INTERPLAN
INTEgrated opeRation PLAnning tool towards the Pan-European Network

Work Package 3

Requirements, scenarios and use cases definition

Deliverable D3.1

INTERPLAN requirements

Grant Agreement No:	**773708**
Funding Instrument:	**Research and Innovation Action (RIA)**
Funded under:	**H2020 LCE-05-2017: Tools and technologies for coordination and integration of the European energy system**
Starting date of the project:	**01.11.2017**
Project Duration:	**36 months**

Contractual delivery date:	**31.10.2018**
Actual delivery date:	**31.10.2018**
Lead beneficiary:	**3 - DERlab European Distributed Energy Resources Laboratories (DERlab) e.V.**
Deliverable Type:	**Report (R)**
Dissemination level:	**Public (PU)**
Revision / Status:	**Released**

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 773708

Document Information

Document Version:	6
Revision / Status:	Released
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Distribution List	INTERPLAN consortium
Keywords:	Requirements, Intermittent Renewable Energy Resources, Storages, Flexible demand response, Electric vehicles, TSO level, DSO level, TSO-DSO interfaces, Data models and sources, Controllers, Grid equivalent, Grid models, Simulation, OpSim, INTERPLAN

Document History

Revision	Content / Changes	Resp. Partner	Date
1	The initial structure was created	DERlab	06.02.18
2	Documenting the methodology section	DERlab	14.09.18
3	Integrate the requirements in the deliverable	All partners	25.09.18
4	Introduction and conclusion of the deliverable	DERlab	09.10.18
5	Final version ready for review	DERlab	16.10.18
6	Revision and improvements	DERlab	31.10.18

Document Approval

Final Approval	Name	Resp. Partner	Date
Review Task Level	Melios Hadjikypris	FOSS	22.10.18
Review WP Level	Sawsan Henein	AIT	24.10.18
Review WP Level	Diana Strauss-Mincu	DERlab	30.10.18
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Abbreviations

CIM	*Common Information Model*
DER	*Distributed Energy Resource*
DERlab	*European Distributed Energy Resources Laboratories e.V.*
DG	*Distributed Generation*
DSO	*Distribution System Operators*
EU	*European Union*
EV	*Electric vehicles*
FACTS	*Flexible Alternating Current Transmission System*
FRR	*Fast Frequency Response*
G2V	*Grid-to-Vehicle*
ID	*Identification*
INTERPLAN	*INTEgrated opeRation PLAnning tool towards the Pan-European Network*
KPI	*key performance indicator*
LCE	*Low Carbon Energy*
LV	*Low voltage*
MV	*Medium voltage*
OpSim	*Test- and simulation-environment for grid control and aggregation strategies*
PC	*Project Coordinator*
PU	*Public*
R	*Report*
RES	*Renewable Energy Sources*
RIA	*Research and Innovation Action*
SCN	*Subversion*
TSO	*Transmission System Operator*
V2G	*Vehicle-to-Grid*
WP	*Work package*

Executive Summary

INTERPLAN project provides an INTEgrated opeRation PLAnning tool for the pan-European Network, with a focus on the TSO-DSO interactions, to support the EU in reaching the expected low-carbon targets, while maintaining the network security and reliability. The project aims to generate grid equivalent tools as a growing library able to cover phenomena relevant to operation planning issues that might occur in a large interconnected power system at all voltage levels (transmission, distribution and TSO-DSO interfaces). Moreover, novel control strategies and operation planning architectures are investigated in order to ensure the security of supply and flexibility of the interconnected EU electricity grid, based on a close cooperation between TSOs and DSOs.

In this context, INTERPLAN consortium has defined forty-five requirements serving as the basis for the activities of the project. A methodology was established to define the project requirements considering the project's objectives and foreseen activities. In the first step, a preliminary list of requirements was created that was later validated and revised. After the revision process, an intermediate list of requirements was created that was further grouped, classified and prioritized. The low priority requirements were eliminated from the final list of requirements. The methodology used to define INTERPLAN requirements is presented in Figure 1.

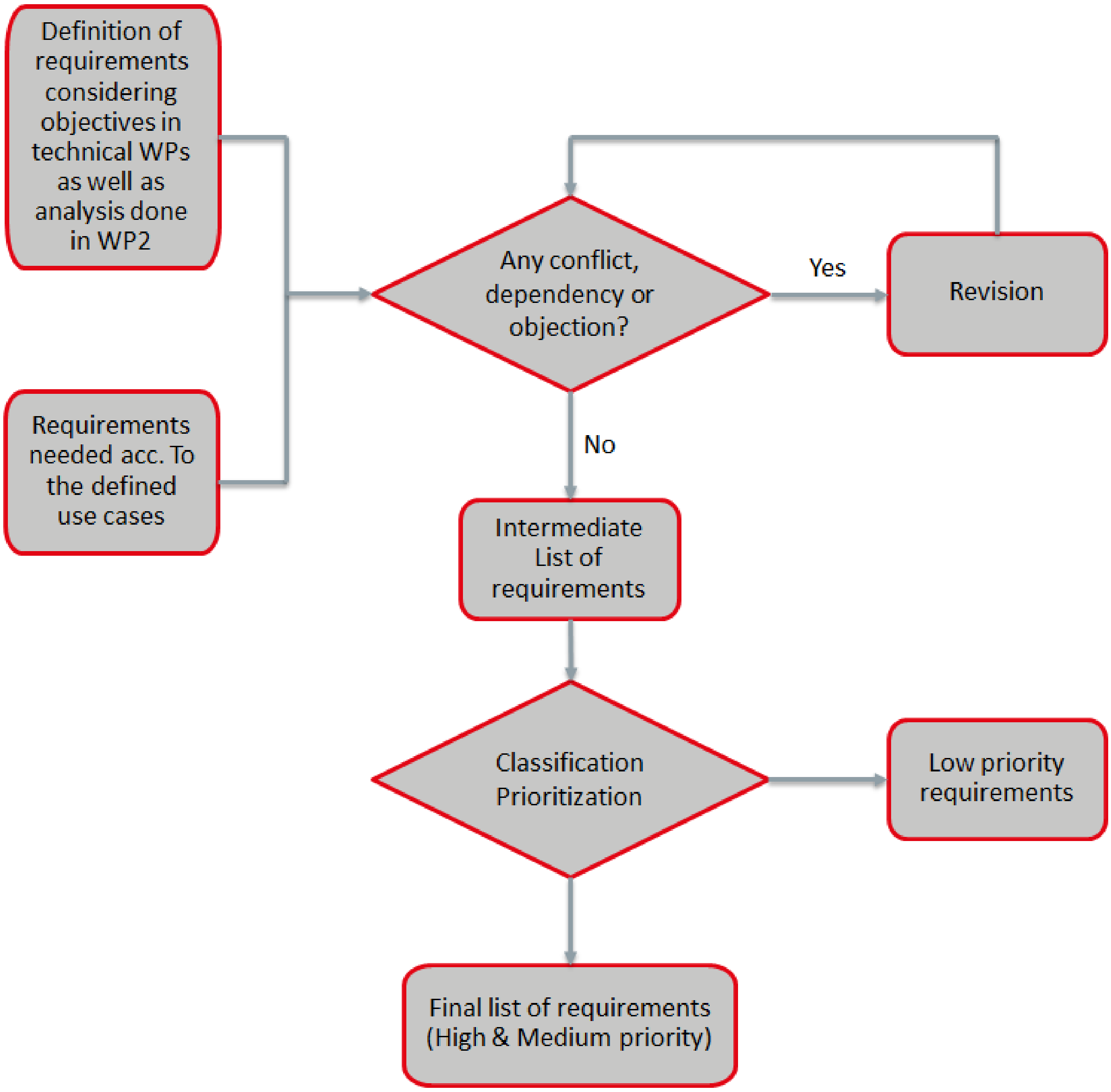

Figure 1: Methodology used to define the INTERPLAN requirements

The requirements were grouped into four sets:

1. use cases,
2. grid clustering and grid equivalenting,
3. operation planning tool, showcases and controller,
4. testing and validation.

A glossary of terms and definitions is presented in the annex section. Table 1 presents the final list of requirements defined by INTERPLAN consortium.

Table 1: The final list of requirements defined by INTERPLAN consortium

ID	Name of the requirement
1	DSOs support grid energy balancing by optimising the power flow at the distribution level
2	Requirements for simulating a use case/showcase
3	Co-simulation subcomponents must implement the OpSim data model and communication protocol and must support the common time series format
4	Any co-simulation subcomponent must be able to run in real-time or faster
5	Co-simulation subcomponent must be tested in stand-alone operation before they are connected to the co-simulation
6	There must be at least one test defined which validates the subcomponent interface to the OpSim platform
7	The co-simulation platform must provide a mechanism which synchronizes all subcomponents
8	All co-simulation subcomponents must be able to synchronize using a mechanism provided by the co-simulation platform
9	All co-simulation subcomponents must be able to announce their state to the co-simulation platform
10	All co-simulation subsystems must be able to uniquely identify themselves towards the co-simulation platform
11	Models for electric vehicles are required
12	Use case must be prioritized before selection
13	The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase
14	Co-simulation subcomponents must communicate only through well-defined co-simulation platform data structure
15	Operation planning tool definition is needed
16	DSOs and TSOs must operate in a coordinated system
17	DSOs must participate in active and reactive power control and voltage support both in distribution and transmission systems
18	DSOs must be involved in the voltage regulation scheme as a real competitor

ID	Name of the requirement
19	DSOs and TSOs must have a control mechanism over technical controllable units
20	There must be a TSOs-DSOs coordination interface to improve the DER management
21	Use case description must be detailed
22	The operation planning tool must focus on exploitation of flexibility sources
23	Control system logics must suit the complexity of the integrated grid
24	The equivalent model is requested to accurately and reliably represent a real grid
25	Intermittent RES power controllers must react to voltage violation at LV and MV networks
26	Aggregated effects of distributed RES must be taken into consideration in network models and the tool
27	Controller definition is needed
28	INTERPLAN tool must provide support to DSOs and TSOs for grid operation planning
29	Use cases combined under each showcase need to be implemented in the same simulation environment
30	Aggregation of loads and generators in the grid equivalents
31	Each use case/showcase must specify the grid equivalents that will be used
32	Grid equivalent/network model must be defined and a data source must be identified
33	Equivalent DSO grid model must include a detailed model for each resource
34	TSO and DSO grid equivalent models must support active and reactive power control using resources at DSO level
35	Time series data should share a common data format
36	Models for different technologies of storage are required
37	Models for demand response are required
38	Models of synthetic inertia and FFR controller
39	RES and storage provide ancillary services
40	Showcase definition is needed
41	Control signals must not override each other
42	Use cases algorithms used within a given showcase should not create any conflicts between themselves
43	The operation planning tool must reduce the cost of energy
44	INTERPLAN grid equivalent models must be compatible with CIM format
45	Use cases should address the operating challenges of the current and future EU networks

1 Introduction

1.1 Purpose of the Document

The purpose of the document at hand is to summarise the results from task 3.1 "Define INTERPLAN requirements". This task elicits the requirements for the network models and interfaces (TSO, DSO, TSO-DSO).

1.2 Scope of the Document

This document summarizes the requirements that are defined for INTERPLAN project by the consortium with a specific focus on use cases and showcases, grid clustering and grid equivalenting, operating planning tool and testing and validation. The requirements are described in this deliverable.

1.3 Structure of the Document

Chapter 2 presents the project objectives. The methodology that has been used to define the requirements is presented in chapter 3. The use cases requirements and the grid clustering and grid equivalents requirements are documented in chapter 4 and 5, respectively. The requirements concerning the operation planning tool, showcases and controller are documented in chapter 6. The fourth set which is documented in chapter 7, focuses on testing and validation the co-simulation tools. Last but not least, chapter 8 summaries the conclusion from this deliverable.

2 INTERPLAN project

The European Union (EU) energy security policy faces significant challenges as we move towards a pan-European network based on the wide diversity of energy systems among EU members. In such a context, novel solutions are needed to support the future operation of the EU electricity system in order to increase the security of supply and also accounting for the increasing contribution of renewable energy sources (RES). The goal of INTERPLAN project is to provide an INTEgrated opeRation PLAnning tool towards the pan-European Network, with a focus on the TSO-DSO interfaces to support the EU in reaching the expected low-carbon targets, while maintaining the network security and reliability.

A methodology for proper representation of an “equivalent grid” model of the pan-European network using a clustering methodology is provided in Figure 2, with the aim to generate grid equivalents as a growing library able to cover all relevant system connectivity possibilities occurring in the real grid, by addressing operation planning issues at all network levels (transmission, distribution and TSO-DSO interfaces). The chosen top-down approach leads to an “integrated” tool, both in terms of voltage levels, going from high voltage down to low voltage and to end consumer, and in terms of building a bridge between static, long-term planning and considering operational issues by introducing controllers in the operation planning. In addition, novel control strategies and operation planning approaches are investigated in order to ensure the security of supply and flexibility of the interconnected EU electricity grid, based on a close cooperation between TSOs and DSOs.

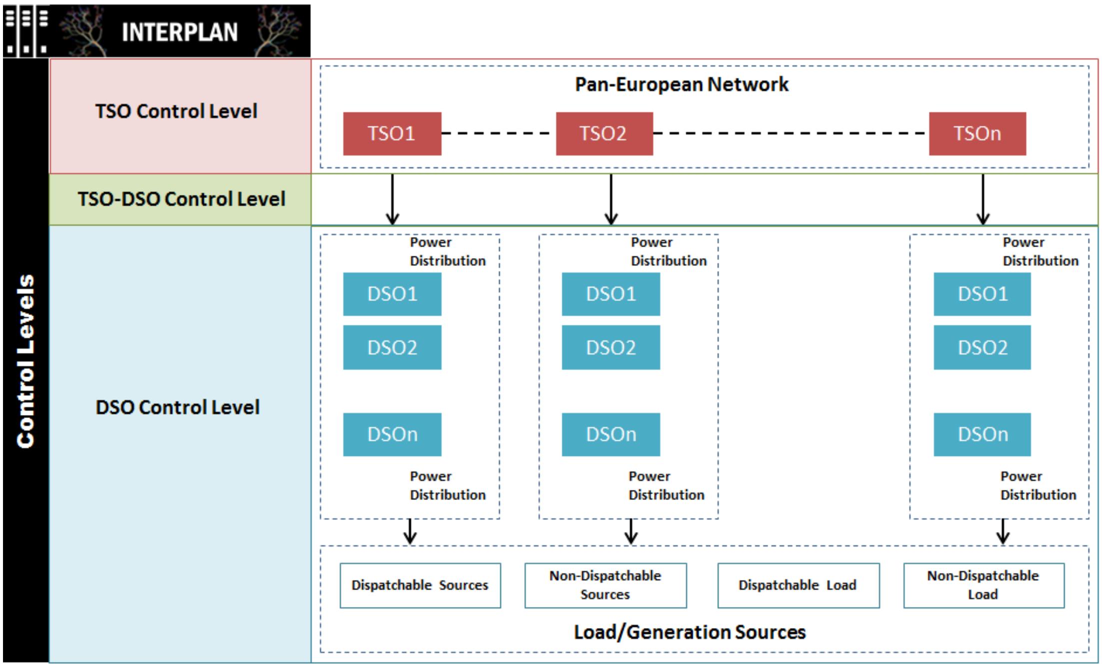

Figure 2: Graphical representation of the INTERPLAN concept

The main objectives of INTERPLAN project are:

- Definition of a set of detailed use cases to be addressed by future network planning and operation at all network levels, including TSO-DSO interfaces, and the establishment of requirements for network models and grid equivalents.
- Development of network models and the identification and characterization of clustering methods.
- Development of a detailed approach for generating grid equivalents for different use cases.
- Development of an operational planning tool which can use not only real network data but also grid equivalents with the aim to control the operating conditions at all network levels,

and applies adequate possible intervention measures through cluster and interface controllers.

- Validation of INTERPLAN tools and testing with the aim to show the effectiveness of the tool to ensure stability and security of the interconnected EU electricity system.
- Analysis of the European electricity grid, including the main interconnection issues and criticalities, both within EU countries and at a pan-European level.
- A detailed assessment of the regulatory framework in Europe including existing grid codes.
- On the policy front, a proposal with all possible recommendations for grid codes development.

3 Methodology

3.1 Introduction

This chapter presents the methodology used to define the INTERPLAN requirements. INTERPLAN consortium defined the requirements considering the project's activities and objectives in technical work packages (WP4: Grid equivalenting, WP5: Operation planning and semi-dynamic simulation and WP6: INTERPLAN model validation and testing), as well as the analysis that was done in WP2: Technical assessment and regulatory status of European electricity grid. Moreover, the requirements definition took into consideration INTERPLAN uses cases defined in T3.2: Identification of scenarios and definition of INTERPLAN use cases.
A preliminary list of requirements was created and validated. During the validation process, conflicts and dependencies between requirements were identified. Furthermore, any objection to any of the requirements was pointed out.

The consortium defined conflict, dependency and objection as follows:
<u>Dependency</u>: Requirements that have some dependency on other requirements.
<u>Conflict</u>: Requirements that cannot be implemented if another requirement is implemented or a conflict due to an insufficient definition of the requirement.
<u>Objection</u>: A reason or argument offered in disagreement, opposition, refusal or disapproval of the requirement.

All the dependencies, conflicts and objections highlighted by experts[1] during the validation stage were revised and solved by the requirement's authors.

3.2 Requirements grouping, prioritization and classification

After the revision process, an intermediate list of requirements was created by INTERPLAN consortium. The requirements in the intermediate list were further grouped, classified and prioritized.

Based on the process above, the requirements were grouped into four sets:

- *<u>Use cases:</u> Those requirements focus on the use cases and sub-use cases.*
- *<u>Grid clustering and grid equivalenting</u>: Those requirements focus on grid clustering and grid equivalenting*
- *<u>Operation planning tool, showcases and controllers:</u> Those requirements focus on the operation planning tool, showcases and controllers*
- *<u>Testing and validation:</u> Those requirements focus on testing and validation of co-simulation*

Some of the requirements could be allocated into two or more groups.

The requirements were also classified according to the following classification:

- *<u>Power system emerging technologies:</u> Intermittent RES; Storages; Flexible demand response*
- *<u>Data models and sources, power and control interfaces:</u> TSO level; DSO level; TSO-DSO interfaces*
- *<u>Power system analysis tools:</u> Controllers; Grid equivalents; Simulations*

Moreover, the requirements were prioritized as follows:

- *<u>High</u>: Requirements in this set are either realizing a key innovation of the project or they are needed to realize it. These requirements are necessary to achieve the goals of the project.*
- *<u>Medium</u>**:** Requirements in this set are not necessary to realize a key innovation but they are necessary or very helpful to realize the project tools.*

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[1] An INTERPLAN workshop was organised with experts during ENERGYCON 2018 to discuss the use cases and the requirements of the project.

- *<u>Low</u>: Requirements in this set are neither realizing a key innovation nor necessary for the tools. However, in a broader context possibly beyond the scope of the project, they may be important.*

The low priority requirements were eliminated from the final list of requirements. The methodology used to define the INTERPLAN requirements is presented in Figure 3. Table 2 presents the final list of requirements defined by INTERPLAN consortium and the requirement set.

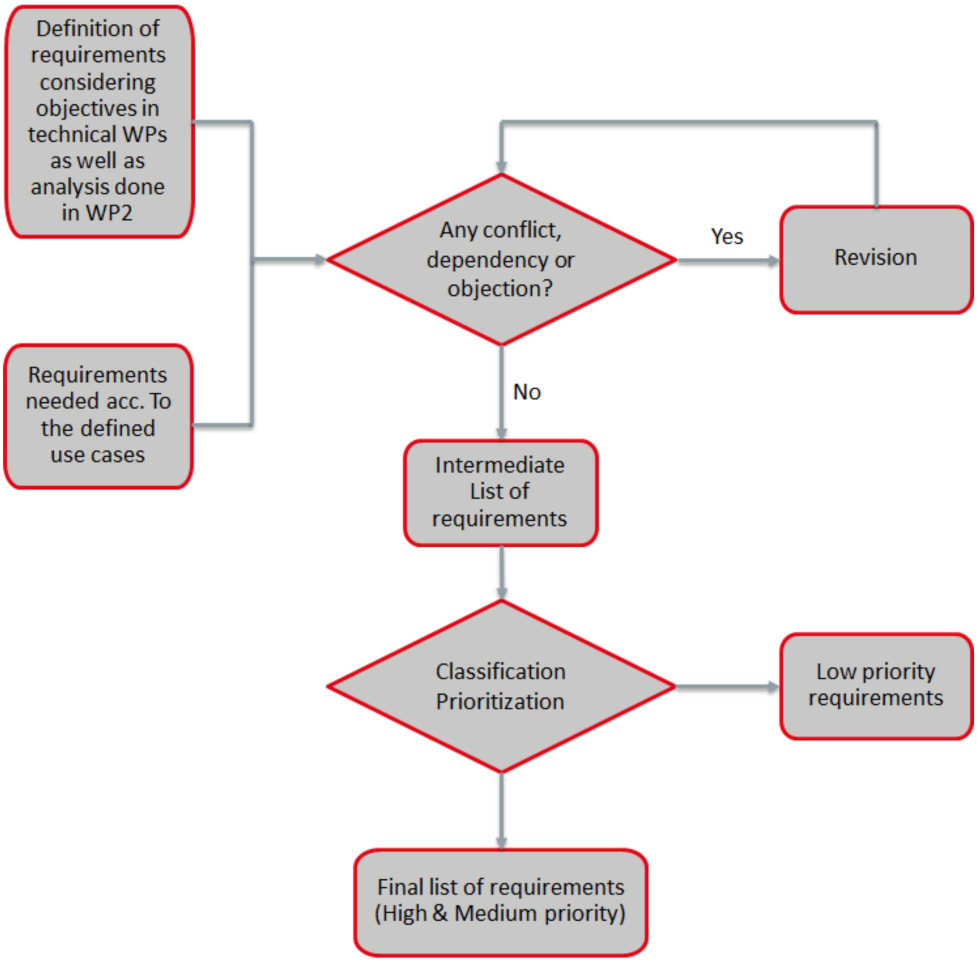

Figure 3: Methodology used to define the INTERPLAN requirements

Table 2: The final list of requirements defined by INTERPLAN consortium

ID	***Name of the requirement***	***Use cases***	***Grid clustering***	***Operational tool***	***Testing & Validation***
1	*DSOs support grid energy balancing by optimising the power flow at the distribution level*			x	
2	*Requirements for simulating a use case/showcase*			x	

ID	Name of the requirement	Use cases	Grid clustering	Operational tool	Testing & Validation
3	*Co-simulation subcomponents must implement the OpSim data model and communication protocol and must support the common time series format*				x
4	*Any co-simulation subcomponent must be able to run in real-time or faster*				x
5	*Co-simulation subcomponent must be tested in stand-alone operation before they are connected to the co-simulation*				x
6	*There must be at least one test defined which validates the subcomponent interface to the OpSim platform*				x
7	*The co-simulation platform must provide a mechanism which synchronizes all subcomponents*				x
8	*All co-simulation subcomponents must be able to synchronize using a mechanism provided by the co-simulation platform*				x
9	*All co-simulation subcomponents must be able to announce their state to the co-simulation platform*				x
10	*All co-simulation subsystems must be able to uniquely identify themselves towards the co-simulation platform*				x
11	*Models for electric vehicles are required*			x	
12	*Use case must be prioritized before selection*	x			
13	*The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase*	x		x	
14	*Co-simulation subcomponents must communicate only through well-defined co-simulation platform data structure*				x
15	*Operation planning tool definition is needed*			x	
16	*DSOs and TSOs must operate in a coordinated system*			x	
17	*DSOs must participate in active and reactive power control and voltage support both in distribution and transmission systems*			x	
18	*DSOs must be involved in the voltage regulation scheme as a real competitor*			x	
19	*DSOs and TSOs must have a control mechanism over technical controllable units*			x	
20	*There must be a TSOs-DSOs coordination interface to improve the*			x	

ID	Name of the requirement	Use cases	Grid clustering	Operational tool	Testing & Validation
	DER management				
21	Use case description must be detailed	x			
22	The operation planning tool must focus on exploitation of flexibility sources			x	
23	Control system logics must suit the complexity of the integrated grid			x	
24	The equivalent model is requested to accurately and reliably represent a real grid		x		
25	Intermittent RES power controllers must react to voltage violation at LV and MV networks			x	
26	Aggregated effects of distributed RES must be taken into consideration in network models and the tool			x	
27	Controller definition is needed			x	
28	INTERPLAN tool must provide support to DSOs and TSOs for grid operation planning			x	
29	Use cases combined under each showcase need to be implemented in the same simulation environment			x	
30	Aggregation of loads and generators in the grid equivalents		x		
31	Each use case/showcase must specify the grid equivalents that will be used	x		x	
32	Grid equivalent/network model must be defined and a data source must be identified		x		
33	Equivalent DSO grid model must include a detailed model for each resource		x		
34	TSO and DSO grid equivalent models must support active and reactive power control using resources at DSO level		x		
35	Time series data should share a common data format			x	
36	Models for different technologies of storage are required			x	
37	Models for demand response are required			x	
38	Models of synthetic inertia and FFR controller			x	
39	RES and storage provide ancillary services			x	

ID	Name of the requirement	Use cases	Grid clustering	Operational tool	Testing & Validation
40	*Showcase definition is needed*			x	
41	*Control signals must not override each other*	x		x	
42	*Use cases algorithms used within a given showcase should not create any conflicts between themselves*	x		x	
43	*The operation planning tool must reduce the cost of energy*			x	
44	*INTERPLAN grid equivalent models must be compatible with CIM format*		x		
45	*Use cases should address the operating challenges of the current and future EU networks*	x			

Table 3 presents the template used to document INTERPLAN requirements. The fields in the template are defined as follows:
ID: Each requirement has its own identification number.
Priority: Each requirement has a priority (high, medium and low). Low priority requirements have been eliminated from this deliverable.
WP: The WP which is responsible for fulfilling and meeting the requirements.
Name: The title of the requirement.
Keywords: Keywords to indicate the requirements.
Description: A statement which describes the intention of the requirement.
Rationale: A justification of the requirement.
Acceptance criteria: A measurement of the requirement for further verification that the solution matches the original requirement.

Table 3: INTERPLAN requirements template

ID		**Priority**		**WP**	
Name					
Keywords					
Description					
Rationale					
Acceptance Criteria					

4 Use cases requirements

4.1 Introduction

INTERPLAN consortium has defined seven requirements for the use cases and sub-use cases. Those requirements focus on defining the main framework for the use cases and sub-use cases. This section from this deliverable acts as a bridge between task 3.1 "Define INTERPLAN requirements" and task 3.2 "Identification of scenarios and definition of INTERPLAN use cases". Some of the requirements focus on the details needed for each (sub-)use case/showcase (e.g. efforts, barriers, grid equivalents needed), while other requirements focus on the control and algorithms requirements. Table 4 presents the requirements for use cases and sub-use cases defined by INTERPLAN consortium.

Table 4: Requirements for use cases and sub-use cases

ID	***Name of the requirement***
12	*Use case must be prioritized before selection*
13	*The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase*
21	*Use case description must be detailed*
31	*Each use case/showcase must specify the grid equivalents that will be used*
41	*Control signals must not override each other*
42	*Use cases algorithms used within a given showcase should not create any conflicts between themselves*
45	*Use cases should address the operating challenges of the current and future EU networks*

4.2 Requirements

4.2.1 Use case must be prioritized before selection

ID	12	**Priority**	High	**WP**	3
Name	*Use case must be prioritized before selection*				
Keywords	Sub-use case, priority				
Description					
All the use cases must be prioritized. There shall be at least three priority classes (High, Medium, Low). The use cases with high and medium priority will be selected and reported.					
Rationale					
The most relevant use cases should be considered.					
Acceptance Criteria					
Priorities were defined at the time of use case definition and validation.					

4.2.2 The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase

ID	13	**Priority**	Medium	**WP**	3
Name	*The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase*				
Keywords	Use cases, showcases, effort, barriers, risk				
Description					
For any use case and showcase, there shall be an estimation about the effort needed to simulate it. There shall be at least three effort classes (High, Medium, Low). Barriers to implementation shall be identified at the time of use case and showcase definition, and also risks and risk mitigation measures shall be defined.					
Rationale					
Risks in the project implementation phase should be anticipated as soon as possible.					
Acceptance Criteria					
An estimation of the implementation effort, implementation barriers and risks as well as risk mitigation strategies (if applicable) is carried out during the development of each use case and showcase. The showcases and use cases are eventually modified in order to make risks and implementation efforts acceptable.					

4.2.3 Use case description must be detailed

ID	21	**Priority**	Medium	**WP**	3
Name	*Use case description must be detailed*				
Keywords	Use case				
Description					
A use case description should be detailed enough taking into consideration the simulation, grid equivalents and needed controllers.					
Rationale					
Use cases should be as specific as possible, as opposed to being generic.					
Acceptance Criteria					
The use case description contains information on the simulation environment, the procedure of simulation, required grid equivalents and controllers.					

4.2.4 Each use case/showcase must specify the grid equivalents that will be used

ID	31	**Priority**	High	**WP**	3, 4
Name	*Each use case/showcase must specify the grid equivalents that will be used*				
Keywords	Use cases, grid equivalents, DSO, TSO, DSO-TSO interaction, controllers, data models and sources, grid models, simulation				
Description					
A strong focus has to be set on how observable results of use cases/scenario are impacted by grid equivalents.					
Rationale					
To ensure that, the KPIs of use cases can be calculated for utilized grid equivalents					
Acceptance Criteria					
A library of grid equivalents will be provided. A document will be included, specifying for which use cases or showcases particular grid equivalents can be used.					

4.2.5 Control signals must not override each other

ID	41	**Priority**	High	**WP**	3, 5
Name	*Control signals must not override each other*				
Keywords	Control, conflict, use case, showcase				
Description					
Use cases should not control the same power system objects in a conflicting way if they are a part of the same showcase - in other words within a showcase set-points created by one use case shall not override set - points from another use case.					
Rationale					
The occurrence of such conflicts prevents given use cases from forming a showcase.					
Acceptance Criteria					
Control signals within a showcase do not override.					

4.2.6 Use cases algorithms used within a given showcase *should* not create any conflicts between themselves

ID	42	**Priority**	High	**WP**	3, 5
Name	*Use cases algorithms used within a given showcase should not create any conflicts between themselves.*				
Keywords	Conflict, use case, showcase				
Description					
For a given showcase, use cases that form it should be defined and prepared in such a way that they can be integrated with each other - no inconsistency shall exist within their sequences of action, control algorithms and their end goals shall not be in conflict.					
Rationale					
During development of control algorithms, it shall be kept in mind that the use case could be later integrated with another use case and this process might be repeated several times during the project, therefore, the use cases should be easily transferable from one model to another.					
Acceptance Criteria					
Use cases algorithms used within a given showcase do not create any conflicts between themselves.					

4.2.7 Use cases should address the operating challenges of the current and future EU networks

ID	45	**Priority**	High	**WP**	2, 3, 5
Name	Use cases should address the operating challenges of the current and future EU networks				
Keywords	Use Case, network operation				
Description					
Use cases should address the operating challenges of the current and future EU networks with emerging technologies including RES, storages, demand response and electric vehicles. These operating challenges will be identified based on analysis done in the WP2 on national and international grid codes and regulatory framework.					
Rationale					
The use cases are defined for the INTERPLAN models and the tool, which should be prepared to identify operation challenges and apply intervention measures.					
Acceptance Criteria					
The use cases should cover the shortcomings identified in the grid codes and regulatory framework analysis.					

5 Grid clustering and grid equivalents requirements

5.1 Introduction

INTERPLAN consortium has defined six requirements for grid clustering and grid equivalenting. Those requirements act as a bridge between WP3: Requirements, scenarios and use cases definition and WP4: Grid equivalenting. Those requirements focus on defining the data source and models' format that are going to be used. Moreover, they focus on functionalities which the grid equivalents models will support. Table 5 presents the requirements for grid clustering and grid equivalents defined by INTERPLAN consortium.

Table 5: Requirements for grid clustering and grid equivalents

ID	***Name of the requirement***
24	*The equivalent model is requested to accurately and reliably represent a real grid*
30	*Aggregation of loads and generators in the grid equivalents*
32	*Grid equivalent/network model must be defined and a data source must be identified*
33	*Equivalent DSO grid model must include a detailed model for each resource*
34	*TSO and DSO grid equivalent models must support active and reactive power control using resources at DSO level*
44	INTERPLAN grid equivalent models must be compatible with CIM format

5.2 Requirements

5.2.1 The equivalent model is requested to accurately represent real grids

ID	24	**Priority**	High	**WP**	4, 5
Name	*The equivalent model is requested to accurately and reliably represent a real grid*				
Keywords	Grid equivalents, TSO, DSO, TSO-DSO interfaces, intermittent RES, storages, flexible demand response, electric vehicles				
Description					
Grid equivalents allowing simulations should meet specific criteria defining adequacy of the response of the equivalent as compared to the full model. It includes requirements to analyse the impact of coordinated reactive power control on the losses in a multi-voltage level test case. The used grid equivalents need to be accurate regarding active power losses and voltages.					
Rationale					
To keep a reasonable level of accuracy in the substituted part of the model. To ensure the correct behaviour of distributed RES in the planning and operation practices.					
Acceptance Criteria					
The comparison between the response of the full model and its equivalent should not result in a difference larger than a specified threshold as calculated with root mean square error or any other method. Power flow results for grid equivalents and full models are acceptable for the given side conditions of grid equivalents. The comparison between the losses and voltage values within the full model and an average model where some parts are modelled in detail and some parts are replaced by equivalents should not result in a difference larger than a specified threshold as calculated with root mean square error or any other method.					

5.2.2 Aggregation of loads and generators in the grid equivalents

ID	30	**Priority**	High	**WP**	4, 5, 6
Name	*Aggregation of loads and generators in the grid equivalents*				
Keywords	DSO, TSO, TSO-DSO interface, data models and sources, controllers, grid models, simulation				
Description					
The reduction of the full grid to grid equivalents requires to assign load/generation data of the replaced grid to suitable locations in the grid equivalent.					
Rationale					
To keep a reasonable level of accuracy in the substituted part of the model					
Acceptance Criteria					
A methodology needs to be identified or defined to replace loads/generators in real network models to the most appropriate node in a grid equivalent. This can be solved with tools known from graph theory (e.g. graph centrality). However, a special focus is needed for grids with a number of branches, that will be replaced by a grid equivalent.					

5.2.3 Grid equivalent/network model must be defined and a data source must be identified

ID	32	**Priority**	High	**WP**	4, 5, 6
Name	*Grid equivalent/network model must be defined and a data source must be identified*				
Keywords	Grid equivalents, simulations, data models and resources, controllers, DSO, TSO, TSO-DSO interfaces				
Description					
For any grid equivalent/network model, all input data (generation, line characteristics, etc.) need to be defined and a data source needs to be identified. Data may be synthetically generated.					
Rationale					
Risks in the project implementation phase should be anticipated as soon as possible.					
Acceptance Criteria					
Each grid equivalent/network model contains an estimation of the implementation barriers and risks as well as risk mitigation strategies (if applicable).					

5.2.4 Equivalent DSO grid model must include a detailed model for each resource

ID	33	**Priority**	High	**WP**	4, 5
Name	*Equivalent DSO grid model must include a detailed model for each resource*				
Keywords	DSO, Grid equivalents, Simulations, Controllers				
Description					
Equivalent DSO grid model including a detailed model for each resource (storage, controllable loads, renewable generators).					
Rationale					
Needed to study DSO issues					
Acceptance Criteria					
DSO grid with a necessary number of nodes to study peak power and peak transformer load reduction management.					

5.2.5 TSO and DSO grid equivalent models must support active and reactive power control using resources at DSO level

ID	34	**Priority**	High	**WP**	4, 5
Name	*TSO and DSO grid equivalent models must support active and reactive power control using resources at DSO level*				
Keywords	TSO, DSO, grid equivalents, simulations, controllers				
Description					
Equivalent TSO and DSO grid models must support active power and reactive control at TSO level, by using resources at DSO level					
Rationale					
Needed to implement use cases related to the active and the reactive power control at TSO level by using resources at DSO level.					
Acceptance Criteria					
At least one equivalent TSO grid model with related equivalent DSO grid model for the relevant use cases (active power control at TSO level, by using resources at DSO level)					

5.2.6 INTERPLAN grid equivalent models must be compatible with CIM format

ID	44	**Priority**	High	**WP**	4
Name	*INTERPLAN grid equivalent models must be compatible with CIM format*				
Keywords	Simulation, CIM format, grid models				
Description					
INTERPLAN grid equivalent models must be compatible with CIM format and available on INTERPLAN website for download.					
Rationale					
INTERPLAN models must be compatible with CIM format in order to be able to communicate with each other in a standardized way.					
Acceptance Criteria					
There must be at least 10 equivalent models compatible with CIM format and available on INTERPLAN website.					

6 Requirements for the operation planning tool, showcases and controllers

6.1 Introduction

INTERPLAN consortium has defined twenty-seven requirements for the operation planning tool, showcases and controllers. Some of those requirements are common with another requirement set. Those requirements act as a bridge between WP3: Requirements, scenarios and use cases definition and WP5: Operation planning and semi-dynamic simulation. The requirements presented in this section form the structure of INTERPLAN operation planning tool and the controllers used for it. Table 6 presents the requirements for the operation planning tool, showcases and controllers defined by INTERPLAN consortium.

Table 6: Requirements for the operation planning tool, showcases and controller

ID	*Name of the requirement*
1	*DSOs support grid energy balancing by optimising the power flow at the distribution level*
2	*Requirements for simulating a use case/showcase*
11	*Models for electric vehicles are required*
13	*The effort, barriers, risk and risk mitigation must be estimated for each use case and showcase*
15	*Operation planning tool definition is needed*
16	*DSOs and TSOs must operate in a coordinated system*
17	*DSOs must participate in active and reactive power control and voltage support both in distribution and transmission systems*
18	*DSOs must be involved in the voltage regulation scheme as a real competitor*
19	*DSOs and TSOs must have a control mechanism over technical controllable units*
20	*There must be a TSOs-DSOs coordination interface to improve the DER management*
22	*The operation planning tool must focus on exploitation of flexibility sources*
23	*Control system logics must suit the complexity of the integrated grid*
25	*Intermittent RES power controllers must react to voltage violation at LV and MV networks*
26	*Aggregated effects of distributed RES must be taken into consideration in network models and the tool*
27	*Controller definition is needed*
28	*INTERPLAN tool must provide support to DSOs and TSOs for grid operation planning*
29	*Use cases combined under each showcase need to be implemented in the same simulation environment*
31	*Each use case/showcase must specify the grid equivalents that will be used*
35	*Time series data should share a common data format*

ID	Name of the requirement
36	*Models for different technologies of storage are required*
37	*Models for demand response are required*
38	*Model of synthetic inertia and FFR controller is required*
39	*RES and storage provide ancillary services*
40	*Showcase definition is needed*
41	*Control signals must not override each other*
42	*Use cases algorithms used within a given showcase do not create any conflicts between themselves*
43	*The operation planning tool must reduce the cost of energy*

6.2 Requirements

6.2.1 DSOs support grid energy balancing by optimising the power flow at the distribution level

ID	1	**Priority**	High	**WP**	5
Name	*DSOs support grid energy balancing by optimising the power flow at the distribution level*				
Keywords	Intermittent RES, storages, flexibility, demand response, DSO, optimise power flow				
Description					
In the operation planning tool, the DSOs should support TSOs in grid energy balancing by optimising the power flow at the distribution level.					
Rationale					
For the realization of the EU 2030 and 2050 energy targets, more involvement of all actors is needed.					
Acceptance Criteria					
The dispatchable energy sources and loads connected to the distribution level will respond to the request of power grid operators or the plant owner and participate in the power market. (This could include DGs RES, EVs, storage and consumers.)					

6.2.2 Requirements for simulating a use case/showcase

ID	2	**Priority**	High	**WP**	3, 5, 6
Name	*Requirements for simulating a use case/showcase*				
Keywords	Simulation, use cases, controllers, input data, data source				
Description					
For any use case/showcase to be simulated, a clear definition of simulation scenarios, involved controllers and/or sub-simulation components needs to be developed. According to simulation input data and time series need to be defined and a data source needs to be identified. Data may be synthetically generated.					
Rationale					
Project risk anticipation and mitigation. Use cases cannot be simulated without according data.					
Acceptance Criteria					
For a use case/showcase to be simulated, there is a description of needed simulation input data and possible sources for that data are identified. The first draft of this description is developed at the time of defining the use case, and the description is continuously refined and updated.					

6.2.3 Models for electric vehicles are required

ID	11	**Priority**	Medium	**WP**	4, 5
Name	*Models for electric vehicles are required.*				
Keywords	Electric vehicles, DSO, modelling				
Description					
EVs will be used as flexibility resources in the operation planning tool. Models for EVs are required.					
Rationale					
Models for simulating EVs are needed for their inclusion in the use cases which foresee their usage as controllable resources.					
Acceptance Criteria					
Correct behaviour of EVs based on the specific aim of the use case, which foresees the usage of EVs as controllable resources to manage operation issues at the distribution level.					

6.2.4 Operation planning tool definition is needed

ID	15	**Priority**	High	**WP**	3, 4, 5
Name	*Operation planning tool definition is needed*				
Keywords	Showcase, use case, sub-use case, scenario, grid equivalents, controllers				
Description					
Definition of the operation planning tool is needed for its proper development and implementation/validation.					
Rationale					
For the operation planning tool definition, several building blocks are needed: showcases, use cases/sub-use cases, scenarios, grid equivalents, simulation type, time series data and controllers. All these building blocks need to be defined in detail for the implementation and simulation phases.					
Acceptance Criteria					
All the building blocks composing the tool are defined and detailed enough for the operation planning tool implementation.					

6.2.5 DSOs and TSOs must operate in a coordinated system

ID	16	**Priority**	High	**WP**	4, 5
Name	*DSOs and TSOs must operate in a coordinated system*				
Keywords	TSO, DSO, intermittent RES, storages, flexible demand response, controller, grid equivalents				
Description					
The operation planning tool should ensure that DSOs and TSOs operate in a more coordinated way.					
Rationale					
Close coordination between DSOs and TSOs is needed for optimal and secure operation of power systems as demanded by European regulation ([1], Preamble (4), (10), (12); Articles 23, 24, 27, 29, 33, 37, 40; Chapter 3 “Data exchange between TSOs and DSOs within the TSO’s control area”, Chapter 5 “Data exchange between TSOs, DSOs and distribution-connected power generating modules”). Due to the reduced number of conventional synchronous generators connected to TSO grids (in some analysed future scenarios) leading to lower fault levels of the grid, TSOs must tap the resources at the distribution grid when provided. (This could include DGs, RES, EVs, storages and consumers.)					
Acceptance Criteria					
There must be a process definition for technical coordination between DSOs and TSOs for stable grid operation. Also, one or more of the following must be fulfilled: • There are controllers which make use of or enable DSO/TSO coordination • The operation planning tool enables planning DSO/TSO coordination actions					

6.2.6 DSOs must participate in active and reactive power control and voltage support both in distribution and transmission systems

ID	17	**Priority**	High	**WP**	4, 5
Name	*DSOs must participate in active and reactive power control and voltage support both in distribution and transmission systems*				
Keywords	TSO, DSO, intermittent RES, storages, flexible demand response, on-load tap changers of distribution grid, controller				
Description					
European regulation demands that TSOs “shall determine the voltage control actions in coordination with DSOs” and “agree with each transmission-connected DSO on the reactive power setpoints, power factor ranges and voltage set-points for voltage control at the connection point” ([1], Article 29). This is in accordance with Article 15 of the European Network Code on Demand Connection [2]. In the operation planning tool, the DSOs need to participate in reactive power control and voltage support both in distribution and transmission systems.					
Rationale					
Reactive power/voltage control in the distribution grid should not be conducted traditionally, e.g. through local tap operation, but rather by utilizing all available resources.					
Acceptance Criteria					
The DSOs distributes reactive power/voltage set points considering different priorities between TSO requests and DSO objectives.					

6.2.7 DSOs must be involved in the voltage regulation scheme as a real competitor

ID	18	**Priority**	Medium	**WP**	4, 5
Name	*DSOs must be involved in the voltage regulation scheme as a real competitor*				
Keywords	Intermittent RES, storages, flexible demand response, DSO, grid equivalents				
Description					
In the operation planning tool, the DSOs needs to be involved in the voltage regulation scheme as a real competitor.					
Rationale					
Integration of DSOs in a voltage regulation market is a known concept from research [3] [4] [5]. Active inclusion of distribution grid into TSO voltage regulation scheme would be possible with the provision of flexibilities in a proper time horizon for real-time regulations.					
Acceptance Criteria					
A voltage regulation scheme is defined which includes the DSO. There must be a fair and open competition between DSO assets and alternative voltage regulation means.					

6.2.8 DSOs and TSOs must have a control mechanism over technical controllable units

ID	19	**Priority**	High	**WP**	4, 5
Name	*DSOs and TSOs must have a control mechanism over technical controllable units*				
Keywords	Intermittent RES, storages, flexible demand response, DSO, TSO, controller				
Description					
In the operation planning tool, the DSOs and/or TSOs need to have a control mechanism (e.g. remote control) over technically controllable units (power system emerging technologies, DER).					
Rationale					
For the active contribution of defined units, they must be remotely controlled. Current European regulation already defines requirements for remote controllability of generators using logic interfaces, applicable to certain generator types according to TSOs specifications ([6], Article 13-15).					
Acceptance Criteria					
With the remote control in operation, respective units can be controlled according to requirements produced by the developed tool.					

6.2.9 There must be a TSOs-DSOs coordination interface to improve the DER management

ID	20	**Priority**	High	**WP**	5
Name	*There must be a TSOs-DSOs coordination interface to improve the DER management*				
Keywords	Intermittent RES, storages, flexible demand response, DSO, TSO, controller				
Description					
In the operation planning tool, a TSOs-DSOs coordination interface is needed to improve the DER management					
Rationale					
In the future power grid, the presence of DER will be higher and higher, so it is necessary to provide means for their management to improve network security.					
Acceptance Criteria					
With the TSOs-DSOs coordination interface, the power grid observability and security are improved at all levels (High Voltage (HV) to Low Voltage (LV)).					

6.2.10 The operation planning tool must focus on exploitation of flexibility sources

ID	22	**Priority**	High	**WP**	4, 5
Name	*The operation planning tool must focus on exploitation of flexibility sources*				
Keywords	Storage, flexible demand response, DSO, TSO, controllers, simulation				
Description					
The operation planning tool needs to focus on the exploitation of flexible energy sources (storage and demand response) installed all over the electric power network, and on their functional representation from the transmission and transmission/distribution interface perspective.					
Rationale					
The increasing share of variable renewable energy sources is calling for important changes in the energy system, such as more flexibility. The key is in managing all relevant flexible energy sources as "local active elements" within the grid, thereby involving DSOs in the balancing process.					
Acceptance Criteria					
Flexibility measures need to be included in the operation planning process as control parameters used to solve the operational issues identified in semi-dynamic/dynamic simulations of grid equivalents through proper control system logic.					

6.2.11 Control system logics must suit the complexity of the integrated grid

ID	23	**Priority**	High	**WP**	4, 5
Name	*Control system logics must suit the complexity of the integrated grid*				
Keywords	Storages, flexible demand response, controllers, simulation, DSO, TSO				
Description					
Control system logics need to suit the complexity of the integrated grid and apply the adequate intervention measures.					
Rationale					
To increase network observability, system logics should operate at all voltage levels.					
Acceptance Criteria					
Controllers for managing the physical clusters and interfacing controllers for effective linking of the physical clusters to form the integrated grid need to be developed. The control system logic needs to be able to cover a significant number of operational challenges within the chain transmission - end user. The appropriate control parameters need to be identified.					

6.2.12 Intermittent RES power controllers must react to voltage violation at LV and MV networks

ID	25	**Priority**	High	**WP**	5
Name	*Intermittent RES power controllers must react to voltage violation at LV and MV networks*				
Keywords	Intermittent RES, DSO, controllers, voltage violation, power quality, voltage stability, grid codes				
Description					
The voltage violation at LV and MV networks caused by intermittent RES needs to be compensated through power controllers. Power generation curtailment should be enforced only in extreme cases.					
Rationale					
To ensure the voltage stability of the system according to the grid codes.					
Acceptance Criteria					
The intermittent RES power controller must be able to react to a set-point request made by DSO or TSO or act according to the grid codes in order to compensate violations.					

6.2.13 Aggregated effects of distributed RES must be taken into consideration in network

models and the tool

ID	26	Priority	High	WP	4, 5
Name	*Aggregated effects of distributed RES must be taken into consideration in network models and the tool*				
Keywords	Intermittent RES, DSO, modelling				
Description					
The aggregated effects of distributed RES need to be taken into consideration in network models and the tool.					
Rationale					
To ensure the correct simulation of distributed RES in the planning and operation practices.					
Acceptance Criteria					
The distributed RES are simulated in an aggregated way in the network models and the tool. The error between the simulated model and actual data should not exceed a specific threshold.					

6.2.14 Controller definition is needed

ID	27	Priority	High	WP	3, 5
Name	*Controller definition is needed*				
Keywords	Use case, controllers, cluster, interface				
Description					
Definition of controllers including the related area/device under control is needed for their proper development and implementation/validation.					
Rationale					
For the control system logic development, the area (cluster or interface) and/or the device subjected to control needs to be defined in detail, based on the technical specifications of use cases and related sub use cases, and on the data sources.					
Acceptance Criteria					
The area/device subjected to control is clearly identifiable from the technical specifications of use cases. The data sources are defined and detailed enough for the controllers' development					

6.2.15 INTERPLAN tool must provide support to DSOs and TSOs for grid operation planning

ID	28	Priority	High	WP	3, 5
Name	INTERPLAN tool must provide support to DSOs and TSOs for grid operation planning				
Keywords	Tool, TSO, DSO, use cases, operation planning, controllers				
Description					
INTERPLAN tool will support DSOs and TSOs for grid operation planning through the implementation of the use cases and the related control system logic.					
Rationale					
In order to support the grid operators for operation planning of future power network, INTERPLAN tool needs to implement all the use cases developed to address the future operation planning issues, by also providing the proper solutions through controllers.					
Acceptance Criteria					
DSOs and TSOs must be able to implement the developed use cases through INTERPLAN tool.					

6.2.16 Use cases combined under each showcase need to be implemented in the same simulation environment

ID	29	**Priority**	High	**WP**	3, 5
Name	Use cases combined under each showcase need to be implemented in the same simulation environment				
Keywords	Use case, showcase, simulation				
Description					
The use cases combined under each showcase will be implemented in the same simulation environment.					
Rationale					
In order to guarantee a proper combination of use cases under each showcase (through the related sequence of actions), they need to be implemented in the same simulation environment.					
Acceptance Criteria					
The use cases under each showcase will be implemented in the same simulation environment. However, for different showcases, several simulation environments can be used.					

6.2.17 Models for different technologies of storage are required

ID	36	**Priority**	High	**WP**	4, 5
Name	*Models for different technologies of storage are required*				
Keywords	Storage, DSO, modelling				
Description					
Different technologies of storage will be used as flexibility resources in the operation planning tool. Proper models for simulating different technologies of storage are therefore required.					
Rationale					
Different technologies of storage meeting complementary requirements of the integrated grid need to be modelled thus facilitating the analysis and operation of the actively integrated grid.					
Acceptance Criteria					
The correct response of different types of storage based on the specific aim of the use case, which foresees the usage of storage systems as controllable resources to manage operation issues at the distribution level.					

6.2.18 Models for demand response are required

ID	37	**Priority**	High	**WP**	4, 5
Name	*Models for demand response are required.*				
Keywords	Demand response, DSO, modelling				
Description					
Demand response will be used as flexibility resource in the operation planning tool. Proper models for simulating demand response are required.					
Rationale					
Models for simulating aggregated demand response are needed for their inclusion in the use cases which foresee their usage as a controllable resource.					
Acceptance Criteria					
The correct behaviour of demand response based on the specific aim of the use case, which foresees its usage as a controllable resource to manage operation issues at the distribution level.					

6.2.19 Models of synthetic inertia and FFR controller

ID	38	**Priority**	High	**WP**	5
Name	*Models of synthetic inertia and FFR controller are required*				
Keywords	Intermittent RES, storage, TSO, DSO, data models and sources				
Description					
Models of synthetic inertia and Fast Frequency Response (FFR) controller must be present in DIgSILENT PowerFactory so that it is possible to simulate and validate RES and storage capability to provide additional inertia to the power system.					
Rationale					
Models for simulating synthetic inertia and FFR capabilities of converter-connected RES and storage units are needed in order to include those technologies into the inertial response of the electric power system. Since synthetic inertia is a relatively new concept, proper models, in particular for dynamic models of large systems might not be available or might not represent the real devices in an accurate way.					
Acceptance Criteria					
The correct response from synthetic inertia and FFR controllers.					

6.2.20 RES and storage provide ancillary services

ID	39	**Priority**	High	**WP**	5
Name	*RES and storage provide ancillary services*				
Keywords	Intermittent RES, Storage, TSO, DSO				
Description					
RES and storage should be able to participate in providing ancillary services. This means that all needed controllers and models are available in the simulation environment and also that there is a regulatory framework established for this kind of services and power market can potentially be used to trade them.					
Rationale					
The operation planning tool needs to have the ability to enable the DER participation in the ancillary services (e.g. frequency support) to achieve a secure and reliable power system.					
Acceptance Criteria					
RES and storage are able to provide ancillary services.					

6.2.21 Showcase definition is needed

ID	40	**Priority**	High	**WP**	3, 4, 5
Name	*Showcase definition is needed*				
Keywords	Showcase, use case, scenario, grid models				
Description					
Showcase definition is needed in order to develop a consistent set of showcases that can be then implemented using the chosen simulation environment.					
Rationale					
For defining showcases properly several building blocks are needed: use cases, chosen scenario, grid models, simulation type and time-series data. All given building blocks should be defined in detail so that showcases can be properly implemented and simulated.					
Acceptance Criteria					
All building blocks are defined and detailed enough for a showcase implementation.					

6.2.22 The operation planning tool must reduce the cost of energy

ID	43	**Priority**	Medium	**WP**	5
Name	*The operation planning tool must support the reduction of the cost of energy*				
Keywords	TSO, DSO, TSO-DSO interface, simulation				
Description					
INTERPLAN planning tool should be able to support the schedule of the generation and consumption and reduce the cost of energy.					
Rationale					
The INTERPLAN tool must optimise planning of the system operation in such a way that the energy delivered to the end user is as cheap as possible, considering the variable RES cheapest cost of energy.					
Acceptance Criteria					
The cost of energy is calculated by the INTERPLAN tool, which will consider maximising the share of RES and reduce the losses as to planning criteria for system operation. Therefore, the tool operates the system in a cost-effective way.					

7 Requirements for testing and validation

7.1 Introduction

INTERPLAN consortium has defined ten requirements for validating and testing INTERPLAN tools. Those requirements act as a bridge between WP3: Requirements, scenarios and use cases definition and WP6: INTERPLAN model validation and testing. Those requirements form the foundation for co-simulation and OpSim platform. Table 7 presents the requirements for validating and testing INTERPLAN tools defined by the consortium.

Table 7: Requirements for validating and testing INTERPLAN tools

ID	Name of the requirement
3	*Co-simulation subcomponents must implement the OpSim data model and communication protocol and must support the common time series format*
4	*Any co-simulation subcomponent must be able to run in real-time or faster*
5	*Co-simulation subcomponents must be tested in stand-alone operation before they are connected to the co-simulation*
6	*There must be at least one test defined which validates the subcomponent interface to the OpSim platform*
7	*The co-simulation platform must provide a mechanism which synchronizes all subcomponents*
8	*All co-simulation subcomponents must be able to synchronize using a mechanism provided by the co-simulation platform*
9	*All co-simulation subcomponents must be able to announce their state to the co-simulation platform*
10	*All co-simulation subsystems must be able to uniquely identify themselves towards the co-simulation platform*
14	*Co-simulation subcomponents must communicate only through well-defined co-simulation platform data structure*
35	*Time series data should share a common data format*

7.2 Requirements

7.2.1 Co-simulation subcomponents must implement the OpSim data model and communication protocol and must support the common time series format

ID	3	Priority	High	WP	5, 6
Name	*Co-simulation subcomponents must implement the OpSim data model and communication protocol and must support the common time series format*				
Keywords	co-simulation, OpSim, communication protocol, data model, subsystem				
Description					
Any co-simulation subcomponent to be used in WP6 must implement the OpSim data model and communication protocol. This is usually done by using a proxy/client module which interfaces to OpSim. Also, subcomponents must support the common time series format. The latter requirement should also be fulfilled by WP5 simulation components.					
Rationale					
Subcomponents need to be compatible with the OpSim platform. The data model and communication protocol are common to all subsystems. A common time series format for all subcomponents is preferred because it removes the need for data format conversions, thus removes the risk of data inconsistencies and conversion errors.					
Acceptance Criteria					
All co-simulation subcomponents to be used in WP6 implement the OpSim data model and communication protocol and can read the common time series format.					

7.2.2 Any co-simulation subcomponent must be able to run in real-time or faster

ID	4	Priority	High	WP	5, 6
Name	*Any co-simulation subcomponent must be able to run in real-time or faster*				
Keywords	Use cases, subcomponent, simulation				
Description					
Any co-simulation subcomponent must be able to run in real-time or faster.					
Rationale					
The co-simulation speed can only be as fast as the slowest subcomponent, and the WP6 goal is to simulate in real-time.					
Acceptance Criteria					
Any co-simulation subcomponent is able to run in real-time or faster					

7.2.3 Co-simulation subcomponents must be tested in stand-alone operation before they are connected to the co-simulation

ID	5	Priority	High	WP	6
Name	*Co-simulation subcomponents must be tested in stand-alone operation before they are connected to the co-simulation*				
Keywords	Co-simulation, test, subcomponent, simulation				
Description					
Any co-simulation subcomponent to be used in WP6 must be tested in a stand-alone operation mode according to predefined criteria. Tests must be passed before the subcomponent is connected to the co-simulation.					
Rationale					
Only tested subcomponents of similar matureness can be successfully connected in a co-simulation.					
Acceptance Criteria					
There are testing procedures defined and documented for each subcomponent to be used in WP6. Tests were passed before connection to the co-simulation platform.					

7.2.4 There must be at least one test defined which validates the subcomponent interface to the OpSim platform

ID	6	**Priority**	High	**WP**	6
Name	*There must be at least one test defined which validates the subcomponent interface to the OpSim platform*				
Keywords	Co-simulation, test, subcomponent, OpSim, simulations				
Description					
For any co-simulation subcomponent which is used in WP6, there must be at least one test defined which validates the subcomponent interface to the OpSim platform. According to tests must have passed before integration of the subsystem within the co-simulation platform.					
Rationale					
Inoperable interfaces are a common problem in a co-simulation environment, so it must be made sure that all interfaces are correct.					
Acceptance Criteria					
For each subcomponent to be used in WP6, at least one test according to the requirement description is defined, documented and passed before integration in the co-simulation platform.					

7.2.5 The co-simulation platform must provide a mechanism which synchronizes all subcomponents

ID	7	**Priority**	High	**WP**	6
Name	*The co-simulation platform must provide a mechanism which synchronizes all subcomponents*				
Keywords	Co-simulation, synchronization, subcomponents, simulations				
Description					
The co-simulation platform must provide a mechanism which synchronizes all subcomponents.					
Rationale					
Time and event synchronization are basic needs in a distributed co-simulation environment. Also, there need to be well-defined means for starting, stopping, and eventually suspending the co-simulation.					
Acceptance Criteria					
All subcomponents are synchronized with the co-simulation platform					

7.2.6 All co-simulation subcomponents must be able to synchronize using a mechanism provided by the co-simulation platform

ID	8	**Priority**	High	**WP**	6
Name	*All co-simulation subcomponents must be able to synchronize using a mechanism provided by the co-simulation platform*				
Keywords	Co-simulation, subcomponents, synchronization, simulations				
Description					
All co-simulation subcomponents to be used in WP6 must be able to synchronise using a mechanism provided by the co-simulation platform.					
Rationale					
Subcomponents eventually need to suspend and wait until results from other subcomponents are available. Also, subcomponents need to be able to be started, stopped and eventually suspended by the co-simulation platform.					
Acceptance Criteria					
Co-simulation subcomponents to be used in WP6 are able to synchronise using the mechanism provided by the co-simulation platform.					

7.2.7 All co-simulation subcomponents must be able to announce their state to the co-simulation platform

ID	9	**Priority**	High	**WP**	6
Name	*All co-simulation subcomponents must be able to announce their state to the co-simulation platform*				
Keywords	Co-simulation, subcomponents, state, simulations				
Description					
All co-simulation subcomponents to be used in WP6 must be able to announce their state to the co-simulation platform, where allowed states at least include: ready, started, stopped, and failed.					
Rationale					
The co-simulation platform needs to know the status of each subcomponent in order to successfully organize synchronization.					
Acceptance Criteria					
All co-simulation subcomponents to be used in WP6 announce their state to the co-simulation platform (ready, started, stopped, failed).					

7.2.8 All co-simulation subsystems must be able to uniquely identify themselves towards the co-simulation platform

ID	10	**Priority**	High	**WP**	6
Name	*All co-simulation subsystems must be able to uniquely identify themselves towards the co-simulation platform*				
Keywords	Co-*simulation*, subsystems, simulations, identification				
Description					
All co-simulation subsystems to be used in WP6 must be able to uniquely identify themselves towards the co-simulation platform.					
Rationale					
The co-simulation master must be able to identify available subsystems					
Acceptance Criteria					
The co-simulation platform is able to uniquely identify all the co-simulation subsystems.					

7.2.9 Co-simulation subcomponents must communicate only through well-defined co-simulation platform data structure

ID	14	**Priority**	High	**WP**	6
Name	*Co-simulation subcomponents must communicate only through well-defined co-simulation platform data structure*				
Keywords	Simulation, co-simulation, subcomponents, communication				
Description					
Individual co-simulation subcomponents to be used in WP6 may not bilaterally communicate directly, but only through well-defined co-simulation platform data structures.					
Rationale					
Reduction of complexity and sources for bugs.					
Acceptance Criteria					
Each co-simulation subcomponent has exactly one well-defined communication channel to the co-simulation platform only.					

7.2.10 Time series data should share a common data format

ID	35	**Priority**	Medium	**WP**	5, 6
Name	*Time series data should share a common data format*				
Keywords	Time series, simulation, co-simulation				
Description					
The time series data for electricity generation and load, and also secondary data (e.g. data needed for generating synthetic forecasts) needed for simulation should be stored in a common data format, and all simulation components should be able to read that format.					
Rationale					
Reduction of complexity and sources for bugs. Ensuring that the same time series data is used in all simulations and data is not corrupted through buggy data format conversion.					
Acceptance Criteria					
There is a unique data format defined for time series, and only this format is used by all simulations. Any time series obtained in another format is converted to the common format before the simulation.					

8 Summary and outlook

This document summarizes the requirements that are defined for INTERPLAN project by INTERPLAN consortium. The consortium has defined forty-five requirements to act as the foundation for INTERPLAN project. A preliminary list of requirements was created and later validated and revised by the whole consortium. After the revision process, an intermediate list of requirements was created that was further grouped, classified and prioritized. The requirements were grouped into four sets:

- Use cases
- Grid clustering and grid equivalenting
- Operation planning tool, showcases and controller
- Testing and validation

and where described in detail in the present report. The first set of requirements focuses on use case requirements, while the second set focuses on grid clustering and grid equivalent requirements. The use case requirements and the grid clustering and grid equivalents requirements are documented in chapter 4 and 5, respectively. The third set focuses on the operation planning tool, showcases and controller requirements which is documented in chapter 6. The fourth set which is documented in chapter 7 which focus on testing and validation the co-simulation tools. Those requirements serving as the basis for the project activities.

In the further stages of the project, based on the defined requirements as well as defined use cases and identified EU grid scenarios (which will be reported in D3.2: INTERPLAN use cases in parallel), a series of showcases as well as required grid equivalent models will be developed. Then, a set of dynamic and semi-dynamic simulations for each showcase will be performed, and the possible criticalities as well as the possible solutions will be identified.

9 References

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10 Annex

10.1 List of Figures

10.2 List of Tables

10.3 Glossary of terms and definitions

10.3.1 Definition of project general terms

Term	Definition
Use Case	The specification of a set of actions performed by a system, which yields an observable result that is, typically, of value for one or more actors or other stakeholders of the system.
Sub Use Case	Description of a specific situation a use case is applied to. A Sub Use Case is always attributed to one (main) use case, but one use-case may have multiple sub use cases which detail the main use case in at least one aspect.
Showcase	Presentation of use case(s) in the frame of the chosen scenario, simulation type, test model, time-series data and planning criteria
Scenario	Definition of a future situation applying to a well-defined time (most often a year). A scenario can be fictional or predicted from the present situation. In INTERPLAN, scenarios describe the future situation of the European electric network, typically including grid topology, generation mix, loads and diffusion of EV, RES and storages.
Dynamic Simulation	A simulation experiment which considers the time-dependent behaviour of a physical system, looking at events occurring in real-time operation, with a frequency of occurrence of less than one second of real time. The simulation may run faster or slower than real time, and may, despite the fast event frequency, span a total time interval of several hours real-time.
Semi-Dynamic Simulation (also: Quasi-Dynamic Simulation)	A medium- to long-term simulation experiment based on steady-state analysis, considering the state of a physical system at discrete steps of real-time through user-defined time step sizes. The real-time between the steps is at least one minute.
Grid Cluster	A group of grids and parts of grids with similar characteristics.
Grid Equivalent	A simplified network model, which approximately behaves like an associated complex physical network or a group of physical networks. The grid equivalent thus is a representation of the physical network(s), which is typically used for a simulation experiment.
Controller	A device, which implements an algorithm or methodology that is used for real-time grid operation. A controller may influence the operation state of distributed generators, loads or grid assets (e.g. tap changer, power switch, FACTS) based on information from different sources.
Interface	A means of transmitting information between two or more controllers or actors. It usually includes a specification about which information is to be transmitted, how this information is represented by data elements and defines a physical means for transmission of those data elements.
Cluster Controller	A controller having the aggregated behavior of individual controller characteristic in a larger grid.
Interface	A controller which is intended to be installed in a specific "home" cluster, and

Term	Definition
Controller	uses information received through an interface from at least one other cluster data source outside the home cluster. This data source could e.g. be another cluster, but also e.g. an external weather forecast provider using an interface
Local Controller	A controller which is associated with a single specific generator, load or grid asset and which operation does not rely on remotely received information originating from any remote source. i.e. the operation only relies on information available within the local area network of the local controller's installation site.
Co-simulation	A simulation which consists of different parts that form a coupled problem and are modelled and simulated in a distributed manner (cp. Wikipedia). The parts are called "Co-simulation subsystems" and are exchanging data during the simulation. Different models and simulation means can be used in different subsystems. The Co-simulation (in the ideal case) is carried out by running the subsystems, which were individually tested and validated beforehand, in a black-box manner. In INTERPLAN, the data exchange between subsystems is done by the OpSim platform.
Co-simulation subsystem / Co-simulation subcomponents	A part of a Co-simulation which is developed, modelled and validated individually, while at the same time able to be integrated into the Co-simulation platform. In INTERPLAN, a subsystem might represent e.g. a DSO or TSO operation centre, a controller, or even the real physical network model.
Data model	An abstract model that represents a real-world entity, and defines, organizes and standardizes the description of the data elements related with that entity. Since real-world entities are typically consisting of other entities (e.g. an electric grid consists of lines, transformers etc.), a data model typically is hierarchically structured and also allows to define interrelations between entities.
V2G and G2V	Vehicle-to-grid (V2G) describes a system in which plug-in electric vehicles communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate. When an EV is being charged, it’s called G2V (Grid to Vehicle).

10.3.2 Definition of actors

Term	Definition
TSO - Transmission System Operator	The natural or legal person responsible for operating, ensuring the maintenance of the transmission system and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. The term ‘transmission’ means the transport of electricity on the extra-high-voltage and high-voltage interconnected system with a view to its delivery to final customers or to distributors but does not include supply.
DSO - Distribution	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where

Term	Definition
System Operator	applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity. The term 'distribution' means the transport of electricity on high-voltage, medium-voltage and low-voltage distribution systems with a view to its delivery to customers, but does not include supply.
ESCO	Electricity supply company (sometimes also: Electricity service company). General term for a company which supplies end users with electric energy. An ESCO may offer additional services, e.g. electricity generation, metering or supply with non-electric energy.
Prosumer	Active energy consumer who consumes and produces electricity. Various types of prosumers exist residential prosumers who produce electricity at home - mainly through rooftop PV, citizen-led energy cooperatives, commercial prosumers whose main business activity is not electricity production, and public institutions.
Generator	A device which produces electricity.
Load	A device which consumes electricity.
Producer	A natural or legal person generating electricity.
Consumer	A natural or legal person consuming electricity.
Distributed Energy Resource (DER)	A source or sink of electric power that is located on the distribution system, any subsystem thereof, or behind a customer meter. DER may include distributed generation, electric storage, electric vehicles and demand response.
Aggregator	The company who grouping distinct agents in a power system (i.e. consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the system operator(s).
Distributed generation (DG) unit	Any source of electric power of limited capacity, directly connected to the power system distribution network. DG can be powered by a photovoltaic system, micro-turbines, combustion engines, fuel cells, wind turbines, geothermal, etc.
Flexible Loads	A load which consumption can be influenced in terms of power, time, or total energy consumed while still serving its intended purpose. The influence may be exerted by manual means (e.g. switching the load on or off at arbitrary times) or automatic means (e.g. external control signal).