THEME [ENERGY.2012.7.1.1] Integration of Variable Distributed Resources in Distribution Networks

(Deliverable – 8.1)

Definition of scalability and replicability of the SuSTAINABLE concept

Lead Beneficiary:

TUB

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List of Acronyms and Abbreviations

DER	Distributed Energy Resources
DG	Distributed Generation
DSO	Distribution System Operator
DR	Demand Response
HV	High Voltage
LV	Low Voltage
MV	Medium Voltage
PV	Photovoltaic
QoS	Quality of Supply
RES	Renewable Energy Sources
TSO	Transmission System Operator
TVPP	Technical Virtual Power Plant
VPP	Virtual Power Plant

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Executive Summary of Deliverable 8.1

This deliverable investigates scalability and replicability of the functionalities under development in the SuSTAINABLE Project. Two sets of questionnaires one for scalability and the other for replicability have been developed. The responders of this survey are the project partners who have been involved in the development of functionalities as a team leader or contributors. Scalability and replicability of each functionality have been analysed and potential barriers to the large-scale deployment of the SuSTAINABLE concept have been identified.

1. Introduction

Work Package 8 focuses on the analysis of scalability, replicability, and implementation conditions of the SuSTAINABLE concept. Scalability is the ability of a system, network or process to accommodate the growth in demand by increasing respectively its size, scope or range. Scalability is important for the SuSTAINABLE concept because each functionality is developed and validated in different demonstration sites with different technical requirements and the inputs for the validation of each functionality are limited. The scalability analysis is the first step in order to be able to deploy the SuSTAINABLE concept on a large-scale.

Replicability is the ability of a system, network or process to be duplicated in another location or time. Replication of the SuSTAINABLE concept is studied because of differences in technologies and costs applied for different countries. At the same time, technical requirements are strongly connected to the regulatory and social conditions in each country.

This deliverable investigates scalability and replicability of the functionalities under development in the SuSTAINABLE Project. Two sets of questionnaires one for scalability and the other for replicability have been developed. The responders of this survey are the project partners who have been involved in the development of functionalities as a team leader or contributors. Scalability and replicability of each functionality have been analysed and potential barriers to the large-scale deployment of the SuSTAINABLE concept have been identified.

Surveys are provided in Appendix I and Appendix II.

2. Large Scale Deployment of the SuSTAINABLE Concept

This survey aims to clarify the requirements for large-scale deployment of the methodologies developed as a result of the SuSTAINABLE project. This includes consideration of scalability and replicability of major outcomes of the project to other countries of the EU. Responses clarifies the boundary conditions identified in the SuSTAINABLE project. Those conditions are expected to directly affect the Key Performance Indicators (KPIs) of the integration of variable distributed resources in distribution networks.

2.1 Introduction

We have received the response on the scalability and replicability of the SuSTAINABLE Project from the project partners as shown in Table 1. These responses are the basis of the analysis on scalability and replicability of the developed tools/techniques in the SuSTAINABLE Project.

Table 1: Participation summary of the project partners in the survey

Functionality	No. of responses to the survey	Countries
SF1	6	Greece, Spain, UK
SF2	8	Greece, Portugal, Spain
SF3	8	Greece, Portugal, Spain, UK
SF4	9	Greece, Portugal, Spain
SF5	2	Germany, Greece
SF6	4	Germany, UK
SF7	2	Greece
SF8	3	Germany, UK
SF9	3	Greece, Portugal

2.2 Analysis of the Scalability and the Replicability Surveys

This survey provides views of investigators involved in the SuSTAINABLE Project with particular focus on scalability and replicability of their findings. Below we provided summary of results received from participants of the project in relation to each functionality.

2.2.1 SF1: Load Forecasting

The objective of this functionality is to develop forecasting tools to make reliable predictions of load at the Medium Voltage (MV) level.

Scalability Analysis of SF1

Figure 1 demonstrates how scalable the load forecasting tool is based on views provided by project participants. Great majority of the responders (75%) agreed that the load forecasting tool is scalable for distribution and transmission systems. Majority of the responders (66%) pointed out that the load forecasting tool is not scalable or scalable with major modifications for wind farm operators. This indicates that further research is required and the tool may need some additional modifications.

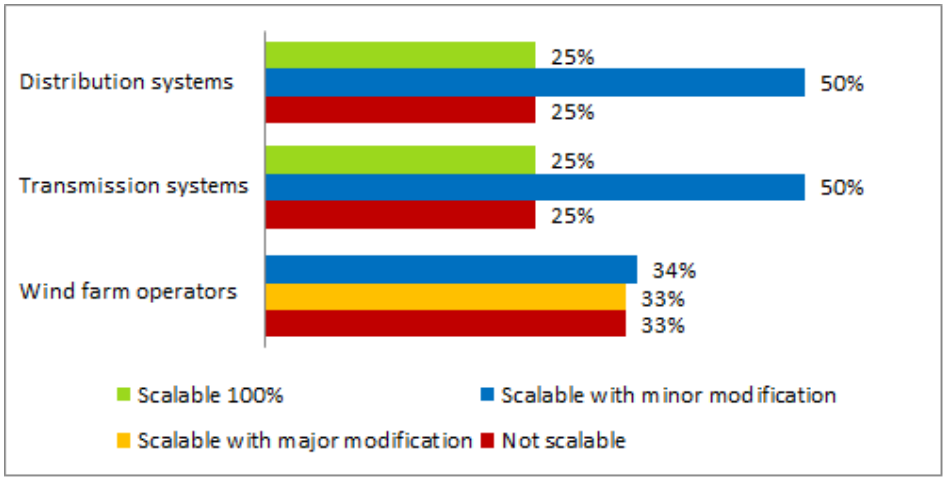

Figure 1: SF1 scalability for distribution systems, transmission systems, and wind farm operators.

Figure 2 represents possible barriers for scaling-up developed tools/techniques in SF1. Majority of the responders (60%) indicated that increasing penetration of the market of electric vehicles is a high barrier for scaling-up the load forecasting tool. However, significant number of the responders (40%) agreed that increasing penetration of the market by electric vehicles is a low barrier for scaling-up the load forecasting tool. This indicates that this particular tool is not necessarily scalable in regard to increasing penetration of electric vehicles. Further research is required.

All of the responders agreed that increasing penetration of the market of electric heaters does not represent any significant barrier for scaling-up the load forecasting tool. Great majority of the responders (80%) also agreed that increasing penetration of the market of air conditioners does not represent any significant barrier for scaling-up the load forecasting tool.

All of the responders agreed that increasing penetration of the market of heat pumps does not represent any significant barrier for scaling-up the load forecasting tool.

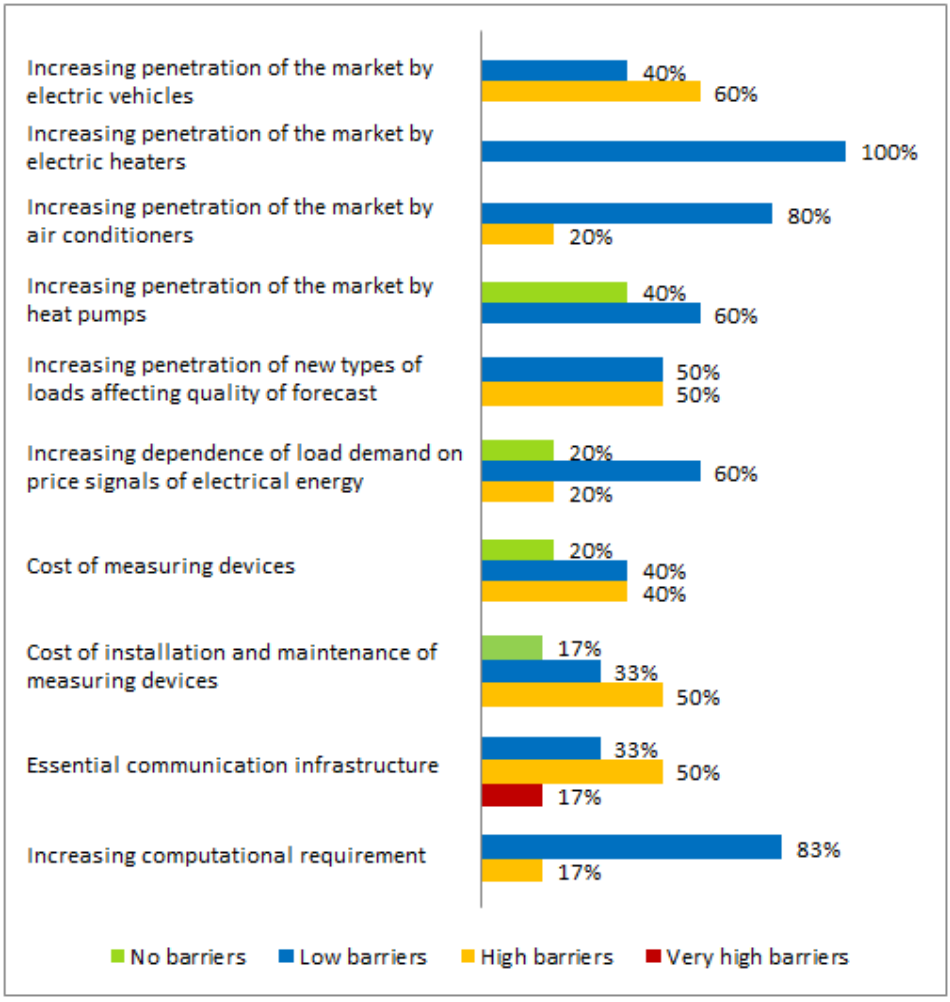

Figure 2: Possible barriers for scaling-up developed tools/techniques in SF1.

Half of the responders (50%) indicated that increasing penetration of the market of new types of loads affecting quality of forecast represents a high barrier for scaling-up the load forecasting tool. However, the other half of the responders agreed that increasing penetration of new types of loads represents a low barrier for scaling-up the load forecasting tool. This indicates that further research regarding new types of loads and their characteristics is required.

Great majority of the responders (80%) agreed that increasing dependence of load demand on price signals of electrical energy is a low barrier or not a barrier for scaling-up the load forecasting tool.

Majority of the responders (60%) agreed that cost of measuring devices does not represent any significant barrier for scaling-up the load forecasting tool. However, significant number of the responders (40%) indicated their concerns with the cost of measuring devices as a potential barrier for scaling-up the developed tool. This indicates that cost of measuring devices can represent a real barrier for scaling-up this tool.

Half of the responders (50%) agreed that cost of installation and maintenance of measuring devices is not a barrier or a low barrier for scaling-up the load forecasting tool. However, the other half of the responders indicated that cost of installation and maintenance of measuring devices is a high barrier for scaling-up the load forecasting tool. As above, this indicates that cost of installation of measuring devices can represent a real barrier for scaling-up.

Majority of the responders (67%) indicated their concern that the essential communication infrastructure can represent a real barrier (from high to very high) for scaling-up the load forecasting tool. This indicates that the absence of essential communication infrastructure may be a barrier for the tools/techniques developed for load forecasting.

Great majority of the responders (83%) agreed that increasing computational requirement is a low barrier for scaling-up the load forecasting tool.

In summary, increasing penetration of the market by electric vehicles, new types of loads affecting quality of forecasts, costs of measuring devices, their installation and maintenance costs as well as limitations of the existing communication infrastructure represent significant barriers to scaling-up the SF1 functionality.

Replicability Analysis of SF1

Figure 3 demonstrates how replicable the load forecasting tool is based on views provided by project participants. Majority of the responders (75%) agreed that the load forecasting tool is fully replicable or replicable with minor modification for distribution systems. All of the responders agreed that the load forecasting tool is fully replicable or replicable with minor modification for transmission systems. Half of the responders (50%) pointed out that the load forecasting tool is replicable with major modification for wind farm operators. The other half of the responders agreed that the load forecasting tool is replicable with minor modification for wind farm operators. This indicates that further research is required and the tool may need some additional modifications.

Figure 4 represents possible barriers for replicating developed tools/techniques in SF1. Majority of the responders (60%) indicated their concerns with increasing penetration of the market of electric vehicles as a high barrier for replicating the load forecasting tool. However, a significant number of the responders (40%) did not see it as a significant barrier.

This indicates that further research is required and the tool may need some additional modifications to take penetration of electric vehicles into account.

Great majority of the responders (80%) agreed that increasing penetration of the market of electric heaters represents a low barrier for replicating the load forecasting tool.

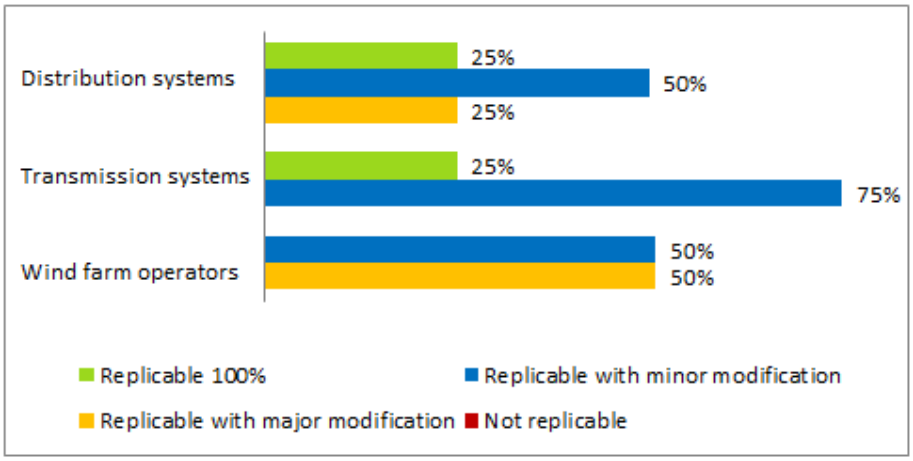

Figure 3: SF1 replicability for distribution systems, transmission systems, and wind farm operators.

Majority of the responders (60%) agreed that increasing penetration of the market of air conditioners does not represent any significant barrier for replicating the load forecasting tool. However, a significant number of the responders (40%) indicated their concerns. This indicates that the tool may need some modifications to take increasing penetration of air conditioners into account.

All of the responders agreed that increasing penetration of the market of heat pumps does not represent any significant barrier for replicating the load forecasting tool.

Majority of the responders (60%) indicated their concerns with increasing penetration of the market of new types of loads affecting quality of forecast as a high barrier for replicating the load forecasting tool. This indicates that further research is required to investigate new types of loads and their modelling technique; the tool may need significant modifications.

Great majority of the responders (80%) agreed that increasing dependence of load demand on price signals of electrical energy does not represent any significant barrier for replicating the load forecasting tool.

Majority of the responders (66%) agreed that cost of measuring devices does not represent any significant barrier for replicating the load forecasting tool. However, significant number of the responders (34%) indicated their concerns with the cost. Majority of the responders (66%) agreed that cost of installation and maintenance of measuring devices does not represent any significant barrier for replicating the load forecasting tool. However, significant number of responders (34%) indicated their concerns with the cost of installation and maintenance. This indicates that further research is required and the tool

may need significant modifications to improve its robustness if not all measuring devices are installed as envisage on the original research.

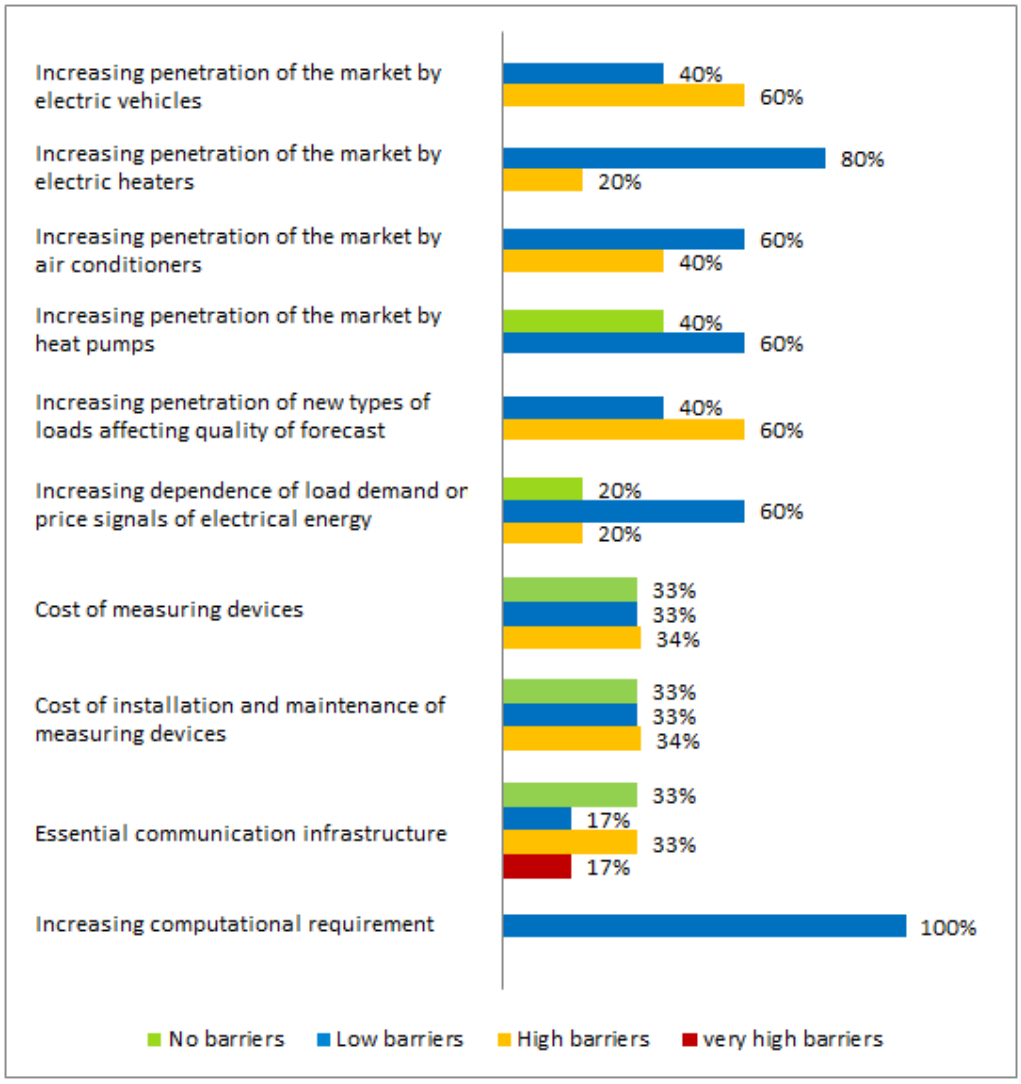

Figure 4: Possible barriers for replicating developed tools/techniques in SF1.

Half of the responders (50%) indicated that the essential communication infrastructure could represent a real barrier (from high to very high) for replicating the load forecasting tool. The other half of the responders did not see it as any significant barrier for replicating the developed tool. This indicates that further research is required and the tool may need some additional modifications regarding its robustness under limited access to the communication infrastructure.

Finally, all of the responders agreed that increasing computational requirement is a low barrier for replicating the load forecasting tool.

In summary, increasing penetration of the market by electric vehicles, new types of loads

affecting quality of forecast, and limitations of the existing communication infrastructure represent significant barriers to replicating the SF1 functionality.

2.2.1 SF2: RES Forecasting

The objective of this functionality is to develop forecasting tools to make predictions of generation from wind and photovoltaic units, which are connected at the Medium Voltage (MV) level.

Scalability Analysis of SF2

Figure 5 demonstrates how scalable the Renewable Energy Sources (RES) forecasting tool is based on views provided by project participants. All of the responders agreed that RES forecasting tool is fully scalable or scalable with minor modifications for distribution systems, transmission systems, and wind farm operators.

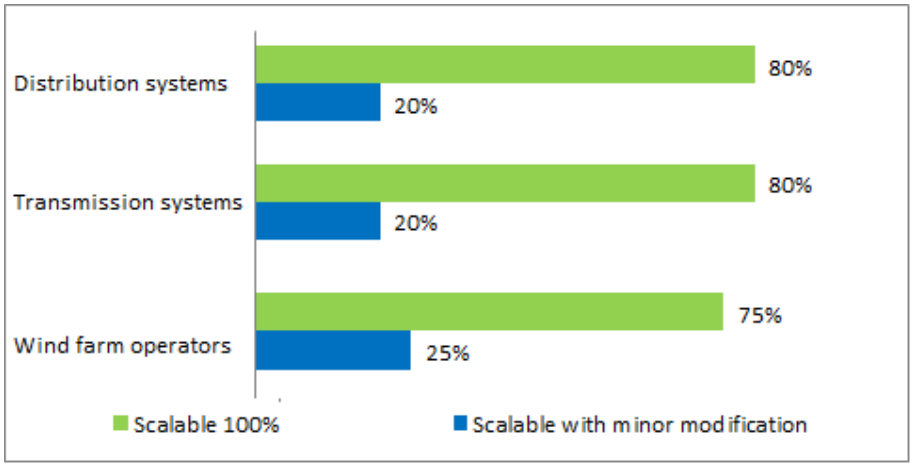

Figure 5: SF2 scalability for distribution systems, transmission systems, and wind farm operators.

Figure 6 identifies possible barriers for scaling-up developed tools/techniques in SF2. Great majority of the responders (86%) agreed that increasing penetration of renewables can affect quality of forecast, but does not present any significant barrier to scaling up the RES forecasting.

Majority of the responders (67%) agreed that cost of measuring devices does not represent a barrier for scaling-up the RES forecasting tool. However, significant number of the responders (33%) indicated their concerns with the cost of measuring devices as a potential barrier for scaling-up the developed tool. This indicates that cost of measuring devices in some circumstances may be a real barrier for scaling-up this particular tool in real large-scale applications.

Half of the responders (57%) agreed that cost of installation and maintenance of measuring devices represents no barrier or a low barrier for scaling-up the RES forecasting tool. However, the other half of the responders (43%) pointed out that cost of installation and maintenance of measuring devices represents a real barrier (from high to very high) for scaling-up the developed tool. The higher number of renewable energy sources to be

controlled, the higher number of measuring devices are required. So, the scaling-up processes is very much related to the number of devices and their costs.

A great majority of the responders (86%) agreed that essential communication infrastructure is a real barrier (from high to very high) for scaling-up the RES forecasting tool. Finally, all the responders agreed that increasing computation requirement represents just a low barrier for scaling-up RES forecasting tool.

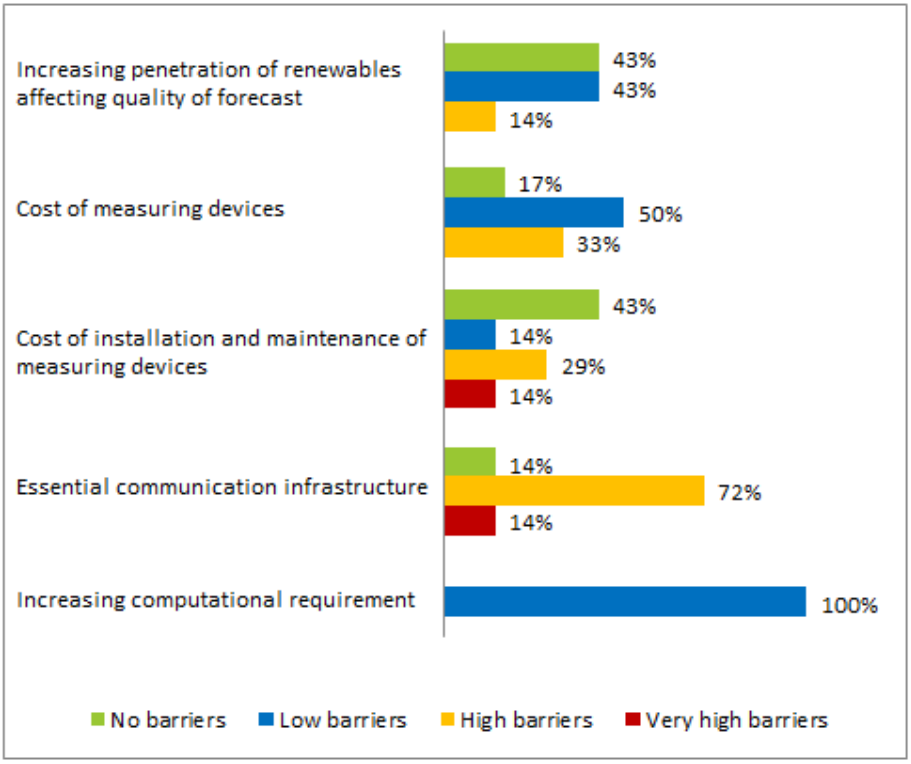

Figure 6: Possible barriers for scaling-up developed tools/techniques in SF2.

In summary, the essential communication infrastructure represents a major barrier to scaling-up the SF2 functionality.

Replicability Analysis of SF2

Figure 7 demonstrates how replicable the Renewable Energy Sources (RES) forecasting tool is based on views provided by project participants. All of the responders agreed that RES forecasting tool is fully replicable or replicable with minor modifications for distribution systems, transmission systems, and wind farm operators.

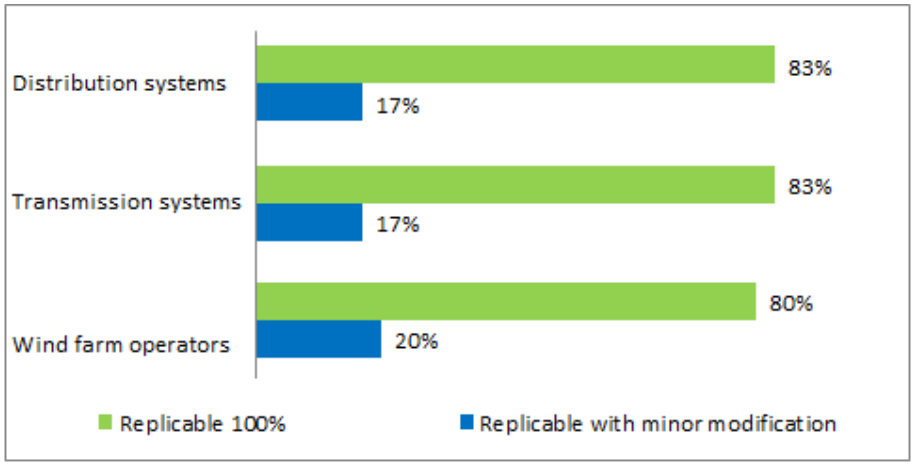

Figure 7: SF2 replicability for distribution systems, transmission systems, and wind farm operators.

Figure 8 identifies possible barriers for replicating developed tools/techniques in SF2. Majority of the responders (76%) indicated their concerns with insufficient communication infrastructure as a real barrier (from high to very high) for replicating the developed tool.

Majority of the responders (75%) agreed that cost of measuring devices does not represent a barrier or represents a low barrier for replicating the RES forecasting tool. Majority of the responders (75%) agreed that cost of installation and maintenance of measuring devices represents no barrier or a low barrier for replicating the RES forecasting tool.

Majority of the responders (71%) agreed that regulatory constraints do not represent any barriers for replicating the RES forecasting tool.

Majority of the responders (62%) indicated their concerns with unavailability of data as a real barrier (from high to very high) for replicating the developed tool. However, a significant number of the responders (38%) agreed that unavailability of data represents a low barrier for replicating the RES forecasting tool. This indicates that further research is required and the tool may need some significant modifications for making it replicable.

Half of the responders (50%) indicated their concerns with computational expenses as a high barrier for replicating the developed tool. However, the other half of the responders agreed that computational expenses is a low barrier for replicating the RES forecasting tool. This indicates that further research is required and the tool may need some development in regard to its computational performance for making it replicable.

In summary, insufficient communication infrastructure, unavailability of data, and computational expenses represent significant barriers to replicating the SF2 functionality.

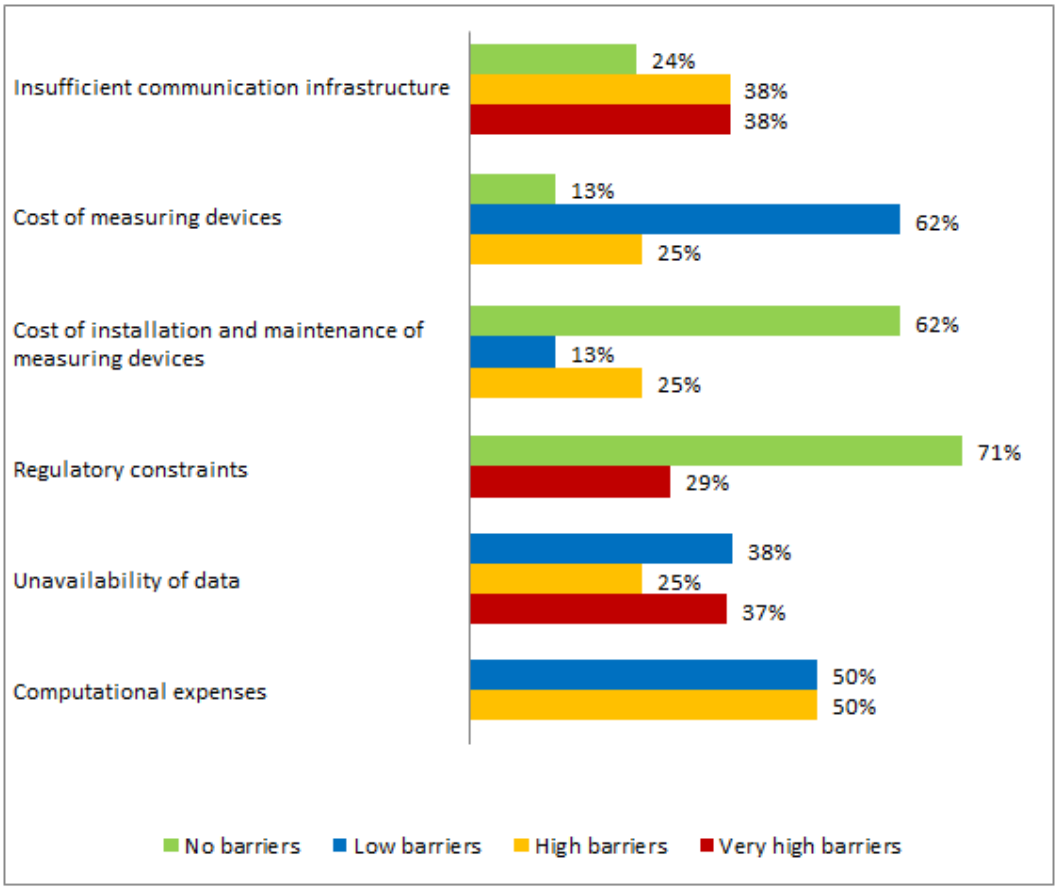

Figure 8: Possible barriers for replicating developed tools/techniques in SF2.

2.2.2 SF3: Monitoring/State Estimation

In order to derive consistent and qualified state estimates, it is necessary to use all the available network data, not just real-time measurements because the availability of real-time measurements might be very limited. The main objective of the state estimation functionality is to find the values for a set of variables (states) that cannot be measured directly using a set of network values (measurements) that is available in real-time.

Scalability Analysis of SF3

Figure 9 demonstrates how scalable the monitoring/state estimation tool is based on views provided by the project participants. All of the responders agreed that the monitoring/state estimation tool is scalable for distribution and transmission systems.

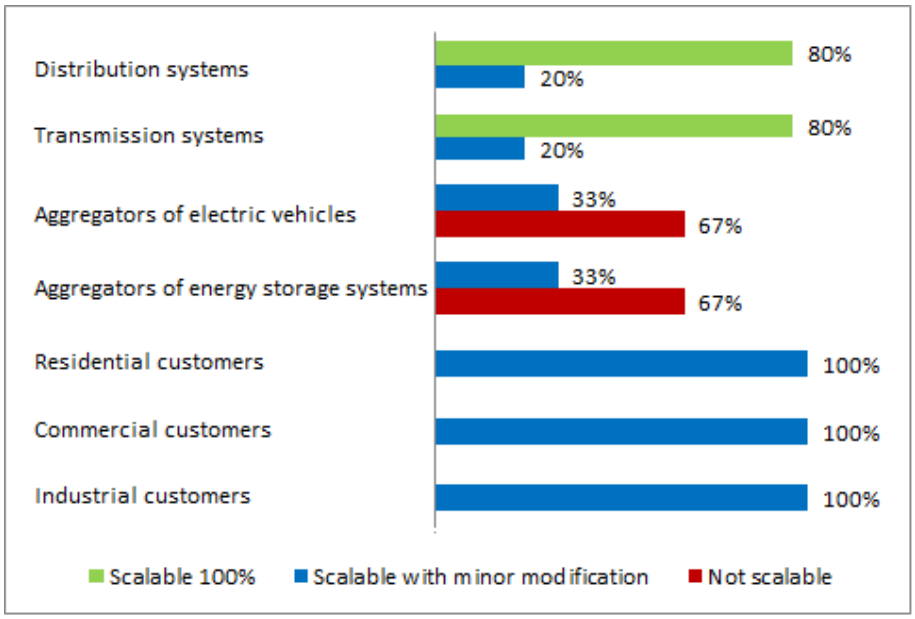

Figure 9: SF3 scalability for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of energy storage systems, residential customers, commercial customers, and industrial customers.

All of the responders agreed that the monitoring/state estimation tool is scalable for residential, commercial, and industrial customers with minor modifications. On the other hand, majority of the responders (67%) indicated their concerns that the monitoring/state estimation tool is not scalable for aggregators of electric vehicles and aggregators of energy storage systems.

Figure 10 represents possible barriers for scaling-up developed tools/techniques in SF3. Great majority of the responders (86%) indicated their concern that the limitations of current practices and regulations for monitoring device placement can represent a real barrier (from high to very high) for scaling-up the monitoring/state estimation tool.

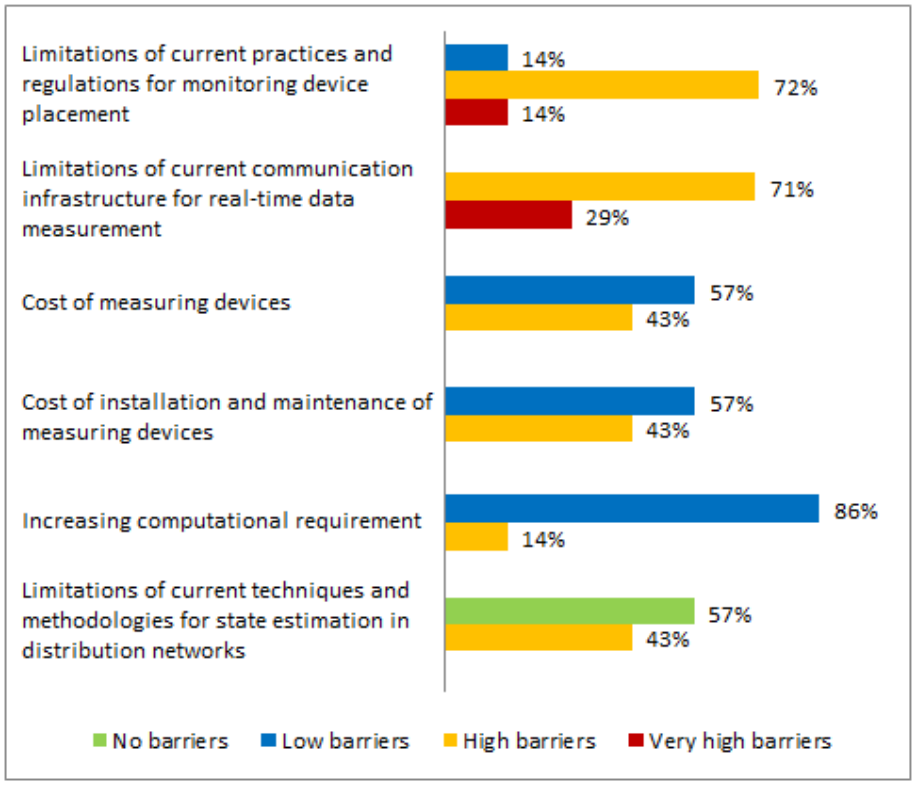

Figure 10: Possible barriers for scaling-up developed tools/techniques in SF3.

All of the responders also indicated their concerns that limitations of the current communication infrastructure for real-time data measurement can represent a real barrier (from high to very high) for scaling-up the monitoring/state estimation tool.

Half of the responders (57%) agreed that cost of measuring devices and their installation and maintenance costs do not represent any significant barrier for scaling-up the developed tool. However, the other half of the responders (43%) indicated their concerns with the cost of measuring devices and their installation and maintenance costs as potential barriers for scaling-up monitoring/state estimation tool. This indicates that further investigation is required to determine requirements for measuring devices and their placement.

Great majority of the responders (86%) agreed that increasing computational requirements represent a low barrier for scaling-up the monitoring/state estimation tool.

Half of the responders (57%) agreed that limitations of current techniques and methodologies for state estimation in distribution networks does not represent any barrier for scaling-up the load forecasting tool. However, the other half of the responders (43%) indicated their concerns with limitations of current techniques and methodologies for state estimation in distribution networks as a potential barrier for scaling-up the developed tool.

In summary, limitations of current practices and regulations for monitoring devices

placement as well as limitations of the current communication infrastructure for real-time data measurement represent significant barriers to scaling-up the SF3 functionality.

Replicability Analysis of SF3

Figure 11 demonstrates how replicable the monitoring/state estimation tool is based on views provided by project participants. All of the responders agreed that monitoring/state estimation tool is fully replicable for distribution and transmission systems. All of the responders also agreed that monitoring/state estimation tool is fully replicable or replicable with minor modification for residential customers. However, great majority of the responders (80%) indicated their concerns that monitoring/state estimation tool is not replicable for aggregators of electric vehicles and storage systems. This indicates that additional investigations may be needed.

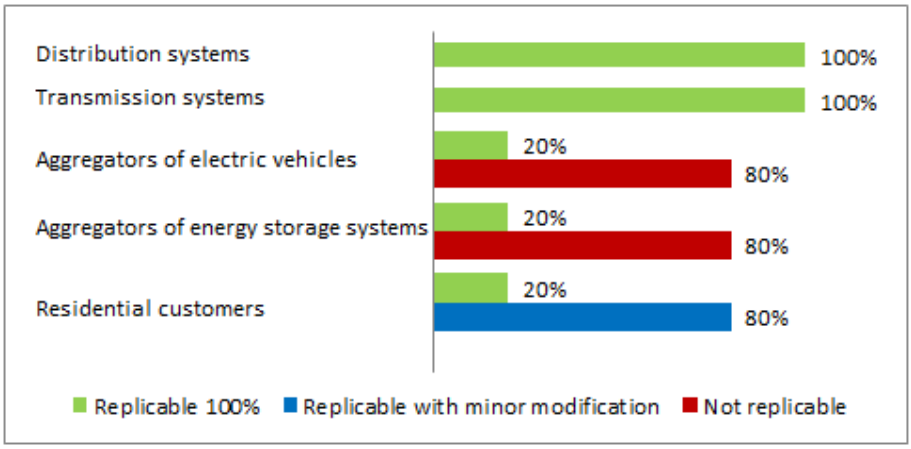

Figure 11: SF3 replicability for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of storage systems, and residential customers.

Figure 12 represents possible barriers for replicating developed tools/techniques in SF3. Majority of the responders (75%) agreed that limitations of current practices and regulations for placement of monitoring devices do not represent barriers or represents low barriers for replicating the monitoring/state estimation tool.

All of the responders indicated their concerns with limitations of current communication infrastructure for real-time data measurement as a real barrier (from high to very high) for replicating the monitoring/state estimation tool.

Majority of the responders (62%) agreed that the cost of measuring devices represents low barrier for replicating the monitoring/state estimation tool. However, significant number of the responders (38%) indicated their concerns with the cost. Majority of the responders (62%) also agreed that the cost of installation and maintenance of measuring devices represents a low barrier for replicating the monitoring/state estimation tool. However, a significant number of the responders (38%) indicated their concerns with the cost. This indicates that further research is required and the tool may need to improve its robustness.

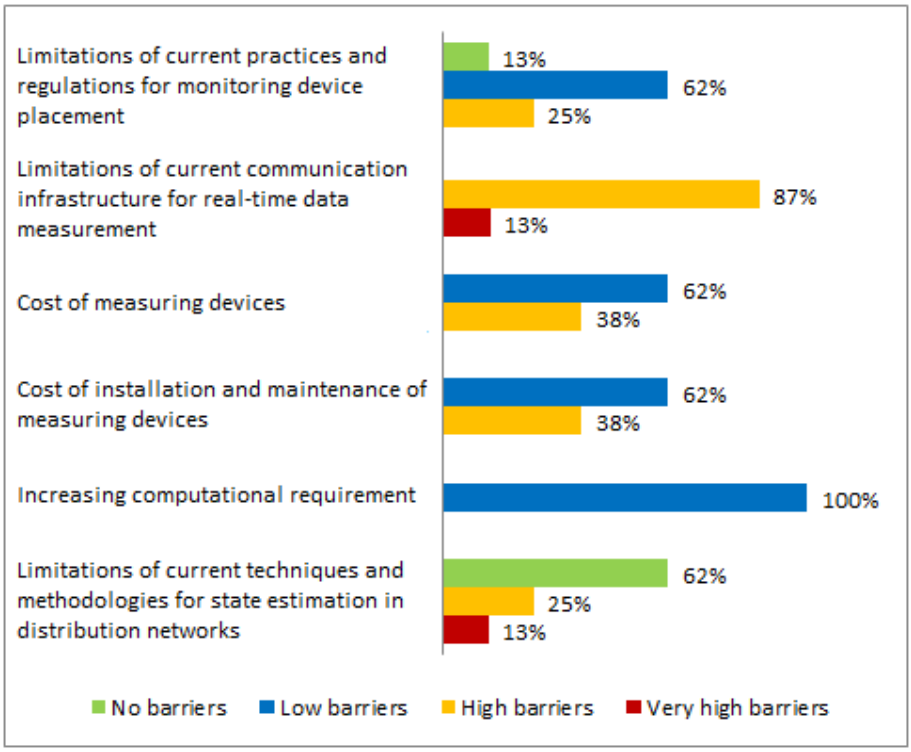

Figure 12: Possible barriers for replicating developed tools/techniques in SF3.

All of the responders agreed that increasing computational requirement represent a low barrier for replicating the monitoring/state estimation tool.

Majority of the responders (62%) agreed that limitations of current techniques and methodologies for state estimation in distribution networks represent no barrier for replicating the monitoring/state estimation tool. However, a significant number of the responders (38%) indicated their concerns. This indicates that further research is required and the tool may need some modifications to make it replicable.

In summary, limitations of the existing communication infrastructure for real-time data measurement represents a significant barrier to replicating the SF3 functionality.

2.2.3 SF4: Coordinated Voltage Control

In order to maximize the integration of renewable energy in the distribution networks, advanced operation strategies are required to be implemented at the level of the HV/MV substations to control voltage magnitudes and real power injections. In order to achieve this, a methodology is developed that controls voltage throughout the network by coordinating all available regulation devices as well as adjusting active and reactive output power of DG units, storage systems, and controllable loads.

Scalability Analysis of SF4

Figure 13 demonstrates how scalable the coordinated voltage control technique is based on views provided by project participants. All of the responders agreed that the coordinated voltage control technique is scalable with minor modifications for distribution systems. In contrast, a great majority of the responders (80%) indicated their concern that the coordinated voltage control technique is not scalable or scalable with major modifications for transmission systems. This indicates that further research is required and the tool may need some additional modification. Majority of the responders (67%) agreed that the coordinated voltage control technique is scalable with minor modification for ancillary service providers. However, a significant number of the responders (33%) indicated their concerns. This indicates that further research is required and the tool may need some additional modification.

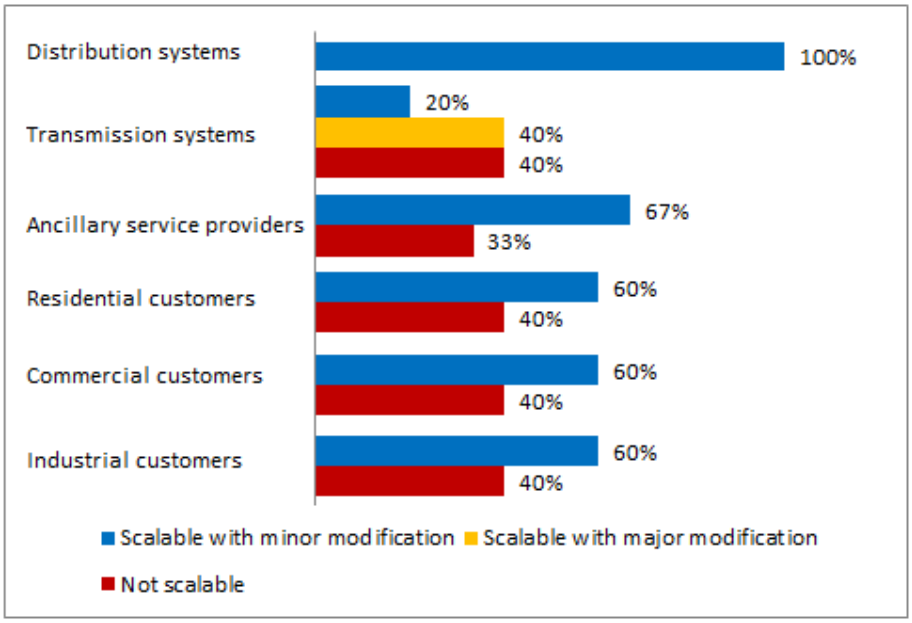

Figure 13: SF4 scalability for distribution systems, transmission systems, ancillary service providers, residential customers, commercial customers, and industrial customers.

Majority of the responders (60%) agreed that the coordinated voltage control technique is scalable with minor modification for residential, commercial, and industrial customers. However, significant number of the responders (40%) indicated their concerns. This indicates that further research is required and the technique may need some modifications for making it scalable.

Figure 14 represents possible barriers for scaling-up developed tools/techniques in SF4. Great majority of the responders (75%) agreed that cost of measuring devices does not represent any significant barrier for scaling-up the coordinated voltage control technique. Majority of the responders (62%) indicated their concern regarding the cost of installation and maintenance of measuring devices as a high barrier for scaling-up the coordinated voltage control technique. This indicates that additional investigations are needed regarding costs associated with installation and maintenance of measuring devices. High costs may represent a real challenge for scaling-up the developed technique.

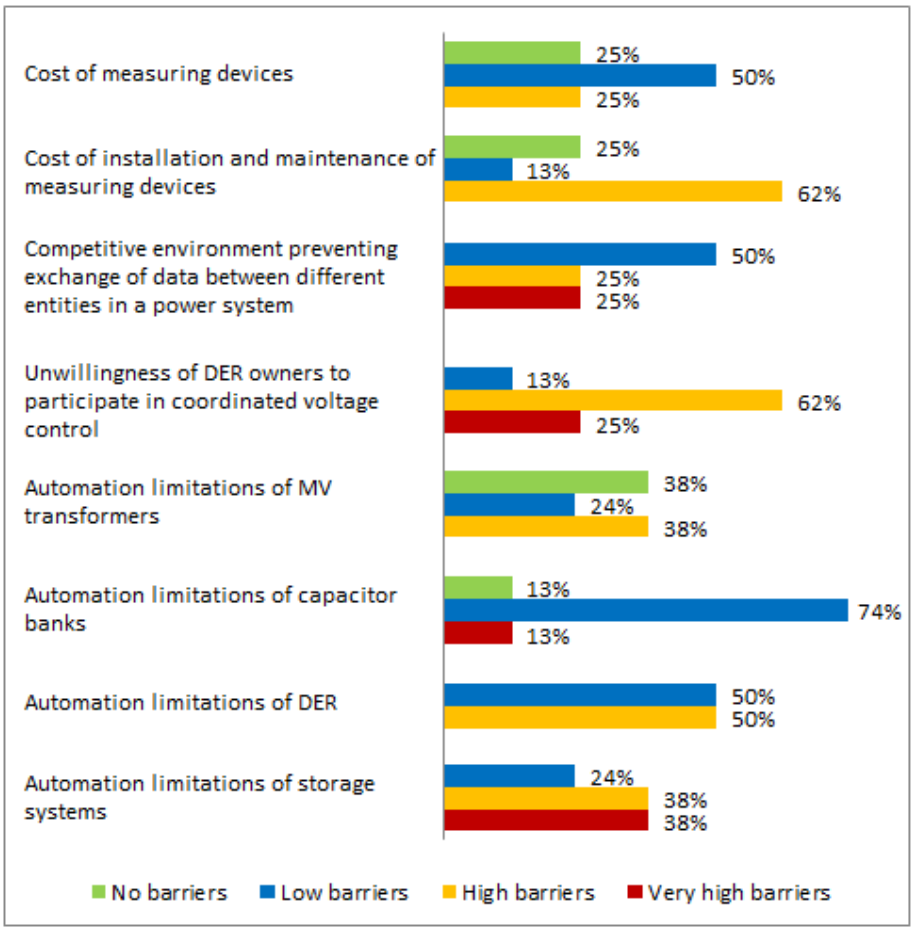

Figure 14: Possible barriers for scaling-up developed tools/techniques in SF4.

Half of the responders (50%) agreed that competitive environment preventing exchange of data between different entities in a power system is a low barrier for scaling-up the

coordinated voltage control technique. However, the other half indicated their concerns. This indicates that further research is required and the technique may need some significant modifications.

Great majority of the responders (87%) indicated their concern with unwillingness of DER owners to participate as a real barrier for scaling-up the coordinated voltage control technique. This indicates that an educational campaign may be needed especially designed for DER owners to ensure successful large-scale deployment of the technique.

Majority of the responders (62%) agreed that automation limitations of MV transformers is not a real barrier for scaling-up the coordinated voltage control technique. However, significant number of the responders (38%) indicated their concerns. This indicates that further research is required and the technique may need some major modifications.

Great majority of the responders (87%) agreed that automation limitations of capacitor banks does not represent any significant barrier for scaling-up the coordinated voltage control technique.

Half of the responders (50%) agreed that automation limitations of DER is a low barrier for scaling-up the coordinated voltage control technique. However, the other half of the responders indicated their concerns with automation limitations of DER. This indicates that further research is required and the tool may need some major modifications.

Great majority of the responders (76%) stated that automation limitations of storage systems can represent a real barrier (from high to very high) for scaling-up the coordinated voltage control technique. This indicates that automation limitations can become a real barrier to the implementation of this technique in real large-scale applications.

In summary, cost of installation and maintenance of measuring devices, competitive environment preventing exchange of data between different entities in a power system, unwillingness of DER owners to participate in coordinated voltage control, and automation limitations of DER as well as automation limitations of storage systems represent significant barriers to scaling-up the SF4 functionality.

Replicability Analysis of SF4

Figure 15 demonstrates how replicable the coordinated voltage control technique is based on views provided by project participants. All of the responders agreed that coordinated voltage control technique is fully replicable or replicable with minor modifications for distribution systems. However, majority of the responders (71%) indicated their concerns that the coordinated voltage control technique is not replicable or replicable with major modification for transmission systems. This indicates that further research is required and the tool may need some modifications.

Majority of the responders (71%) agreed that coordinated voltage control technique is replicable with minor modification for ancillary service providers.

Majority of the responders (67%) agreed that coordinated voltage control technique is replicable with minor modification for residential, commercial, and industrial customers. However, significant number of the responders (33%) indicated their concerns. This indicates that further investigations are needed and the technique may need to be modified to make it fully replicable.

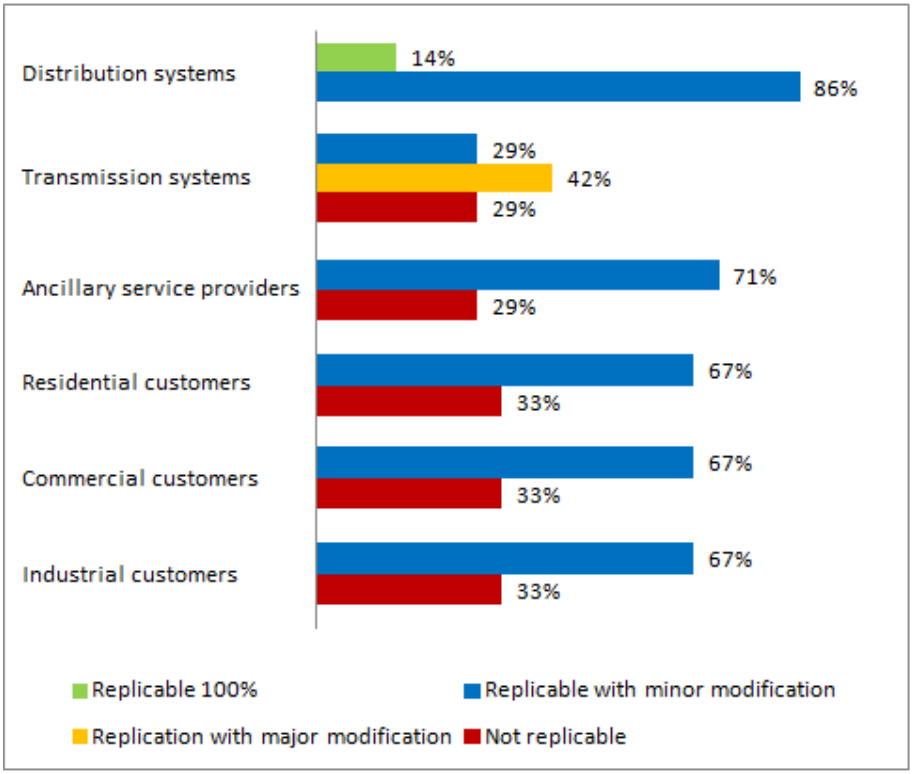

Figure 15: SF4 replicability for distribution systems, transmission systems, ancillary service providers, residential customers, commercial customers, and industrial customers.

Figure 16 represents possible barriers for replicating developed tools/techniques in SF4. Great majority of the responders (78%) agreed that cost of measuring devices does not represent a barrier or represents a low barrier for replicating the coordinated voltage control technique.

Majority of the responders (67%) agreed that cost of installation and maintenance of measuring devices does not represent a barrier or represents a low barrier for replicating the coordinated voltage control technique. However, significant number of the responders (33%) indicated their concerns with the cost. This indicates that further research is required and the tool may need some modifications to improve its robustness.

Half of the responders (55%) indicated their concerns with the competitive environment preventing exchange of data between different entities in a power system as a real barrier (from high to very high) for replicating the coordinated voltage control technique. However, the other half of the responders (45%) agreed that this represents only a low

barrier for replicating the developed technique. This indicates that further research is required into data exchange rules and protocols.

All of the responders agreed that unwillingness of DER owners to participate in coordinated voltage control technique represents a real barrier (from high to very high) for replicating the coordinated voltage control technique. This indicates that an educational campaign may be needed to educate DER owners on advantages of the coordinated voltage control. Alternatively, a regulatory scheme can be placed to force DER owners to cooperate.

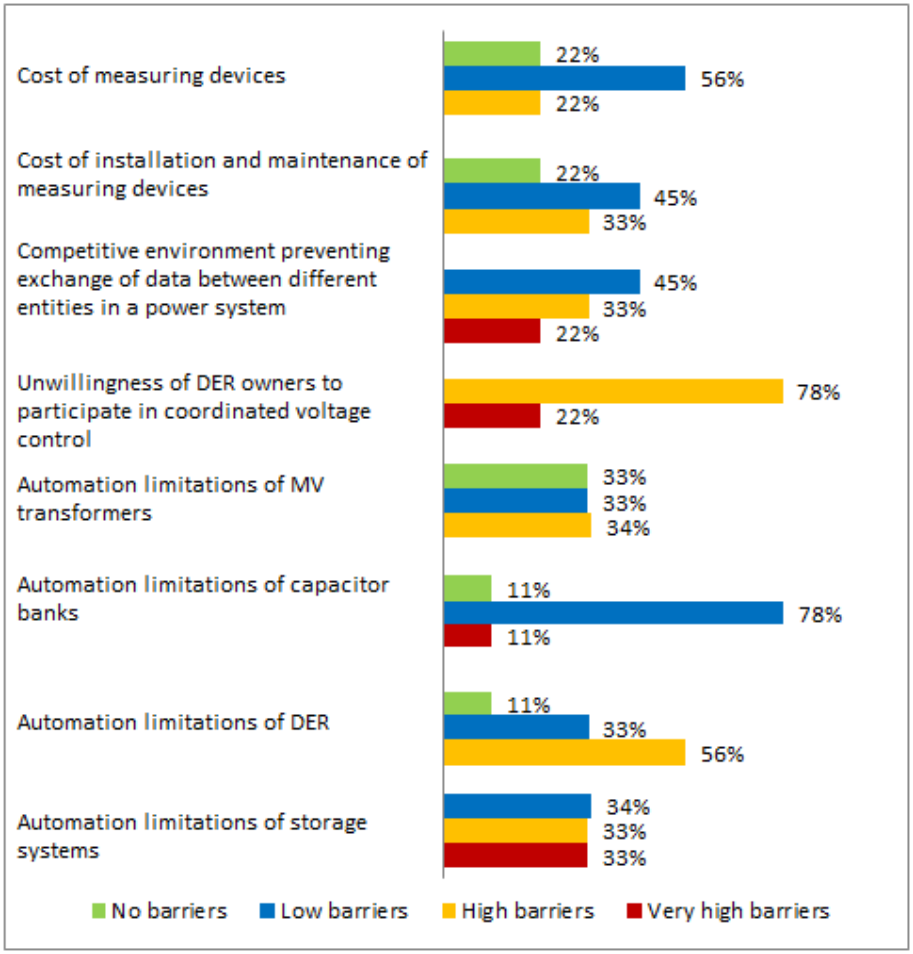

Figure 16: Possible barriers for replicating developed tools/techniques in SF4.

Majority of the responders (66%) agreed automation limitations of MV transformers does not represent a real barrier for replicating the coordinated voltage control technique. However, a significant number of the responders (34%) indicated their concerns. This indicates that further research is required and the tool may need some modifications.

Great majority of the responders (89%) agreed that automation limitations of capacitor banks does not represent a barrier or represents a low barrier for replicating the coordinated voltage control technique. Half of the responders (56%) indicated their

concerns with the automation limitations of DER as a high barrier for replicating the coordinated voltage control technique. However, the other half of the responders (44%) do not see it as a barrier. This indicates that further research is required and the technique may need significant modifications.

Majority of the responders (66%) indicated their concerns that the automation limitations of storage systems represents a real barrier (from high to very high) for replicating the coordinated voltage control technique. However, a significant number of responders (34%) see it only as a low barrier. This indicates that further research is required and the technique may need some modifications to make it replicable.

In summary, competitive environment preventing exchange of data between different entities in a power system, unwillingness of DER owners to participate in coordinated voltage control, and automation limitations of DER as well as automation limitations of storage systems represent significant barriers to replicating the SF4 functionality.

2.2.4 SF5: TVPP as a Support for DSO/TSO

The Virtual Power Plant (VPP) represents the concept of aggregating hybrid resources available to DSO/TSO. These include wind farms, PV panels and plants, stationary battery energy storage systems, electric vehicles, resources of demand response, and combined heat and power units. The first type of the VPP coordinates actions between neighbouring distribution systems, in order to cover fluctuations that might happen due to the intermittent nature of renewable energy resources. The second type of the VPP is concerned with congestion management and electricity market operation to provide energy and ancillary services.

Scalability Analysis of SF5

Figure 17 demonstrates how scalable the TVPP is as a supporting tool to DSO/TSO based on views provided by project participants. All of the responders agreed that the TVPP as a supporting tool to DSO/TSO is scalable with minor modifications for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of energy storage systems, residential customers, commercial customers, industrial customers, intra-day spot energy markets, day-ahead spot energy markets, and ancillary service providers.

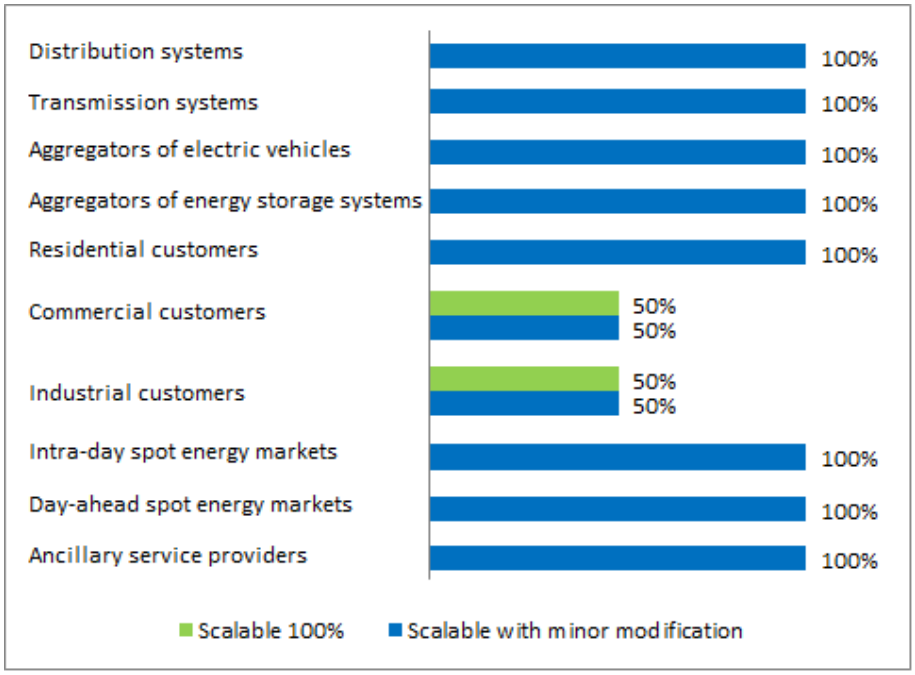

Figure 17: SF5 scalability for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of energy storage systems, residential customers, commercial customers, industrial customers, intra-day spot energy markets, day-ahead spot energy markets, and ancillary service providers.

Figure 18 represents possible barriers for scaling-up developed tools/techniques in SF5. All of the responders indicated their concerns with limitations of existing communication

infrastructure as a real barrier (very high) for scaling-up the TVPP tool. This indicates that the developed tools/techniques may need some improvements regarding their robustness where communication infrastructure is not sufficient.

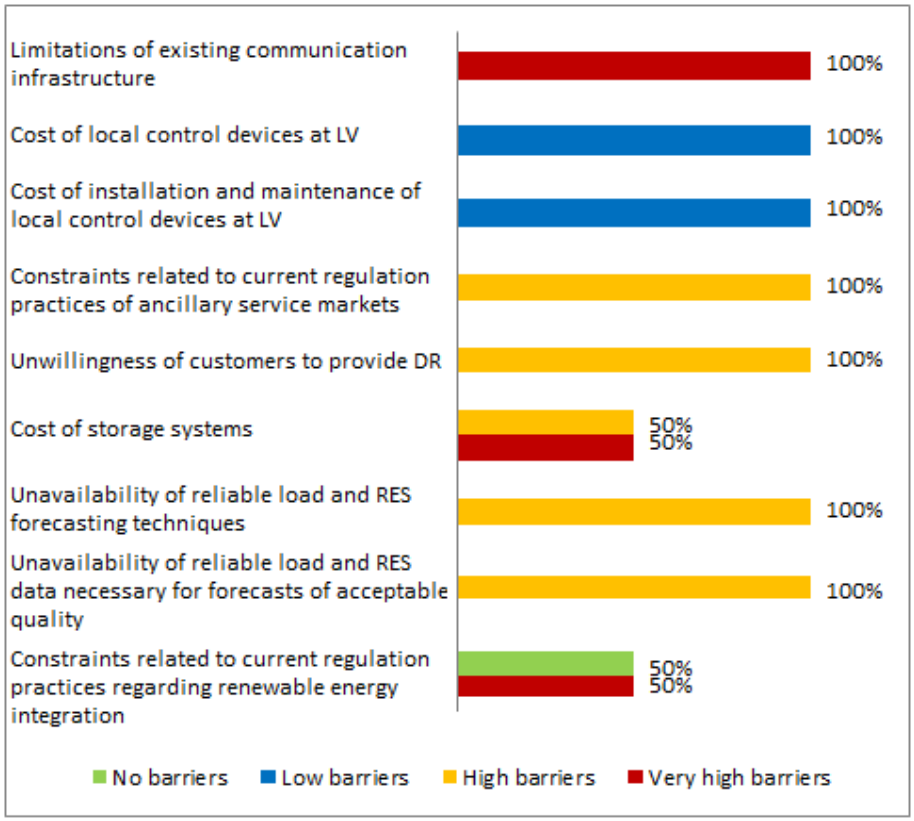

Figure 18: Possible barriers for scaling-up developed tools/techniques in SF5.

All of the responders agreed that cost of local control devices at LV as well as cost of installation and maintenance of local control devices at LV are low barriers for scaling-up the TVPP tool.

All of the responders indicated their concerns with constraints related to current regulation practices of ancillary service markets, unwillingness of customers to provide DR, cost of storage systems, unavailability of reliable load and RES forecasting techniques, and unavailability of reliable load and RES data necessary for forecasts of acceptable quality as real barriers (from high to very high) for scaling-up the TVPP. This indicates that further research is required and the tool may need significant modifications.

Finally, half of the responders (50%) agreed that constraints related to current regulation practices regarding renewable energy integration is not a barrier for scaling-up the TVPP tool. However, the other half of the responders indicated their concerns. This indicates that further research is required.

In summary, limitations of the existing communication infrastructure, constraints related

to current regulation practices of ancillary service markets, unwillingness of customers to provide DR, cost of storage systems, unavailability of reliable load and RES forecasting techniques, unavailability of reliable load and RES data necessary for forecasts of acceptable quality, and constraints related to current regulation practices regarding renewable energy integration represent significant barriers to scaling-up the SF5 functionality.

Replicability Analysis of SF5

Figure 19 demonstrates how replicable the Technical Virtual Power Plant (TVPP) tool is based on views provided by project participants.

All of the responders agreed that TVPP tool is replicable with minor modifications for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of energy storage systems, residential customers, commercial customers, industrial customers, intra-day spot energy markets, day-ahead spot energy markets, and ancillary service providers.

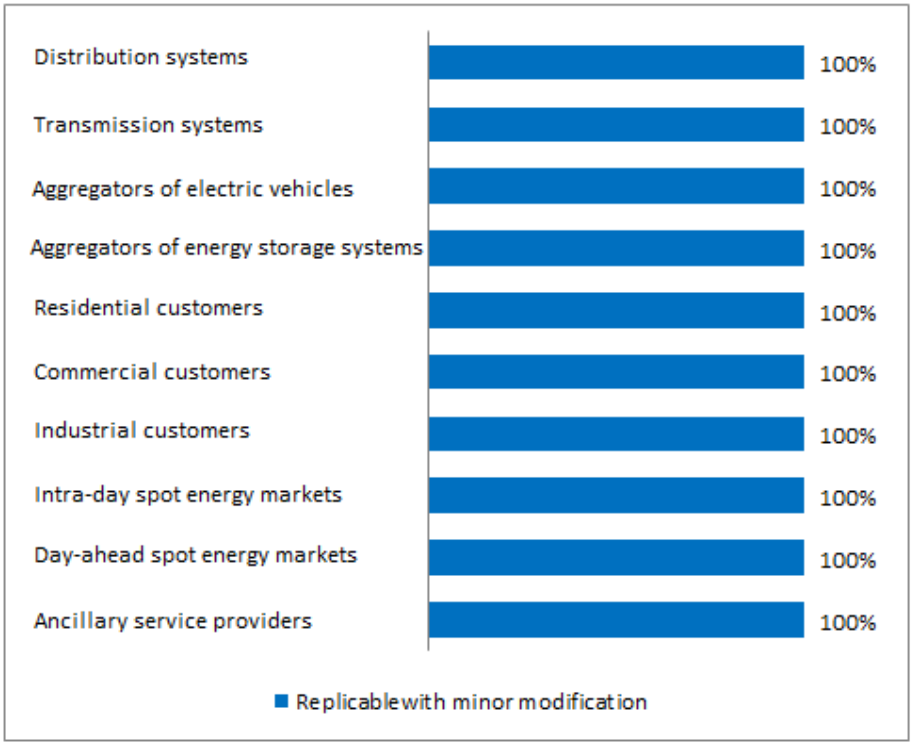

Figure 19: SF5 replicability for distribution systems, transmission systems, aggregators of electric vehicles, aggregators of energy storage systems, residential customers, commercial customers, industrial customers, intra-day spot energy markets, day-ahead spot energy markets, and ancillary service providers.

Figure 20 represents possible barriers for replicating developed tools/techniques in SF5. All of the responders indicated their concerns that the limitations of existing communication

infrastructure represents a real barrier (very high) for replicating the TVPP tool. This indicates that further research is required and the tool may need to improve its robustness to accommodate for the limitations in existing communication infrastructure.

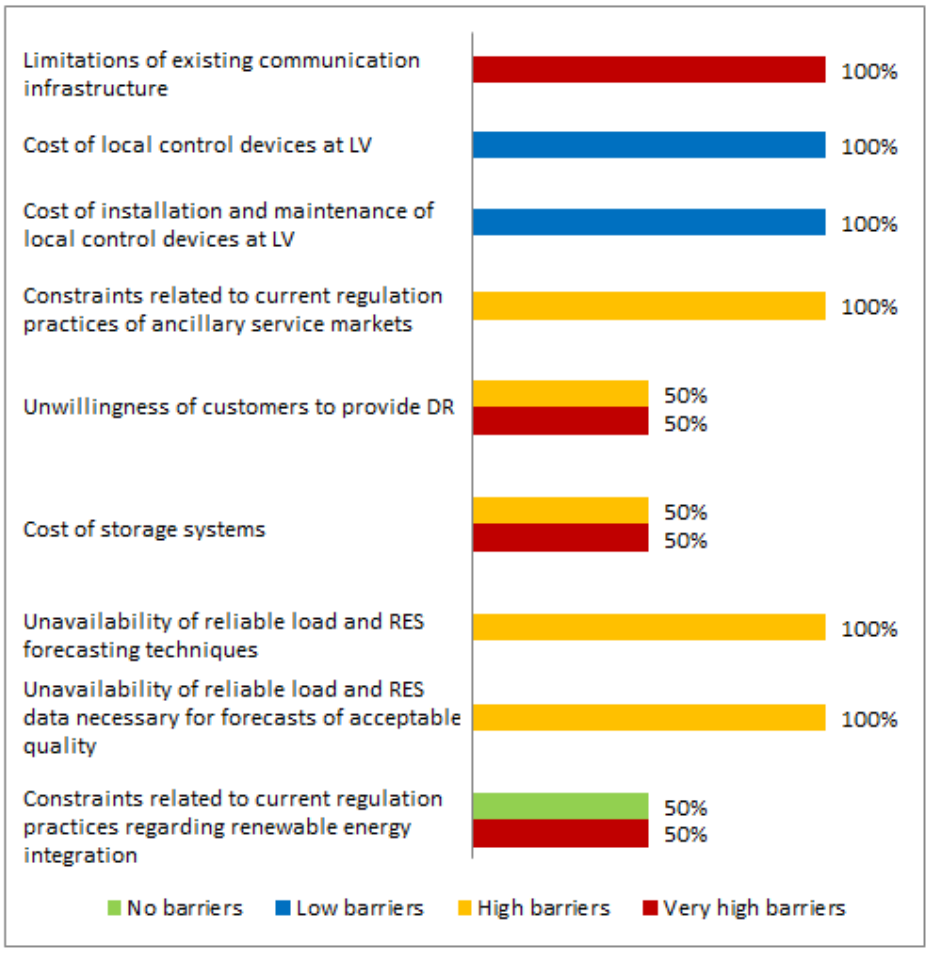

Figure 20: Possible barriers for replicating developed tools/techniques in SF5.

All of the responders agreed that the cost of local control devices at LV as well as the cost of installation and maintenance of local control devices at LV represent low barriers for replicating the TVPP tool.

All of the responders indicated their concerns that the constraints related to current regulatory practices of ancillary service markets, unavailability of reliable load and RES forecasting techniques, and unavailability of reliable load and RES data necessary for forecasts of acceptable quality represent real barriers (high) for replicating the TVPP tool. This indicates that further research is required.

All of the responders indicated their concerns that unwillingness of customers to provide DR represents a real barrier (from high to very high) for replicating the TVPP tool. This indicates that an educational campaign may be needed to educate customers on

advantages of DR. All of the responders indicated their concerns that the cost of storage systems represents a real barrier (from high to very high) for replicating the TVPP tool. This indicates that further research is required.

Half of the responders (50%) agreed that constraints related to current regulation practices regarding renewable energy integration is not a barrier for the TVPP tool. However, the other half of the responders see this point as a very high barrier. This indicates that further research is required into current regulation practices.

In summary, limitations of the existing communication infrastructure, constraints related to current regulation practices of ancillary service markets, unwillingness of customers to provide DR, cost of storage systems, unavailability of reliable load and RES forecasting techniques, unavailability of reliable load and RES data necessary for forecasts of acceptable quality, and constraints related to current regulation practices regarding renewable energy integration represent significant barriers to replicating the SF5 functionality.

2.2.5 SF6: Provision of Differentiated QoS

This task aims at developing a methodology for optimal and close to real-time provision of required Quality of Supply (QoS) to different parts, i.e. different customers of the network with Distributed Generation (DG) (in particular intermittent and stochastic power electronic interfaced DG). Power quality vision of SuSTAINABLE envisages varying grades of power quality at different pricing levels. The overall aim of the functionality is to develop a methodology for optimal and close to real-time provision of required QoS to different parts of the power distribution network. The phenomena under consideration include harmonics, voltage imbalance, and voltage sags.

Scalability Analysis of SF6

Figure 21 demonstrates how scalable the provision of differentiated quality of supply tool/technique is based on views provided by project participants. All of the responders agreed that the provision of differentiated QoS is scalable or scalable with minor modifications for distribution systems.

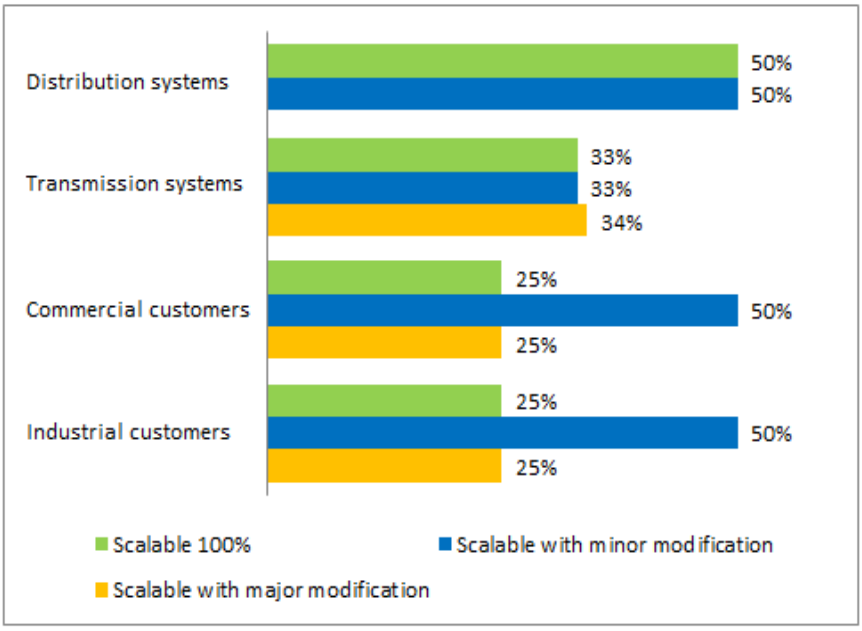

Figure 21: SF6 scalability for distribution systems, transmission systems, commercial customers, and industrial customers.

Majority of the responders (66%) agreed that the provision of differentiated QoS is scalable or scalable with minor modification for transmission systems. However, a significant number of the responders (34%) indicated their concerns. Great majority of the responders (75%) agreed that the provision of differentiated QoS is scalable or scalable with minor modifications for commercial and industrial customers.

Figure 22 represents possible barriers for scaling-up developed tools/techniques in SF6. All of the responders indicated their concerns with unwillingness of customers to participate as a real barrier (from high to very high) for scaling-up the developed tools/techniques. This indicates that an educational campaign is needed to provide information to customers.

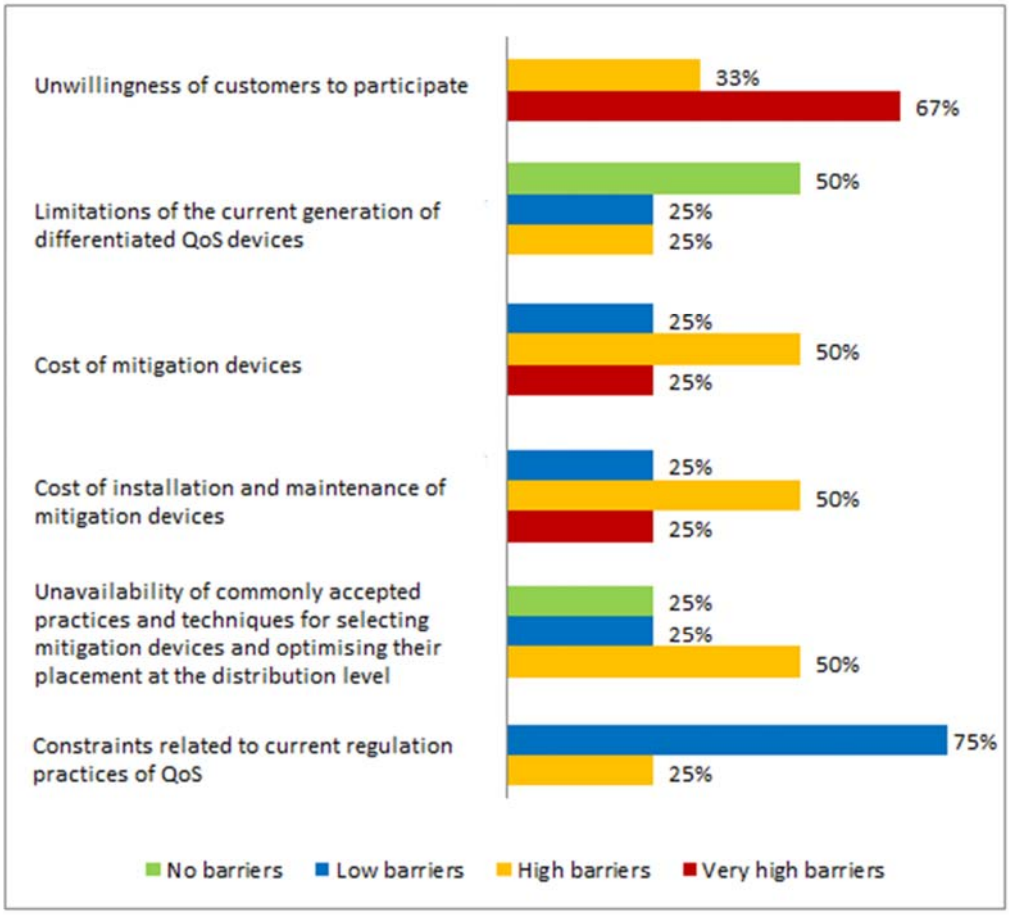

Figure 22: Possible barriers for scaling-up developed tools/techniques in SF6.

Great majority of the responders (75%) agreed that limitations of the current generation of differentiated QoS devices is not a barrier or a low barrier for scaling-up the developed tools/techniques.

Great majority of the responders (75%) indicated their concerns with the cost of mitigation devices and cost of installation and maintenance of mitigation devices as real barriers (from high to very high) for scaling-up the developed tools/techniques. This indicates that further research is required and the tool may need some significant modifications for making it scalable.

Half of the responders (50%) agreed that unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the

distribution level is not a real barrier for scaling-up the developed tools/techniques. However, the other half of the responders indicated their concerns with it as a real barrier (high). This indicates that further research is required and the tool may need some significant modifications for making it scalable.

Majority of the responders (75%) agreed that constraints related to current regulation practices of QoS are not real barriers for scaling-up the developed tools/techniques.

In summary, unwillingness of customers to participate, cost of mitigation devices, their installation and maintenance costs, and unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the distribution level represent significant barriers to scaling-up the SF6 functionality.

Replicability Analysis of SF6

Figure 23 demonstrates how replicable the provision of differentiated quality of supply tool/technique is based on views provided by project participants. All of the responders agreed that provision of differentiated quality of supply tool is fully replicable or replicable with minor modification for distribution systems and ancillary service providers. Majority of the responders (66%) also agreed that provision of differentiated quality of supply tool is fully replicable or replicable with minor modification for transmission systems. However, a significant number of the responders (34%) raised their concerns. This indicates that further research is required and the tool may need some significant modifications for making it replicable for transmission systems.

Great majority of the responders (75%) agreed that provision of differentiated quality of supply tool is fully replicable or replicable with minor modification for residential customers, commercial customers, and industrial customers.

Figure 24 represents possible barriers for replicating developed tools/techniques in SF6. All of the responders indicated that the unwillingness of customers to participate represents a real barrier (from high to very high) for replicating the provision of differentiated quality of supply tool/technique. This means that an educational campaign should be considered.

Great majority of the responders (75%) agreed that limitations of the current generation of differentiated QoS devices do not represent any significant barrier for replicating the provision of differentiated quality of supply tool/technique.

Great majority of responders (75%) indicated that the cost of mitigation devices and the cost of their installation and maintenance represent real barriers (from high to very high) for replicating the provision of differentiated quality of supply tool/technique. This means that the tool/technique may need to improve its robustness in order to operate with limited number of mitigation devices.

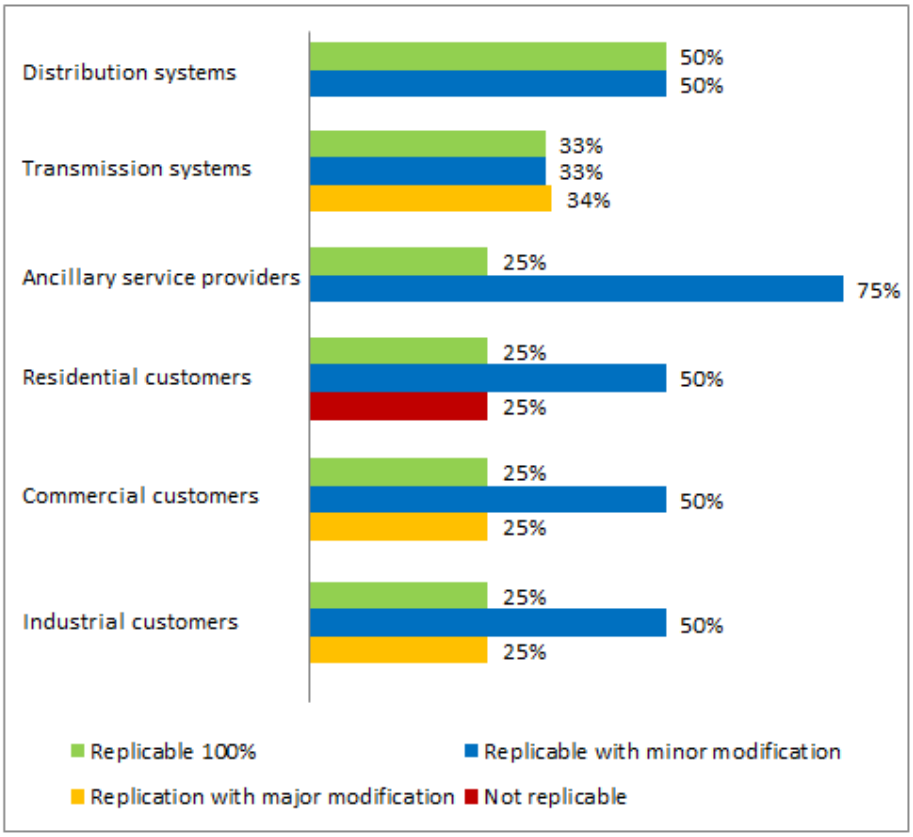

Figure 23: SF6 replicability for distribution systems, transmission systems, ancillary service providers, residential customers, commercial customers, industrial customers.

Half of the responders (50%) agreed that the unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the distribution level is not a barrier or a low barrier for replicating the provision of differentiated quality of supply tool. However, the other half raised their concerns. This indicates that further research is required.

Great majority of responders (75%) agreed that constraints related to current regulation practices of QoS represent low barriers for replicating the provision of differentiated quality of supply tool.

In summary, unwillingness of customers to participate, cost of mitigation devices, their installation and maintenance costs, and unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the distribution level represent significant barriers to replicating the SF6 functionality.

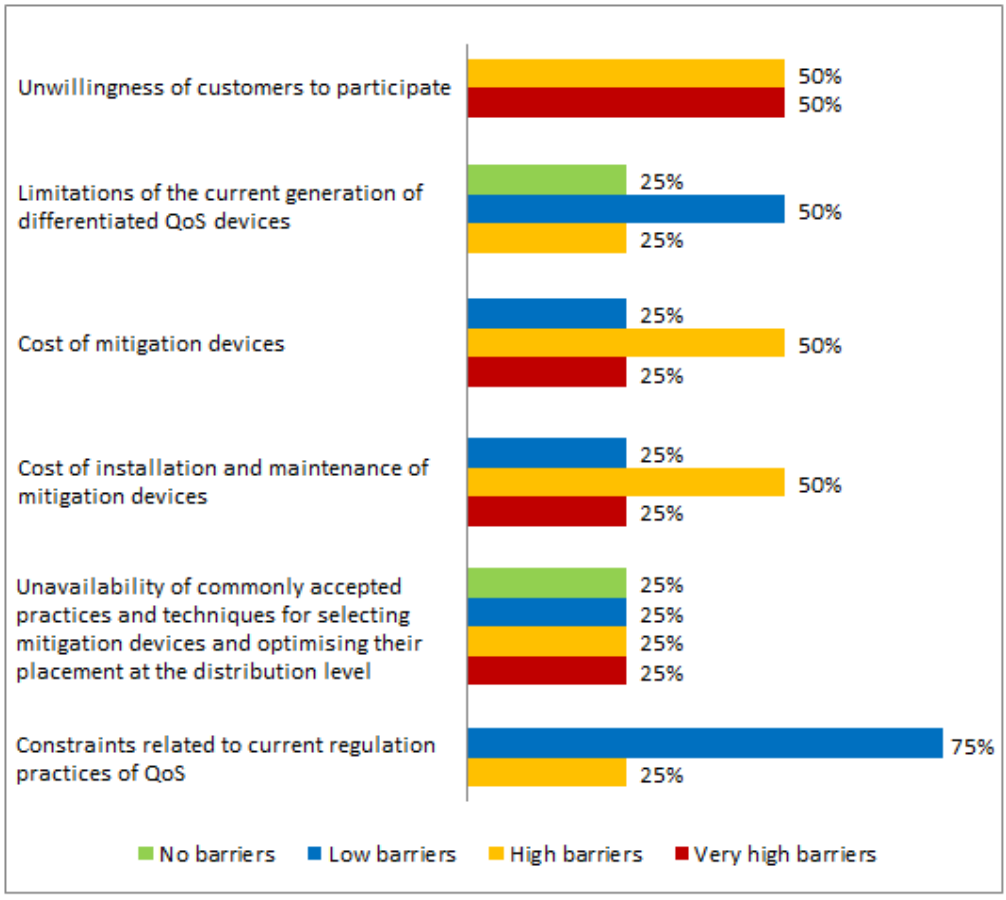

Figure 24: Possible barriers for replicating developed tools/techniques in SF6.

2.2.6 SF7: Flexibility Based Reinforcement Planning

The network reinforcement planning tools are used to investigate several expansion scenarios for real MV and LV power distribution systems. The tools contribute to defer investments regarding capacity expansions in distribution networks.

Scalability Analysis of SF7

Figure 25 demonstrates how scalable the flexibility based reinforcement planning tool is based on views provided by project participants.

Half of the responders (50%) agreed that flexibility based reinforcement planning tool is fully scalable for distribution systems. However, the other half raised their concerns. This indicates that further research is required and the tool may need some significant modifications to improve its robustness to make it scalable.

All of the responders stated that flexibility based reinforcement planning tool is scalable only with major modification for transmission systems, residential customers, commercial customers, and industrial customers. This indicates that further research is required and the tool may need some significant modifications for making it scalable.

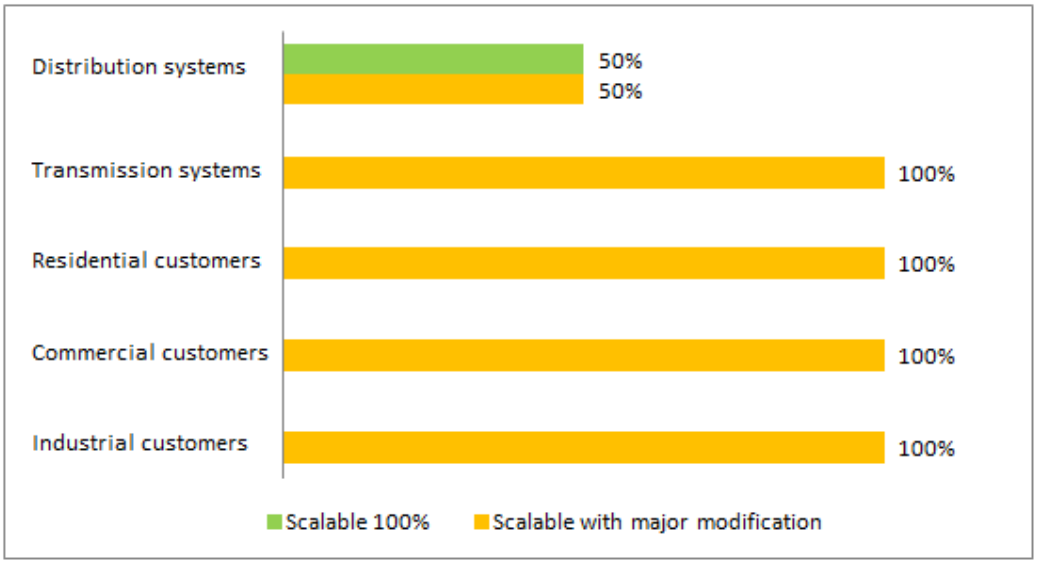

Figure 25: SF7 scalability for distribution systems, transmission systems, residential customers, commercial customers, and industrial customers.

Overall, the SF7 functionality cannot be considered scalable.

Figure 26 represents possible barriers for scaling-up developed tools/techniques in SF7. All of the responders indicated their concerns with the unavailability of historic data related to specific loads and unjustified assumptions related to load growth during the planning

horizon as real barriers (from high to very high) for scaling-up the flexibility based reinforcement planning tool.

Half of the responders (50%) agreed that unavailability of historic data related to renewable energy generation represents a low barrier for scaling-up the flexibility based reinforcement planning tool. However, the other half raised their concerns about this point.

All of the responders agreed that limitations of current regulations related to scheduled upgrades by DSO represent low barriers for scaling-up the flexibility based reinforcement planning tool.

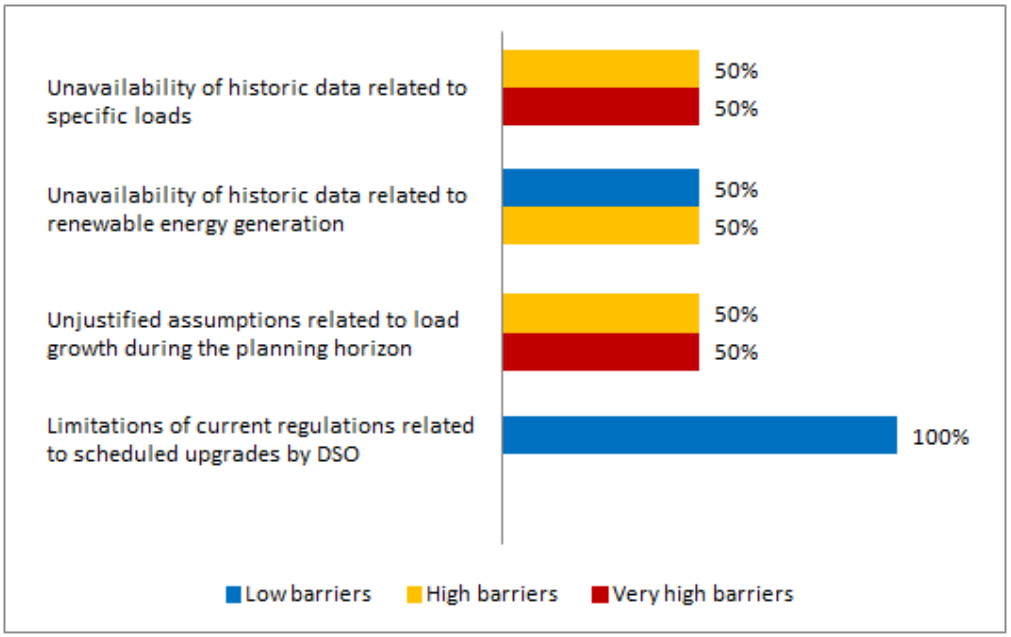

Figure 26: Possible barriers for scaling-up developed tools/techniques in SF7.

In summary, the tool may need to improve its robustness to be able to operate with limited amount of historic data as well as assumptions related to load and renewable generation growth during the planning horizon.

Replicability Analysis of SF7

Figure 27 demonstrates how replicable the flexibility based reinforcement planning tool is based on views provided by project participants.

Half of the responders (50%) agreed that flexibility based reinforcement planning tool is fully replicable for distribution systems. However, the other half raised their concerns and stated that flexibility based reinforcement planning tool is replicable with major

modifications for distribution systems. This indicates that further research is required and the tool may need some significant modifications for making it scalable.

All of the responders indicated that flexibility based reinforcement planning tool is replicable with major modifications for transmission systems, residential customers, commercial customers, and industrial customers.

The answers indicate that the SF7 functionality is rather not replicable in its current state.

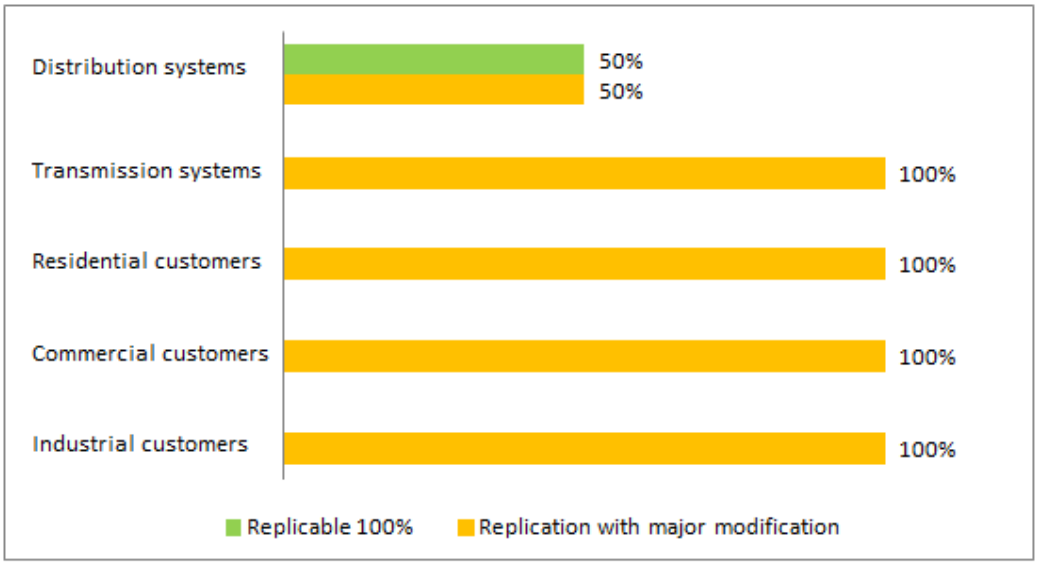

Figure 27: SF7 replicability for distribution systems, transmission systems, residential customers, commercial customers, industrial customers.

Figure 28 represents possible barriers for replicating developed tools/techniques in SF7. All of the responders indicated that unavailability of historic data related to specific loads and unjustified assumptions related to load growth during the planning horizon represent real barriers (from high to very high) for replicating the flexibility based reinforcement planning tool.

Half of the responders (50%) agreed that unavailability of historic data related to renewable energy generation represents a low barrier for replicating the flexibility based reinforcement planning tool. However, the other half indicated their concerns. This indicates that further research is required and the tool may need some significant modifications for making it replicable.

All of the responders agreed that limitations of current regulations related to scheduled upgrades by DSO represent low barriers for replicating the flexibility based reinforcement planning tool.

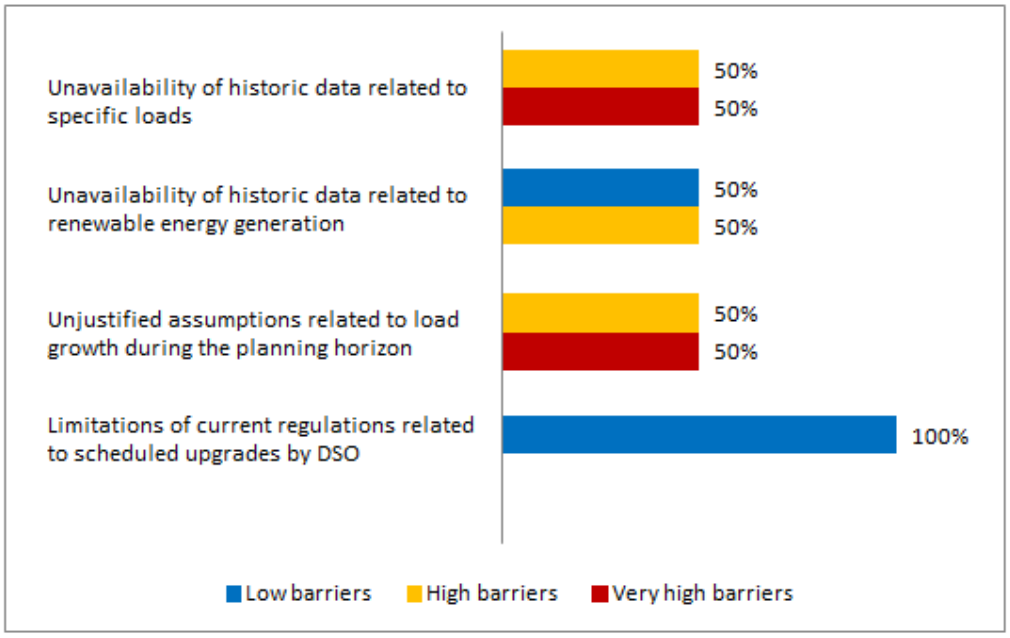

Figure 28: Possible barriers for replicating developed tools/techniques in SF7.

In summary, the tool may need to improve its robustness to be able to operate with limited amount of historic data as well as assumptions related to load and renewable generation growth during the planning horizon.

2.2.7 SF8: Power Quality Planning

This task will focus on optimising the Quality of Supply (QoS) mitigation infrastructure based on customer requirements and presence of stochastic and intermittent power electronics interfaced DG units in the network. Power Quality mitigation can be handled at different levels of system hierarchy. Mitigation options and approaches vary at equipment level, process level, plant level, and network level. A classification of QoS will be proposed with different premiums assigned to each grade depending on location, time, and type/class of customers.

Scalability Analysis of SF8

Figure 29 demonstrates how scalable the power quality planning tool is based on views provided by project participants. All of the responders agreed that power quality planning tool is fully scalable or scalable with minor modifications for distribution systems, transmission systems, residential customers, commercial customers, and industrial customers.

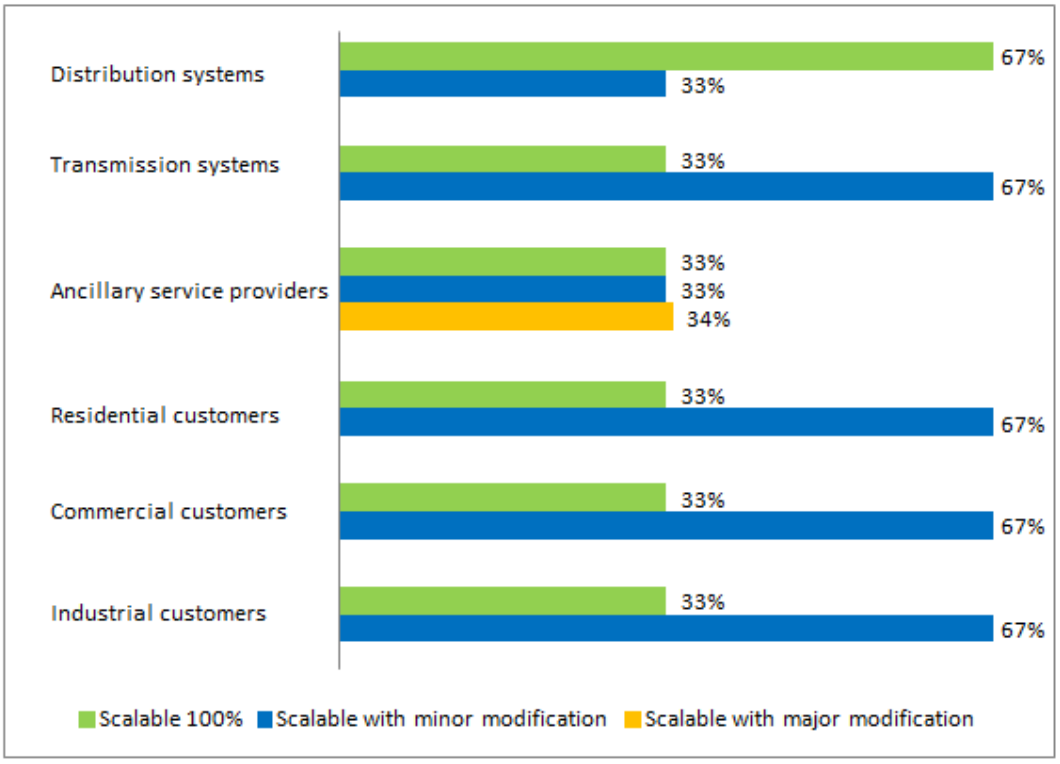

Figure 29: SF8 scalability for distribution systems, transmission systems, ancillary service providers, residential customers, commercial customers, and industrial customers.

Majority of the responders (66%) also agreed that the power quality planning tool is fully scalable or scalable with minor modification for ancillary service providers. However, significant number of the responders (34%) indicated their concerns that the power quality

planning tool is scalable with major modifications for ancillary service providers. This indicates that further research is required and the tool may need some significant modifications for making it scalable.

Figure 30 represents possible barriers for scaling-up developed tools/techniques in SF8. Majority of the responders (67%) indicated that unwillingness of customers to participate in power quality planning represents a real barrier (from high to very high) for scaling-up the power quality planning tool. This indicates that educational campaigns may be required to educate customers on power quality issues and clarify the customers' needs to improve power quality.

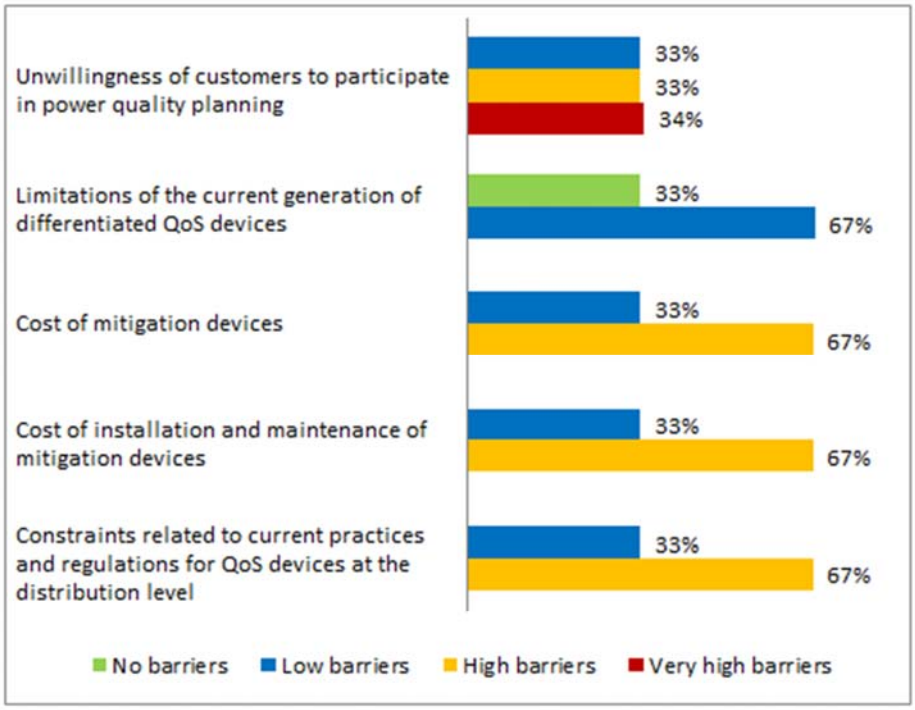

Figure 30: Possible barriers for scaling-up developed tools/techniques in SF8.

All of the responders agreed that limitations of the current generation of differentiated QoS devices do not represent any significant barrier to scaling-up the power quality planning tool.

Majority of the responders (67%) indicated their concerns with the cost of mitigation devices as well as cost of installation and maintenance of mitigation devices as high barriers for scaling-up the power quality planning tool.

Majority of the responders (67%) agreed that the constraints related to current practices and regulations for QoS devices at the distribution level represent high barriers for scaling-up the power quality planning tool.

In summary, unwillingness of customers to participate in power quality planning, cost of

mitigation devices, their installation and maintenance as well as constraints related to current practices and regulations represent significant barriers to scaling-up the SF8 functionality.

Replicability Analysis of SF8

Figure 31 demonstrates how replicable the power quality planning tool is based on views provided by project participants. All of the responders agreed that power quality planning tool is fully replicable or replicable with minor modification for distribution systems, transmission systems, residential customers, commercial customers, and industrial customers.

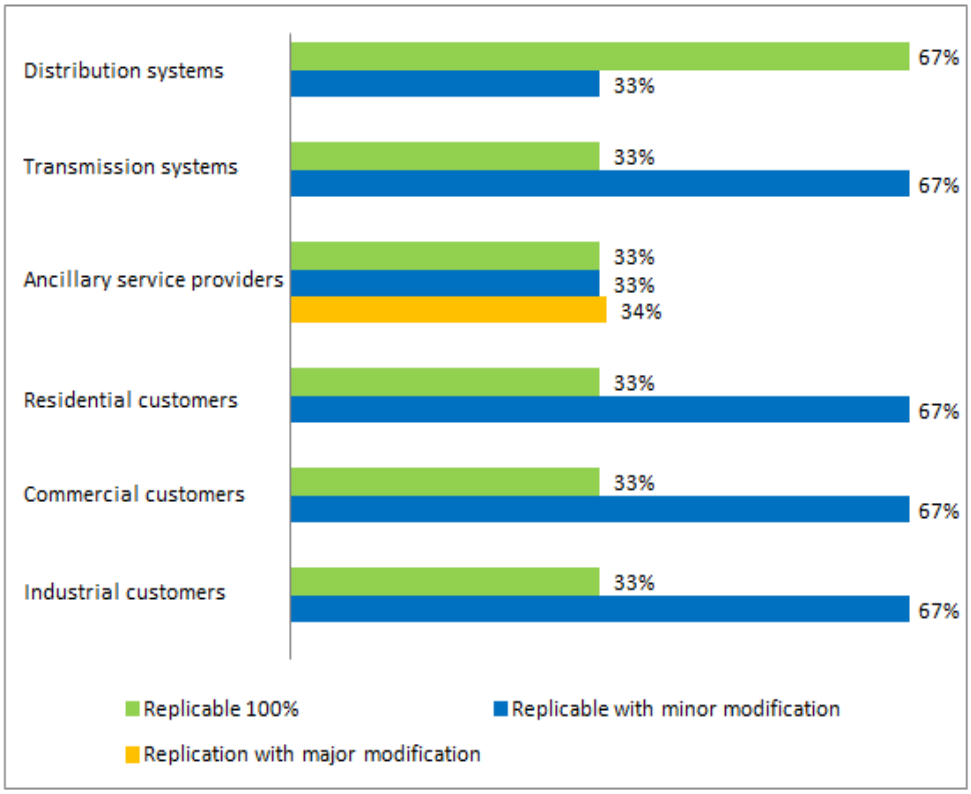

Figure 31: SF8 replicability for distribution systems, transmission systems, ancillary service providers, residential customers, commercial customers, and industrial customers.

Majority of the responders (66%) also agreed that the power quality planning tool is fully replicable or replicable with minor modification for ancillary service providers.

Figure 32 represents possible barriers for replicating developed tools/techniques in SF8. Majority of the responders (67%) indicated their concerns that unwillingness of customers to participate in power quality planning, cost of mitigation devices, cost of installation and maintenance of mitigation devices as well as constraints related to current practices and

regulations for QoS devices at the distribution level represent high barriers for replicating the power quality planning tool.

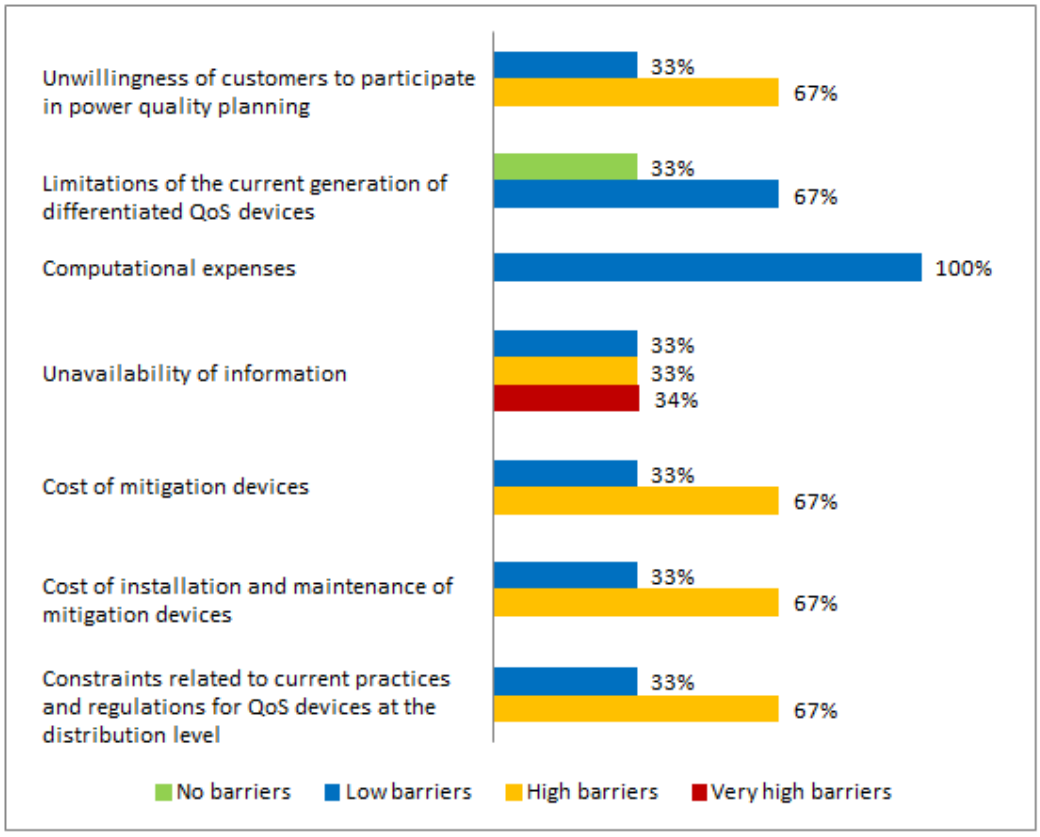

Figure 32: Possible barriers for replicating developed tools/techniques in SF8.

All of the responders agreed that limitations of the current generation of differentiated QoS devices do not represent any significant barrier for replicating the power quality planning tool.

All of the responders agreed that computational expenses represent low barriers for replicating the power quality planning tool.

Majority of the responders (67%) indicated that unavailability of information represents a real barrier (from high to very high) for replicating the power quality planning tool.

In summary, unwillingness of customers to participate in power quality planning, unavailability of information, cost of mitigation devices, their installation and maintenance costs as well as constraints related to current practices and regulations for QoS devices at the distribution level represent significant barriers to replicating the SF8 functionality.

2.2.8 SF9: Advanced Protection Planning

Advanced protection system is proposed by incorporating flexible schemes for distribution network protection and grid interconnection protection of DG units, in order to minimise/avoid protection failure. The high penetration of renewables introduces bidirectional power flows and it contributes to short-circuit power variation which are considered in the protection planning. Nuisance tripping will be minimized, limiting the impact of adjacent feeder faults. The proposed model aims at improving the selectivity of protection relays, by performing dynamic tuning of their protection setting, enhancing the role and performance of DG units.

Scalability Analysis of SF9

Figure 33 demonstrates how scalable the advanced protection planning tool is based on views provided by project participants. All of the responders agreed that advanced protection planning tool is fully scalable for distribution and transmission systems.

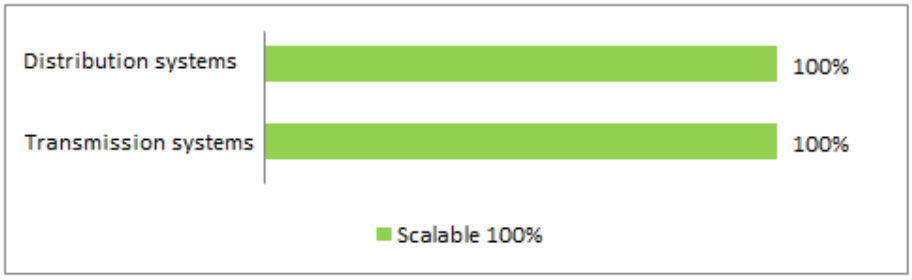

Figure 33: SF9 scalability for distribution and transmission systems.

Figure 34 represents possible barriers for scaling-up developed tools/techniques in SF9. All of the responders agreed that limitations related to functionalities of a current generation of protection devices used in distribution networks do not represent any significant barrier for scaling-up the advanced protection planning tool.

Majority of the responders (67%) raised their concerns with cost of protection devices as well as cost of installation and maintenance of protection devices as high barriers for scaling-up the advanced protection planning tool.

Majority of the responders (67%) indicated their concerns with limitations of communication infrastructure at the distribution network level as a very high barrier for scaling-up the advanced protection planning tool.

All of the responders agreed that limitations of the current practices and regulations in protection coordination represent low barriers for scaling-up the advanced protection planning tool.

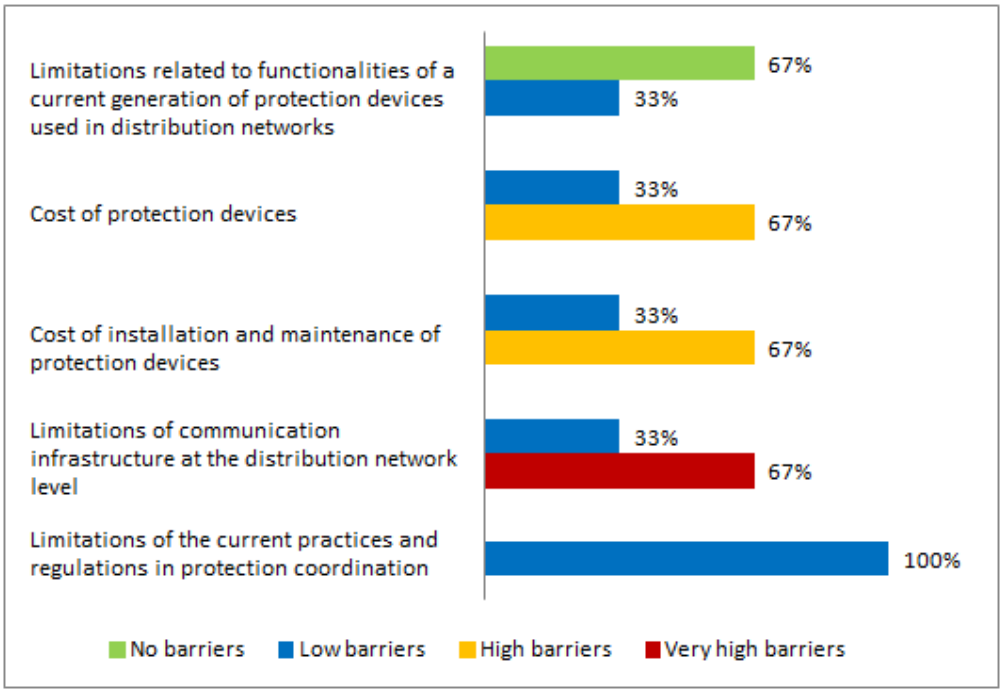

Figure 34: Possible barriers for scaling-up developed tools/techniques in SF9.

In summary, cost of protection devices as well as their installation and maintenance costs, and limitation of communication infrastructure at the distribution network level represent real barriers to scaling-up the SF9 functionality.

Replicability Analysis of SF9

Figure 35 demonstrates how replicable the advanced protection planning tool is based on views provided by the project participants. All of the responders agreed that the advanced protection planning tool is fully replicable for distribution and transmission systems.

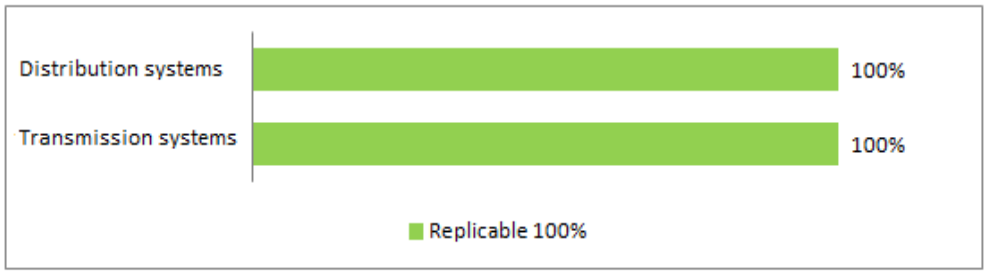

Figure 35: SF9 replicability for distribution and transmission systems.

Figure 36 represents possible barriers for replicating developed tools/techniques in SF9. Majority of the responders (67%) indicated their concerns that cost of protection devices, cost of installation and maintenance of protection devices, and limitations of

communication infrastructure at the distribution network level represent high barriers for replicating the advanced protection planning tool.

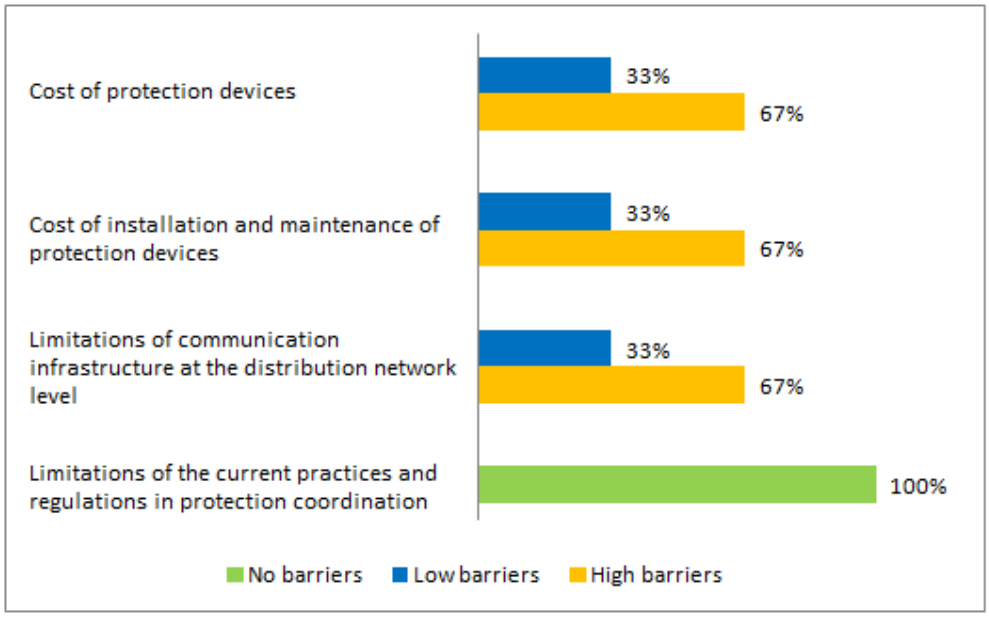

Figure 36: Possible barriers for replicating developed tools/techniques in SF9.

All of the responders agreed that limitations of the current practices and regulations in protection coordination represent no barriers for replicating the advanced protection planning tool.

In summary, cost of protection devices and their installation and maintenance costs as well as limitations of communication infrastructure at the distribution network level represent real barriers to replicating the SF9 functionality.

3. Conclusions

This section summarizes the potential scalability and replicability barriers for large-scale deployment of the functionalities which are developed in the SuSTAINABLE Project. The barriers have been identified based on the analysis of the responses to the scalability and replicability surveys. Project participants responded to these surveys. Those barriers are summarized in Table 2.

Table 2: Summary of the identified scalability and replicability barriers for large-scale deployment of the functionalities which are developed in the SuSTAINABLE Project based on the surveys

Functionality	Scalability barriers	Replicability barriers
SF1: Load forecasting	Increasing penetration of the market by electric vehicles New types of loads affecting quality of forecasts Costs of measuring devices and their installation and maintenance costs Limitations of the existing communication infrastructure	Increasing penetration of the market by electric vehicles New types of loads affecting quality of forecast Limitations of the existing communication infrastructure
SF2: RES forecasting	Essential communication infrastructure	Insufficient communication infrastructure Unavailability of data Computational expenses
SF3: Monitoring/state estimation	Limitations of current practices and regulations for monitoring devices placement Limitations of the current communication infrastructure for real-time data measurement	Limitations of the existing communication infrastructure for real-time data measurement

SF4: Coordinated voltage control	Cost of installation and maintenance of measuring devices Competitive environment preventing exchange of data between different entities in a power system Unwillingness of DER owners to participate in coordinated voltage control Automation limitations of DER Automation limitations of storage systems	Competitive environment preventing exchange of data between different entities in a power system Unwillingness of DER owners to participate in coordinated voltage control Automation limitations of DER Automation limitations of storage systems
SF5: TVPP as a support for DSO/TSO	Limitations of the existing communication infrastructure Constraints related to current regulation practices of ancillary service markets Unwillingness of customers to provide DR Cost of storage systems Unavailability of reliable load and RES forecasting techniques Unavailability of reliable load and RES data necessary for forecasts of acceptable quality Constraints related to current regulation practices regarding renewable energy integration	Limitations of the existing communication infrastructure Constraints related to current regulation practices of ancillary service markets Unwillingness of customers to provide DR Cost of storage systems Unavailability of reliable load and RES forecasting techniques Unavailability of reliable load and RES data necessary for forecasts of acceptable quality Constraints related to current regulation practices regarding renewable energy integration

SF6: Provision of differentiated QoS	Unwillingness of customers to participate Cost of mitigation devices and their installation and maintenance costs Unavailability of commonly accepted practices and techniques for selecting mitigation devices Optimising their placement at the distribution level	Unwillingness of customers to participate Cost of mitigation devices and their installation and maintenance cost Unavailability of commonly accepted practices and techniques for selecting mitigation devices Optimising their placement at the distribution level
SF7: Flexibility based reinforcement planning	Limited amount of historic data related to specific loads Assumptions related to load and renewable generation growth	Limited amount of historic data related to specific loads Assumptions related to load and renewable generation growth
SF8: Power quality planning	Unwillingness of customers to participate in power quality planning Cost of mitigation devices and their installation and maintenance costs Constraints related to current practices and regulations	Unwillingness of customers to participate in power quality planning Unavailability of information Cost of mitigation devices and their installation and maintenance costs Constraints related to current practices and regulations for QoS devices at the distribution level
SF9: Advanced protection planning	Cost of protection devices and their installation and maintenance costs Limitations of communication infrastructure at the distribution network level	Cost of protection devices and their installation and maintenance costs Limitations of communication infrastructure at the distribution network level

Appendix I: The Questionnaire for Scalability of SuSTAINABLE Functionalities

A Questionnaire for Scalability of SuSTAINABLE Functionalities

This survey aims to clarify the requirements for large-scale deployment of the methodologies developed as a result of the SuSTAINABLE project. This includes consideration of scalability of major outcomes of the project to other countries of the EU.

Responses will clarify the boundary conditions identified in the SuSTAINABLE project. Those conditions are expected to directly affect the Key Performance Indicators (KPIs) of the integration of variable distributed resources in distribution networks.

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In this questionnaire, we investigate scalability of the findings of the SuSTAINABLE project. Please provide answers relevant to functionalities.

Name:

Affiliation:

Email:

Please select the functionalities that your research group is involved in.

Functionality	Leader	Contributor
SF1. Load Forecasting	☐	☐
SF2. RES Forecasting	☐	☐
SF3. Monitoring/State Estimation	☐	☐
SF4. Coordinated Voltage Control	☐	☐
SF5. TVPP as support to DSO/TSO	☐	☐
SF6. Provision of Differentiated QoS	☐	☐
SF7. Flexibility based Reinforcement Planning	☐	☐
SF8. Power Quality Planning	☐	☐
SF9. Advanced Protection Planning	☐	☐

SF1. Load Forecasting

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Wind farm operator ☐

Scalable 100%	☐
Scalable with minor modification	☐
Scalable with major modification	☐
Not scalable	☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Increasing penetration of the market by new types of loads:

- Electric vehicles ☐
- Electric heaters ☐
- Air conditioners ☐
- Heat pumps ☐

Any others? Please specify.

Increasing penetration of new types of loads affecting quality of forecast ☐

Increasing dependence of load demand on price signals of electrical energy ☐

Cost of measuring devices ☐

Cost of installation and maintenance of measuring devices ☐

Essential communication infrastructure ☐

Increasing computational requirement ☐

Any other? Please specify.

SF2. RES Forecasting

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Wind farm operator ☐

- Scalable 100% ☐

Scalable with minor modification	☐
Scalable with major modification	☐
Not scalable	☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Increasing penetration of renewables affecting quality of forecast	
Cost of measuring devices	
Cost of installation and maintenance of measuring devices	

Essential communication infrastructure ☐

Increasing computational requirement ☐

Any other? Please specify.

SF3. Monitoring/State Estimation

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Aggregators of electric vehicles ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Aggregators of energy storage systems ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Residential customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Commercial customers ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Industrial customers ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Limitations of current practices and regulations for monitoring device placement ☐

Please specify.

Limitations of current communication infrastructure for real-time data measurement ☐

Please specify.

Cost of measuring devices	☐
Cost of installation and maintenance of measuring devices	☐
Increasing computational requirement	☐
Limitations of current techniques and methodologies for state estimation in distribution networks	☐

Any other? Please specify.

SF4. Coordinated Voltage Control

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Ancillary service provider ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Residential customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Commercial customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Industrial customers ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

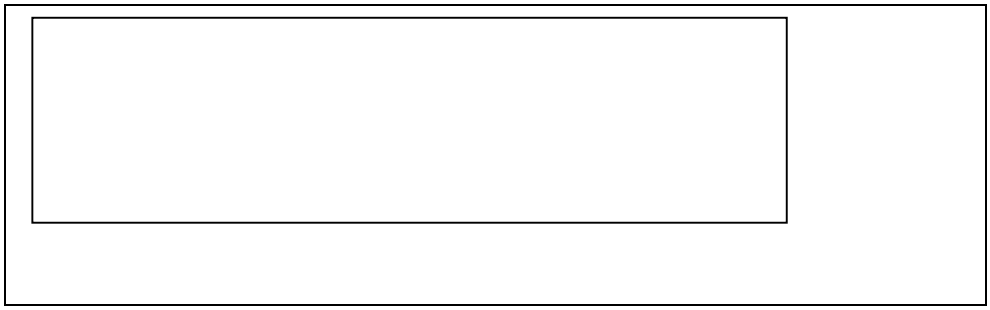
Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Cost of measuring devices	☐
Cost of installation and maintenance of measuring devices	☐
Competitive environment preventing exchange of data between different entities in a power system	☐
Unwillingness of DER owners to participate in coordinated voltage control	☐
Automation limitations:	
• MV transformers	☐
• Capacitor banks	☐
• DER	☐
• Storage systems	☐
• Any other? Please specify.	☐

Any other barrier? Please specify.



SF5. Technical Virtual Power Plant (TVPP) as support to DSO/TSO

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Aggregators of electric vehicles ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Aggregators of energy storage systems ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Any other aggregator? Please clarify if needed.

Residential customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Commercial customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Industrial customers ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Intra-day spot energy market ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Day-ahead spot energy market ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Ancillary service provider	☐
Scalable 100%	☐
Scalable with minor modification	☐
Scalable with major modification	☐
Not scalable	☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Limitations of existing communication infrastructure	
Cost of local control devices at LV	

Cost of installation and maintenance of local control devices at LV	☐
Constraints related to current regulation practices of ancillary service markets	☐
Unwillingness of customers to provide DR	☐
Cost of storage systems	☐
Unavailability of reliable load and RES forecasting techniques	☐
Unavailability of reliable load and RES data necessary for forecasts of acceptable quality	☐
Constraints related to current regulation practices regarding renewable energy integration	☐

Any other? Please specify.

SF6. Provision of Differentiated Quality of Supply (QoS)

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Commercial customer ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Industrial customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unwillingness of customers to participate	☐
Limitations of the current generation of differentiated QoS devices	☐
Please specify.	
Cost of mitigation devices	☐
Cost of installation and maintenance of mitigation devices	☐
Unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the distribution level	☐
Constraints related to current regulation practices of QoS	☐
Any other? Please specify.	

SF7. Flexibility Based Reinforcement Planning

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Residential customer ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Commercial customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Industrial customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unavailability of historic data related to specific loads	
Unavailability of historic data related to renewable energy generation	
Unjustified assumptions related to load growth during the planning horizon	
Limitations of current regulations related to scheduled upgrades by DSO	

Any other? Please specify.

SF8. Power Quality Planning

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Ancillary service provider ☐

- Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Residential customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Commercial customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Industrial customer ☐

Scalable 100% ☐

Scalable with minor modification ☐

Scalable with major modification ☐

Not scalable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unwillingness of customers to participate in power quality planning	
Limitations of the current generation of differentiated QoS devices	
Please specify.	
Cost of mitigation devices	
Cost of installation and maintenance of mitigation devices	
Constraints related to current practices and regulations for QoS devices at the distribution level	
Any other? Please specify.	

SF9. Advanced Protection Planning

1. How scalable the developed tools/techniques are for:

Distribution system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

Transmission system ☐

- Scalable 100% ☐
- Scalable with minor modification ☐
- Scalable with major modification ☐
- Not scalable ☐

Please clarify if needed.

2. Identify possible barriers for scaling-up developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Limitations related to functionalities of a current generation of protection devices used in distribution networks	
Please specify.	
Cost of protection devices	
Cost of installation and maintenance of protection devices	
Limitations of communication infrastructure at the distribution network level	
Limitations of the current practices and regulations in protection coordination	
Please specify.	

Any other barrier? Please specify.

Appendix II: The Questionnaire for Replicability of SuSTAINABLE Functionalities

A Questionnaire for Replicability of SuSTAINABLE Functionalities

This survey aims to clarify the requirements for large-scale deployment of the methodologies developed as a result of the SuSTAINABLE project. This includes consideration of replicability of major outcomes of the project to other countries of the EU.

Responses will clarify the boundary conditions identified in the SuSTAINABLE project. Those conditions are expected to directly affect the Key Performance Indicators (KPIs) of the integration of variable distributed resources in distribution networks.

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Tel: 0049 30 31426846
Email: ehsan.abbasi@tu-berlin.de

In this questionnaire, we investigate replicability of the findings of the SuSTAINABLE project. Please provide answers relevant to your functionalities.

Name:

Affiliation:

Email:

Please select the functionalities that your research group is involved in.

Functionality	Leader	Contributor
SF1. Load Forecasting	☐	☐
SF2. RES Forecasting	☐	☐
SF3. Monitoring/State Estimation	☐	☐
SF4. Coordinated Voltage Control	☐	☐
SF5. TVPP as support to DSO/TSO	☐	☐
SF6. Provision of Differentiated QoS	☐	☐
SF7. Flexibility based Reinforcement Planning	☐	☐
SF8. Power Quality Planning	☐	☐
SF9. Advanced Protection Planning	☐	☐

SF1. Load Forecasting

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Wind farm operator ☐

- Replicable 100% ☐

Replicable with minor modification	☐
Replication with major modification	☐
Not replicable	☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Increasing penetration of the market by new types of loads:

- Electric vehicles
- Electric heaters
- Air conditioners
- Heat pumps

Any others? Please specify.

Increasing penetration of new types of loads affecting quality of forecast ☐

Increasing dependence of load demand on price signals of electrical energy ☐

Cost of measuring devices ☐

Cost of installation and maintenance of measuring devices ☐

Essential communication infrastructure ☐

Increasing computational requirement ☐

Any other? Please specify.

SF2. RES Forecasting

1. How replicable the developed tools/techniques are for:

Distribution system	☐
Replicable 100%	☐
Replicable with minor modification	☐
Replication with major modification	☐
Not replicable	☐

Please clarify if needed.

Transmission system	☐
Replicable 100%	☐
Replicable with minor modification	☐
Replication with major modification	☐
Not replicable	☐

Please clarify if needed.

Wind farm operator	☐
Replicable 100%	☐

Replicable with minor modification	☐
Replication with major modification	☐
Not replicable	☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Insufficient communication infrastructure	
Cost of measuring devices	
Cost of installation and maintenance of measuring devices	

Regulatory constraints ☐

Please specify.

Unavailability of data ☐

Computational expenses ☐

Any other? Please specify.

SF3. Monitoring/State Estimation

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Aggregators of electric vehicles ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Aggregators of storage systems ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Residential customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Limitation of current practices and regulations for placement of monitoring devices	
Please specify.	
Limitations of current communication infrastructure for real-time data measurement	
Please specify.	
Cost of measuring devices	
Cost of installation and maintenance of measuring devices	
Increasing computational requirement	
Limitations of current techniques and methodologies for state estimation in distribution networks	

Any other? Please specify.

SF4. Coordinated Voltage Control

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Ancillary service provider ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Residential customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Commercial customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Industrial customers ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Cost of measuring devices ☐

Cost of installation and maintenance of measuring devices ☐

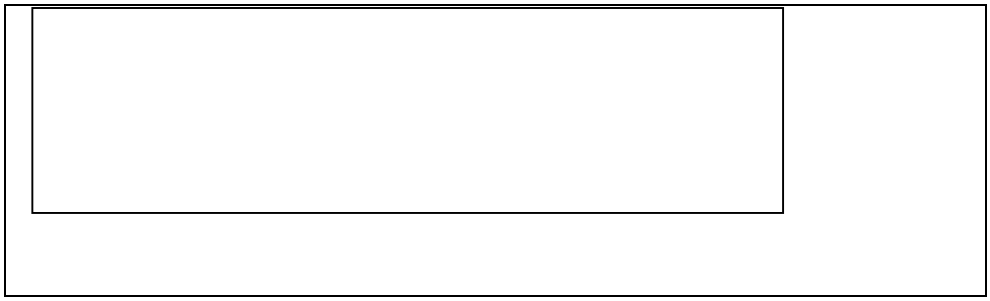
Competitive environment preventing exchange of data between different entities in a power system ☐

Unwillingness of DER owners to participate in coordinated voltage control ☐

Automation limitations:

- MV transformers ☐
- Capacitor banks ☐
- DER ☐
- Storage systems ☐
- Any other? Please specify. ☐

Any other barrier? Please specify.



SF5. Technical Virtual Power Plant (TVPP) as support to DSO/TSO

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Aggregators of electric vehicles ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Aggregators of energy storage systems ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Any other aggregator? Please clarify.

Residential customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Commercial customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Industrial customers ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Intra-day spot energy market ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Day-ahead spot energy market ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Ancillary service provider ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Limitations of existing communication infrastructure	
Cost of local control devices at LV	
Cost of installation and maintenance of local control devices at LV	
Constraints related to current regulatory practices of ancillary service markets	
Unwillingness of customers to provide DR	
Cost of storage systems	
Unavailability of reliable load and RES forecasting techniques	
Unavailability of reliable load and RES data necessary for forecasts of acceptable quality	
Constraints related to current regulation practices regarding renewable energy integration	

Any other? Please specify.

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SF6. Provision of Differentiated Quality of Supply (QoS)

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Ancillary service provider ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Residential customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Commercial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Industrial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unwillingness of customers to participate	
Limitations of the current generation of differentiated QoS devices	
Please specify.	
Cost of mitigation devices	
Cost of installation and maintenance of mitigation devices	
Unavailability of commonly accepted practices and techniques for selecting mitigation devices and optimising their placement at the distribution level	
Constraints related to current regulation practices of QoS	
Any other? Please specify.	

SF7. Flexibility Based Reinforcement Planning

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Residential customer ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Commercial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Industrial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unavailability of historic data related to specific loads	
Unavailability of historic data related to renewable energy generation	
Unjustified assumptions related to load growth during the planning horizon	
Limitations of current regulations related to scheduled upgrades by DSO	

Any other? Please specify.

SF8. Power Quality Planning

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Ancillary service provider ☐

- Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Residential customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Commercial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Industrial customer ☐

Replicable 100% ☐

Replicable with minor modification ☐

Replication with major modification ☐

Not replicable ☐

Please clarify if needed.

Any other? Please specify.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Unwillingness of customers to participate in power quality planning	
Limitations of the current generation of differentiated QoS devices	
Please specify.	
Computational expenses	
Unavailability of information	
Cost of mitigation devices	
Cost of installation and maintenance of mitigation devices	
Constraints related to current practices and regulations for QoS devices at the distribution level	

Any other? Please specify.

SF9. Advanced Protection Planning

1. How replicable the developed tools/techniques are for:

Distribution system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

Transmission system ☐

- Replicable 100% ☐
- Replicable with minor modification ☐
- Replication with major modification ☐
- Not replicable ☐

Please clarify if needed.

2. Identify the possible barriers for replicating developed tools/techniques:
   Please put numbers in the boxes below:
   0: no barriers; 1: low barriers; 2: high barriers; 3: very high barriers;

Cost of protection devices	
Cost of installation and maintenance of protection devices	
Limitations of communication infrastructure at the distribution network level	
Limitations of the current practices and regulations in protection coordination	

Please specify.

Any other barrier? Please specify.