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Deliverable 2.1: Value Chain - Report

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Acronyms

OBU	Vehicle On-Board Unit
PLC	Power Line Communication
ICT	Information and Communication Technology
EC-G	Energy Charging Gateway
ICT-G	Information and Communication Technology Gateway
OTC	Over-The-Counter
RES	Renewable Energy Sources

Glossary

Primary technique	Primary technique includes all grid assets regarding to the main task of an electrical grid – the transmission of electrical energy
Secondary technique	Secondary technique includes all grid assets regarding to support of the main task – they are indirectly involved in the transmission of energy
Protection technique	Part of the Secondary technique, Protection technique includes all grid assets which focus especially on the protection of the Primary technique (e.g. circuit breaker, monitoring devices, etc.)

1. Description of the Value Chain

The analysis of the *Value Chain* is carried out in accordance with Porter's concept from business management. A detailed description of this concept has been done in the circulated (e-room) document "Important terms and definitions within work package 2", version 1.0, 19th February 2010. Due to the fact that the time horizon of the project lies on 2020 and beyond and the project involves many partners from different countries a time- and country-independent approach for the analysis of the Value Chain is chosen. Regarding to the differentiation of *Value Chain* and *Supply Chain* the following approach is pursued.

Starting point of the investigation is the consideration of all necessary infrastructure and existing or imaginable added values in the environment of a mass introduction of electric vehicles. In this analysis the environment of the electric vehicles is primarily formed by main activities of the energy and information and communication branch. In addition activities of branches which want to participate in the providing of services to electric vehicles are considered. These main activities are constituted as value added steps or elements which are aggregated in the *Value Chain*. The *Value Chain* itself doesn't provide any information about the connection of the different elements but sorts them into different levels of added value. Thus the Value Chain in accordance to Porter is an aggregation of functionally sorted value added elements or activities which are mainly needed to provide services to electric vehicles or to purchase services from electric vehicles.

The idea of this presentation of the *Value Chain* is to have a modular system which contains all necessary infrastructure and all existing or imaginable value added steps in the environment of a mass introduction of electric vehicles. It is independent of the currently situation and country-specific regulations according to the ownership unbundling. This regulatory framework is part of the investigations of work package 3. Moreover the modular system can depict all supply chains of different products or product groups by building combinations of the infrastructure or identified value added steps. The detailed analysis of added value of the different elements of the value chain is shifted to the description of these combinations. Therefore in the following chapters several basic use cases are chosen to analyse the interactions between the elements. The basic use cases content all infrastructure and value added elements shown in figure 1. They will be completely elaborated in detail and delivered in the report on basic business concepts in the second phase of the project. In this case they serve as examples to clarify the approach of the *Value Chain*.

The creation of value in the G4V environment takes place on different levels and steps (figure 1).

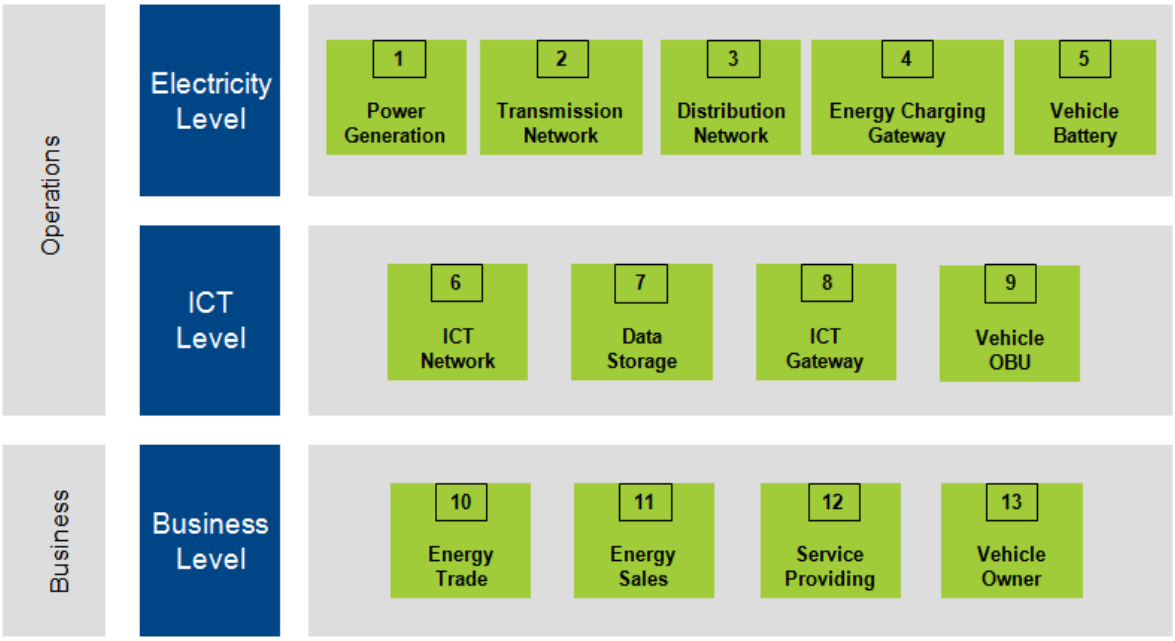

figure 1: Value Chain

The identified levels are the electricity level, the ICT level and the business level. Each element alone on the different level can fulfil at least two functions, either regarding required technical aspects for connecting EV and/or regarding own value added. Furthermore the combination of two or more elements can be additional value added or can be a scenario for a business model: For example a charging station probably consists of an Energy Charging Gateway and an ICT Gateway. The business model could be a provider of service stations. But it is also possible, that the both components are in different hands, i. e. a utility company and Telecommunication provider.

The electricity level (number 1 to 5) contains all infrastructure and value added steps regarding to installation, operation and maintenance of grid assets. Especially the impact of the mass introduction of electric vehicles on the distribution network is focused in work package 5.

In analogy to the electricity level the ICT level (number 6 to 9) consists of all infrastructure and value added steps with regard to the ICT assets. The development of ICT-solutions in this level is the task of work package 4.

The value added steps of the business level (number 10 to 12) do not contain any assets which are in the scope of the investigations. On the business level the providing of products and services by using the electricity- and/or ICT-Infrastructure is focused. These value added steps are part of the investigations of work package 2.

2. Description of the value added elements

The description of the infrastructure and value added elements contain the definition of the elements as well as their specific features.

2.1 Power Generation [1]

Power Generation is the generation of electricity by centralized/decentralized power plants, including renewable energies. It can be connected in both the Transmission as well as the Distribution Networks with different power output levels (figure 2).

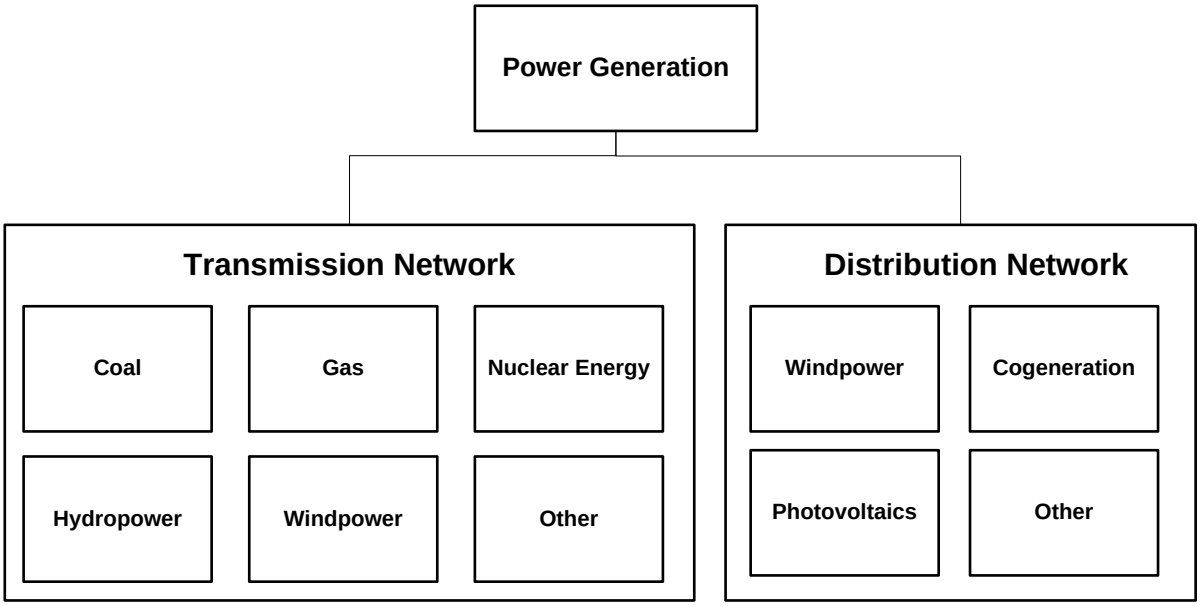

figure 2: kinds of power generation regarding to the network of supply

2.2 Transmission Network [2]

- also transmission, transmission grid, transmission system

The Transmission Network realizes the bulk transmission of electric power on the main high voltage electric networks. It provides physical grid access to generating companies (including renewable energies), distributors and directly connected customers. The Transmission Network includes grid assets in order to ensure the security of supply and the safe operation of the network.
The operation of the Transmission Network includes as well the tasks of system operation concerning the management of energy flows, reliability of the system and availability of all necessary system services (ancillary services).

The operation of the Transmission Network is a traditional market function and has in itself a value added.

2.3 Distribution Network [3]

- also distribution, distribution grid, distribution system

The function of the Distribution Network is to deliver electric energy from the transmission substations or small generation stations (including renewable energies) to each customer transforming to a suitable voltage where necessary. The Distribution Network also includes grid assets in order to ensure the security of supply and the safe operation of the network.

The operation of the Distribution Network includes as well the tasks of system operation concerning the management of energy flows, reliability of the system and availability of all necessary system services (voltage stability, frequency sustainment, etc.).

The operation of the Distribution Network is a traditional market function and has in itself a value added. Because of the fact, that most of the EVs will be connected to the Distribution Network it has a crucial function. Additional services in new business models are imaginable.

2.4 Energy Charging Gateway [4]

The Energy Charging Gateway (EC-G) is an interface between the Distribution Network and the Vehicle Battery for the purpose of transferring energy in both directions. It includes primary (contactor, wires, sockets, etc.) and protection technique (residual-current circuit breaker, miniature circuit breaker, etc.). It may be a metering device included.

The value added of EC-G is the connection between Distribution Network and the EV. It is a central part in the technical architecture.

2.5 Vehicle Battery [5]

The Vehicle Battery is a rechargeable traction battery used as an energy storage device. The stored energy can be used for the supply of the electric motor or for the feed-in of energy to the Distribution Network.

The value added of the battery is the possibility to store energy. The manufacture or the dealing of the battery could be an own business model.

2.6 ICT Network [6]

The ICT Network is a communication network for the wired and wireless transmission of data, including devices for operating the communication network securely. ICT Networks differ in the physical realization of the infrastructure (wired and wireless communication), as well as in the communication protocols technologies. Different types of networks can be connected by gateways or communication units, as well as the users' terminals.
Future secondary technique (e.g. devices for switching operations, grid monitoring devices and intelligent controllers) of the Transmission and Distribution Network is also part of the ICT Network.

The value added of the ICT Network is the transportation of information.

2.7 Data Storage [7]

The Data Storage is a repository for electronically stored data. It consists of devices for the storage of data (master data) including the hard- and software. The main task is to manage large amounts of data and to provide the required format to the user or the application software. Therefore the means to retrieve and analyze data, to extract, transform and load data, and to manage the data dictionary are also considered essential components of a Data Storage system.

The value added of a Data Storage is to store a huge amount of data for different needs and customers.

2.8 ICT Gateway [8]

The ICT Gateway (ICT-G) is seen as an interface between OBU, EC-G and the ICT Network in order to enable communication between these components by realizing a protocol conversion. Within a communication network the ICT-G is a node equipped for interfacing with another network, therefore it can operate at any layer of the OSI model. The ICT-G may contain devices such as protocol

translators, impedance matching devices, rate converters, fault isolators, or signal translators as necessary to provide system interoperability. A metering device may be included.

The value added of the ICT-G is to enable communication between all involved partners connected through interfaces in order to fulfill tasks and products, which arise by and through the introduction of electric vehicles. It is a central part in the technical architecture.

2.9 Vehicle Onboard Unit [9]

The Vehicle Onboard Unit (OBU) is a communication module for receiving control commands via the ICT-G, as well as sending information about the status of the battery. The OBU controls the charge controller. It may include a metering device.

The value added of the OBU is the connection between the charge controller and the ICT-G.

2.10 Energy Trade [10]

Energy Trade includes the trade of electrical energy on wholesale markets. Wholesale markets are primarily formed by the electricity exchange and the bilateral OTC market. A distinction is made between short-term (intra-day, day-ahead, after-day) and long-term (futures, forwards) trading.

The value added is the enabling of trading energy.

2.11 Energy Sales [11]

Energy Sales means all tasks which concerns the sale of energy to the customer on a retail market. Main tasks are forecasting of the power demand of the customer and the accounting of energy.

The value added is the sales of energy to the customer.

2.12 Service Providing [12]

Service Providing aggregates all activities which belong to the providing of services or products which are to be investigated with regard to the mass introduction of electric vehicles. These include products for the vehicle owner (additional services, special electricity tariffs ...) as well as products for other entities (ancillary services ...) which are provided by the vehicle owner.
A Service provider has no infrastructure by himself. He is making use of the infrastructure from Electricity and/or ICT-Level.

Main value added is the aggregation of power of single electric vehicles to tradable quantities and the account of products of the involved stakeholders.

2.13 Vehicle Owner [13]

The vehicle owner is the legal entity who has contractual relationships to other entities in order to purchase or provide ancillary, additional and other services.

The vehicle owner is only mentioned for the sake of completeness. He has no additional value but is necessary for the explanation of contract relationships.

3. Exemplary use cases

In order to analyse the interactions between the elements of the Value Chain exemplary use cases are chosen. The modular system of the value chain is used to describe the added value due to the interaction of the involved value added steps.

3.1 Added Value in the charging process

In figure 3 the elements are shown which are involved in the charging process. At first the process is broadly described to allocate the interfaces between the elements. After that, the value addition, which is generated by combining elements, is described.

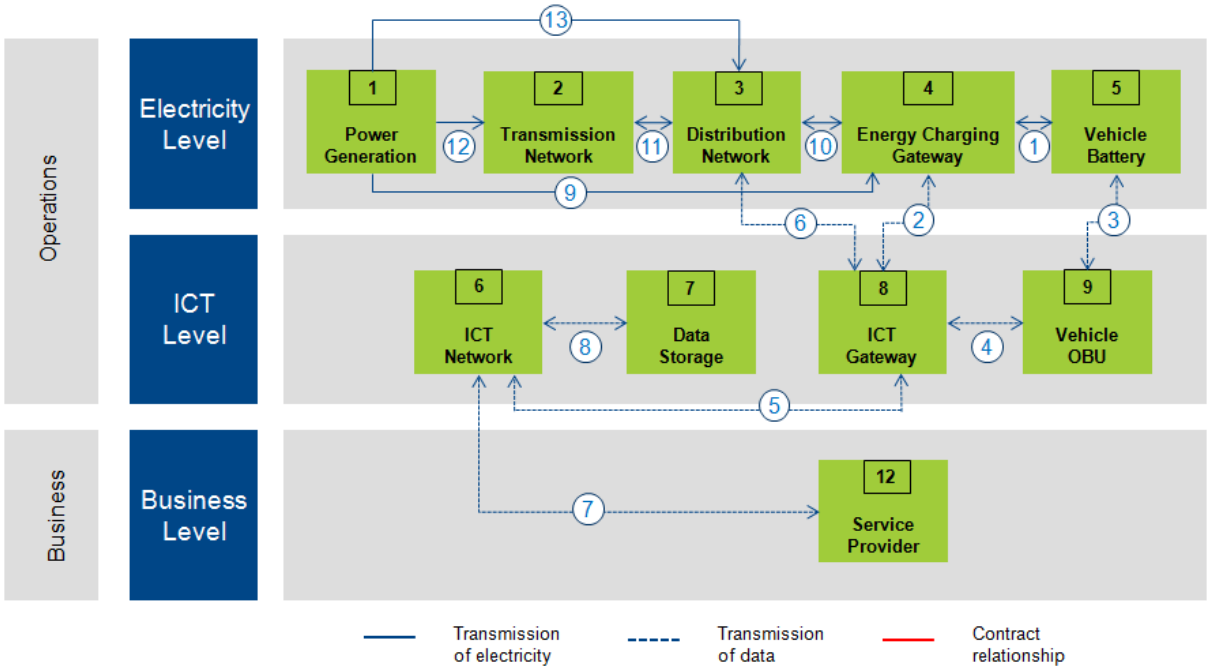

figure 3: added value in the charging process

Broad description of the use case:

- Vehicle Battery is connected to the EC-G (electricity level)
- OBU is connected to the ICT-G (ICT level)
- The ID of the car, which is provided by the OBU or another identification unit (e.g. smart card), is verified by a service provider (service of managing all master data)
- Therefore the ID data is transferred by using the ICT-G and the ICT Network
- The service provider authenticates the ID by accessing the Data Storage via the ICT Network
- The Service Provider activates the EC-G by sending control commands via the ICT Network to the ICT-G
- The transmission of energy begins

Description of the interfaces and their added value with regard to figure 3:

1. **EC-G – Vehicle Battery:**

   The EC-G provides a physical access for the vehicle battery to the Distribution Network or the decentralized Power Generation (RES), when the RES is directly connected to EC-G.
   The value addition depends on the load installed, because with a higher load it is possible to charge the vehicle battery faster. For that wires have to be dimensioned properly. Furthermore safety functions secure the charging process and the components involved. The higher the

degree of protection and the higher the nominal capacity of the cables, the higher is the value addition.

2. **EC-G – ICT-G:**

   With an ICT-G the EC-G is able to receive data/commands from all kinds of ICT Networks and protocols. The ICT-G translates activation commands into switching operations for the primary technique of the EC-G. So the EC-G can be controlled/operated by a central unit. Furthermore the EC-G can be equipped with additional functions, which can be controlled by the ICT-G, e.g. the downloading of software or the identification of the vehicle owner.

3. **Vehicle Battery – OBU:**

   The vehicle battery is usually charged according to battery-specific charging profiles to lengthen its lifespan. The OBU translates external control commands into charging profiles, thus the storage process of energy can be influenced. The generation and the consumption of power can be decoupled. A feed-in of energy into the Distribution Network can be controlled by the OBU.
   Furthermore the OBU evaluates the status and condition of the battery in order to translate these data into commands or to create status signals.

4. **OBU – ICT-G:**

   The ICT-G enables the OBU to communicate bidirectional by translating the protocol of the OBU into the protocol of the ICT Network and vice versa. Therefore the possibility of using the ICT Network is generated. The OBU can react immediately on external commands and change the charging profile on call for example. Real-time operation and data transfer is possible. Furthermore data of the vehicle battery or the charging process can be forwarded for further processing. The possibility of implementing additional functions is generated, e.g. the storage of data in the OBU for automatic identification.

5. **ICT-G – ICT Network:**

   The ICT-G translates the protocol of the data of all terminals into the protocol of the ICT Network. Thus the access to the ICT Network of the terminals is provided. The possibility of real-time communication is created between the terminals, since the ICT Network is able to establish a communication session between them. The value addition depends on the transmission technology of the ICT Network, since it influences the latency on the one hand and on the other hand it differs in the costs for building up and using the ICT Network.

6. **ICT-G – Distribution Network:**

   This interface is a particular case. It only exists, if the Distribution Network is used as the ICT Network. In this case the assets for communication via the Distribution Network belong also to the ICT-level. The value generated is similar with the one described in point **5**. Moreover the value addition arises because of using the same assets for transferring energy as well as data.

7. **ICT Network – Service Providing:**

   The ICT Network is used for providing all kinds of services. The value addition depends on the transmission technology (cf. point **5)**, since some services are only feasible with a certain latency. The value addition also depends on whether the commands are send uni- or bidirectional, since with the bidirectional communication the reaction on commands can be controlled.

8. **ICT Network – Data Storage:**

   The ICT Network transmits data from the Data Storage to a user and vice versa. The user gets the opportunity to receive access to relevant data, which are needed for his processes. Further he can provide data for other users, to whom he has a contractual relationship, without direct communication. The Data Storage enables the outsourcing and central storage of data and the ICT Network enables the real-time access to it.

9. **Power Generation – EC-G:**

   The Power Generation supplies the EC-G directly with energy. The Distribution Network does not have to be used, thus the costs for transportation of energy are reduced. So the utilization of the Distribution Network can be lowered. The CO_2 emissions are reduced by the amount of the emissions for the transport of energy. In case of RES, the energy fed into the vehicle battery is nearly CO_2-free.

10. **Distribution Network – EC-G**

    The EC-G receives grid access to the Distribution Network and thus it can transfer energy to the vehicle battery on the one hand. On the other hand the feed-in of energy out of the vehicle battery is enabled. The value addition depends on the load installed, because with a higher load it is possible to feed-in more power into the grid as well as charging the battery faster.

11. **Transmission Network – Distribution Network**

    The Transmission Network enables the transfer of energy of large-scale power plants into the Distribution Network. Furthermore the Transmission Network provides system services to the Distribution Network, so that the quality of energy transferred to the Distribution Network is guaranteed.

12. **Power Generation – Transmission Network**

    The high power of the large-scale power plants can be fed into the Transmission Network since the assets of the Transmission Network are engineered for such high loads. Furthermore the energy generated can be transferred over long distances, where needed.

13. **Power Generation – Distribution Network**

    The power of decentralized power plants can be fed into the Distribution Network without using the Transmission Network first. Thus costs for energy transfer are reduced.

3.2 Added Value in the environment of the provisioning of a balancing product

In figure 4 the elements are shown which are involved in the provisioning of a balancing product.

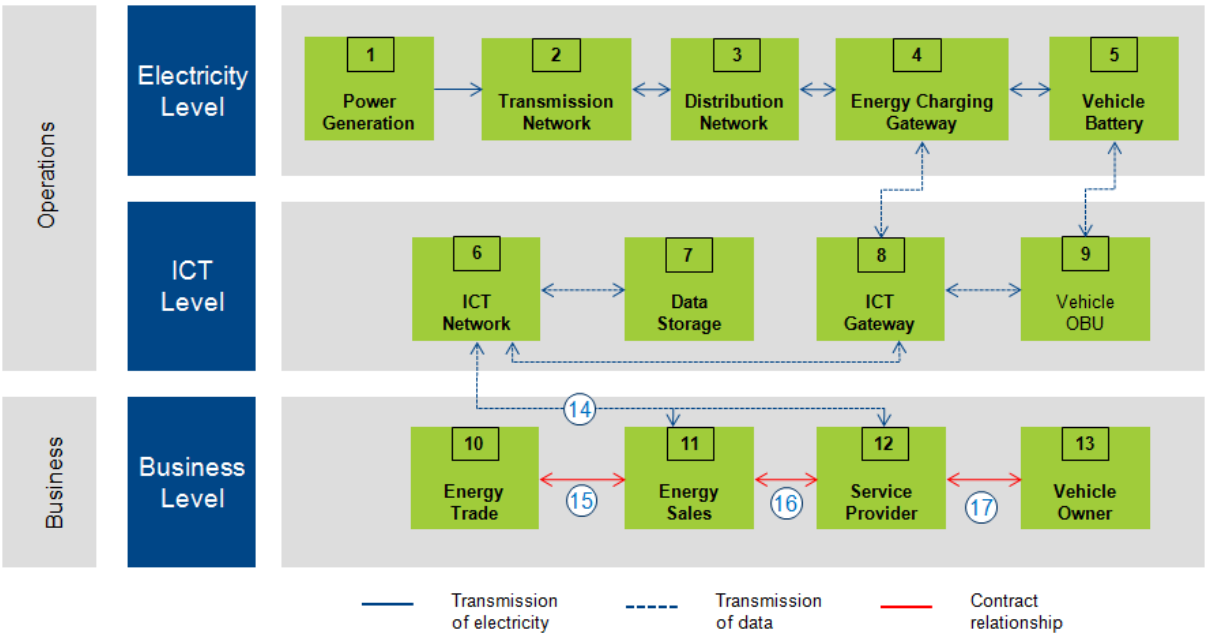

figure 4: added value in the environment of a balancing product

Description of further interfaces and their added value with regard to figure 4 in addition to the charging process of chapter 3.1:

14. ICT Network – Energy Sales

The access of Energy Sales to the ICT Network allows the storage of data related to the supply of energy (load profiles, customer relationships …).

15. Energy Trade – Energy Sales

The procurement of energy for the supply of electric vehicles takes place on the different markets of Energy Trade. The arrangement of contract relationships between Energy Sales and Energy Trade constitutes the generation of value.

16. Energy Sales – Service Providing

The added value at the interface of Energy Sales and Service Providing consists of the coordination of the supply of energy considering possible future products which influence the procurement of energy. The coordination takes place by means of the ICT Network and Data Storage.

17. Service Providing – Vehicle Owner

Service Providing enables the vehicle owner to participate in future energy markets for system and ancillary services. The added value depends on the arrangement of the contract relationship. Furthermore additional services can be purchased by the vehicle owner.