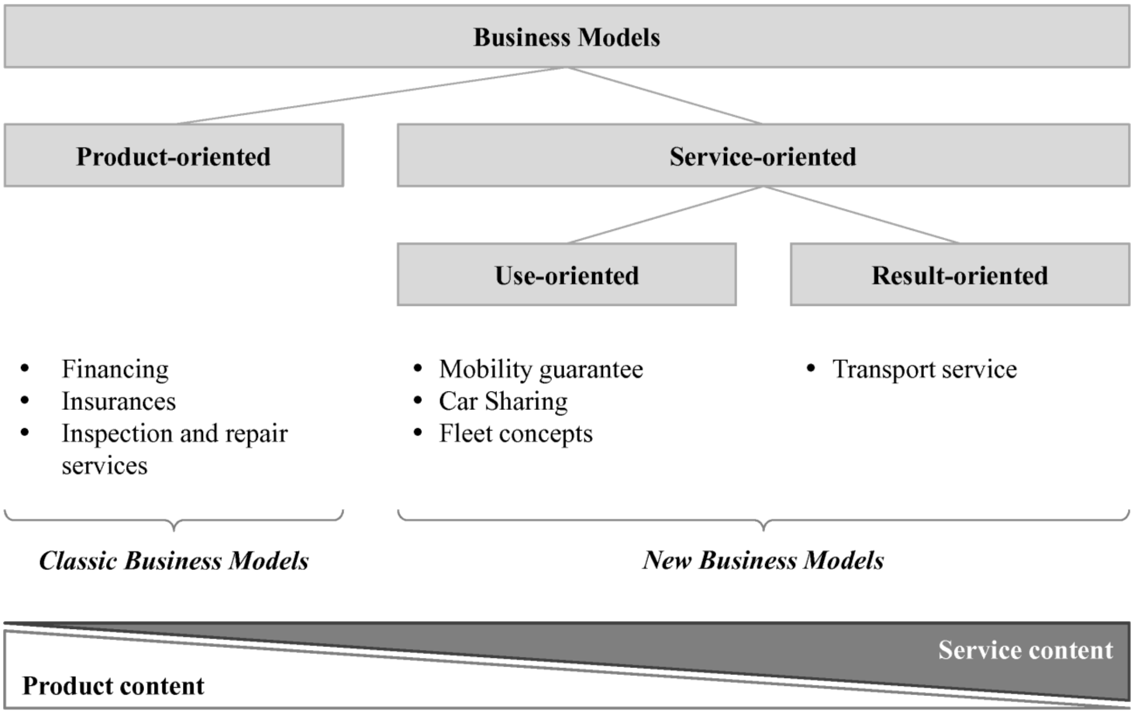
A structured approach which implicitly follows the above definition and includes a methodical procedure differentiates business models into three elements (see Timmers 1998; Lehmann-Ortega/Schoettl 2005):

1. *Value proposition:* Defines the promised value of a product offered by the manufacturer to the client beforehand. When looking at the classical business model for internal combustion engine vehicles (ICEs), the car manufacturer promises to deliver the customer a high quality vehicle with the individual features the customer wanted.
2. *Value chain configuration*: Describes the potential possibilities to design the product offered with regard to the different shareholders involved in a business model. The car manufacturer produces the vehicle including the supplier parts and combustion engine and delivers the product to the final customer who then uses it over a certain period of time. Who carries out repairs or maintenance is chosen by the customer and is not usually explicitly stipulated. The infrastructure in the form of filling stations is operated by other stakeholders so that mobility can be guaranteed.
3. *Revenue model*: Fixes the type of payment the customer makes to the supplying shareholder as part of the offer. The revenue generation model has been designed so far along the lines that the customer pays the car producer for the vehicle in the form of a sales price or a leasing rate. Repairs or maintenance work on the vehicle and fuelling are charged separately to the customer by the respective services provider.

The classical business model described here, large parts of which are used for combustion engine vehicles, cannot be transferred to mobility concepts based on electric drives because of technological restrictions. If innovative mobility concepts are considered, the integration of mobile energy storage into the power system or the build-up of charging infrastructure, then it is inevitable that there will be shifts in the value chain, the revenue model, and the value proposition.

To further develop business models and examine them systemically, it has to be asked how this classical business model can be clearly differentiated from new, innovative models. Baines et al. (2007), for example, describe business models as a combination of tangible and intangible components and Tukker (2004) derives three different main types which crop up in the existing literature in the same or similar form (Welp et al. 2008; Sundin et al. 2008). These three basic types lie between offering purely a product and purely a service (see Figure 2-1). If these are applied to mobility, two possibilities result for the final customer. He can buy the product in the form of a vehicle or purely the service in the form of a taxi. Between these two extreme forms, however, there are numerous other ways to offer mobility services to the final customer. The following three categories describe a mix of tangible and intangible products, with an increasing share of services (Tukker 2004; Williams 2005).

Figure 2-1: Applying Tukker's typology (Tukker 2004) and transferred on business models for mobility concepts



The first category describes the "product-oriented business model," which follows the classical business model as described above to the greatest extent. Here, additional services to the core product are offered by the carmakers. These classical business models do not contain any performance guarantees, once the customer has bought the product. The focus of the manufacturer is therefore still on the core product and services are seen only as supportive instruments which help to sell the product and strengthen customer loyalty. Characteristic for this category is that additional services do not start during the vehicle's service period. Typical services offered in product-oriented business models are, for example, financing, insurance offers as well as inspection and repair services.

In contrast to this, categories two and three, which can also be called "service-oriented business models" are applied in the vehicle's service period (see Markeset/Kumar 2005) and are described as new or innovative business models because of their novelty and limited distribution. Service-oriented business models can be further split into the two categories of “use-oriented” and “result-oriented”. In other words, the core product is no longer the focus but rather a contractually guaranteed performance even after delivery, which is provided with the help of the core product. If this concept is transferred to mobility offers, for use-oriented business models, this means that a certain value is promised with the purchase of a vehicle. For battery-powered electric drives this covers mobility guarantees, car-sharing concepts or fleet concepts, for example, which guarantee the supply of vehicles or of mobility services without the customer having to actually own a car. For result-oriented business models, in contrast, this means that the final customer can always get from A to B with the help of the mobility provider. The customer does not own a vehicle, but is given the guarantee of being able to cover a certain distance any time he wants. This would be the case, for example, if a transport service is being offered. The difference to the classical taxi concept is that no external service provider is needed; instead a car manufacturer offers this service.

Companies still have to ask which framework conditions are necessary to be able to offer the business models outlined above or other new ones. Because of the complexity involved, a systematic classification of business models for electric mobility should be developed which allows suitable actors in a business model to be identified on the one hand and, on the other hand, checks the feasibility of the envisaged business model.

Morphological analysis is one way to develop such a holistic instrument. Lay et al. (2003), for example, already used this approach to systematize and compare business models in the capital goods industry. The principle of the morphological box represents a creative way of illustrating all the potential solutions to existing problems in a structured format by defining different features with several configurations with regard to a problem (Zwicky/Wilson 1967). These potential solutions can then be reduced to a few concrete solutions by the logical combination of different configurations and the exclusion of technically impossible or unprofitable ones.

3 Holistic approach to describing business models

In order to develop such a holistic instrument for business models concerning electric mobility, it is necessary to consider those components which are influenced by battery-based electric mobility concepts within the overall system, or which help to dismantle obstacles and thus promote the introduction of electric vehicles. The identified drivers, discussed in literature, here include:

- the vehicle together with the battery (regarded e.g. in Delucchi/ Lipman (2001); Ahn et al. (2008); Axsen et al. (2010)),
- the infrastructure system (regarded e.g. in Morrow et al. (2008); Brown et al. (2010); RMI (2009), Kley et al.)2010)), and
- system services which integrate electric vehicles into the energy system (regarded e.g. in Tomic/Kempton (2007); Jorgensen (2008); Andersen et al. (2009); Brown et al. (2010); Guille/Gross (2010)).

In the following, the value chain architecture and the revenue model are elaborated for these three different components and presented in the form of a morphological box. These can be formulated in concrete terms using a potential value proposition.

3.1 Vehicle and battery characteristics

Business models can refer to several characteristics for both the battery and the vehicle, which seem to be observed in separate ways (see Andersen et al. 2009) When considering new business models, one basic question is who owns the vehicle or the battery (regarded e.g. in Saldarriaga-Isaza/Vergara (2009)). Classical stakeholders like carmakers, independent traders, for example in the form of a bank, and the final customer have to be considered here. However, due to the new propulsion technology, battery producers and energy supply companies have to be added to these, which results in five stakeholders participating in ownership. When looking at new mobility concepts, moreover, battery and vehicle do not necessarily have to belong to the same owner which means that numerous combinations are possible.

Paying for the battery or the vehicle could be done in the classical way via the selling price (pay for equipment). A fixed rate is also conceivable, either independent of use or dependent on it (pay per use). The type of billing depends heavily on the mobility concept offered as well as on the ownership relations.

Another component which plays a role throughout the entire life cycle of battery and vehicle is the so-called "after sales service" (regarded e.g. in Cheron/Zins (1997)). In new business models, it is particularly important which stakeholder is responsible for maintenance or repairs of the vehicle or battery. Potential operators here also include automobile and battery manufacturers. Another possibility would be for energy utilities or independent operators, e.g. garages, to offer these services. It would also be conceivable that customers do the necessary repairs themselves.

In addition, both battery and vehicle can be used by one or by several customers (see Andersen et al. 2009). This is described under the final characteristic of the exclusiveness of utilization. Under exchange systems, for example, the batteries can be used for more than one customer; a vehicle can also be made available to several customers in a car sharing scheme. If these characteristics and their different design possibilities are presented in a morphological box, the following combination results (see Figure 3-1).

Figure 3-1: Morphological box for the systemic description of business models for battery and vehicle

Vehicle and battery

Characteristic		Design possibility				
Property	Vehicle	Customer	Independent provider	Energy utility	Battery producer	Vehicle manufacturer
	Battery	Customer	Independent provider	Energy utility	Battery producer	Vehicle manufacturer
Type of billing	Vehicle	Pay for equipment	Fixed rate	Pay per use		
	Battery	Pay for equipment	Fixed rate	Pay per use		
After-sales services provider	Vehicle	Customer	Independent provider	Energy utility	Battery producer	Vehicle manufacturer
	Battery	Customer	Independent provider	Energy utility	Battery producer	Vehicle manufacturer
Exclusiveness of use	Vehicle	One customer	More than one customer			
	Battery	One customer	More than one customer			

Degree of innovation, maturity

Looking at the box, it becomes obvious that the left-hand side captures classical business models and the right-hand side profiles more innovative ones. The demands made of the involved stakeholders increase with a higher degree of innovation.

3.2 Infrastructure characteristics

The second component describes the charging infrastructure for supplying the electric vehicles with power. The different possibilities currently being discussed include wired (conductive) and wireless charging points as well as exchanging the vehicle's battery. The charging infrastructure can also be differentiated by the type of accessibility; for instance, vehicles requiring a wired connection can be charged at domestic power outlets or at specialized public charging points (see Wietschel et al. 2009); wireless technology can be used due to cost reasons only to a certain extend in the private domain, and battery exchanges can only be managed as a public scheme similar to today's filling stations.

In general, it is possible to identify a private, semi-public or public connection. Semi-public connections are basically restricted access and are only available to authorized users such as, e.g., employees permitted to use companies' private car parks. An existing fast charging function is frequently highlighted in the literature or by the suppliers of charging points. Beyond the batteries and the power electronics required, the power provided at the charging point is decisive for how quickly the vehicle can be re-charged. In Europe, domestic power connections range from 3.7 kW (one-phase) to about 11 kW (three-phase). Power connections above this can usually no longer be realized domestically and therefore tend to be envisaged more for public connections. Because the voltage available across Europe is 230 V, high voltage charging points can still be realized using alternating current. In the US and Japan, however, these are usually direct current because of the lower voltage level there of 110 V. In analogy to this division, three levels are used in North America to classify the different power connections (see Morrow et al. 2008, p. 16ff).

The type of connection is another characteristic which is important for use; unidirectional connections can only deliver power in one direction, while bidirectional connections transmit electricity in both directions. The use of potential system services such as, e.g., back-feeding energy into the grid is dependent on this. Similarly, the communication links have to be considered, which are needed to control the charge, among other things. If there is no communication interface, charging takes place in an uncontrolled manner. If there is only a unidirectional interface, control is based on grid or vehicle data. Only a bidirectional communication channel allows both components to be integrated in controlling the charging process. With a real-time connection, exchanging data from both sides can lead to an immediate modification in the charging profile.

Possible operators of charging infrastructure include private households as well as semi-public organizations, energy utilities, other independent operators or the state. The operator takes on the responsibility for installation, maintenance and repair of the supply unit in question. How the user is billed by the electricity provider or the operator can vary: no fee, pay per use, or a fixed rate.

Figure 3-2: Morphological box for the systemic description of business models for setting up and supplying infrastructure

Infrastructure				
Characteristic	**Design possibility**			
Type of power supply	Conductive (wired)	Inductive (wireless)	Battery exchange	
Accessibility	Private	Semi-public (e.g. at employer)	Public	
Power connection	1-phase (Level 1)	3-phase (Level 2)	High voltage AC (Level 3)	High voltage DC (Level 3)
Power type	Unidirectional	Bidirectional		
Communication connection	None	Unidirectional	Bidirectional	Real-time
Operator of power supply	Private	State	Energy utility	Independent provider
Type of billing	No fee	Pay per use	Fixed rate	

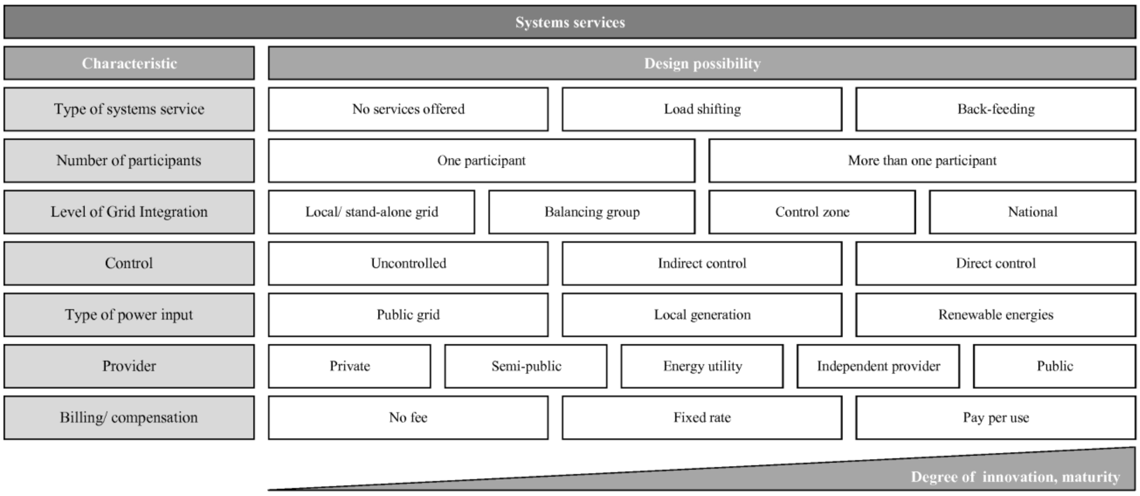
Degree of innovation, maturity →

The corresponding morphological box is shown in Figure 3-2. When looking at the box, it is clear that the profile shifts further to the right with increasing maturity and advanced expansion of the infrastructure. However, a higher level of maturity is also linked with additional investments and higher resource use.

3.3 System services characteristics

The final component to be considered when developing business models is integrating the grid, or the possibilities for supplying systems services arising from this. Participants here include either individual persons or more vehicles being pooled together. The number of participants has impacts on the systems services offered because of technical restrictions. The potential systems services considered are load shifting and back-feeding power. Both variants theoretically allow grid support, participation in the power regulation services market and the integration of fluctuating generation or load balancing. The potential for load shifting is limited by the kilometers driven or the energy consumed by the vehicle. Back-feeding energy allows greater freedom of scope for systems services. If, in contrast, neither load shifting nor back-feeding is done, in other words, the vehicle user charges according to his individual needs, then no services are offered.

Figure 3-3: Morphological box to systemically describe business models for the integration into the energy system



Another characteristic describes the level of grid integration in which the system service takes place. An individual participant can only provide the service for his own household (private) or for semi-public organizations in a stand-alone grid. A participant pool, on the other hand, can offer systems services for the balancing group, control zone or even at national level. Possible systems service operators include private individuals, energy utilities or other independent operators. For systems services to be possible, it is necessary to have some form of control of the charging or back-feeding process. Indirect control in this context describes control via a price signal. Direct control allows switching signals to be sent to the battery in the vehicle. In practice, mixed forms of these two variants are also conceivable. Uncontrolled charging corresponds to a case without services.

The power required can be guaranteed by local generation units such as cogeneration plants or photovoltaic plants as well as the public grid. Renewable energies are listed separately on account of their low emissions and the problems with integrating fluctuating generation sources. Billing the customer can be done individually after each charge or back-feeding power (usage-related) or via a flat rate or at no cost. The morphological box shown in Figure 3-3 results for integrating the power grid to provide systems services. Again, it is clear here that the profile of a business model shifts from the left-hand side of the box to the right with an increasing level of maturity regarding the use of mobile storage units.

4 Framework conditions for new business models

The three morphological boxes elaborated here can be combined to develop or describe a business model. Doing so results in a structured approach to developing business models. The following section shows which framework conditions have to predominate for the three components discussed here in order to spark potentials for new business models for electric mobility. In order to examine the feasibility of these potentials from the viewpoint of a holistic approach, we make greater reference to the other elements of electric mobility when looking at the individual components.

4.1 Mobility concepts and battery solutions

Innovative mobility concepts are often regarded as a “silver bullet” solution to the introduction of electric drive systems. And yet, little is known so far about which concepts actually create advantages compared to vehicles with classical combustion engines. So that economic improvements can be achieved here, attention has to be paid to technological features and their impacts on profitability when developing innovative mobility concepts. For instance, first studies show that electric cars generate advantages at higher utilization rates and higher mileages because of their lower consumption costs. Furthermore, electric cars are superior to conventional ones, if there is a high share of inner city driving involved because of their better energy efficiency and the limited distances involved (Biere et al. 2009).

Mobility has to be differentiated into offers for private individuals (regarded e.g. in Ahn et al. (2008)) and for companies (regarded e.g. in Mandell (2009)). Since companies tend to calculate on a total cost basis much more than private individuals, the commercial domain seems to harbor particular potentials for the introduction of electrically-powered vehicles. In addition to this, companies have the opportunity to switch only parts of their fleet. To do so, however, they have to know their own driving/parking profiles and be able to evaluate them correctly. In this way, the share of vehicles suitable for inner-city use could be identified and then converted to electric drives. In addition, there is the possibility to equip logistics companies operating in inner-city areas, as well as delivery companies with electric vehicles. Again, driving analyses would have to be conducted for the entire fleet in order to convert certain shares to electric drives. Furthermore, companies in particular represent an interesting way to offer systems services. If several batteries can be switched together, back-feeding and load shifting are possible accompanied by an improvement in grid quality. Up to now, the widespread introduction of electric cars among private individuals seems to be more difficult because their purchasing decisions are more emotionally motivated. So-called mobility guarantees may help to overcome some of the obstacles to electric cars here and thus raise their acceptance level. When forming business models for private individuals therefore, it is important to consider the infrastructure system's level of maturity.

Different solutions for offering innovative battery concepts were considered in the same way. Batteries make up a large share of the total cost of an electric vehicle (Delucchi/Lipman 2001) and consequently represent the key element for its economic efficiency. In the current discussion, above all the lifespan of the battery is seen as being critical. If battery capacity decreases over time, far-reaching restrictions would result with regard to driving range, and mobility possibilities would be drastically reduced. However, batteries whose capacities seem too low for driving purposes could still be used as stationary energy storage units. If several vehicle batteries were combined, power regulation services ("balancing power") could be offered to generate additional income. This would lead to a higher residual value of the battery which could improve the economic efficiency of the total vehicle. Battery exchange concepts represent another possibility which is closely related to mobility concepts. Here, the battery remains the property of the manufacturer and is exchanged between different vehicles. In this case, vehicle and battery would be independent of each other which makes it even more difficult to design the respective business models. Moreover, additional economic potential results for a business model if the battery concept plans to integrate renewable energies or provide systems services. Supplying balancing energy in particular seems a very promising solution.

4.2 Realizable infrastructure concepts

The development of a charging infrastructure is also part of the call to promote electric mobility. As described in Section 3.2, the possibilities to do so are numerous and the associated business models relatively unclear. To understand the demand for infrastructure, the future charging behavior and demand have to be analyzed. Kley et al. (2010) therefore examined, e.g., the times and places where vehicles are left standing in a one-week mobility panel in Germany. The result was that wired, private charging at low power connections is sufficient to convert more than 50% of all the existing vehicles to battery-electric ones based on both mobility behavior and economic calculations. Meeting a large share of today's mobility demands would be possible with this charging infrastructure, but rapid charging would not. In order to counter the low range of an electric car and the drivers' associated fear of getting stuck (known also as "range anxiety", see Tate et al. 2008), as well as to reach urban areas without sufficient private parking places, the build-up of a public charging infrastructure is demanded. However, evaluations from the pilot tests conducted in the 1990s[1] or today in London and Berlin[2] reveal that public charging points are actually used relatively rarely. In fact this issue is more a psychological phenomenon (see Taylor 2009) which business models also have to account for when considering access to the charging infrastructure. A small proportion of public charging possibilities seems to foster the market penetration of electric cars. However, since private infrastructure is actually used for charging, the number of public charging points should be kept to a minimum. Furthermore, because of their low rate of utilization, these points are not likely to pay off via the amount of power sold at them. Concepts such as using the terminals as advertising spaces may help to improve the financial calculation. Mainly, however, an infrastructure mix needs to be offered to customers by one provider and in which a transition of the business model from "access to infrastructure" to "mobility guarantees" takes place. The few, isolated public charging points could then be offset against the installed basis of all charging points.

The types of connection and communication links are basically driven by the type of system services offered and are therefore described in more detail there. Questions such as, e.g., whether participation in the power markets pays off, are driving the development of controlled and bidirectional infrastructure concepts.

4.3 System integration

Large shares of today's energy supplied in the form of liquid fuels could be shifted into the electricity sector as a result of electric mobility. Business models therefore have to take into account the special characteristics of the energy source electricity. For the user, this means a grid-bound supply and a comparatively low energy storage density. At the level of the overall system, there are new challenges to be faced due to the large number of small, mobile consumers and energy storage units. New approaches are required by the high level of

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1 See estimates of the Mendrisio project in Meier-Eisenmann et al. (2001).

2 Discussed in Hoffmann (2010).

charging concurrency and the increase this causes in the grid's peak load. How loads can be shifted or controlled in the future is, therefore, an essential factor for business models with the objective of system integration. The transition to flexible electricity consumption is not just limited to electric mobility, but affects the implementation of information and communication technology in all areas of the electricity system. To what extent the intelligent control of electric vehicles can be realized will therefore be determined by how the electricity system develops towards a more distributed structure with lots of active participants. Because of the increasing shares of fluctuating generation, controlling electricity demand is becoming ever more important as an additional option of electricity management. Hence, the high penetration of intermittent renewable energy sources means that electric mobility is becoming more relevant because its consumption can be shifted and controlled.

Alongside the intelligent control of demand, there are also opportunities from the storage capacities of electric vehicles. Due to the use of vehicle batteries as short-term storage units, fluctuations in generation and demand can be evened out. However, the applications for this type of storage are limited. For example, only about 350,000 vehicles are necessary in Germany to completely cover primary power regulation[3]. Back-feeding power increases the level of complexity because of the necessary bidirectional power electronics and grid monitoring. In addition, it is difficult to estimate the ageing effect of the batteries and the costs arising from this. At today's costs and the expected revenue on the regulation power markets, back-feeding electricity does not appear really profitable. More advanced service models increase the level of battery utilization and open up the possibility of chalking up an additional value. The main value of any vehicle, however, remains the fulfillment of mobility needs.

The question posed for business models is whether systems services can make a major contribution to improving the economic efficiency of electric vehicles. A prominent example is the provision of balancing energy (Kempton et al., 2001). However, the complexity and costs of this business model are usually underestimated (Dallinger et al., 2010). Controlling a battery in order to supply regulation power services is technically possible, but requires a high communication effort to be invested in real-time control as well as a customer who accepts this type of interference. Direct control with external access to the vehicle's battery will probably fail to clear the acceptance hurdle of users and automobile com-

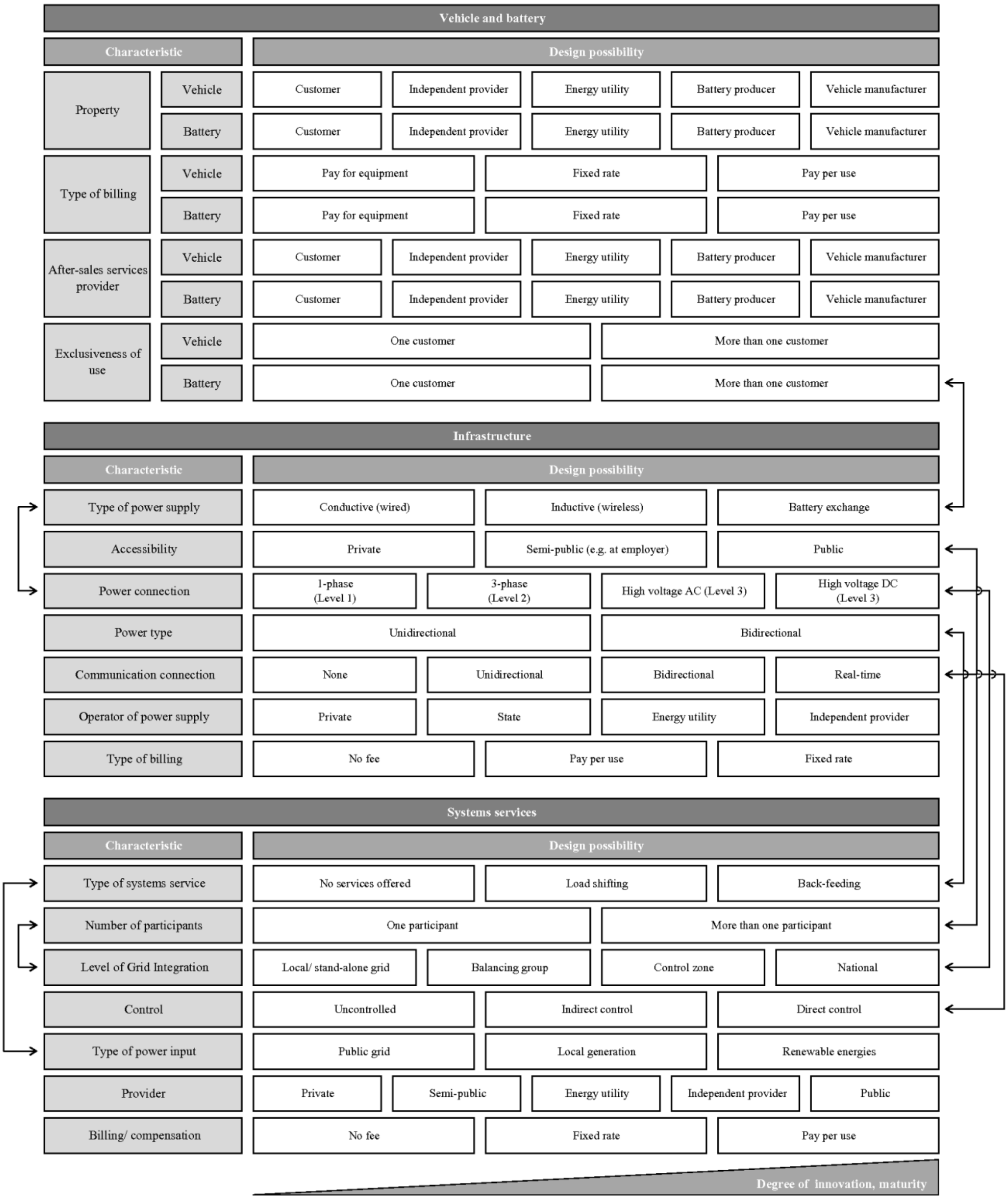
3 Dallinger et al., 2010, p 19.

panies. Indirect control via price signals for energy and output is less accurate and makes it necessary to forecast user reactions to incentive signals. Simple business models such as two-stage electricity prices are already being implemented today and have the potential to improve the economic efficiency of the overall concept. Even here, however, savings in the range of several thousand euros are not expected.

5 Conclusions

The previous section made it clear that several activities have been triggered so far in the field of new business models. Looking at all the business concepts envisaged for the different components reveals that there are existing economic potentials in all areas which should be exploited in the context of introducing electric drive systems. And yet their widespread introduction is still facing major challenges. The different companies not only have to venture into new areas, the value added shares between traditional and new stakeholders also have to be redefined.

Figure 5-1: Holistic instrument for defining new electric mobility business models



The respective connections which were discussed between vehicle and battery, infrastructure and system integration also show that there are dependencies between them which make it very difficult to consider the individual parts which make up electric mobility in isolation. In order to be able to develop feasible concepts when designing new business models it is important not only to look at the individual level, but also to take an overall view to analyze the very complex system as a whole.

The instrument presented therefore pursues a systemic approach with the objective of defining and describing individual business models both separately as well as from the viewpoint of an overall system. If the three approaches are integrated in one morphological box, this not only provides an overall view, but additionally the chance to define dependencies (see Figure 5-1).

The connections between the main components whose characteristics have inescapable impacts on each other are illustrated on the right-hand side of the morphological box. The links on the left-hand side of the box illustrate the unavoidable dependencies within a component. When looking at this diagram, it becomes clear once again how difficult it is to design new business models for introducing electric vehicles.

The identified potentials show that new business models can be developed in the different areas of electric mobility in both the near and the more distant future. For the various stakeholders, these imply new opportunities and risks which will arise during the introduction of electric drives alongside vehicles with combustion engines.

6 Acknowledgement

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