RESERVE

D6.5 v1.0

CSR impact of business models and energy systems for the transition towards 100% RES, V1

The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 727481.

Project Name	RESERVE
Contractual Delivery Date:	31.03.2018
Actual Delivery Date:	31.03.2018
Contributors:	Kai Kappner (RWTH), Philipp Weidinger (RWTH), Mihai Paun (CRE), Mihai Mladin (CRE), Marco Cupelli (RWTH), Steffen Bretzke (EDD)
Workpackage:	WP6 – T6.2
Security:	PU
Nature:	R
Version:	1.0
Total number of pages:	37

Abstract:

The new energy system designs will result in societal, economic and environmental consequences which need to be thoroughly measured and assessed. Based on the analysis of these consequences, D6.3 will provide the first version of the CSR guidelines for the development of business models and energy system designs that inherent trade-offs into account.

Keyword list:

Corporate social responsibility; Business model; Market structure; up to 100% RES; Network codes; Guidelines

Executive Summary

The new energy system designs will result in societal, economic and environmental consequences which need to be thoroughly measured and assessed. Based on the analysis of these consequences, D6.5 will provide the first version of the CSR guidelines for the development of business models and energy system designs by taking inherent trade-offs into account.

The energy transition will create some opportunities as well as some challenges with regard to the integration of new techniques and business opportunities into the existing structure. On the other hand, government policy will have to live up to its spearheading role by creating a framework for a sustainable energy transition. Such a framework will contain not only harmonising rules for existing players in the current top down-market structure, but also enabling society to participate in the energy transition in a bottom-up market model.

This document will discuss the opportunities and changes arising from the energy transition towards 100% RES. In preparation, stakeholders were identified in an initial workshop and new business actors were determined in the project. From the three pillars of corporate social responsibility (CSR) – the economic, environmental and social perspective – this document evaluates challenges and threats stemming from the energy transition for existing and upcoming players.

Using examples of the changing roles of TSOs and DSOs, the canvas business model is extended to all three perspectives. These business models are also analysed by using the sustainable balanced scorecard to identify strategic and operational objectives exemplary for TSOs and DSOs in the future.

One of the outcomes of this deliverable is to recognise the need for customer participation to ensure a successful and sustainable development towards 100% RES. This also follows the idea of a bottom-up market model in the future. Involving society means setting a framework for customer participation as well as taking into account the social and environmental (mostly positive but also negative) impacts the energy transition will create.

In addition to the technical requirements that the energy transition demands, the transformation of different national grids into one sustainable and harmonised pan-European grid will require additional and modified network codes. These network codes can be distinguished into the categories of technical, social, environmental and economic requirements, whereby there are no clear dividing lines between the different categories.

This document provides, based on the intermediate outcomes of this project, initial (categories of) guidelines for the development of sustainable business models as well as assessing the network codes proposed in this project with regard to the requirements of CSR and of sustainability.

D6.5 provides the first version of the CSR guidelines for the development of business models and energy system designs. These guidelines are condensed into the outcomes of the stakeholder analysis, the business canvas model and the sustainability balanced scorecard. A first evaluation of already existing and newly created network codes confirms the need for additional guidelines and for the individual consideration of the three pillars of economic, environmental and social perspectives.

Authors

Partner	Name	e-mail
RWTH		
	Kai Kappner	kappner@controlling.rwth-aachen.de
	Philipp Weidinger	weidinger@controlling.rwth-aachen.de

Table of Contents

1. Introduction

Renewables in a Stable Electric Grid (RESERVE) is a three-year project funded by the European Commission in the Work Programme Horizon 2020 – Competitive Low-Carbon Energy (LCE) 2016-2017. The project officially started in October 2016.

1.1 Task 6.2

The upcoming substantial new designs for energy systems, which are being analysed in RESERVE, will result in new business models, which shift away from market shares and institutional influence towards new or established actors. The changes involved will have substantially impact on the environment and society. Whereas the transition towards renewable energies is a consequence of scientific findings on climate change and of the finiteness of fossil resources, it is not clear whether corporate social responsibility (CSR) impact is always positive. With different trade-offs inherent to potential future designs of energy systems—including the infrastructure components of such systems—environmental aspects need to be identified, simulated and assessed.

1.2 Objectives of the Work Report in this Deliverable

The deliverable D6.5 was introduced in order to provide a thorough documentation and assessment of the CSR aspects of the different energy systems, which have been developed by our project partners, and their corresponding business models. The aim of this document is to provide the necessary information for comparing the different energy systems' design options. Also, the objective of this document is to come up with a framework regarding the assessment of different technologies. This will lead to a regulatory framework for energy systems as well as setting incentives for realising environmentally and socially compatible business models. Moreover, this deliverable will provide input for guidelines which define the impact of CSR on business models and energy systems in the transition towards 100% renewable energy sources (RES) on a regulatory and voluntary basis.

1.3 Outline of the Deliverable

The present deliverable starts from the harmonisation of network codes and the promoting of their adoption internationally. From a proposed set of technical options, it will be issued the preliminary landmarks for corresponding business models which should be considered when it comes to determining the appropriate governance framework for the future electricity transmission networks beyond 2040. The investigation of the sustainability of the possible business models for renewable energy is also one of the main goals set up in this deliverable. This aspect has to be taken into consideration, because the rise or fall of these new technologies is affected by the manner in which they are integrated into our society and into energy-providing systems. This deliverable also enhances the visibility as well as the synergies of the RESERVE H2020 project and its supported actions.

1.4 How to Read this Document

The outcome of this deliverable will be a categorization of the scenarios regarding future designs of the electrical network from work package 1 (WP1). Together with the developed strategies for the implementation of frequency control (WP2) and voltage control (WP3) and the associated requirements for information and communication technology (ICT) (see D1.3), it was possible to create an overall picture, on which the work in this deliverable is based.

Specifically, this document is generated from the input of previous deliverables from the RESERVE project.

The contents of these deliverables are:

- D1.1: Scenarios and architectures for 100% RES and the roles of sector actors
- D1.2: Requirements placed on energy systems on the transition to 100% RES
- D1.3: Requirements placed on ICT for energy systems with up to 100% RES
- D1.4: Use case definition for research in frequency and voltage control
- D2.2: Review of relevance of current techniques for advanced frequency control
- D3.2: Demand response and DG control considering voltage control and stability
- D6.1: Regulatory, governance and legal issues of the transition towards 100% RES

Figure 1-1 below shows the information flow of the deliverables providing input for D6.5.

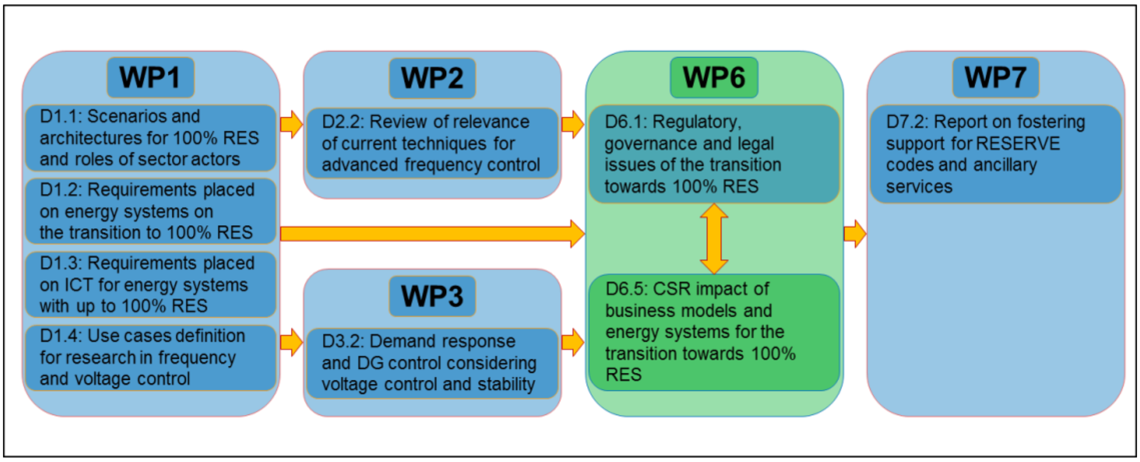

Figure 1-1: Relationship between work packages

1.5 Approach Used to Undertake the Work

The following steps were iteratively applied in order to develop the results reported in this deliverable:

- Analysis of scenarios
- Investigation of appropriate methodologies for identifying CSR aspects
- Two workshops with entire RESERVE consortium
- Identification of relevant developments from scenarios
- Analysis of changes in market structure and new market actors
- Investigation of sustainability of selected business models
- Introduction of a CSR measurement system
- First version of CSR and network code guidelines

2. Rationale and Methodology of Study

2.1 Rationale

The aims of RESERVE are fully driven by the needs of different stakeholders, e.g. private customers. Climate change and a growing awareness for sustainability need to be respected. The following list identifies the gaps in the status quo.

- Need for RES
  Society and government policy recognize the need for changing the pattern of energy consumption. Since climate change is becoming the focus of more and more stakeholders, so it is the willingness towards sustainable energy growing. As electrical energy represents a huge share of the energy consumption in Europe (Eurostat, 2012), sustainable generation via photovoltaics (PV) and wind turbines will help to implement the goals. Even if EU government policy defines only a scenario of 75% RES in energy consumption by 2050, and a scenario of 98% RES for electricity consumption (European Commission, 2015), RESERVE respects the goal of 100% RES for the latter.
- Need to organise/stabilise the grid
  Assuming 100% RES, the grid needs to be organised differently in some points. Because of the decreasing number or even elimination of synchronous machines in generation, frequency stability will become a central point for future grids. Frequency stability in the context of 100% RES can only be acquired by new grid management concepts. RESERVE also offers a new way to stabilize the network faster and more efficiently with rate of change of frequency (RoCoF).
- Energy supply volatility

The connecting of electrical energy generation to renewable resources also indicates a dependency on time frames which are not manageable by human beings. Moving towards 100% renewable energy, it is more and more challenging to generate energy at the time when the demand is at its peak. In addition, there is no mechanical inertia to stabilize the frequency levels in the grid. Therefore, energy storage will play an important role in 100% RES scenarios.

- Changes in the generation of electrical energy
  100% RES also means a decentralisation of energy generation. Large facilities will be shut down, such as nuclear power plants (1.3 GW average power in Germany (Fraunhofer ISE, 2017)) or lignite power plants (2 GW average power in Germany (Fraunhofer ISE, 2017)). Instead, generation will be organised via smaller and decentralised units, such as wind farms (30-40 MW average power, (Office of Indian Energy and Economic Development, 2016)) or PV panels (up to 300MW, (Mehos *et al.*, 2012)). With prosumers and microgrids, private individuals will also participate in the generation process.
- Disruptive changes in the energy market
  New and changing business models in future market structures will be service-oriented and decentralised. Peer-to-peer payment will play an important role as well. With decentralised energy generation, power can be generated and supplied close to the location of the customer. Peer-to-peer payment will allow goods to be traded directly without the usage of large infrastructures.
- New business models
  Summarising the innovations described above, new business models will arise. For grid stabilisation and storage, suppliers will be able to help transmission system operators (TSOs) to fulfil their tasks. In addition, ICT service providers can be involved in managing the grid. But also at the other end of the supply chain, changes will characterise the future grids. Peer-to-peer payment and a decentralised generation will enable the trading of energy at the local market place. Private households will be able to change from being pure customers to being so-called prosumers, who produce and consume electrical power.

This section has shown the different impacts that society and EU government policy will face in the future. Nobody can deny the need for sustainable energy generation. The changing frameworks on account of RES will generate both opportunities and risks. The next section will describe the methodologies used to exploit the opportunities and to reduce the risks to a minimum.

2.2 Methodology

The aim of RESERVE is not only to create new scenarios in terms of grid stability but also to validate these scenarios in use cases. This deliverable follows that concept from business perspective. To facilitate an understanding of the different methodologies, the following sections will briefly explain the needs and outcomes.

2.2.1 Societal, Economic and Environmental Consequences of the Transition Towards 100% RES

Corporate social responsibility (CSR) is recognised as a (mostly voluntary) contribution of an individual company, but also of an entire economy, to a sustainable development that goes beyond the legal requirements. In 2011, the European Commission interpreted CSR as the responsibility of companies for the impact of their actions on the whole environment (European Commission, 2011):

"*Enterprises should have a process in place to integrate social, environmental, ethical human rights, and consumer concerns into their business operations and core strategy in close cooperation with their stakeholders. The aim is:*

- to maximize the creation of shared value, which means to create returns on investment for the company's shareholders at the same time as ensuring benefits for the company's other stakeholders;
- to identify, prevent and mitigate possible adverse impacts which enterprises may have on society."

Another definition relevant to the determination of sustainability is that of the Brundtland Commission of 1987 (Brundtland, 1987):

"*Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*"

Among other things, these definitions and the ideas behind them regarding sustainable development and the resulting responsibility of individual companies to contribute towards this have led to the concept of the three pillars of sustainability.

This concept implies that sustainable development exists when the three pillars of economy, environment and society are in balance.

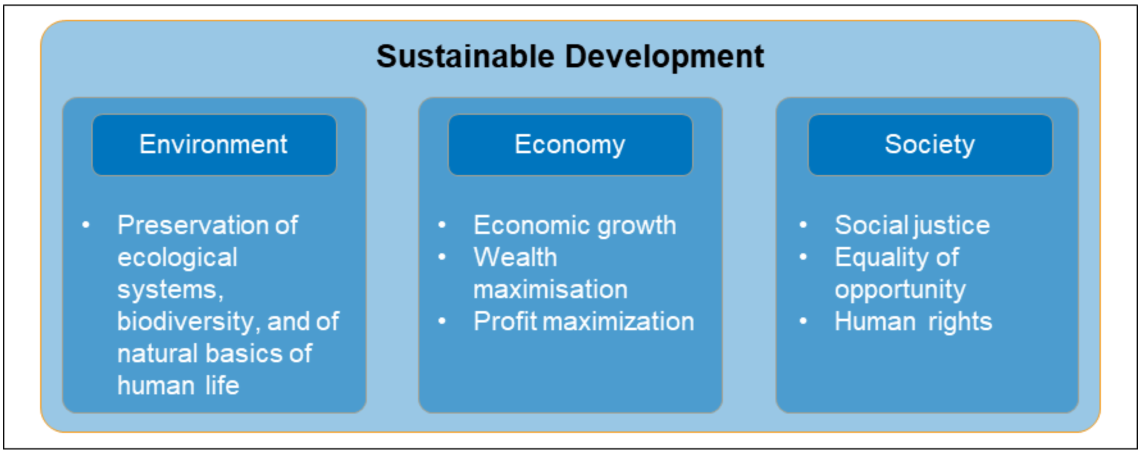

Figure 2-1: Concept of Sustainable Development

The idea behind this concept is the dependence of the three pillars on each other. If one pillar is ignored, over time it will also lead to impairments in the other two areas. An illustrative example is the greenhouse effect, which incurs costs in the long run due to the lack of consideration of ecological sustainability. Currently, such a mode of action can leave the social and economic pillars unaffected or even be beneficial to them. However, future impacts can affect all three pillars. Inter alia, the warming of the world climate in the ecological area could generate political instability with further impact on the social field and on the economic field, and follow-up costs for the society. In particular, the cost of remedying damage can far exceed the costs saved by disregarding environmental sustainability.

These interdependencies are the reason why, even with a changeover to 100% RES, the consideration of sustainable development and CSR has great importance. Aligning power grids with a 100% RES power supply primarily addresses the goal of environmental sustainability by enabling reduction to the point of completely avoiding emissions through power generation. However, reaching this objective can only be fully sustainable if economic development finances such change and if there are no cuts at the social level.

2.2.2 Case Study

Across a variety of disciplines, the case study is widely used as a tool to add strength to propositions that have been made through previous research. Briefly said, a case study analyses the effects of developmental factors in relation to the environment on a special unit. It also leads to a deeper understanding of complex or abstract issues. Especially in the social sciences, the case study is a popular method to examine real-life situations under consideration of a previously formulated hypothesis. In contrast to other research methods, case studies do not have a clear approach or framework. In fact, the case study represents a research strategy. Likened to an experiment, a history or a simulation, it may be considered to be an alternative research strategy (Yin, 1981).

For a case study to be exemplary, it must

- be significant
- be complete
- consider alternative perspectives
- display sufficient evidence
- be composed in an engaging manner (Bruns Jr., 1989)

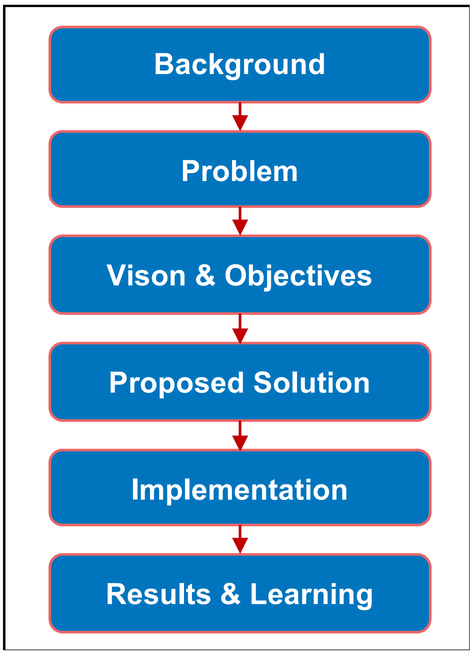

Figure 2-2: Case Study visualisation

Unfortunately, because of the singularity of each case study, the significance of this method can be questionable. The inability to replicate exactly the same case study in order to confirm an author's results might cause a problem with its credibility. The usual concentration of a case study into a small group of persons or a small unit also triggers a classification issue. It can be problematical to generalize the results of a case study acquired within a small field of research.

The popularity of case studies in all kinds of research fields might be due to their big advantage: to simplify a huge hypothesis and to illustrate, through a concrete example, an idea under investigation. The case study can even help researchers to adapt such ideas and can lead to new hypotheses, which can be useful. The application of a theoretical concept to a real-life situation can be enriching for the researchers themselves but also for all stakeholders involved in the process.

2.2.3 (Sustainable) Canvas Model for Business Modelling

The objective of this deliverable is to evaluate the impact of new and changing business models from the perspective of CSR. This will ensure that the changes in the electricity grid, as investigated in this project, not only solve the technical challenges of 100% RES, but also take into account a certain form of sustainability. This applies to the economic component, but also, to the same extent, to the social and environmental aspects of sustainability.

A business model can be defined as "*the manner by which an enterprise delivers value to customers and entices customers to pay for value and convert this into profit*" (Teece, Pisano and Shuen, 2007). As this quite generic definition indicates, most of the concepts for the formalisation of business models are based on the basic idea of a value to be created for the customer. The construction of the business model canvas, which was developed by OSTERWALDER (Osterwalder and Pigneur, 2002), is generally accepted.

Within the four categories of value proposition, infrastructure, customer and finances, the key aspects are considered for a successful business concept, always with the full focus on the customer, which should lead to optimal value generation.

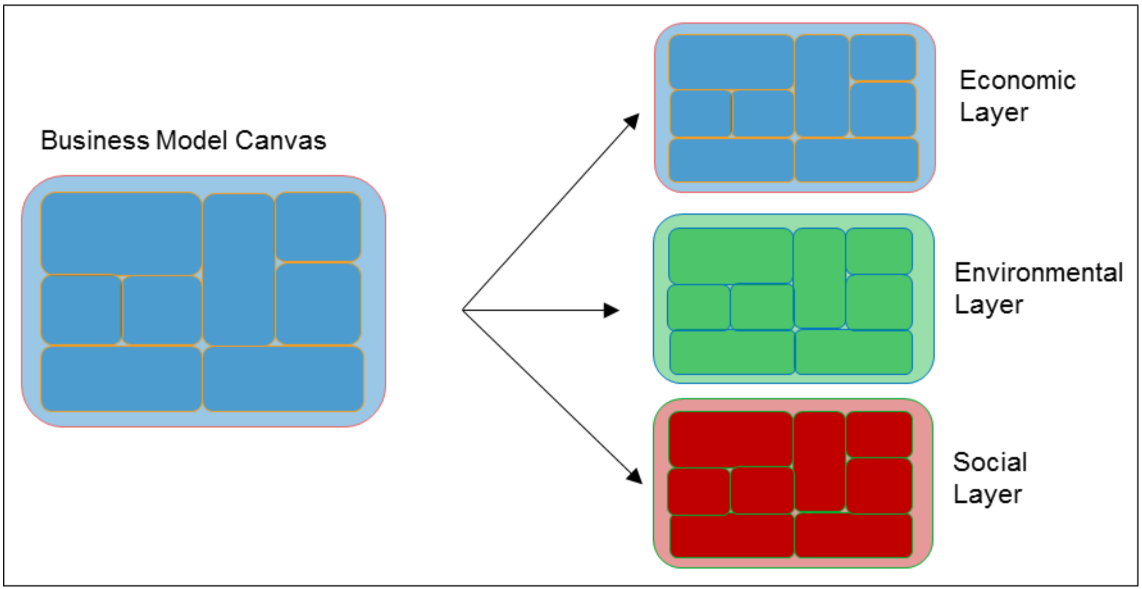

Figure 2-3: Sustainable Business Model Canvas

As already mentioned, the focus of this type of business modelling is solely on the customer. Other stakeholders are considered only to the extent that they are necessary for this alignment. In order to remedy this "maladministration", various concepts have been developed that further develop the idea of conventional business modelling and link it in various ways with the drafts on sustainability and CSR described in the previous section. The following definition describes this type of idea of a sustainable business model:

"*A business model that creates competitive advantage through superior customer value and contributes to a sustainable development of the company and society can be interpreted as a sustainable business model and an organizational eco-innovation.*" (Lüdeke- Freund, 2010)

To create not only value for the customer but also for society and the environment and to consider the impact on these two further levels, the one-dimensional model of the business model canvas has been extended by two further layers. Thus, according to the three pillars of CSR, there are three levels on which business models can be analysed. These three levels are not isolated from each other but correspond to each other, as is usual for the three pillars of sustainability. This model is used in the present study to examine changing and evolving business models.

2.2.4 (Sustainable) Balanced Scorecard

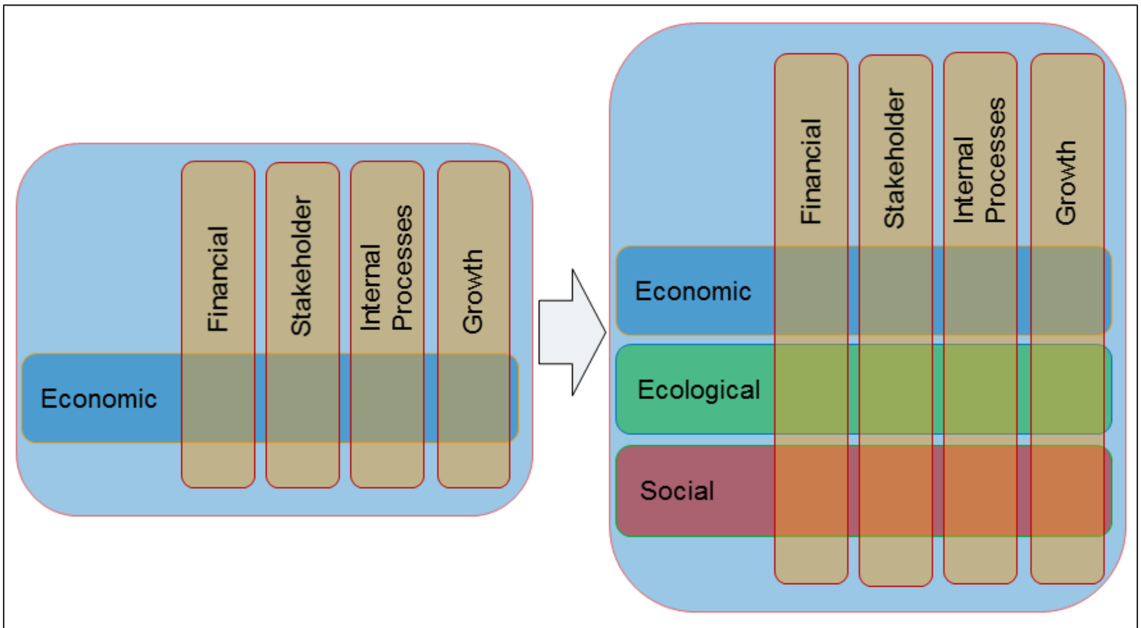

Figure 2-4: Sustainable Balanced Scorecard

The balanced scorecard is a tool of strategic management accounting and was first published in 1992 by KAPLAN and NORTON (KAPLAN and NORTON, 1992). In contrast to many other key performance indicator (KPI) systems of management accounting, which refer to past-related data, the balanced scorecard is future-oriented. The four perspectives of financial, stakeholder, internal processes and growth define strategic goals for a company. For these strategic goals, the associated operational goals are determined. The scorecard then derives KPIs that can be used to monitor the achievement of these goals and to identify measures that can be used to achieve the necessary changes.

In its original form, the balanced scorecard is geared to economic action and the resulting success. If a balanced scorecard is not only intended to determine and measure the economic price of a company in the conventional sense but also to set the price that includes all three aspects of sustainability, the scorecard must be expanded accordingly.

In an integrative approach, the existing perspectives of the balanced scorecard are considered not only on the economic level but also according to the three pillars of sustainability and CSR on the ecological and social levels. Thus, a strategic orientation of a company can be achieved, which meets the requirements of sustainable development and responsibility.

3. Energy System Designs

A full understanding of the changes in future power networks from the customer perspective is needed in order to be able to implement a measurement system and to propose a regulations system, including network codes, see D6.1. From the customer perspective, the reliability of the power network next to an affordable electricity price is still most important. Private and commercial customers need to have reliable access to electrical power at all times. RESERVE is addressing this issue not only by solving technical problems, but also by analysing the perspective of the end users to ensure the fulfilment of the needs of businesses and of society.

The remainder of this section summarises the technical scenarios from the customer perspective and provides an overview of ground-breaking changes compared to the current situation.

3.1 Changes in Energy Generation

Large conventional power plants running on coal, oil or nuclear power are expected to be substituted in the near future by renewable and/or distributed energy resources, which are power electronics interfaced for instance. These will include wind turbines and PV solar power generation as well as several other technologies. Even assuming that conventional hydro power plants will still exist in several countries in the future, in most countries the vast majority of generation units will likely not be based on synchronous machines and, thus, will not provide mechanical inertia to the system. It is thus important to understand how primary and secondary control has to change in order to cope with future generation scenarios.

While lowering the inertia available in the system, small units can be utilised to provide novel control capabilities to the system and perhaps to create new business models. One possibility is to combine small units into one large power virtual power plant and to regulate the voltage and the frequency in the same way that today's conventional power plants are doing. Moreover, small units can be operated independently and can feed-in small amounts of energy in a decentralised way. This happens mainly on the LV grid.

3.2 Design of Frequency Control Scenarios

The following section covers the control of frequency and the needed modifications.

3.2.1 Changes in Control

The control of the system frequency has been (and still is) a role mainly taken on by large synchronous machine-based power plants. To date, renewable energy sources (RES), such as wind and solar power plants, generally do not provide any kind of frequency control. Moreover, the demand side does not provide any frequency control, but contributes to the deviation of the frequency from its nominal value (50 Hz in Europe) by varying the power consumption. This situation is expected to change rapidly due to the reduction of the number of large synchronous power plants resulting from the increasing penetration of RES, energy storage systems (ESS) and flexible loads. Therefore, there is a growing need for a transition from the current large power plants-based frequency control at the transmission system level to a new situation characterised by a larger number of actors and of a different nature, located on both the transmission and distribution sides.

3.2.2 Changes in Storage

ESSs are expected to play a crucial role in the frequency control of future power systems, due to their capability to provide/absorb relatively large amounts of power in very short time scales. Moreover, due to the large number of technologies already available or to be developed, their modularity, and the continuous reduction of the installation and operational costs, ESSs will be ubiquitous on both the transmission and distribution sides. At the transmission system level, large ESSs can provide rate-of-change-of-frequency (RoCoF) and primary frequency controls, likely in a decentralised approach, by supporting and complementing the limited frequency control capability expected from RES. On the other hand, a large number of small ESSs can be coordinated at the distribution system level to contribute to the secondary frequency control at the point of connection with the rest of the grid.

3.3 Design of Voltage Control Scenarios

3.3.1 Changes in Control

In contrast to frequency control, voltage control is only needed in medium voltage (MV) and low voltage (LV) scenarios. Currently, voltage control is undertaken by units in each secondary substation automation unit (SSAU) via electrical circuits. Adding reactive power (Q) will increase the voltage level in the local grid and removing reactive power (Q) will reduce the voltage level. To reduce existing inefficiencies, an interactive voltage control is suggested. In a future communications network, SSAUs will be connected with inverters of small-scale generation units of the distribution systems. An operating system will manage the voltage stability by controlling the generators as required.

Current voltage control maintains the voltage level within allowable values and is accomplished by using capacitors, reactors and on-load tap-changing transformers. In RESERVE, the use of active voltage management (AVM) is suggested. In AVM, the SSAU commands different power converters to inject or to draw real or reactive power from the grid, as well as to maintain the voltage at the converters' connection point. This eliminates or reduces the need for additional assets (e.g. capacitors, reactors).

In addition, current voltage control does not address dynamic voltage stability. Dynamic voltage stability will be a concern in future distribution systems, as the number of power converters in the system will increase. To address this issue, the use of virtual output impedance (VOI) control is suggested in RESERVE. VOI control allows the SSAU monitor to modify the control parameters inside converters in order to maintain dynamic stability.

3.3.2 Changes in Storage

For stability reasons, distribution lines can have capacitators. These are used to manage the voltage today. Communication between the participants in the distribution grid increases the efficiency and reduces the losses on one hand; but on the other hand, there is no need for capacitators any more. Therefore, distribution system operators (DSOs) can reduce assets in the grid.

In the voltage control scenario, there is no need for local storage from the technical perspective, unlike in frequency control scenarios. Nonetheless private storage units connected with the prosumers' inverters can be helpful in order to stabilize the voltage. Furthermore, the use of storage units at the prosumer can ease achieving prosumer acceptance of the new scenario. If the supply of a prosumer is throttled on behalf of the DSO, since this serves the purpose of voltage control, the prosumer misses turnover. The prosumer will be more likely to accept this, if her or his overcapacity flows into a storage unit and can be used or fed-in at a later time. At this point, the DSO must create the corresponding financial incentives for the prosumer in order to facilitate mutually beneficial cooperation.

3.4 Design of ICT Scenarios

Currently, the major function of the communication network between different actors in the power grid is aimed towards the managing of secondary and tertiary control. Future scenarios will have interaction between the different partners in order to optimise the capacity of the network and to guarantee net reliability. In reality, there is a need for communication on all levels of the grid, between these levels and between measurement and control devices. Such communication networks may be based on existing infrastructures, such as power-line communications [PLC] and fibre-optical networks, or future standards of mobile networks, such as 5G telecommunications and Narrowband-IoT.

On the other hand, controlling the electricity network with modern communication systems brings new challenges with it. Data security and data priorities are two very important topics for keeping the system running reliably, and fulfilling the customers' needs for power availability.

3.5 Customer Perspective

The needs of the various types of customers will not change in future. Even in the future, consumers will want

- a reliable supply of electrical energy
- at any time, 24 hours and every day

- at reasonable cost

For future scenarios, customers of power networks will also demand

- data security
- participation in market structures
- more opportunities for self-determination, like energy trading between prosumers or free choice of energy supplier.

Some of these needs are in conflict with suggested changes for the grid structure with 100% RES, e.g. data security in contrast to the needed control of the inverters or potentially cheap energy prices in contrast to giving up the economy of scale in energy generation. For this reason, RESERVE intends to find solutions for regulating market structures and incentive systems based on sustainability and CSR aspects, because the upcoming transition towards 100% RES will only be successful if it is customer-driven.

4. New and Changing Business Models

Business models always entail a holistic view of companies and their work. Business entities usually work in a competitive environment and follow strategic orientations. These alignments can affect the whole company or individual departments as well. To achieve a holistic view, knowledge of the different players, workflows and channels is needed.

The canvas business model of OSTERWALDER and PIGNEUR (Osterwalder and Pigneur, 2002) focuses on the main business segments. The following sub-sections describe these business segments for important business entities in the future energy system with 100% RES.

In addition, JOYCE and PAQUIN (Joyce and Paquin, 2016) complemented the business canvas model with a second and third layer in respect of a company's responsibilities towards the environment and society. These layers are also mentioned in the following sub-sections.

4.1 Changes in the Market Structure

As shown in section 3, the changes investigated in RESERVE are fundamental. On the basis of this project's technical findings, in this section the resulting changes in market structure will be described. The results shown were developed, inter alia, at a workshop for the whole project consortium. Thus, all of the different perspectives have fed into the presented findings.

In the following, two completely opposite situations are distinguished. First the original conventional market structure is shown. This structure is compared to the market structure of the future with up to 100% RES. Part of this are the important tasks of frequency control and voltage control. The following components are presented: market participants, the flow of electricity between the actors, and the links concerning ancillary services. The latter relates to information and control. These are all services whose flows are opposed by corresponding monetary flows.

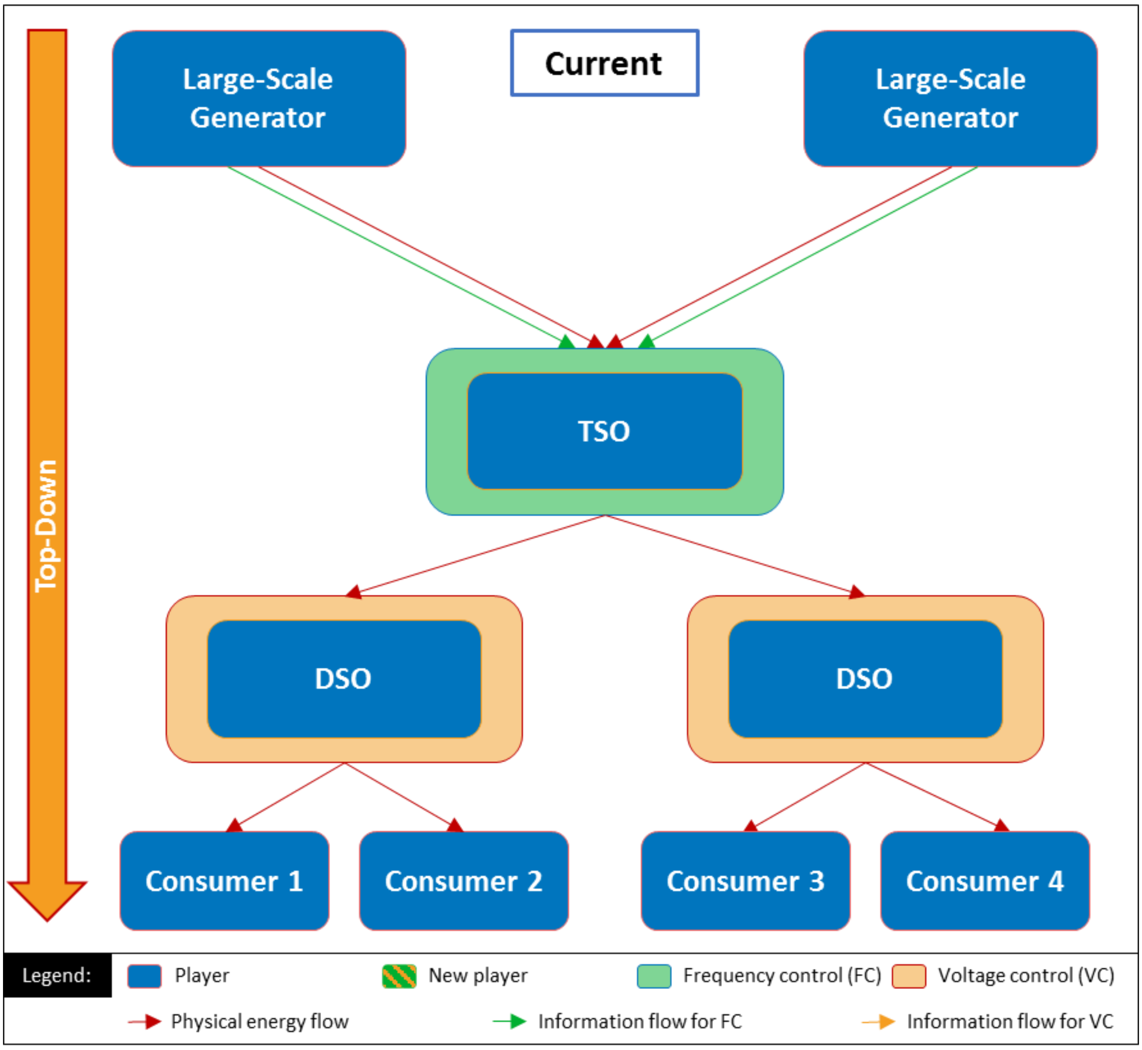

Figure 4-1: Visualisation of the Current Market Structure

The above figure shows the simple structure of the conventional market structure. The system follows the principle of **top-down** only. Electricity is generated by large-scale generators, which feed the electricity into the grid of the TSO. Power is transmitted to DSO networks via the TSO network. These transfer the electricity to the consumer. All market participants get paid for their provided services. Thus, the corresponding monetary flow is bottom-up.

The TSO is responsible for the **frequency control**. The ancillary services required for this are provided by the large-scale generators.

Voltage control is the responsibility of the respective DSO, which controls the stability of the electrical voltage independently without the participation of other actors.

The future structure of the market will no longer be characterised solely by the principle of **top-down** but also by the principle of **bottom-up**.

The additional principle of **bottom-up** concerns both the flow of electrical energy and the provision of ancillary services as well as the connections regarding **frequency** and **voltage control**.

The generation of electrical energy will still be able to take place on a large scale, e.g. at large-scale wind farms. In addition, there will be generating units which feed directly into the electrical grid in LV and storage units at the same level.

Even at the lowest level of voltage, electricity will still be generated. Small-scale entities, such as private and commercial consumers, will become prosumers and will provide self-generated energy, but will also source some energy from the DSO's network. The flow of electricity will be two-way: **top-down** and **bottom-up**. Both the flow top-down and the flow bottom-up have to be remunerated adequately.

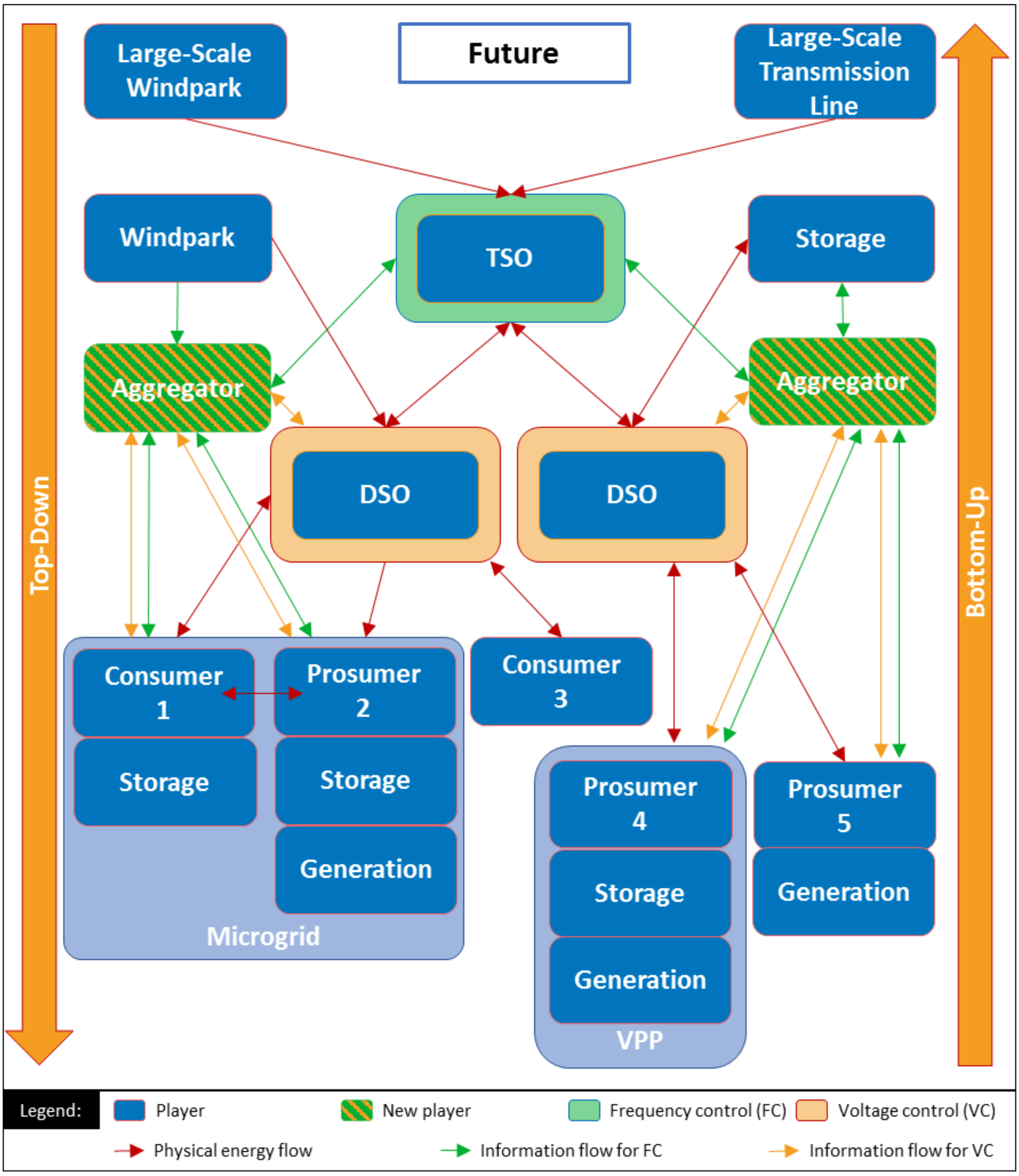

Figure 4-2:Visualisation of the Future Market Structure

Responsibilities for f**requency control** and v**oltage control** will remain with the TSO and DSO; however, other actors will now be involved in the collaboration.

In an up to 100% RES scenario, the TSO no longer has the conventional large-scale generators available for procuring ancillary services. In the future, these services must be provided by other sources. It is necessary to integrate as many consuming and producing units at all levels as possible.

With the current infrastructure, the DSOs will barely be able to stabilize the electrical voltage independently. Due to the two-way flow of electricity, an interaction with the respective actors in the distribution grid, even each small-scale entity, like a private prosumer, is needed.

The transition towards a system with **bottom-up** components and a required interaction with, inter alia, private entities will create the necessity for overall technical and economic coordination. For the TSOs and DSOs it is not feasible to interact with every single (private) prosumer. Likewise, no small-scale entity (private or commercial) will be interested in acting autonomously in the electricity market every day.

One solution toward solving this problem could be the introduction of a new kind of market participant: the so-called aggregator. An aggregator represents a group of small-scale entities vis-à-vis DSOs and TSOs. One important task is to aggregate the possible small-scale services that a prosumer can offer. These services are not relevant for the system operators. A "bundle" of small-scale ancillary services may be a desirable offer that can be used by the system operators for their tasks of **frequency control** and **voltage control**.

In the field of commercial energy generation (especially at the mid-scale level), there are different options concerning interactions with aggregators. For example, the operators of wind farms or larger storage units can integrate their assets into the bundle of services of an aggregator or sell their generated electricity to the system operators directly. Bundling and bringing to market in the form of a virtual power plant is possible as well.

The technology assessment of possible developments requires consideration of all options. The possible design of the role of the aggregator itself is varied. DSOs can also act as aggregators, or energy companies seeking new business opportunities where they can leverage their expertise after discontinuing their former business models.

Regardless of the exact future design of the system, central questions arise concerning the sustainability of the system and the work of companies in the field of CSR:

- Which are the assets and who owns them? Who can control/access the respective assets?
- Who gets paid by whom and for which service?
- Which and how many new assets are needed and what is the resulting environmental impact?
- Is there the opportunity of participation for everyone?
- How can the aspects of reliability and affordability be ensured for all citizens of the EU?

4.2 TSO

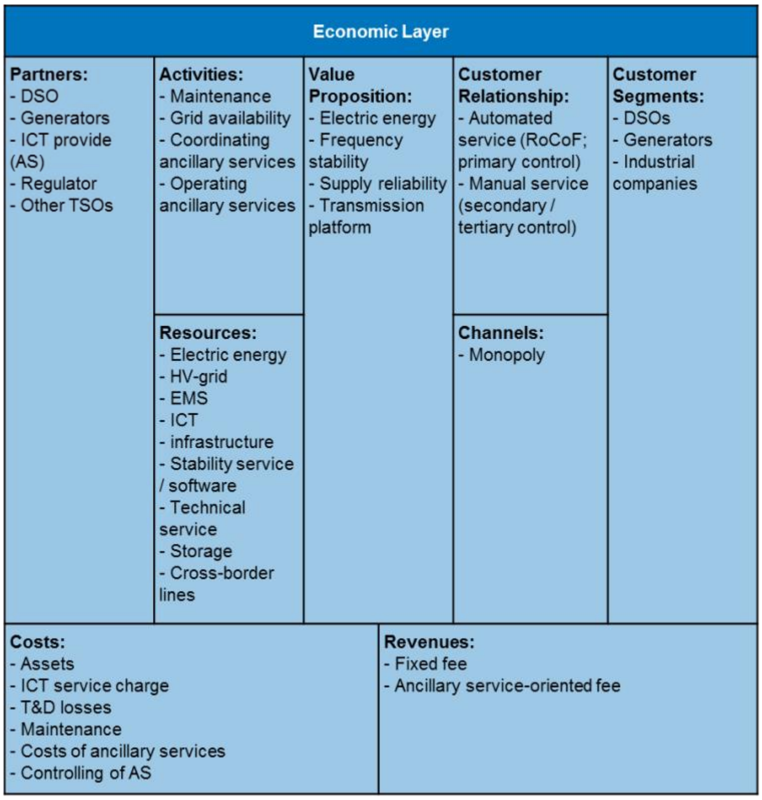

Figure 4-3: TSO Economic Layer

The TSO as transmission grid operator is currently also responsible for frequency stability. In scenarios with less inertia-driven energy generation, frequency stabilisation and ancillary services become more important. This affects not only the economic side of TSOs but also energy prices and technical regulations. TSOs will have a changed role in the future grid. Focusing on reliability and stability, the ordinary transmission will be upstaged. The analysis of the future TSO business model shows no fundamental change in the value proposition. TSOs will still transmit electrical energy, support frequency stability and reliability, and will be transmission platforms, but they will face other cost structures in the future. Besides costs for assets and maintenance, the costs for ancillary services and the controlling of ancillary services will increase. For controlling, networks and internet solutions are needed, so an ICT service charge will come along. This will also happen with the goal of reducing T&D losses. Minimising T&D losses will save costs but will also have environmental impact because of the higher efficiency of the grid.

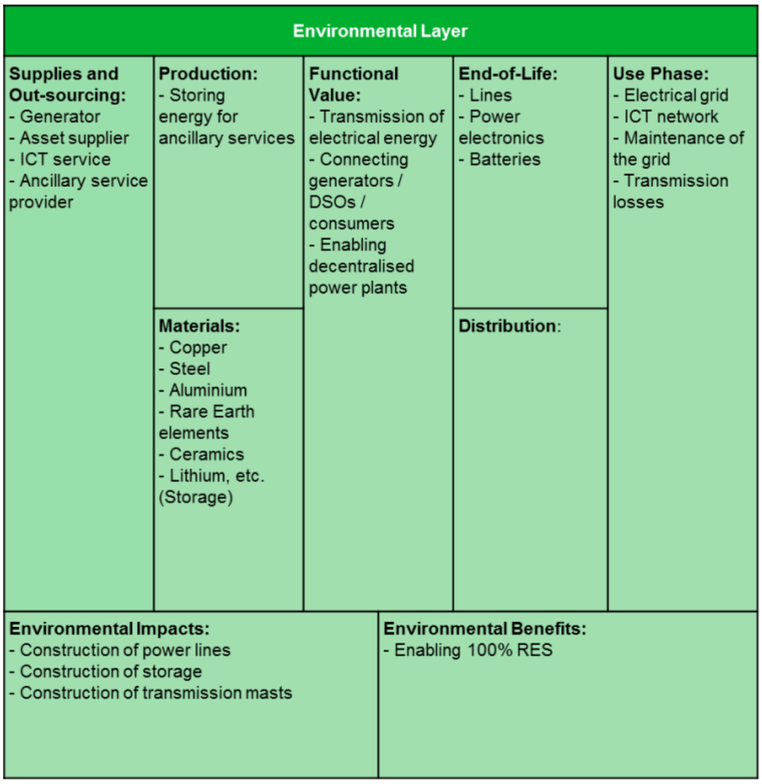

Figure 4-4: TSO Environmental Layer

In the environmental layer, the functional value is similar to the value proposition in the economic layer. The environmental layer shows the settings and the surroundings for the TSO, for instance in future the TSO could need to provide the platform for three offshore wind farms instead of e.g. one large lignite power plant. The main functions which have impact on the environment are the transmission of electrical energy, connecting generators, DSOs, and customers, and enabling decentralised power plants. For implementation, the construction of new power lines, storage systems, and transmission masts will be indispensable; however, the environmental impact must always be considered.

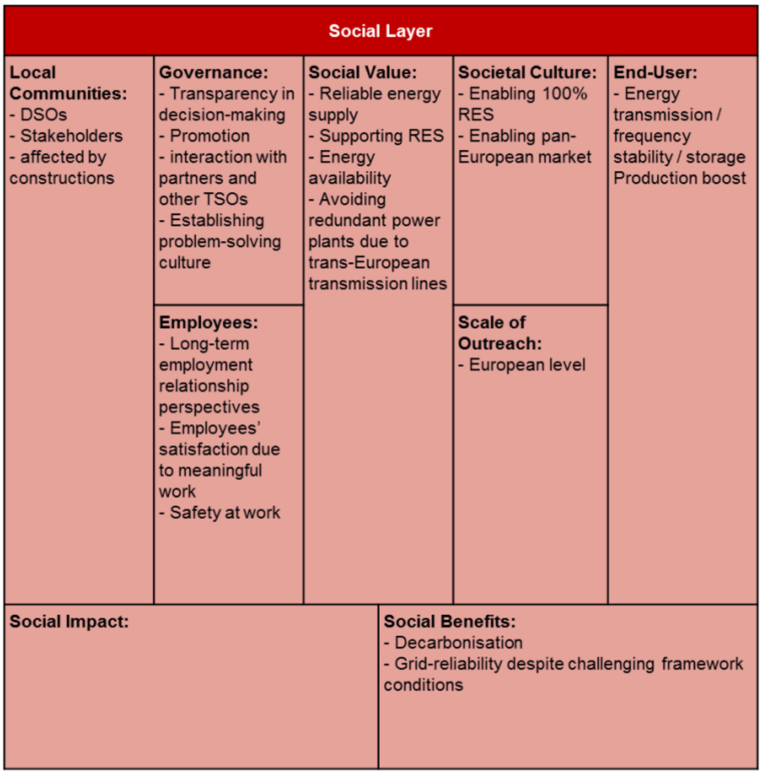

Figure 4-5: TSO Social Layer

Next to a reliable energy supply, the main social value of future TSOs will be in creating a pan-European grid and supporting RES energy availability, which will have huge follow-up effects on society and the environment.

4.3 DSO

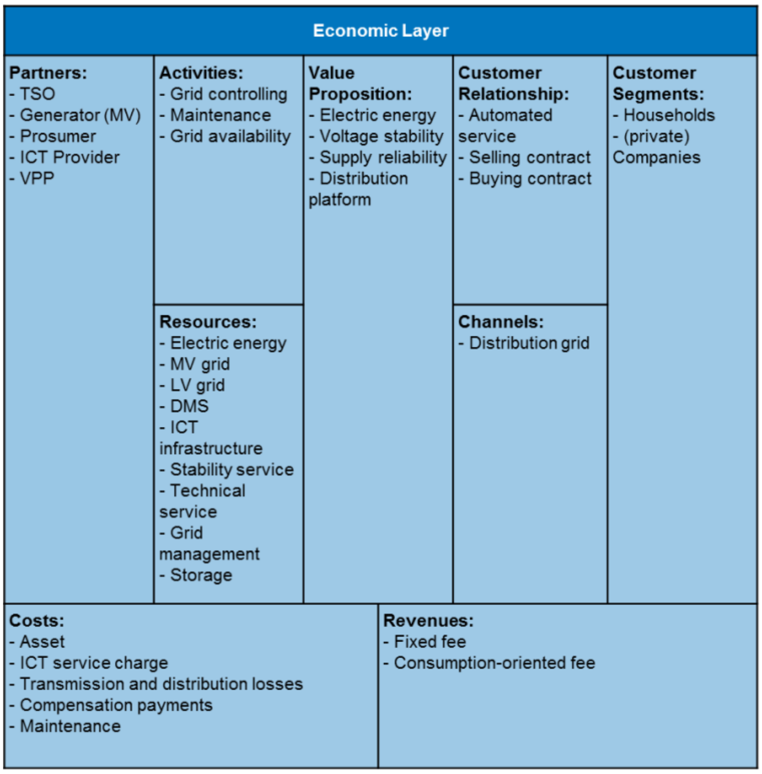

Figure 4-6: DSO Economic Layer

Similarly to TSOs, electrical energy as a value proposition is valid for DSOs as well. Next to the reliable supply, DSOs will face two challenges in future grid scenarios more than today. First, DSOs are responsible for voltage stability. This will be implemented by connected and controlled power electronics. Second the significance of the DSO as a distribution platform will increase. The task of offering the infrastructure for energy distribution will change considering the growing role of micro grids and peer-to-peer payment technologies.
On the other hand, the cost structure of DSOs will change. Assets and maintenance costs will still exist, but there will be also costs for ICT services. Furthermore, similarly to TSOs, DSOs will also be confronted with T&D losses and will have to minimize these. This could happen via an incentive system offering compensation payments.

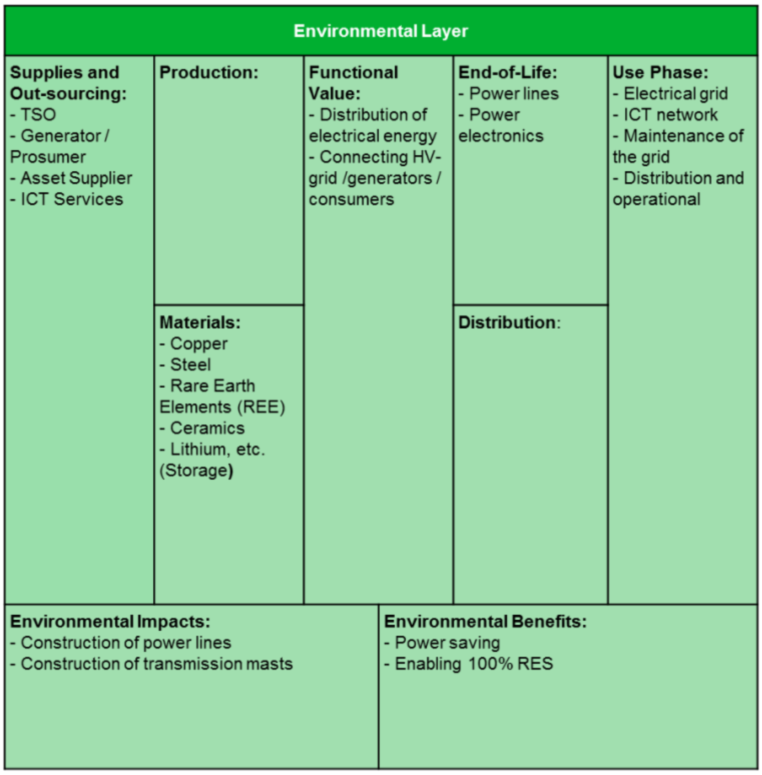

Figure 4-7: DSO Environmental Layer

DSOs face similar challenges in the environmental layer as TSOs do. Also, the environmental value of DSOs is comparable to that of TSOs.

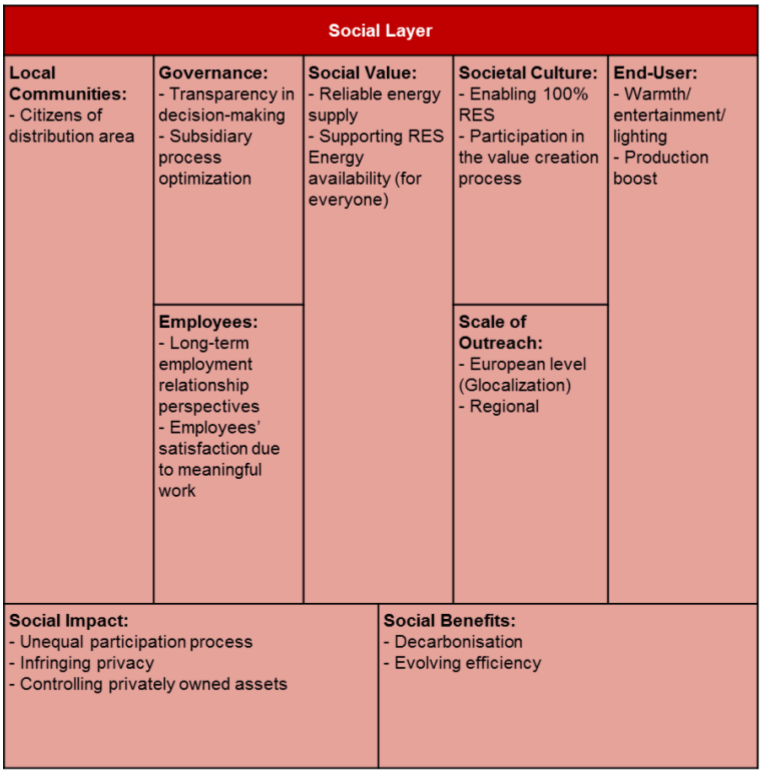

Figure 4-8: DSO Social Layer

In comparison to a TSO, DSOs have a considerable social impact. Regulating the distribution of energy and creating a pricing strategy always means an interference in society. Especially if private households work as prosumers, incentives and compensation fees will be paid by other customers, which increases the end-user's electricity bill and supports the wealth of facility owners.

Society will be also affected by intensified controlling of the grid. If DSOs want to optimise voltage control, access to assets and to data is needed. Data security and data prioritisation are important topics which have to be discussed with stakeholders.

5. Development of a Measurement System

In this deliverable, sustainability and corporate social responsibility (CSR) have been discussed from various angles. The changes in the market structure relevant to the RESERVE project have been considered. Building on this, section 4 detailed the business models of the key actors TSOs and DSOs with regard to their future direction. In doing so, both the current status and aspects that will change as a result of the future developments promoted in RESERVE have been examined in accordance with the economic, environmental and social impacts.

However, it is not the sole purpose of this deliverable to look at the business models once and to discuss their effects on the sustainability of the energy transition. Furthermore, a measurement system has been developed, which can also help in the future to evaluate and constantly monitor the actions of key actors in terms of sustainability.

Measurement Systems are used to scale the performance and impact of an organization. They use performance indicators like profit, turnover and return on investment to evaluate achievements but also consider non- financial influencing variables such as e.g. human resources, efficiency or innovation (Vitezic, 2010). The integration of Performance Measurement Systems and Corporate Social Responsibility (CSR) can have a potentially positive effect on the achievements of corporate objectives (Speziale and Klovienė, 2014).

The Balanced Scorecard is an effective format for reporting CSR indicators, as it illustrates the cause-effect relationship between being a good corporate citizen and being a successful business (Krisnawati, Yudoko and Bangun, 2014) but it measures mainly the company's economic performance. Therefore, in the RESERVE project we decided to focus on a modification of the Balanced Scorecard namely the sustainability balanced scorecard (S-BSC) in order to give emphasis on wider stakeholders. The usage of the sustainability balanced scorecard as measurement system enables us to integrate all three CSR pillars in a holistic approach, while using the advantages of the balanced scorecard approach. Its structure and basic functionality have been explained in sub-section 2.2.4.

This deliverable presents the developments that were compiled in the first half of the project. For each of the aforementioned key actors TSOs and DSOs, an S-BSC with strategic objectives and operational objectives was developed. The present results have been developed on the basis of input from the upstream work packages (WPs). Building on this, further assessments and valuations were obtained at the second CSR Workshop, which was attended by the entire RESERVE consortium. This approach ensured that the views of all stakeholder groups represented in the project were taken into account.

In the following sections, the key aspects of the developed S-BSCs are presented. The complete tables can be found in the appendix.

5.1 TSO

The following are selected examples from the S-BSCs of a TSO that can be used to control and measure sustainable development.

In the financial perspective, the environmental sustainability pillar issues the strategic goal of preparing the electrical grid for the transition towards 100% RES in the own area of responsibility. In accordance with this strategic objective, operational objectives are derived. So, one objective is to enable this development by investing in appropriate measures. In order to be environmentally sustainable, it is also important to invest in environmental protection measures within one's own area of activity.

The "customer & stakeholders" perspective on economic sustainability sets a strategic objective to enhance cooperation with TSOs from neighbouring countries. As RES grows, the availability of electrical energy and ancillary services is becoming increasingly volatile. In this way, costs can be saved if, through successful cooperation across national borders, redundant power capacities can be avoided.

This is followed by an associated operational objective to strive for an organisation of ancillary services across borders, or rather to exchange with the corresponding TSOs in this regard. As already mentioned, costs for rarely needed overcapacity can be reduced. This goal also interacts with other elements of the S-BSC. Thus, the goals presented here also have an influence on the social components of the perspective "customer & stakeholders". This will help to achieve the objective of providing a reliable network for all market participants.

5.2 DSO

For the role of the DSO, which will remain a very important actor in the context of future developments, an S-BSC with strategic and operational objectives has also been developed. Selected examples are shown below.

As discussed in the previous section, the relationship with the private consumers will change for a DSO, among other things. The previous simple relationship will increasingly be characterised by interaction. This will result in additional responsibilities for DSOs that need to be considered.

From the point of view of social sustainability, in the financial perspective, participation in profits or savings in costs realised through interaction with consumers is of great importance. Thus, the private providers must be appropriately remunerated for the services provided by them. Among other things, compensation payments must be developed for the case that the prosumers restrain performance in the service of voltage stability. This becomes particularly relevant when a DSO itself assumes the role of an aggregator.

This example also illustrates the interdependence between the individual areas of sustainability and the four perspectives of the BSC. The mentioned partial profits are in connection with the objective from the perspective "customer & stakeholders" to ensure an affordability of the provided services for all market participants. Here, it is to be differentiated, possibly also by regulatory units, between the fees for private service providers and the source of funds. For example, in the interests of social sustainability, it should be avoided that financially weak sections of the population without access to the active energy market pay for other parts of the population with appropriate equipment.

6. First Version of CSR and Network Code Guidelines

As seen in sections 4 and 5, new strategies and players will affect the energy market of the future. These are necessary to ensure the transition towards 100% RES. RESERVE delivers techniques and ideas to make sure the energy transition will be successful in economic, environmental, and societal aspects.

But new opportunities also bring risks with them. On the structural side as well as on the very practical side, corporate social responsibility and guidelines have to ensure a sustainable transition.

Network Codes (see D6.1) are very important instruments to ensure this aspiration. But first, basics for sustainability in energy transition and energy supply have to be fixed.

Energy transition and energy supply of the future has to be…		
… economic …	… environmental …	… social …
• affordable • efficient • Incentive-driven	• reliable • based on an extended infrastructure	• affordable • including everyone • giving the chance to participate

Based on these principles, network codes can be classified into the three pillars of sustainability and CSR. Selected network codes that RESERVE is suggesting are clustered in the table (see appendix 9.3).

The aim of the suggested network codes in RESERVE is to enable up to 100% RES in electrical energy generation. This so called "wish list" includes the results of new business models and changing market structures and evaluates the sector of sustainability.

Combining the results from analysing the market and business structures and the three pillars of sustainability, RESERVE will create a huge impact based on the goals and principles mentioned above.

Follow up deliverables 6.6 and 6.7 will prepare CSR and network code guidelines for the development of business models and energy system designs.

7. Conclusion

The market structure in the electricity sector will change significantly. We have shown that, based on the previous results of RESERVE, there will be a change in the market structure from an exclusive top-down principle to a system which is guided by two principles: top-down and bottom-up.

This change will concern in particular the two topics covered by RESERVE: frequency control and voltage control. The two responsible actors, TSO and DSO, will no longer be able to execute their control tasks exclusively from the top when the transition towards 100% RES has been achieved. Instead, they will need to obtain services from the end customer in accordance with the bottom-up principle. These changes will entail the need for a new actor. The so-called aggregator will bundle and coordinate the assets and the available services of consumers/prosumers. With these bundled services, the aggregator will be doing business with system operators and will be offering them services that they can use to fulfil their tasks, such as primary or secondary control.

In order to shape the development of the electrical energy supply successfully and sustainably, it is necessary to design the involvement of the consumer in a prudent and meaningful way. To achieve this, the aspects of CSR must be reflected in the policy and strategic management of the companies involved.

Since the protection and successful integration of the end customer is of central importance, the integration of CSR policies into network codes is necessary.

The following steps for the further course of the project are derived from the work already done:

A detailed analysis of the possible business models of the aggregator is required. This applies both to the range of different options for shaping these business models and to sustainability in terms of CSR. The aforementioned possibilities for the integration of the consumer must be evaluated comprehensively.

8. References

Brundtland, G. H. (1987) 'Our Common Future', *Environmental Conservation*, 14(4), pp. 291–294.

Bruns Jr., W. J. (1989) 'A REVIEW of Robert K. Yin's Case Study Research: Design and Methods.', *Journal of Management Accounting Research*, p. 157. doi: 10.1097/FCH.0b013e31822dda9e.

European Commission (2011) *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS*.

European Commission (2015) 'European Commission: Energy Roadmap 2050.', (July). doi: 10.1002/jsc.572.

Eurostat (2012) *Electricity production, consumption and market overview - Statistics Explained*. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_production,_consumption_and_market_overview#Electricity_generation (Accessed: 8 February 2018).

Fraunhofer ISE (2017) *Stromproduktion in Deutschland | Energy Charts*. Available at: https://www.energy-charts.de/power_de.htm?source=uranium&week=48&year=2017 (Accessed: 8 February 2018).

Joyce, A. and Paquin, R. L. (2016) 'The triple layered business model canvas: A tool to design more sustainable business models', *Journal of Cleaner Production*. Elsevier Ltd, 135, pp. 1474–1486. doi: 10.1016/j.jclepro.2016.06.067.

KAPLAN, R. S. and NORTON, D. P. (1992) 'the Balanced Scorecard - Measures That Drive Performance / Robert S. Kaplan, David P. Norton. Tt -', *Harvard business review TA -*, 70(1), p. 71.

Krisnawati, A., Yudoko, G. and Bangun, Y. R. (2014) 'Building a novel model of Performance Measurement System for Corporate Social Responsibility towards sustainable development', pp. 514–519. doi: 10.1109/ICMIT.2014.6942480.

Lüdeke- Freund, F. (2010) 'Towards a Conceptual Framework of Business Models for Sustainability', *Knowledge Collaboration & Learning for Sustainable Innovation ERSCP-EMSU conference, Delft, The Netherlands*, 49(0), pp. 1–28. doi: 10.13140/RG.2.1.2565.0324.

Mehos, M. *et al.* (2012) 'Concentrating Solar Power', *AIP Conference Proceedings*, 1044(2), pp. 331–339. doi: 10.1063/1.2993731.

Office of Indian Energy and Economic Development (2016) *Utility-Scale and Distributed Wind Energy Generation*, *TEEIC*. Available at: https://teeic.indianaffairs.gov/er/wind/restech/scale/index.htm (Accessed: 8 February 2018).

Osterwalder, A. and Pigneur, Y. (2002) 'Business Models and their Elements', *Management*, (October), pp. 4–5. Available at: http://inforge.unil.ch/aosterwa/Documents/workshop/Osterwalder_Pigneur.pdf.

Speziale, M.-T. and Klovienė, L. (2014) 'The Relationship between Performance Measurement and Sustainability Reporting: A Literature Review', *Procedia - Social and Behavioral Sciences*, 156, pp. 633–638. doi: 10.1016/j.sbspro.2014.11.254.

Teece, D. J., Pisano, G. and Shuen, A. (2007) 'Dynamic Capabilities and Strategic Management', *Strategic Management Journal*, 18(7), pp. 509–533.

Vitezic, N. (2010) 'A Measurement System Of Corporate Social Responsibility In The Pharmaceutical Industry Of The Region', *International Journal of Management & Information Systems*, 14(5), pp. 57–67. Available at: https://www.cluteinstitute.com/ojs/index.php/IJMIS/article/view/13/11.

Yin, R. K. (1981) 'The Case Study Crisis: Some Answers', *Administrative Science Quarterly*, 26(1), p. 58. doi: 10.2307/2392599.

9. List of Abbreviations

AVM	Active Voltage Management
B2B	Business to Business
BMS	Building Management System
CAPEX	Capital Expenditure
CENELEC	European Committee for Electrotechnical Standardization
CEP	Complex Event Processing
COTS	Commercial off-the-Shelf
CPMS	Charge Point Management System
CSA	Cloud Security Alliance
CSR	Corporate Social Responsibility
EMS	Decentralised Energy Management System
DER	Distributed Energy Resources
DG	Distribution Grid
DMS	Distribution Management System
DMTF	Distributed Management Taskforce
DSE	Domain Specific Enabler
DSO	Distribution System Operator
DVSM	Dynamic Voltage Stability Monitoring
EAC	Exploitation Activities Coordinator
ENTSO-E	European Network of Transmission System Operators for Electricity
ERP	Enterprise Resource Planning
ESB	Electricity Supply Board
ESCO	Energy Service Companies
ESO	European Standardisation Organisations
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
ESS	Energy Storage System
FCR	Frequency Containment Reserve?
GE	Generic Enabler
HEMS	Home Energy Management System
HV	High Voltage
HVDC	High Voltage Direct Current
I2ND	Interfaces to the Network and Devices
ICT	Information and Communication Technology
IEC	International Electrotechnical Commission
IoT	Internet of Things
KPI	Key Performance Indicator
LSD	Linear Swing Dynamics
LV	Low Voltage
M2M	Machine to Machine
MPLS	Multiprotocol Label Switching
MV	Medium Voltage
NIST	National Institute of Standards and Technology
O&M	Operations and maintenance
OPEX	Operational Expenditure
PLC	Power Line Communications
PM	Project Manager
PMT	Project Management Team
PPP	Public Private Partnership
PRBS	Pseudo Random Binary Sequence
PV	Photovoltaics
QEG	Quality Evaluation Group
QoS	Quality of service
RES	Renewable Energy Sources
RoCoF	Rate of Change of Frequency
S3C	Service Capacity; Capability; Connectivity
S-BSC	Sustainability Balanced Scorecard
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy

SDN	Software Defined Networks
SDOs	Standards Development Organisations
SET	Strategic Energy Technology
SET	Strategic Energy Technology
SG-CG	Smart Grid Coordination Group
SGSG	Smart Grid Stakeholders Group
SME	Small & Medium Enterprise
SoA	State of the Art
SON	Self Organizing Network
SSAU	Secondary Substation Automation Unit
T&D	Transmission and Distribution
TL	Task Leader
TM	Technical Manager
TSO	Transmission System Operator
VOI	Virtual Output Impedance
VPP	Virtual Power Plant
WP	Work Package
WPL	Work Package Leader

10. List of Figures

11. ANNEX

A.1 Figures concerning Frequency and Voltage Control Scenarios

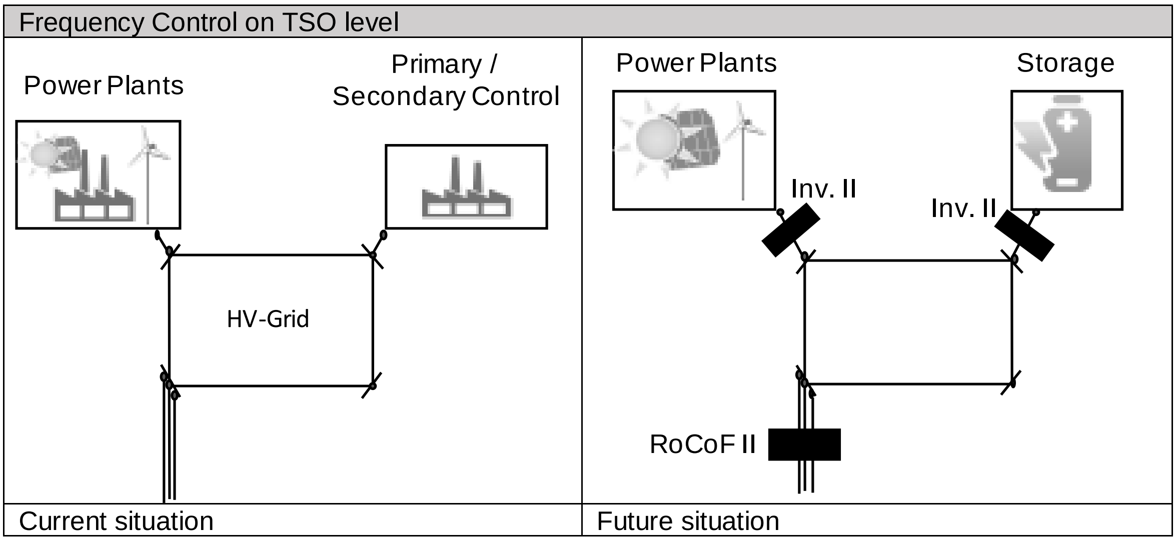

Figure 11-1: Frequency Control on TSO Level

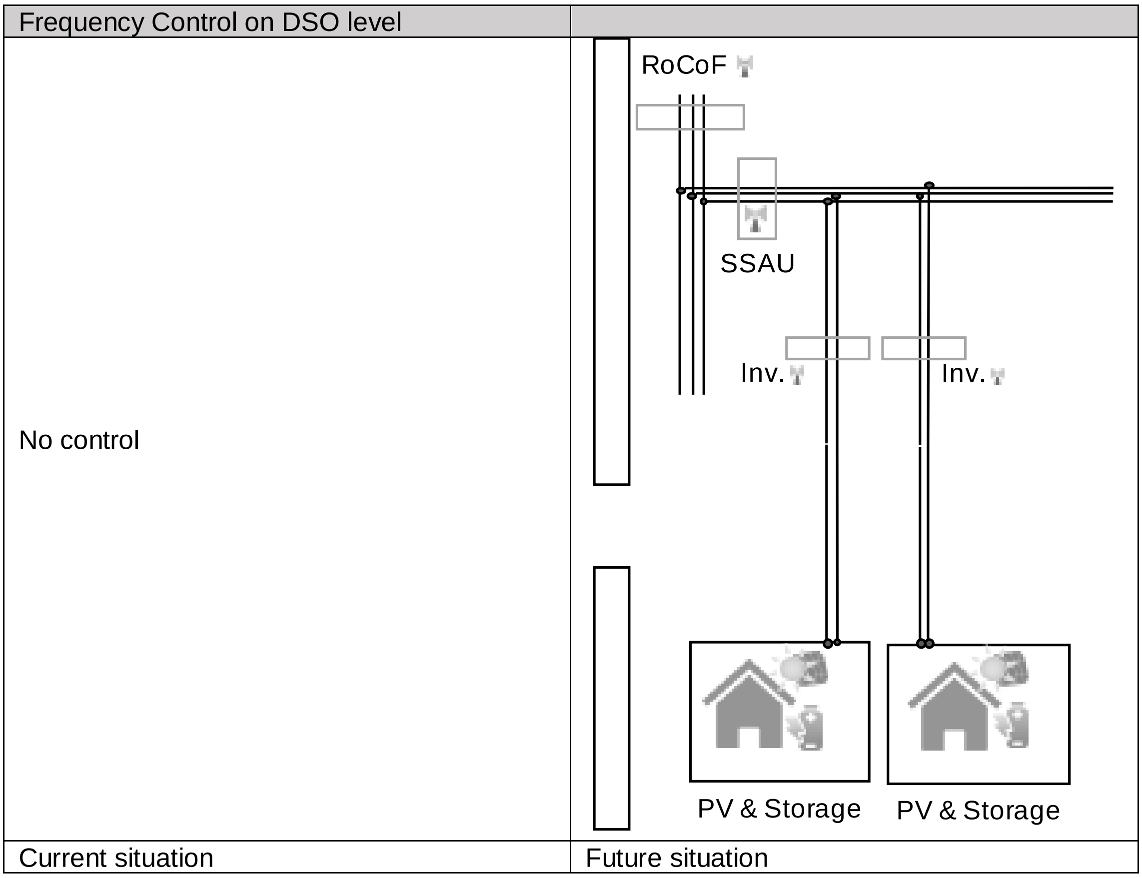

Figure 11-2: Frequency Control on DSO Level

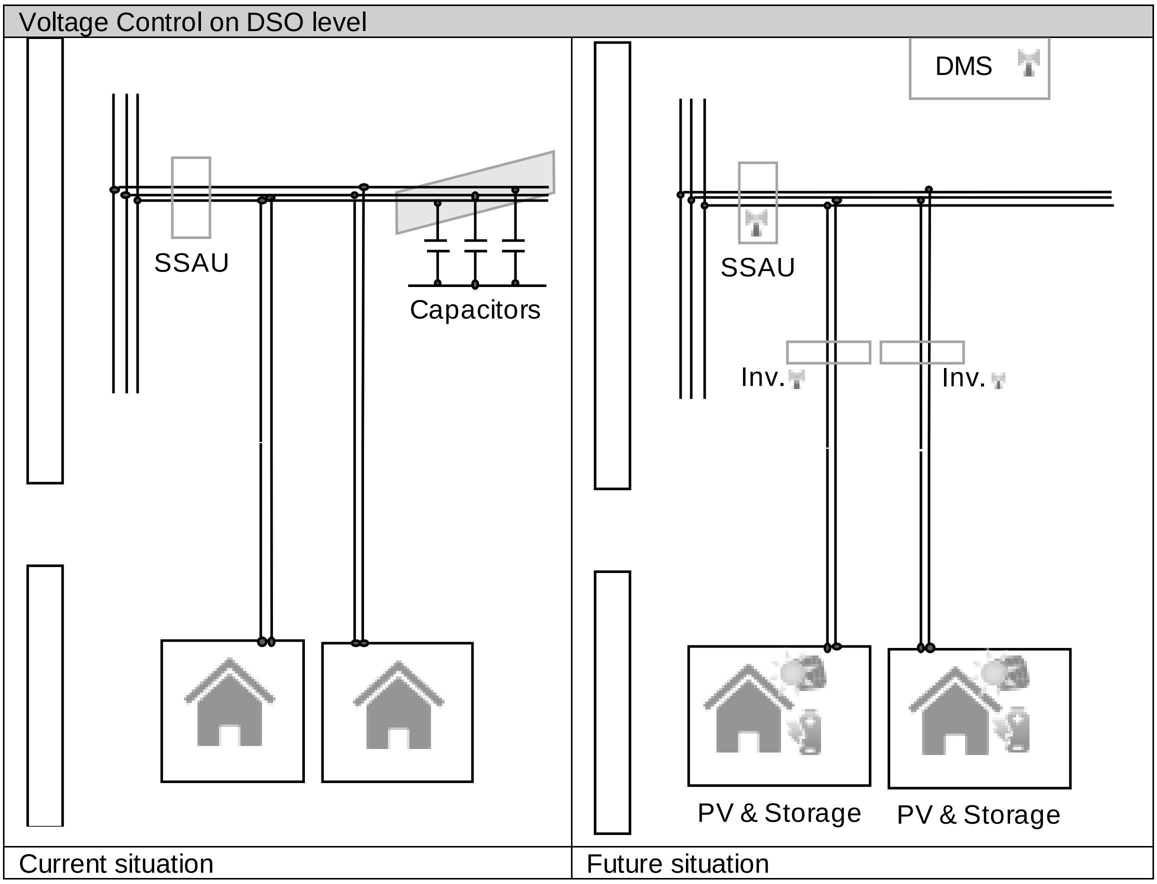

Figure 11-3: Voltage Control on DSO Level

A.2 Sustainability Balanced Scorecards

A.2.1 Sustainability Balanced Scorecard TSO

TSO	Financial		Customer & Stakeholder		Internal Processes		Learning & Growth	
	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective
Economic Sustainability	Profitability	Cash-flow, Payment structure, ROI	Interacting customers and stakeholders	Increase of customer satisfaction; Customer loyalty	Energy efficiency / Minimising T&D losses	Implementation of effective controlling devices and strategies	Innovation capability	Internal knowledge management; training of employees
	Increase of market share	Participating in pan-European TSO union (entso-e)					Employee satisfaction	Internal knowledge management; training of employees
	compensation of services (frequency stability)	Using changes in market structure in order to achieve changes in payment structures					Creating awareness of international cooperation	Exchanges with other TSOs; integration-oriented workshops
	Corporate value	Investments in assets (HV grid, storage devices, EMS)	Enhanced collaboration with TSOs from neighbour countries	Initiating organisation of cross-border ancillary services				
			Strategic for frequency stability	Coordinating storage capacities (and other entities providing ancillary services)				
Social Sustainability	Profit participation	No payment of dividends; non-profit orientation	Stakeholder management	Increasing transparency by Establishing a stakeholder report system	Fair working conditions / Responsibility for employees	Safety at work	Contribution to innovation by R&D activities	Participation in interdisciplinary R&D projects
	Corporate social value	Investments in assets (HV grid, storage devices, EMS)		Round table; Creating acceptance				
	Ensuring secured data transfers	Investment in sub-structures (data security; protection against cyber attacks)	Grid reliability	Ensuring a stable 100% RES-feeded grid as a reliable basis for all market participants	Code of ethics	Women and minorities policies; Learning and communication	Performance of the non-profit orientation	Development of guidelines concerning role in society
			Affordability	Ensuring a cost-effective transmission system and stability service				
Environmental Sustainability	Making the grid ready for 100% RES	Investments in environmental protection	Equipment supplier performance related to environmental commitments	Identifying supplier with eco-label for supply chain	Energy efficiency / Minimising T&D losses	Implementation of effective controlling devices and strategies	Research & development in environment	Considering environmental studies at construction sites
		Investments in measures making the grid ready for 100% RES	Enabling the customer to consume electricity from 100% RES	Providing required infrastrucutre				
			Consideration of a environmental sustainability besides emission reductions	Consideration of NGOs; Checking constructions measures for environmental impacts; Controlling and coordination of partners in order to achieve best possible environmental protection				

Figure 11-4: Sustainability Balanced Scorecard TSO

A.2.2 Sustainability Balanced Scorecard DSO

DSO	Financial		Customer & Stakeholder		Internal Processes		Learning & Growth	
	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective	Strategic Objective	Operational Objective
Economic Sustainability	Profitability	Cash-flow, Payment structure	Interacting customers and stakeholders	Incentives for customer interaction	Energy efficiency / minimizing T&D losses	Implementation of effective controlling devices and strategies	Innovation capability	Internal knowledge management; training of employees
	Increase of market share	Integrating as many as possible structures (microgrids)						
	Corporate value	Investments in assets		Increase of customer satisfaction; Customer loyalty			Employee satisfaction	Internal knowledge management; training of employees
Social Sustainability	Profit Participation	Compensation system for "voltage ancillary services"; Payment system for the service of "voltage stabilisation"	Stakeholder management	Increasing transparency by establishing a stakeholder report system	Fair working conditions / Responsibility for employees	Safety at work	Contribution to innovation by R&D activities	Participation in interdisciplinary R&D projects
	Sponsoring	Creating awareness; Acting as a local partner		Round table; Creating acceptance				
	Integrating as many as possible structures (microgrids)	Investment in sub-structures (microgrids; partly autonomous)	Grid reliability	Ensuring a reliable access to electricity for everyone at any time	Code of ethics	Women and minorities policies; Learning and communication		
	Ensuring secured data transfers	Investment in sub-structures (data security)	Affordability	Ensuring a cost-effective access to electricity for everyone at any time				
Environmental Sustainability	Making the grid ready for 100% RES	Investments in environmental protection	Equipment supplier performance related to environmental commitments	Identifying supplier with eco-label for supply chain	Energy efficiency / minimizing T&D losses	Implementation of effective controlling devices and strategies	Research & development in environment	Considering environmental studies at construction sites
		Investments in measures making the grid ready for 100% RES	Enabling the customer to consume electricity from 100% RES	Providing required infrastructure				

Figure 11-5: Sustainability Balanced Scorecard DSO

A.3 Evaluation of Wish List of Network Codes (see D6.1)

No	Wish list	Short description	Influence in		
			EC	EN	SO
1	Adoption of reference Scenarios - WP 1	WP1 defines four different scenarios. Network codes could "adopt" them as reference scenarios, i.e. ending points of the evolution of the European system by specifying the year by which 100% RES-electricity is expected.	X		
2	Distribution system - frequency control - WP 1	Frequency scenarios focus more on HV and MV networks i. Different architectures of communications have been suggested in D1.3, for inertial primary and secondary control. One of the aspects to be clarified is whether distribution system will help the frequency control or not. If not, (as in case of decentralised control managed by TSO), there is no necessity to define a VPP (virtual power plant) or microgrids as potential actors (as specified in D1.3) ii. From the point 3.a.i, the different actors participating in the control should be deeply described, in terms of technical and market requirements iii. Importance of data integrity, for avoiding lack of information iv. Indication of where and how to install the metering units, control units and so on (also highlighting problems due to intentional attacks on the system).			X
3	Distribution system - voltage control - WP 1	Voltage scenarios focus essentially on LV networks i. In D1.3 (within the appendix on page 78) there is the mention of the EC Article 29.1 Network codes and the ranges note for HV: the ranges mentioned are 0.90 pu to 1.118 pu for connection points between 110 kV and 300 kV stations and for connections between 300 kV and 400 kV the range is 0.90 pu to 1.05 pu. These ranges should either be re-used, or some other similar type of range should be added to the EC Article network codes for LV networks. ii. Concept of dynamic stability of the voltage: future network codes should indicate standard stability margins in terms of gain and phase margins and not only static requirements	X		

4	*Requirements for power converter-based energy storage systems (ESS) connected to the transmission grid (new NC) - WP 2*	*WP2 will study the provision of recommendations on such requirements considering the variety of ESS technologies, capacities, locations, control, etc. Moreover, in systems with 100% RES, i.e. no fossil fuel power plant is in operation, the actual procedures for primary and secondary frequency control may not be valid. Consideration of the storage (other than pumped storage) when providing frequency regulation services should be carefully treated.*	***X***	***X***	
5	*Requirements of minimum system inertia - WP 2*	*In the 100% RES, special circumstances regarding the EU must be assigned to the hydro power plants in order to enable the maintaining of higher inertia in operation. For the power system operator, recommended practice for maintaining mechanical inertia in the system is advisable.*		***X***	
6	*System swing dynamics - WP 2*	*WP2 is studying the concept of linear swing dynamics (LSD) that will result in a linear dynamical system with new requirements and roles in RES-tied converters' control and frequency regulation. Correspondingly, new recommendations will be provided based on the research work conducted in WP2.*	***?***		
7	*Expanding the frequency control strategy to allow using small-sized and/or intermittent energy resources - WP 2*	*Two types of control procedures are currently defined: the centralised control specific to the primary frequency control, and the decentralised control specific to the secondary frequency control. In the future, a diversity of control procedures may be required. For example, the distributed control is introduced. Distributed control refers to the coordinated control within a regional network, including both generation sources and loads, as a low-level control in the centralised scheme. This control strategy refers to the virtual power plant and microgrid concepts. These will require standardisation of their operation in relation to the network operator in the grid codes, such as: communication type; reserve monitoring; QoS monitoring and coordination.*	***X***	***X***	***X***
8	*Frequency control categories and time frame - WP 2*	*WP2 will provide new recommendations from ongoing and future work.*	***X***		
9	*Requirements for the HVDC systems - WP 2*	*WP2 will provide new requirements for HVDC systems that respect the technical constraints and specifications of each AC network. Furthermore, HVDC systems should provide synthetic inertia to the disturbed AC network without compromising the frequency stability of other HVDC-connected AC networks. These activities will definitely consider the coordination between HVDC system owners and the respective TSO.*	***X***		

10	*Recommended settings for the controlled units - WP 2*	*Recommendations regarding the coordination between inverters' characteristics for frequency control and drop values is advisable. This is important to achieve coherency into the interconnected power system. Finally, standardised operation characteristics should be provided for those units that respond to both inertial and primary control. This is important because the two actions are linked in time, and the power provided as frequency control service is set by the same controller.*			***X***
11	*Requirements regarding the DSOs - WP 2*		***X***		***X***
12	*Requirements regarding the information and data exchanges between ENTSO-E and TSOs - WP 2*	*A common complete database of the ENTSO-E system should be available for all system operators.*	***X***		***X***
13	*Requirements regarding the harmonisation of the remuneration rules for frequency containment reserves (FCRs) across all ENTSO-E countries in Continental Europe - WP 2*		***X***		
14	*Decentralised voltage control - WP 3*	*We recommend the practice of decentralised voltage control for the DSO. The underlying ideology is that the large number of inverter-based RES units in the LV grid are seen as degrees of freedom of control.*			***X***

15	*Requirements regarding new behaviour of RES inverters - WP 3*	*In the context of decentralised control, the control command received from a tertiary level or from a microgrid operator might be set-points for real and reactive power in a conventional sense. However, the methods developed in WP3 envision a case where the higher level might modify the behaviour of inverters. By "behaviour" we mean the control parameters themselves. The examples pertaining to WP3 are presented as follows: • The dynamic voltage stability monitoring (DVSM) (SV_A) functionality, which resides in the SSAU, would send control commands back to the VOI controller, which would in turn modify the control parameters of the inverter to achieve the set-point impedance. Hence, the behaviour of inverters is modified here and since the SSAU sends these commands, the DSO grid codes must allow it. • The active voltage management (AVM; SV_B) technique modifies the volt-var curves of the RES inverter. Hence the concept of volt-var curve definition for house RES inverters must be included in the grid codes.*	***X***	***X***	***X***
16	*New requirements regarding the perturbations injected from RES inverters - WP 3*	*Grid codes should be formed related to the injection of a white noise signal into the grid voltage for a short duration. The white noise signal, otherwise known as pseudo random binary sequence (PRBS) is generated in the control loop of the inverter, where the duty cycle or current/voltage reference is perturbed. This induces perturbations on the output voltage and current of the inverter for impedance measurement. In WP3, we will determine the magnitude of perturbation required for accurate determination of impedance and injection time period that is required for the noise injection and will propose them for new grid codes.*		***X***	***X***
17	*Dynamic Stability margins - WP 3*	*Hence for the futuristic grids, we propose the inclusion of dynamic stability margin definitions. Additionally, we envision through our work the determining of minimum dynamic stability margin limits or thresholds that the system must possess.*	***X***		
18	*Leading power factor - WP 3*	*The work done with the scenarios SV_A and SV_B would demand that the RES inverters operate with a leading power factor at times for providing grid voltage support. In the current scenario, the power factor is operated with only a lagging power factor in certain DSOs. Hence this WP will provide recommendations to modify the grid code to include a leading power factor.*	***X***	***X***	
19	*New power system parameter: flexibility - WP 6*	*Similarly to the system inertia, a high percentage of RES will require a new system parameter: flexibility.*		***X***	