SOGNO

D6.2 v1.0

Evaluation of potential new business model opportunities

The research leading to these results has received funding from the European Union's Horizon 2020 Research and Innovation Programme, under Grant Agreement no 774613.

Project Name	SOGNO
Contractual Delivery Date:	31 12 2018
Actual Delivery Date:	31.01.2019
Author(s):	ESB Networks
Workpackage:	WP6 - Standards and business model for SOGNO
Security:	P = Public or CO = Confidential
Nature:	R
Version:	V1.0
Total number of pages:	26

Abstract
As the energy systems integrate increasing volumes of Distributed Energy Resources, new technologies and service-based solutions will be required to ensure the system remains stable, secure and robust. Implementation of these systems and services, required to manage distribution networks efficiently, will require change from both the technical and the business perspectives.

The use of new technical solutions may drive the need for new and adapted business approaches and business models for system operators. Solutions will comprise of the integration of new technologies and services which will enable new operational models which will have to comply with the needs and constraints of the electricity market. These new solutions will also affect existing business models.

This deliverable describes a series of scenarios and potential business models based on the services defined in SOGNO. These software- and cloud-based services are aimed at supporting system operators in their efficient operation and management of their grid. Potential business models are presented in this deliverable from the DSO's perspective, considering sourcing options for all of the of the proposed services. There are a multitude of factors which contribute to the success or failure of a business model. One of the most important factors for system operatos is that of how the business model relates to the constraints of the system operators regulatory framework. For this reason, a second perspective developed in this deliverable discusses how a business model can be developed to best fit regulatory frameworks, supportingthe timely adoption of the new services

Keyword list
Distribution System Operators, 5G-based Monitoring & Automation Services, Distribution grid

monitoring, State estimation, Power control, Power quality, Distributed generation, Smart Electricity Distribution Grids, Business Models, Regulatory framework.

Disclaimer
All information provided reflects the status of the SOGNO project at the time of writing and may be subject to change.

Authors

Partner	Name	e-mail
ESB Networks		
	Jonathan Sandham	jonathan.sandham@esb.ie
	Paul Hayes	paul.hayes@esb.ie
Romanian Energy Center (CRE)		
	Dan Preotescu	dan.preotescu@crenerg.org
	Mihai Mladin	mihai.mladin@crenerg.org
RWTH		
	Kai Klöckner	kloeckner@controlling.rwth-aachen.de

Table of Contents

1. Introduction

Service Oriented Grid for the Network of the Future (SOGNO) is a 30-month project which has started in January 2018 and is funded by the European Commission in the Work Programme Horizon 2020 under the topic 'Next generation innovative technologies enabling smart grids, storage and energy system integration with increasing share of renewables: distribution network. SOGNO develops 5G-based software services for scalable automation and proactive monitoring of smart electricity distribution grid

This deliverable describes the potential for new business models in the electricity utility arena which could help a DSO to evaluate software services as a solution to network control and operation in the future. It will also appraise the evaluation of these new network control and operation technologies in light of current regulatory regimes.

1.1 Motivation and Purpose of the Deliverable

This deliverable assesses a range of future business models based on an increase in DER penetration with DSO networks and on their need to control and operate the low and medium voltage (LV/MV) grid within defined standards.

SOGNO is researching the possibility of external parties offering software services to DSO's to enable new IT and telecommunications techniques to be used by DSO's in their operation and control of the electrical network.

Owing to differing regulatory regimes across the EU, it is not possible to assess each proposed business model with respect to the requirements of all European DSOs. The proposed business models address potential regulatory barriers that may exist, thus enabling the models to operate.

1.2 Related Project Work

This report is based on the ongoing work of WP6 - Standards and Business Model for SOGNO, Task 6.1 – Analysis of Potential New Business Models. The activities carried out within this task are primarily related to those carried out within the same WP6, under the Task 6.2 - Adaptation of SOGNO Results into Standards and Regulations. The scenarios for proposed business models depend to a large extent on how the regulatory framework supports the context of the SOGNO services.

SOGNO services, having as their starting point the scenarios and ICT requirements developed in WP1, are further analysed and designed in detail in WPs 2 and 3, prepared for testing in WP4, and then field trials tested in WP5. These 5G-based software services underpin the foundation of the presented and analysed potential business models. The services are related to the regulatory framework within WP6.

Field tests in WP5 will provide relevant data on the functionality of 5G-based SOGNO services as deployed in normal power networks. The field trial data will provide the input required to remodelling the initially defined business models described in this deliverable, and the revision to the regulatory framework and CSR impact aspects undertaken in WP 6.

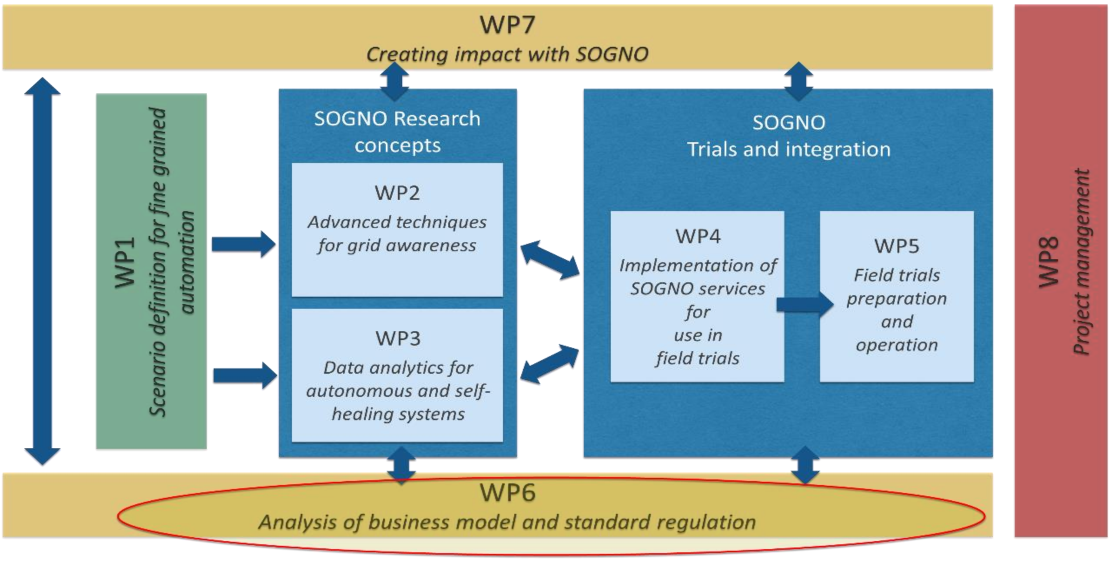

Figure 1: Project overview

1.3 Outline of the Report

The report is composed of two main parts. They cover firstly, the presentation of the services to be developed and trialled in SOGNO by trial sites and secondly, presenting some considerations regarding the potential business models based on the 5 services presented in the chapter 2 of the deliverable: FLISR, State Estimation, Load and Generation Forecasting, Power Quality, and Power Control. In Chapter 3, potential business models are presented from two perspectives: outsourcing or in-house development and whether or not there is regulatory support for these options.

1.4 How to Read this Document

This report can be read as a standalone document. This deliverable is closely related to the following deliverables:

- D1.1 – Scenario & architectures for stable & secure grid (M12): it gives the description of power system scenarios investigated in the project, with the motivations for which the services presented in this Deliverable are key for both today's and tomorrow's distribution grids.
- D6.3 - Identification of economically feasible value chain designs: this deliverable outlines the economic value of the SOGNO 5G-based software services for scalable automation and proactive monitoring of smart electricity distribution grids. The report demonstrates how SOGNO service utilisation is related to Distribution System Operators' (DSOs') operational performance

In addition, consulting the following deliverables would help the reader to get a better view of the concepts advanced in the SOGNO project and to have more details on the grid awareness services:

- D2.2 - Description of initial Interfaces & services for grid awareness
- D3.1 - Description of new SOGNO techniques for autonomous and self-healing power systems
- D3.4 - Description of initial Interfaces & services for autonomous and self-healing power systems
- D4.2 - Report on Development/ Implementation and component tests, V1
- D4.4 - Description of Advanced Data Analytics tool, V1
- D4.7 - Report on initial Integration and initial testing of the solution
- D5.1 - Report on trial preparation and initial feedback from laboratory tests
- D7.4 - Initial report on preparation of exploitation

2. SOGNO Services

This chapter embeds the SOGNO services in the current conditions of network operation and concludes with the conditions that are to be considered with regard to their exploitation on a commercial scale.

2.1 Background

DSO's globally are responsible for operating distribution networks and ensuring that minimal outages occur on the electrical system and at customer premises. ESBN record the amount of time associated with outages to customers (CML – Customer Minutes Lost) and the amount of times customers are interrupted on an annual basis (CI – Customer Interruptions).

Regulated DSO's are accountable for CML and CI. Incentive mechanisms are in place to ensure they are kept to an economic minimum. Through SOGNO, it is possible to appreciate how advanced algorithms for self-healing, in conjunction with low cost monitoring, can allow DSO's globally to realise and demonstrate their networks are operating at an optimal level. It is assumed that using novel approaches to operating existing networks and devices will reduce CML by up to 20%.

To appreciate this potential efficiency gain in its totality, it is necessary to appreciate:

- The operational model of a DSO,
- The physical and operational constraints existing in the electrical system, and
- The situational state of the electrical system (planned outages, storms, general normal state, etc.)

Only after fully understanding and appreciating these details, is it possible to derive and develop algorithms which can be successfully adopted into ‘business-as-usual’ by a Utility or DSO.

The daily work of DSOs comprises all activities necessary to interminably guarantee a reliable operation of the electricity grid such as monitoring of voltage and current or maintenance and repair. DSOs are completely liable for all strategic and operational, grid-related, decision-making.

Increasingly decentralised electricity production from Renewable Energy Sources (RES), which often generate power on an intermittent basis, is challenging DSOs’ tasks whereas technological developments such as 5G-connected measuring devices offer potential solutions to these challenges. In particular, volatile, bi-directional energy flows and decreasing timing of electricity production and consumption hamper DSO’s efforts to avoid power network congestions, overvoltage and interruptions. In contrast to today’s standard ‘**passive network management**’ approach, in which investments in physical assets expanding the grid are the normally chosen remedy to enable the power grid to cope with electricity peaks produced by intermittent RES (‘fit and forget’), an ‘**active network management philosophy**’ [1] supported by modern ICT and innovative monitoring instrumentation permits gains in terms of, for example, quality of supply and RES integration [2]. Consequently, DSOs will needed to process large volumes of data while making use of latest communication standards for reliable and secure data transmission so as to optimise daily operational work.

Up-to-date electricity distribution management is about intelligent grid operation with active voltage and current control, automatic fault recovery, automatic reaction to uncommon transient behaviour and real-time grid-monitoring driven by ICT-connected measuring devices [1]. In that respect, 5G communication supports wide-area communications to manage an enormous increase of connected devices, low latency, cyber security, extremely reliable and ascendible communication to supply decision-support for DSOs and to advance resource allocation within the grid. As described in the following, the SOGNO services are being developed according to DSO’s current and future needs to enable DSOs to cope with the current challenges of electricity distribution.

2.2 Services to be developed and trialled in SOGNO by trial site

SOGNO will be developing algorithms to trial the following services:

2.2.1 FLISR

The Fault Location Isolation and Service Restoration (FLISR) service is being designed to automatically handle the emergency conditions that follow a fault event and aims at limiting the interruption of the power supply to a relatively small number of customers as well as at providing helpful information on the location of the fault, allowing its search and resolution in a shorter period of time. The FLISR algorithm works by processing measurements coming from the field after the occurrence of the fault in order to pursue, sequentially, the following goals:

i) Location of the point in the grid where the fault happened;
ii) Isolation of the faulty section by opening the switches immediately upstream and downstream the fault;
iii) Restoration of the power supply to all the other customers that are connected to portions of the grid not directly affected by the fault and out of the previously isolated area, again by opening or closing remotely controllable switches.

2.2.1.1 The business case for deployment of the SOGNO FLISR service by a DSO:

The deployment of an automatic FLISR service has the potential to bring significant advantages to both customers (in terms of reduction of number and duration of the outages) and DSOs (in terms of improvements of all the indicators associated to the reliability of the power supply and the continuity of the service). Due to the possible penalties applied to DSOs in case of bad indicators on the provision of power supply to the final users, the use of FLISR turns into a clear business case for the DSOs and for this reason, it is one of the most critical and important services to be considered when designing a fully-automated distribution grid.

The impact of FLISR on the duration of interruptions is illustrated in figure 2. Figure 2 illustrates FLISR based on a single interruption in the low voltage (LV) controlled by the DSO, CEZ Romania, which is performing the Romanian Field trial in the SOGNO project. The figure shows that FLISR utilisation reduces the duration of interruptions through automated fault location and recovery and therewith reduces Customer Minutes of service Lost (CML). Reducing Minutes of Customer service lost reduces the penalties which DSOs in Romania, Ireland and Italy have to pay to regulators based on their annual number of Customer Minutes of service Lost (CML). The reduction in penalties to be paid is greater than the currently estimated cost of implementing the SOGNO services in their network.

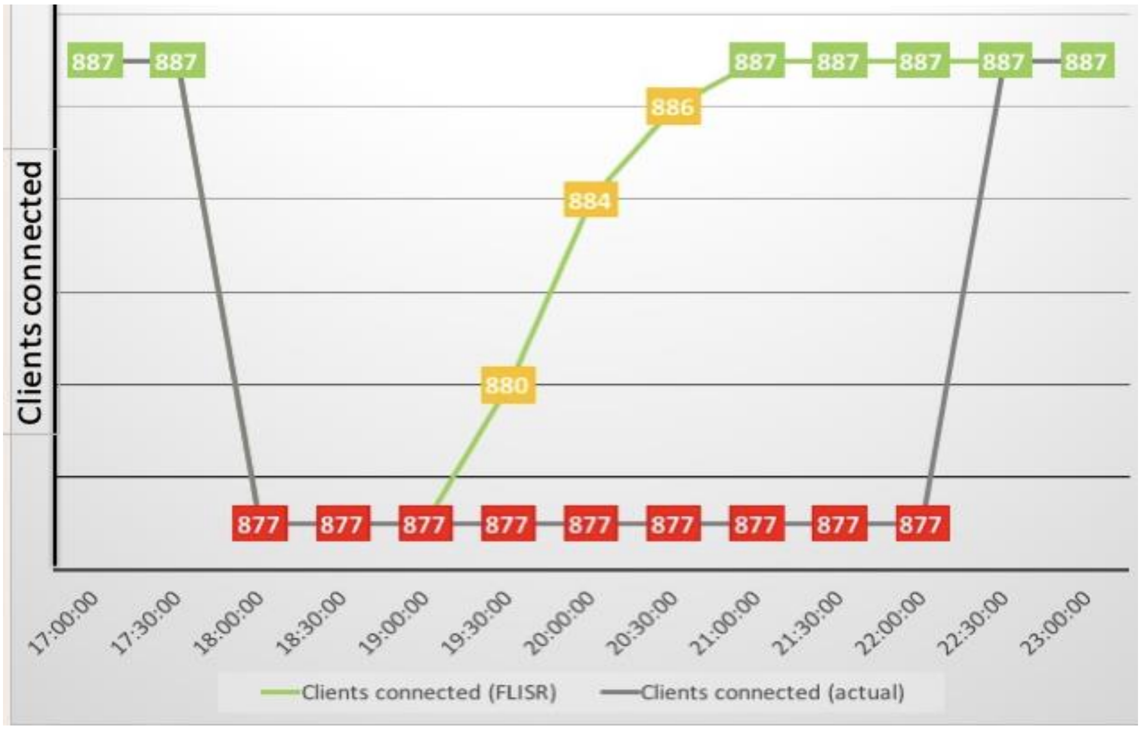

Figure 2: Timeline of a single interruption in the LV grid controlled by CEZ Romania - Status Quo (without) vs. with FLISR utilisation

2.2.2 State Estimation

The State Estimation (SE) service is the tool allowing the monitoring of the electric grid. The goal of SE is to compute the operating state of the network at a given instant of time by processing the measurement information provided by the instrumentation available on the field. The monitoring data provided by the SE algorithms can be used by grid operators to assess the performance of their network and to detect possible anomalies in the grid operation. In addition, they can serve as an input for more complex management/control functions implemented by the DSOs to operate their network more efficiently and in a reliable way. An example of service deployed on top of SE is the power control service described later in this report (Chapter 4). Other services that could use SE results as a starting point include (but are not limited to) network topology reconfiguration, voltage control and, in a future perspective, demand side management and demand response.

2.2.3 Load and Generation Forecasting

The Load Prediction (LP) and Generation Prediction (GP) algorithms aim at forecasting the future values of power consumption and injection, respectively, in order to give to the DSO the awareness on how the grid operating conditions are expected to evolve in the future. This service works by processing the historical data on the power consumption/injection of the customer, generator, or substation under analysis, and possibly taking into account other information that is likely to affect the power levels (e.g. like weather conditions, temperature, etc.). The forecast given by the LP and GP can refer to different time horizons and can have a different time resolution, according to the requirements of the DSOs and to the specific use for which these algorithms are intended. As an example, day ahead forecasts (for example with a time resolution of 15 minutes) can be generated in order to predict possible contingencies and, in case, to be prepared to take adequate countermeasures. Day ahead forecasts could be refined by shorter-term forecasts, e.g. a forecast referred to the next hour, which in general could be more reliable since it can be based on more recent information on the grid status. This could be, for example, a solution to apply preventive control schemes aimed at minimizing the risk of problems in the grid. On the other side, longer term forecast (e.g. on a seasonal or yearly basis) are also possible and it can be needed by DSOs for planning purposes and to support strategical decisions on the management or reinforcement of the grid. In SOGNO, the focus will be on LP and GP algorithms with time horizon of the forecast within one day.

2.2.4 Power Quality

The concept of power quality in electric grids covers a broad range of phenomena that can potentially affect the “quality” of the power supply delivered to the final customer. Usually, power quality issues are defined as those phenomena, which lead the voltage supply in the grid to differ from its ideal characteristics. Classical examples of power quality issues include voltage (or current) unbalance, voltage (or current) harmonics, interharmonics and flicker. In a broader sense, power quality definition sometimes also incorporates other aspects that are responsible for the inefficient operation of the electric grid. As an example, low power factors (determined by the presence of relatively high reactive power with respect to the carried active power) are sometimes also considered as a power quality issue.

The Power Quality Evaluation (PQE) service designed in the SOGNO project aims at providing the identification and monitoring of the most important phenomena commonly associated to power quality issues. This is mainly achieved by means of the Advanced Power Measurement Unit (APMU), which is a low-cost device able to directly measure on the field some key parameters related to power quality, such as: harmonics, reactive power, power factor, unbalance factors (for both voltages and currents), neutral currents, etc. The information directly provided by the APMU can be optionally complemented by the results of SE or by additional post-processing algorithms implemented in the ViSA cloud platform for the computation of other power quality indicators.

The goal of the PQE service is thus to give situational awareness to the grid operators about the quality of the power supply in their grid and, in case anomalies are detected, to trigger suitable countermeasures to prevent asset stress or failures, and outages. The produced power quality information can be thus used as input for more complex management and control functions used by the DSOs to operate efficiently their grid. In this regard, control or optimization functionalities built based on the PQE service can lead to:

- reduced costs by reducing outages and their associated regulator fines;
- reduced asset failures due to low power quality;
- reduced time to identify outages related to poor power quality;
- improved service quality and efficiency of the power delivery.

2.2.5 Power Control

The Power Control (PC) service aims at obtaining the optimum management of the power flows in the distribution grid (at both MV and LV level) for preventing possible contingencies (e.g. violation of the voltage limits, overloading of grid components, etc.) and to foster a more efficient and reliable operation of the system. This is obtained through the smart control of the active and reactive power injected (or consumed) by converter-based components connected to the grid, such as Distributed Generation (e.g. PV plants, wind turbines) and energy storage units. With respect to the management of the Distributed Generation based on renewable energy sources, an additional objective is to maximize the use of green energy while respecting the operational constraints of the electric grid, thus minimizing as much as possible the power curtailment of renewable generation. The use of smart power control algorithm in high-RES scenario is expected to bring significant benefits in terms of efficient operation of the grid, improvement of the power quality, and enhancement of the grid reliability. This service can be defined as an “active service”, since it actively acts on some of the power system components to modify their operation.

2.3 Commercialisation of the SOGNO Services

Many ways of designing the SOGNO value chain (described in D6.3) to launch the SOGNO services are conceivable and the consortium partners are correspondingly preparing to agilely adapt to the needs of individual DSO’s. This is of particular importance as the DSOs differ with regard to characteristics like size, number of loads, grid length and configuration, number of DG units, financial resources or IT competencies. For instance, large DSOs typically dispose an IT department whereas small DSOs possibly operate the network more conventionally, lesser pronouncing data management and analysis. As a consequence, both the effectiveness of the scale of grid automation as well as the effectiveness of the depth of data evaluation, as results of SOGNO service utilisation, vary in relation to individual DSO characteristics. Hence, different scenarios to launch the SOGNO services are being considered among the project partners. For example, it is not only conceivable for DSOs to purchase the SOGNO services in form of software licenses from an external party thereby doing the corresponding output data analysis by themselves but also to purchase externally output data interpretation to various degrees up till final recommendations for operational decision-making optimised based on the data collected by the sensors and power measurement units.

Data collection and transmission for the implementation of the SOGNO services takes place by means of hardware like sensors and power measurement units as well as information and communication technology (ICT) that establishes the connectivity of devices and data transfer. Investment in and ownership of the corresponding equipment comes along with capital expenditures (CAPEX) in form of depreciation and debt remuneration and with operational expenditures (OPEX) in form of personnel cost for the human labour that is related to (communication) infrastructure maintenance, software development, data processing and interpretation. Depending on the financial resources of particular DSOs, also different constellations of hardware ownership, service design and pricing are conceivable. On the one hand, for instance, all the equipment is possibly owned by value chain partners other than the DSO whereas the DSOs pays periodical fees to obtain the required degree of data visualisation and interpretation to the partner with which it contracts. On the other hand, DSOs having sufficient amounts of capital at their disposal conceivably invest in the required hardware like sensors in order to obtain ownership whereby they possibly receive, from an external party, the required degree of data visualisation and interpretation, based on the data collected from the sensors, ‘as-a-service’[1] by paying periodical fees to the contracting party. In this context, service-pricing depends on the degree of data visualisation and interpretation.

[1] The meaning of service in the present context requires precision. Service stands for a technical function provided by the use of ICT, hardware and software components that a DSO can use in its operational work. Further, ‘service’ is the complementary term to ‘product’. In this case, service refers to the way of selling and purchasing functions. If a DSO invests in the SOGNO services it means that the DSO purchases partly the hardware and software components needed to provide a certain function. The DSO purchases functions ‘as-a-service’ if it makes no investment in hardware or software components needed to generate the function, but obtains the function, or visualisation and interpretation of data as results of implementing the function, by paying periodical fees to the provider of the function, data visualisation and interpretation.

For the exploitation of the SOGNO services it is hence critical to understand in which cases a DSO

- prefers to purchase the SOGNO services ‘as-a-service’ against investments to internally operate the SOGNO-services (software, equipment, …),
- prefers to purchase the SOGNO services ‘as-a-service’ against investments in network expansion (or similar investments that increase the regulatory asset base[2] and possibly substitute the SOGNO services),
- prefers investments to internally operate the SOGNO services (software, equipment, …) against investments in network expansion (or similar investments that increase DSOs’ regulatory asset base and possibly substitute the SOGNO services).

The expected increase in DER penetration on distribution networks especially at low voltages will provide several challenges for DSOs in management of the network at this level. DSOs will have to find ways to manage this issue via the existing method of building or reinforcing or by procuring new types of services as the ones developed in SOGNO. In order to understand the potential changes in DSOs business models as a result of SOGNO service utilisation it is hence necessary to evaluate how different designs of the SOGNO services as well as the regulatory frameworks affect the business model of a DSO and thereby the diffusion of SOGNO services.

[2] The operating principles of DSOs with regard to the characteristics of national regulations are delineated in deliverable 6.3.

3. Potential Business Models and Evaluation

In order to obtain understanding on the issues mentioned above, forms of availing of services e.g. externally procured or internally developed and operated are to be evaluated both in light of the existing regulated asset base structure and the possible redesign to allow the offset of capital investment to be taken into account when calculating allowed revenues and in light of the consequentially emerging effects for DSO's business model.

3.1 DSO's Business Model

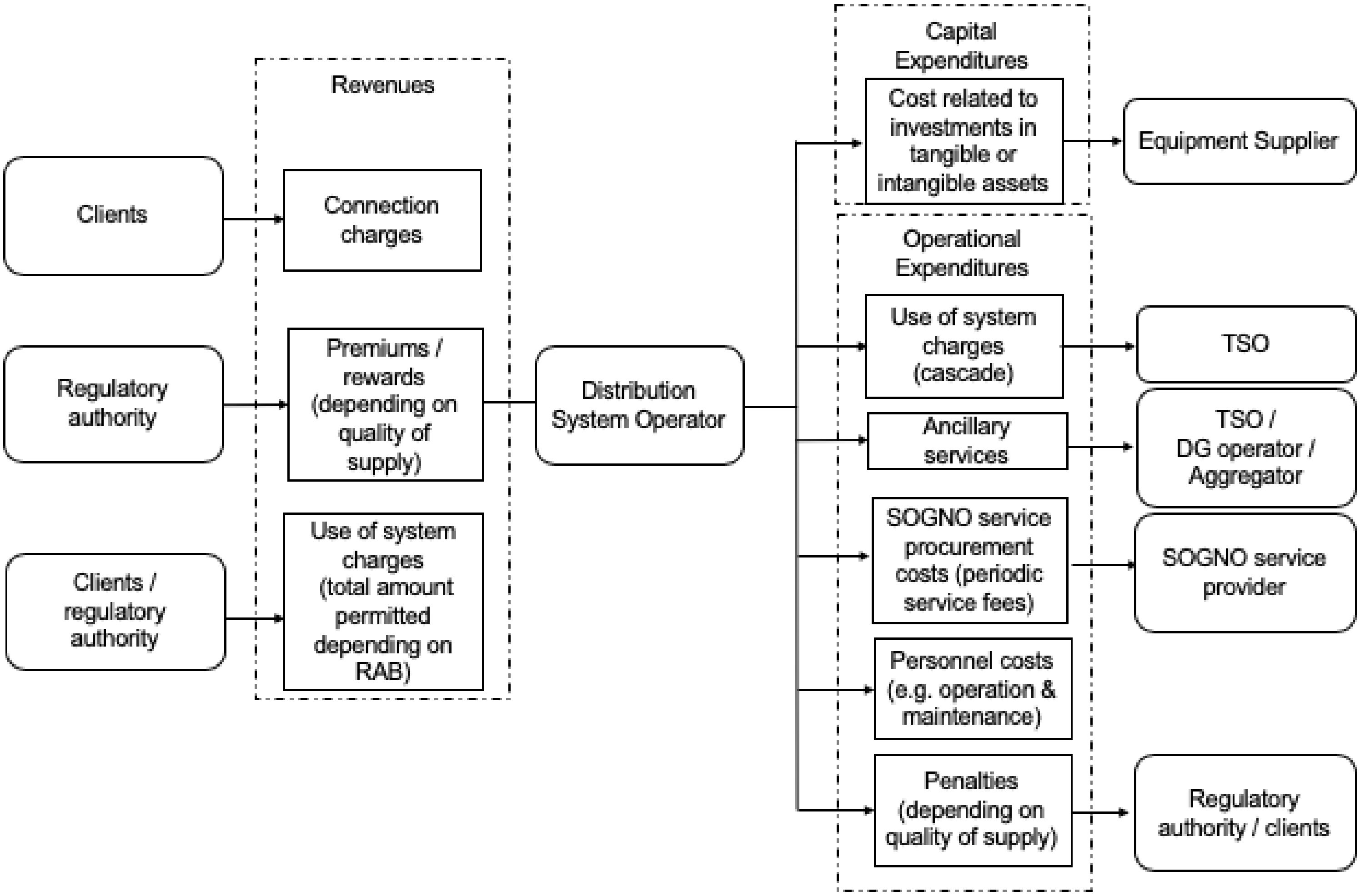

Figure 3: Conceptual representation of DSO's business model[3]

The economic success of DSO's is not governed by the principle of competitive markets but exposed to regulatory control. Total revenues, as explained in deliverable 6.3, are determined as a rate of return based on the regulated asset base in combination with a quality component that incentivises the DSOs to achieve sufficient quality of supply (most countries). DSO's obtain the revenues, as shown in figure 3, via connection charges and use of system charges both the clients served have to pay. Besides, rewards and premiums granted by the regulatory authority that depend with the quality of supply shape DSO's revenues. Based on national regulation, quality components affecting DSO's income exist also in form of penalties to be charged by the regulatory authority or by the clients served requiring the DSO to compensate for insufficient quality of supply. Apart from that, the OPEX of DSOs roughly comprise the use of system charges to be paid to TSOs, the cost of ancillary services, personnel cost for operation and maintenance and, potentially, cost that occur in association with the procurement of the SOGNO services, e.g. periodic service fees (De Joode, Jansen, Van der Welle, & Scheepers, 2009).

[3] The figure is taken from Joode et al. (2009) and has been adapted with regard to the specific effects of SOGNO service utilisation on DSO's business models.

It is explained in the following how the design of the SOGNO services effect a DSO's business model taking into account the impact of potential changes national in regulatory frameworks on SOGNO service evaluation from the DSO's perspective.

3.2 Legal Issues

Currently, the regulatory framework in most European countries encourages investments in the development of energy networks, with a focus on CAPEX (Capital Expenditures). Services of the type proposed in SOGNO can be a less expensive and at the same time more efficient alternative to operating networks, impacting on performance metrics, reducing penalties, and increasing customer satisfaction.

The latest version of the "Winter Package" published by the European Commission (EC) brings to discussion the TOTEX perspective and makes recommendations on the holistic view that energy regulation must have in order to support both investment in network development (CAPEX perspectives) as well as the acquisition of services with impact on a better network operation (OPEX perspective - Operational Expenditures perspective).

This EC recommendation represents a major first step on the way to the adoption of concrete regulatory support measures that will be found independently at the level of each national regulatory authority. Further on, each national regulatory authority will have its own way of going through the understanding and reaction process until the adoption of concrete measures that respond to the holistic TOTEX perspective with impact in supporting services implementation at the DSO level.

In order to account for these potential changes in national regulation frameworks, two prototypical models of SOGNO service design are distinguished within two scenarios that vary with regard to the characterisation of the regulated asset base, respectively. We distinguish in the following between a 'conventional' regulatory framework in which the cost of services or investments in the related equipment do not constitute components of the RAB and a 'novel' regulatory framework that allows the total expenditures (CAPEX & OPEX) that are related to SOGNO service utilisation to constitute components of the RAB.

3.3 Changes in DSO's Business Model depending on SOGNO service design and national regulation

3.3.1 Model 1 - SOGNO services externally operated

Model one assumes that a DSO obtains the individually required degree of data visualisation and interpretation as a result of SOGNO service implementation from a contracting external party that charges periodic service fees without requiring the DSO to make any investment in distribution network assets. The required power electronics, sensors, ICT hardware and software are obtained 'as-a-service'.

3.3.1.1 Scenario 1 - Conventional regulatory framework

In this case, SOGNO service utilisation becomes beneficial for a DSO if the potential gains (more rewards / less penalties) as a result of improved operational performance due to SOGNO service utilisation exceed the periodic cost of SOGNO service procurement. Besides, the effects highlighted in figure 4, it is also conceivable that SOGNO service utilisation leads to decreases in equipment and maintenance cost due to less stress of assets and lower personnel costs in general due to higher degrees of automation. However, the incentive for DSOs to procure the SOGNO services are impaired if alternative investments in tangible assets (e.g. network expansion) that increase the RAB potentially substitute the SOGNO services.

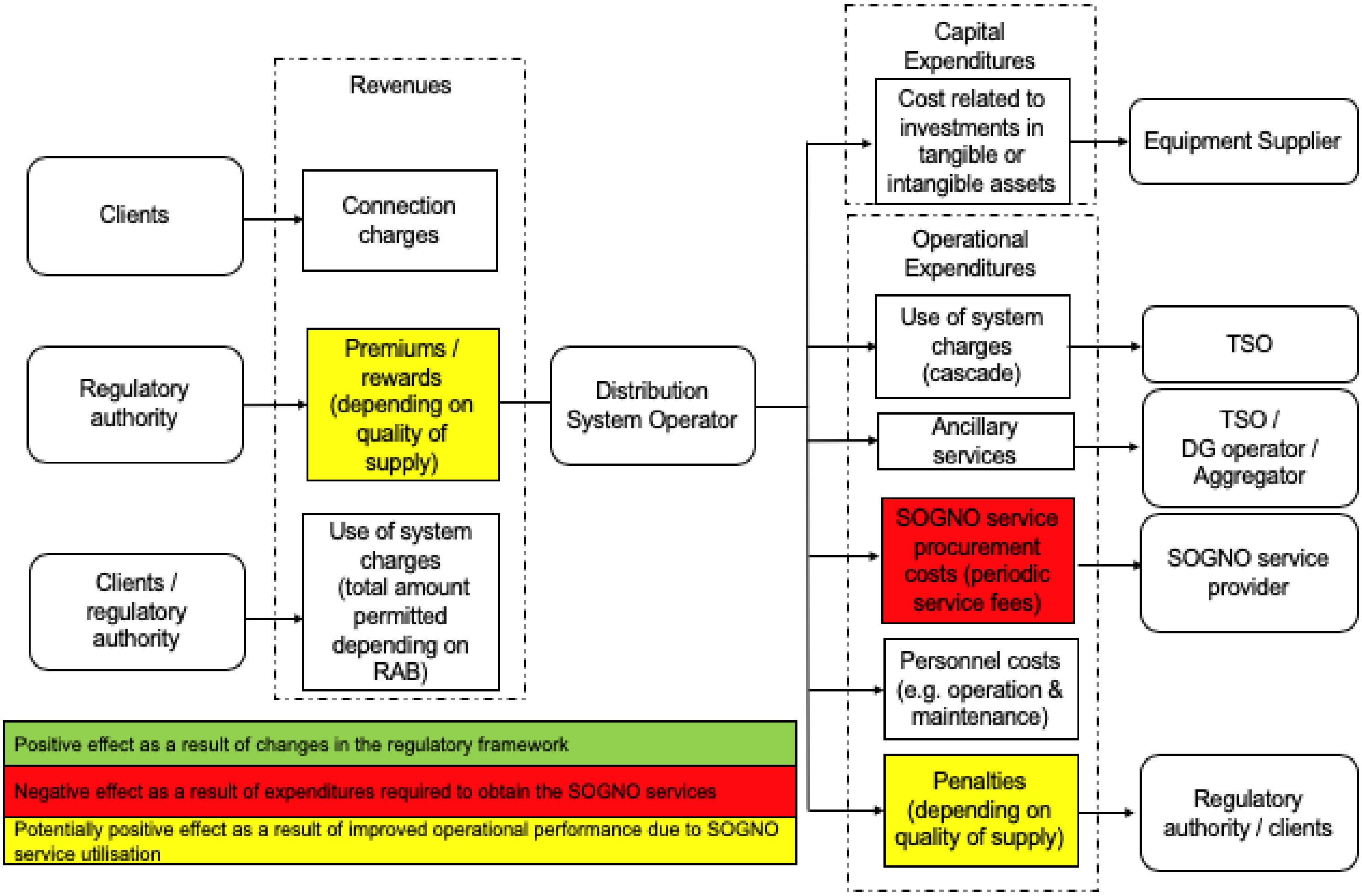

Figure 4: Model 1 given the conventional regulatory framework[4]

[4] The figure is taken from Joode et al. (2009) and has been adapted with regard to the specific effects of SOGNO service utilisation on DSO's business models.

3.3.1.2 Scenario 2 - Novel regulatory framework

If the regulatory framework changes and allowances the cost of SOGNO service procurement become components of the RAB, incentives to purchase the SOGNO services are no longer impaired by alternative investments in tangible assets that increase the RAB. As shown in figure 5, the DSO would in this case contrast both the potential gains as a result of improved operational performance due to SOGNO service utilisation and the increase of total allowed revenue as a result of the novel regulatory framework allows the RAB to depend on service costs with the cost of SOGNO service procurement. Besides, the pure procurement costs there are also transaction costs to be taken into account that potentially emerge as a result of contracting with the SOGNO service provider. In addition, DSOs also take into account cyber security risks that potentially appear as a result of allowing an external party access to a DSO's IT systems and externally hosting DSO's data off site.

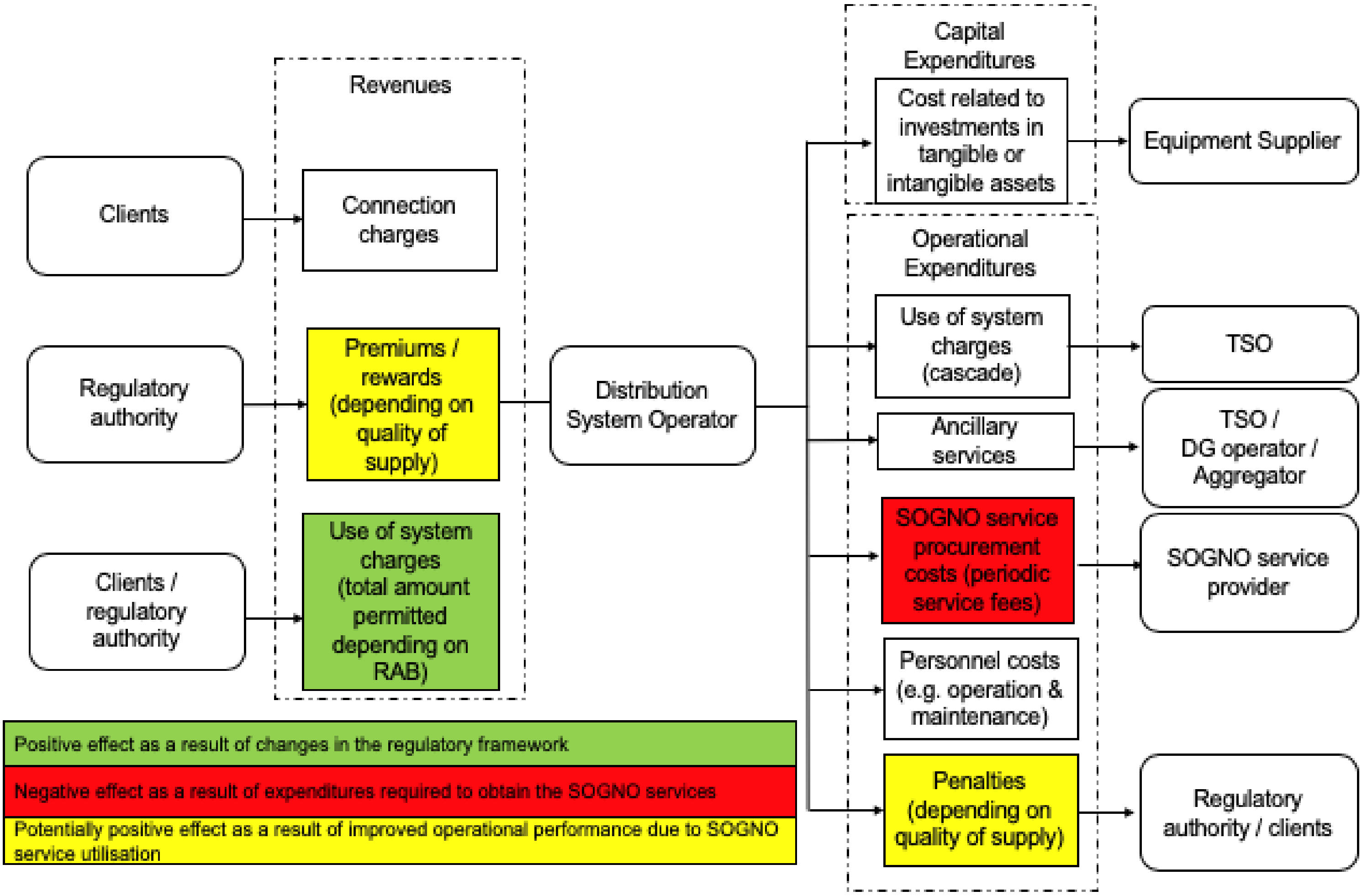

Figure 5: Model 1 given a novel regulatory framework[5]

[5] The figure is taken from Joode et al. (2009) and has been adapted with regard to the specific effects of SOGNO service utilisation on DSO's business models.

3.3.2 Model 2 - SOGNO services internally operated

Model two assumes the other extreme of SOGNO service design which means that a DSO develops internally the competencies to obtain the required degree of data visualisation and interpretation as a result of SOGNO service implementation and invests in the required power electronics, sensors, ICT hardware and software.

3.3.2.1 Scenario 1 - Conventional regulatory framework

As shown in figure 6, SOGNO service utilisation is beneficial for a DSO if the potential gains (more rewards / less penalties) as a result of improved operational performance due to SOGNO service utilisation exceed the non-regulated CAPEX related to investments in tangible and intangible assets required to operate the SOGNO services as well as the corresponding personnel costs required to operate the SOGNO services internally. However, there are no transaction costs as a result of contracting with an external party and less cyber security risks to be taken into account.

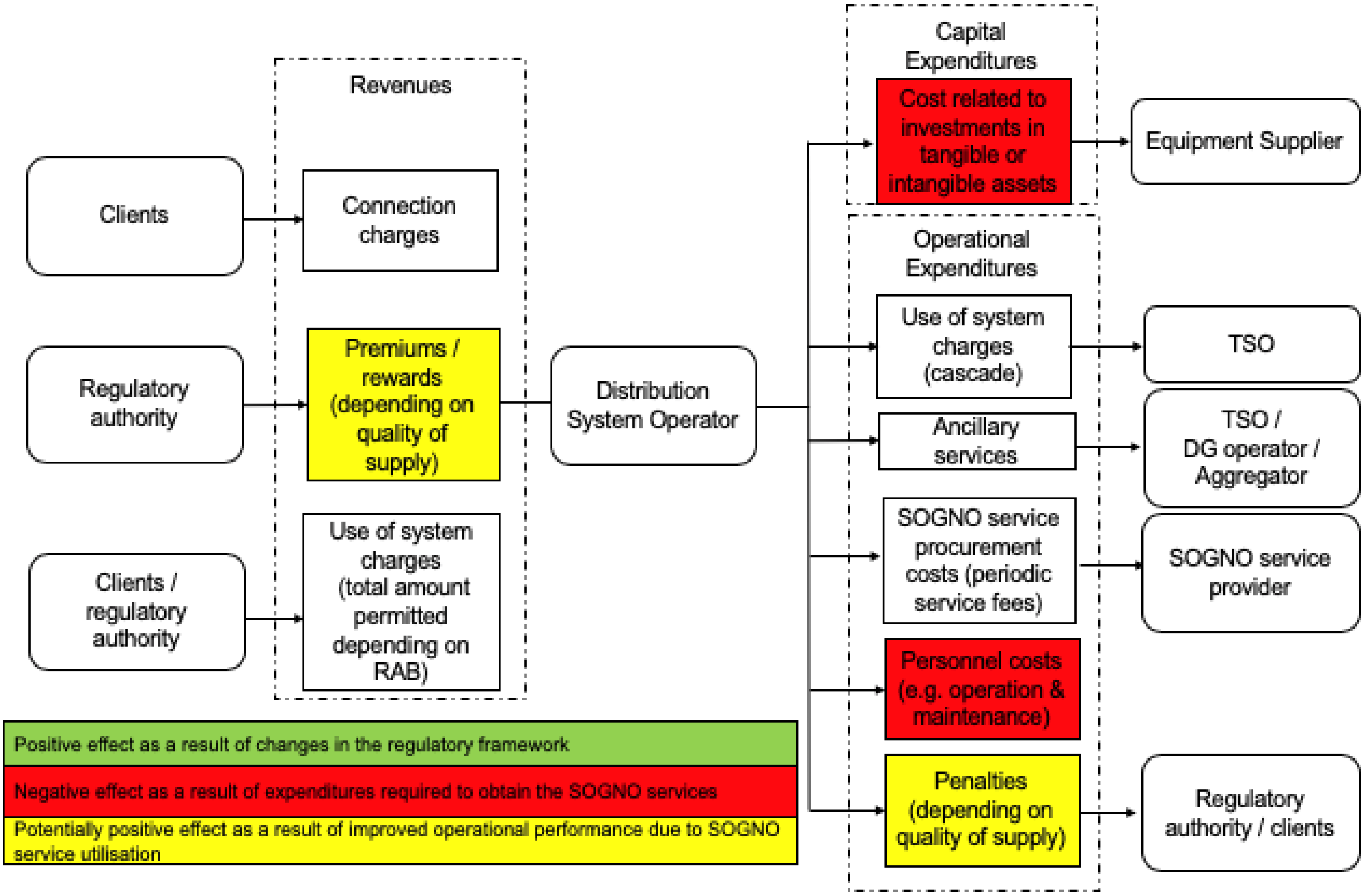

Figure 6: Model 2 given the conventional regulatory framework[6]

[6] The figure is taken from Joode et al. (2009) and has been adapted with regard to the specific effects of SOGNO service utilisation on DSO's business models.

3.3.2.2 Scenario 2 – Novel regulatory framework

If the regulatory framework changes and investments in power electronics, sensors, ICT hardware and software required to operate the SOGNO services become components of the RAB, the utilisation of the SOGNO services becomes beneficial if the correspondingly obtained allowed revenue increases in combination with potential gains (more rewards / less penalties) as a result of improved operational performance due to SOGNO service utilisation exceed the personnel costs required to operate the SOGNO services internally for a given time frame (see figure 7).

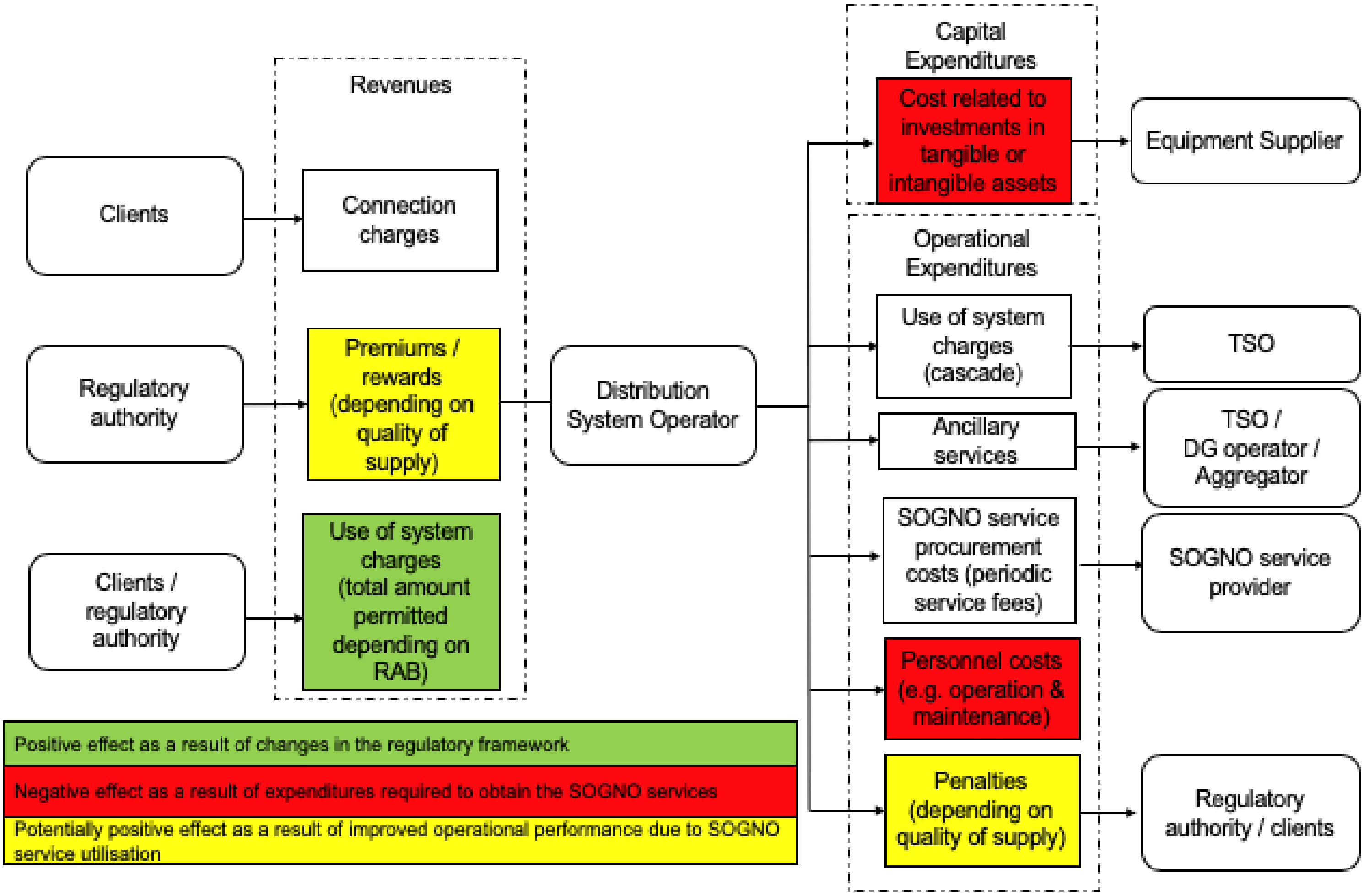

Figure 7: Model 2 given a novel regulatory framework

3.4 Model Evaluation

To enable a DSO to evaluate the potential business models that best serve its needs then all factors need to be taken into account. These factors include: costs of implementing equipment to feed data to SOGNO service, ongoing costs of operating service wither in house or from external contractor, improvement in network operation bringing regulatory reward, costs of not increasing asset base if regulated income based on this.

Across the EU DSO's face differing regulatory regimes and market structures so factors may differ between EU states. Some of these factors are:

Quality of supply – The DSO must operate the network within agreed standards to ensure the quality of supply to its customers. Parameters such as voltage, harmonics, and power factor are used as targets with penalties for DSO's when they fall outside the standard.

Customer Interruptions – Outside of storm events faults happen on electricity networks due to environmental and accidental reasons. Regulators incentivise DSO's to minimise the interruptions to supply of electricity by setting targets for number of customer interruptions and also the amount of time customers have their supply disrupted for. There are different measures that can be used to assess a DSO's performance in this area such as CML, CI, SAIDI, and SAIFI.

Return on Investment – Traditionally a DSO's income is based on the Regulated Asset Base that it manages. The definition of "asset" historically referred to electrical equipment employed to deliver electricity to customers. The SOGNO project proposes to deliver software solutions that will supersede the need for these type of assets.

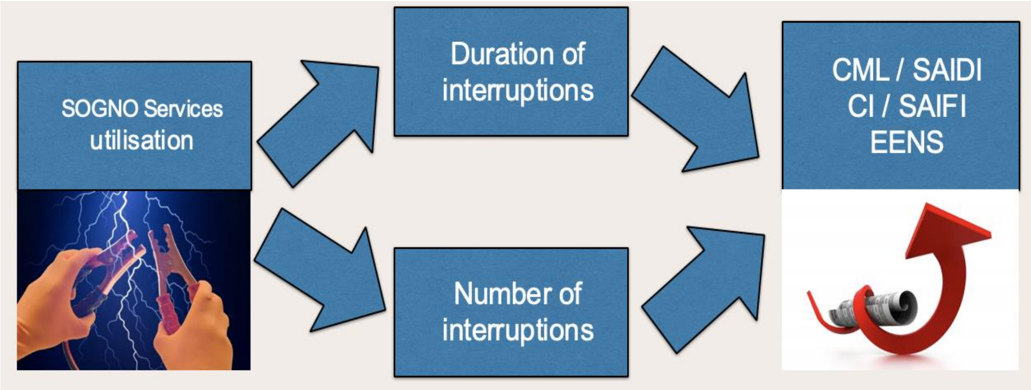

Figure 8: Illustration of the impact of SOGNO service utilisation on DSOs operational performance

Even though it is expected from the project partners that service utilisation increases operational performance of DSOs (see figure 4) and hence reduces penalties or enhances rewards, DSOs besides take into account for evaluation of the services the installation and operation costs and lifetime costs in relation to regulated income and benefits from any regulatory incentives. Capital expenditures arise mainly through investments in equipment and operational expenditures arise mainly through human-time-consuming activities and material which is consumed in connection with these activities.

To estimate the cost for a full network rollout, the network is to be analysed to estimate where to place sensors and collect data. Based on this, an estimate for the cost of providing the service can be made. A field trial of the service on a small scale, such as the field trials of SOGNO, will provide the basis information to enable such cost estimates. It is through the field trials that the benefits to a DSO such as ESB Networks can be assessed. As an example of this for the FLISR service a DSO can compare the costs of forced outages on its network between the current method utilised for FLISR and the results when the SOGNO FLISR service is implemented. The Irish Filed Trials being carried out in WP5 take two separate parts of it MV Network that have differing FLISR schemes currently and run the SOGNO FLISR service in parallel with these for the duration of 2019. At the end of this period a comparison can be carried out between the actual Customer Interruptions (CI's) and Customer Minutes Lost (CMLs) as seen by existing methods and compared to the outcomes if SOGNO FLISR service had been deployed. As there is a monetary value placed by the Irish Regulator on CML's then the real financial benefit to ESB can be derived. This benefit will then feed into the assessment of rolling out the service across the entire MV network for ESB.

The factors to evaluate the models have been qualitatively analysed for possibly changing regulatory conditions as shown in the following tables. The text in the tables are respectively mentioning the benefits vs. the costs that occur for a DSO in relation to SOGNO service utilisation.

Table 1: Evaluation of model 1

<table>
<tr><th colspan="2" rowspan="2">Business Model Evaluation</th><th colspan="2">Model 1 - SOGNO Services externally operated</th></tr>
<tr><th>Conventional regulatory framework</th><th>Novel regulatory framework</th></tr>
<tr><td>Capital Expenditures / Total allowed revenue (TAR)</td><td>All SOGNO services</td><td>Reduction of non-regulated CAPEX due to prevention of asset stress and failures as a consequence of service utilisation VS. Increases of TAR as a consequence of alternative investments in regulatory asset base (e.g. physical network expansion)</td><td>Increases of TAR as a consequence of purchasing services from external parties + Reduction of non-regulated CAPEX due to prevention of asset stress and failures as a consequence of service utilisation VS. Increases of TAR as a consequence of alternative investments in regulated asset base (e.g. physical network expansion) + Increases of other (non-regulated) transaction costs as a result of contracting with external parties</td></tr>
<tr><td rowspan="5">Operational Expenditures / Penalties & Rewards</td><td>FLISR</td><td>Reduction of penalty cost caused by reduction of CML + Reduction of personnel cost caused by reduction of working time (manual fault recovery) VS. Cost of service in form of service fees to be charged by external-party + increases of other service-related transaction costs</td><td>Increases of TAR as a consequence of purchasing services from external parties + Reduction of penalty cost caused by reduction of CML + Reduction of personnel cost caused by reduction of working time (manual fault recovery) VS. increases of other (non-regulated) service-related transaction costs as a result of contracting with external parties</td></tr>
<tr><td>Power Control</td><td rowspan="2">Reduction of penalty cost caused by reduction of CML+ Rewards from better quality of supply + Rewards from better RES integration/lower curtailment + reduction of other costs as a consequence of better operational decision-making VS. Cost of service in form of service fees to be charged by external-party + increases of other service-related transaction costs</td><td rowspan="2">Increases of TAR as a consequence of purchasing services from external parties + Reduction of penalty cost caused by reduction of CI + Rewards from better quality of supply + Rewards from better RES integration/lower curtailment + Reduction of other costs as a consequence of better operational decision-making VS. increases of other (non-regulated) service-related transaction costs as a result of contracting with external parties</td></tr>
<tr><td>Load & Generation Forecasting</td></tr>
<tr><td>State Estimation</td><td rowspan="2">Reduction of personnel cost caused by reduction of working time (manual maintenance) + reduction of transaction costs as a consequence of better operational decision-making VS. Cost of service in form of service fees to be charged by external-party + increases of other service-related transaction costs</td><td rowspan="2">Increases of TAR as a consequence of purchasing services from external parties + Reduction of personnel cost caused by reduction of working time (manual maintenance) + reduction of other costs as a consequence of better operational decision-making VS. increases of other (non-regulated) service-related transaction costs as a result of contracting with external parties</td></tr>
<tr><td>Power Quality</td></tr>
</table>

Table 2: Evaluation of model 2

<table>
<tr><th colspan="2" rowspan="2">Business Model Evaluation</th><th colspan="2">Model 2 - SOGNO Services internally operated</th></tr>
<tr><th>Conventional regulatory framework</th><th>Novel regulatory framework</th></tr>
<tr><td>Capital Expenditures / Total allowed revenue (TAR)</td><td>All SOGNO services</td><td>Increase of non-regulated CAPEX as a consequence of investments in hardware dedicated to develop the service internally + Reduction of CAPEX due to prevention of asset stress and failures as a consequence of service utilisation VS. Increases of TAR as a consequence of alternative investments in regulated asset base (e.g. physical network expansion)</td><td>Reduction of CAPEX due to prevention of asset stress and failures + Increases of TAR as a consequence of investments in hardware to operate service internally VS. Increases of TAR as a consequence of alternative investments in regulated asset base (physical network expansion)</td></tr>
<tr><td rowspan="5">Operational Expenditures / Penalties & Rewards</td><td>FLISR</td><td colspan="2">Reduction of penalty cost caused by reduction of CML + Reduction of personnel cost caused by reduction of working time (manual fault recovery) VS. Increase of personnel costs for software development, data processing, system administration</td></tr>
<tr><td>Power Control</td><td colspan="2" rowspan="2">Reduction of penalty cost caused by reduction of CI + Rewards from better quality of supply + Rewards from better RES integration/lower curtailment + Reduction of other costs as a consequence of better operational decision-making VS. Increase of personnel costs for software development, data processing, system administration</td></tr>
<tr><td>Load & Generation Forecasting</td></tr>
<tr><td>State Estimation</td><td colspan="2" rowspan="2">Reduction of penalty cost caused by reduction of CI + Rewards from better quality of supply + Reduction of personnel cost caused by reduction of working time (manual maintenance) + Reduction of other costs as a consequence of better operational decision-making VS. Increase of personnel costs for software development, data processing, system administration</td></tr>
<tr><td>Power Quality</td></tr>
</table>

The technical partners are currently specifying the quantity structures of equipment required to host the services in future energy systems. Considering model 2, for instance, the installation of sensors in the grid raises capital costs for purchasing the sensors as the DSO owns these sensors. Considering a form of model 1, the SOGNO service provider or any value chain partner other than the DSO owns these sensors and there are no capital costs for purchasing and owning the sensors to occur for the DSO. In that case, the service provider charges the DSO a service-fee for utilising the service (including the equipment). The service fee, in that case, constitutes operational costs for the DSO. A regulatory scheme that captures the total cost (TOTEX approach in contrast to the conventional schemes), would allow the DSO to increase their TAR through expenditures for service utilisation. Especially for relatively small DSOs it would be beneficial if they can utilise the services with low up-front expenditures for equipment or skill development. SOGNO has already distributed messages among energy stakeholders across Europe that there is a need for regulatory change to incentivise for DSOs the adaption of innovative services like the ones developed in SOGNO.

In this context, SOGNO has been lobbying for changes in national and European regulations, and recently, the EC has proposed such changes in the Winter Package 2018 to the national regulators. The use of total cost (TOTEX) as proposed in the Winter Package 2018 needs to be adopted by national regulators and enacted as national regulation in order for it to come into force in commercial energy markets. If the EC proposal is adopted nationally, the DSO's will have an incentive to use a service oriented approach to the implementation of new services, as proposed by SOGNO. This would be particularly beneficial to the thousands of smaller DSO's in Europe which currently do not have an internal IT department. They are particularly limited in their ability to purchase and deploy data driven power network optimisation services as they lack the competence to operate the services themselves internally and they are penalised if they currently purchase such services, rather than purchasing equipment and software as assets, and operating the services internally.

4. Conclusion

The present working report initially delineates the commercialisation of SOGNO services and explains how the utilisation of SOGNO services affects the business models of DSOs considering potentially changing regulatory frameworks that govern their businesses as natural monopolies. The deliverable shows that current regulations do not directly incentivise DSO's to prefer software service utilisation over investments in network expansion for situations in which both would lead to the same goal.

It has been described the economic value of SOGNO service utilisation which is expected from the project partners CEZ Romania and ESB to emerge due to decreasing duration and number of interruptions as a result of SOGNO service utilisation. However, as service-induced improvements in operational performance are only predictable under uncertainty, there are no obvious incentives for DSOs not involved in the project to adapt services such as those developed in SOGNO under the currently valid national regulations. This is because the DSOs are currently not entitled to offset the cost of the purchase of services, such as those proposed by SOGNO, against the price they can ask customers to pay for power. However, the new SOGNO services are needed in order to ensure security and continuity of supply and to sufficiently cope with current operational challenges that arise from volatile, bi-directional electricity flows and decreasing simultaneity of electricity consumption and production. SOGNO has been lobbying for changes in current regulation during 2018 and now the Europen Commission proposes in the Winter Package 2018, that national regulators should change regulations to enable DSO's to offset the Total Cost of Expenditure (TOTEX) to operate their power networks against the price customers pay them for power. If these, proposals are adopted nationally, DSOs will be incentivised to purchase data driven automation services, enabling them to better serve their customers and reduce CO2 emmissions by integrating higher levels of RES into their power generation and power grid management services.

The deliverable shows systematically how the SOGNO services and corresponding changes in regulatory frameworks are assessed from the perspective of a DSO as a service recipient. By delineating the economic impact of SOGNO service utilisation on DSOs' business models, the deliverable has made transparent the connections between the regulatory framework that governs the DSOs' business models and the evaluation parameters that DSOs consider when confronted with innovative service-solutions. With a view to the market adoption of the SOGNO services, it was derived therefrom the need to revise national regulatory frameworks in order to facilitate for the DSO's to contribute to the transition towards sustainable energy systems.

Increasing amounts of data to be processed by a DSO to actively manage the network will ultimately lead to software to provide the solutions. The IT and operational technology worlds are expected to come closer together and with SOGNOs aims of showing that software services can provide solutions for DSOs then the historically heavy engineering industry will become more reliant on software providing the answers.

5. List of Tables

6. List of Figures

7. List of References

J. De Joode, J. C. Jansen, A. J. Van der Welle and M. J. J. Scheepers, "Increasing penetration of renewable and distributed electricity generation and the need for different network regulation," *Energy Policy,* vol. 37, no. 8, pp. 2907-2915, 2009.

McDonald, J. (2008). Adaptive intelligent power systems: Active distribution networks. Energy Policy, 36(12), 4346-4351.

8. List of Abbreviations

CAPEX	Capital expenditures
CML	Customer minutes lost
CI	Customer interruptions
DER	Distributed energy resources
DG	Distributed generation
DSO	Distribution system operator
EC	European Commission
EENS	Electrical energy not supplied
ICT	Information and communication technology
LV	Low voltage
MV	Medium voltage
OPEX	Operational expenditures
RAB	Regulatory asset base
SAIDI	System average interruption duration index
SAIFI	System average interruption frequency index