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ESTABLISHMENT OF THE SECOND LIST OF UNION PROJECTS OF COMMON INTEREST

EVALUATION OF CANDIDATE PROJECTS OF COMMON INTEREST IN THE FIELD OF SMART GRIDS

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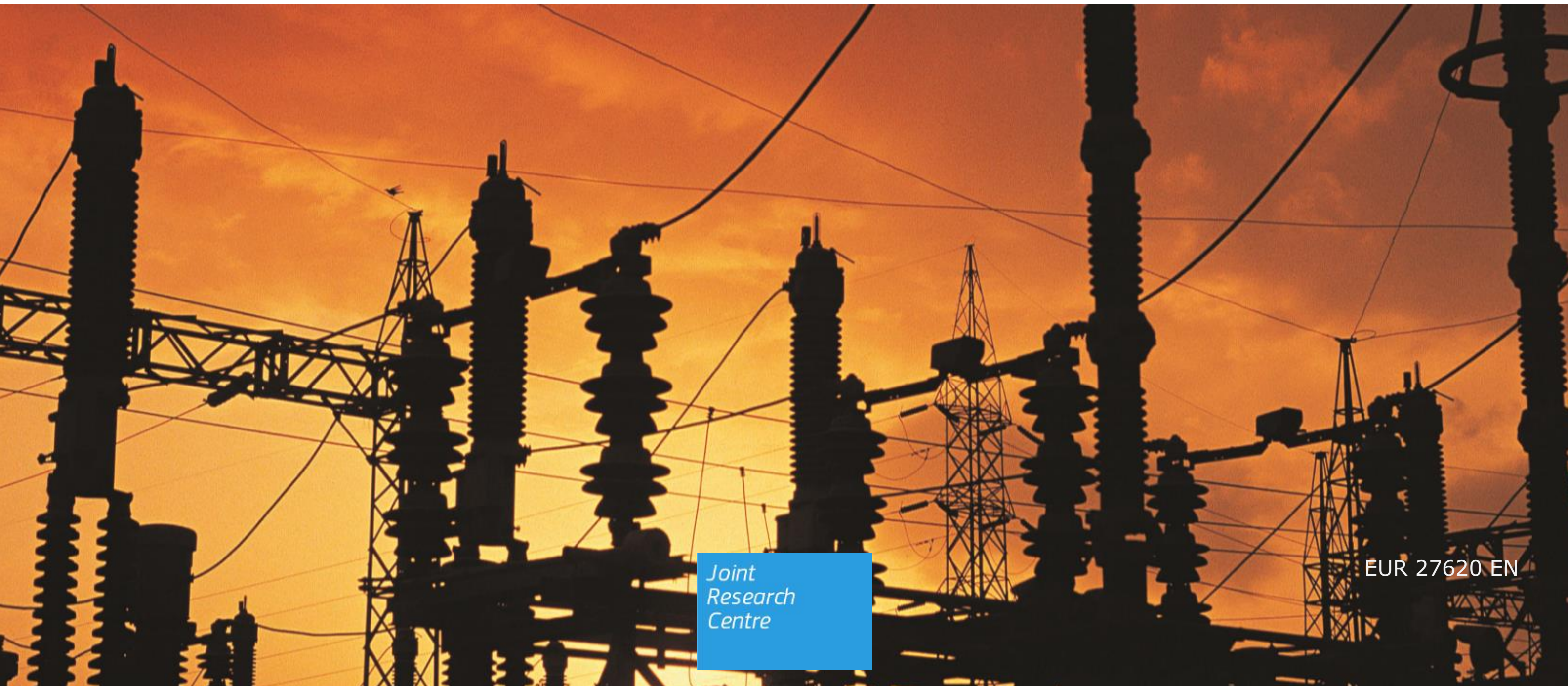

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Abstract
Evaluation of candidate Projects of Common Interest in the field of Smart Grids
The document presents the outcome of the evaluation process of candidate Projects of Common Interest in the area of Smart Grids, under the trans-European energy infrastructure regulation. The evaluation follows the guidelines of the assessment framework for Smart Grid projects, developed by the JRC within the EC Smart Grid Task Force.

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Executive summary

Policy context

Projects of Common Interest are key energy infrastructure projects essential for completing the European internal energy market and reaching the Union's energy policy objectives of affordable, secure and sustainable energy. This report supports the implementation of the EU Regulation on trans-European energy infrastructure (Regulation EU No. 347/2013) and in particular the assessment of candidate Projects of Common Interest in the field of Smart Grids. It is intended to assist the Smart Grid Thematic Group (comprised of competent Ministries, national regulatory authorities, electricity transmission operators, project promoters, ENTSO for Electricity, the Agency, and the European Commission) in selecting Projects of Common Interest in the area of Smart Grids. Moreover, the document provides lessons learned from the evaluation process and on that basis proposes further developments in the assessment and selection of Smart Grid Projects of Common Interest.

Key conclusions

The document presents the outcome of the evaluation process of Smart Grid Candidate Projects of Common Interest, based on the assessment framework for Smart Grid Projects of Common Interest, developed by the JRC and adopted within the EC Smart Grid Task Force.

Three candidate projects have been submitted and evaluated, namely: North-Atlantic Green Zone (Member States: Ireland and UK-Northern Ireland), GREEN integration of renewable energy in the north Mediterranean (Member States: Italy and France) and SINCROGRID (Member States: Slovenia and Croatia).

The EU Regulation on trans-European energy infrastructure calls upon the assessment of key energy infrastructure projects against a set of economic and technical criteria. Considering that not all the project features can be adequately captured in quantified or monetary terms, the techno-economic evaluation of each project proposal was carried out through a societal Cost-Benefit Analysis (CBA), a Key Performance Indicator (KPI) assessment and a qualitative appraisal of benefits. The valuing of selected impacts via the respective Key Performance Indicators served as a basis for monetising these impacts in the societal CBA. In this regard, the KPI-based analysis can be seen as a complementary approach to the CBA analysis, adopted to assess quantifiable impacts that cannot be reliably monetised.

The number of Smart Grid candidate Projects of Common Interest, especially when compared to electricity transmission candidate projects, is still rather low. The turnout of project applications deserves special attention and further analysis in order to understand the underlying root causes, which certainly include regulatory, financial and methodological aspects. Against this background, and with particular reference to the methodological aspects, this document provides lessons learned from the evaluation process and proposes further developments in the assessment methodology (with special regard to certain Key Performance Indicators). This is expected to support project promoters in future application submissions for Smart Grid candidate Projects of Common Interest.

Related and future JRC work

The JRC aims to support the European Commission's Energy Union strategy to make energy more secure, affordable and sustainable, and foster sustainable and efficient transport in Europe. A modern energy infrastructure is crucial for an integrated energy market and to enable the EU to meet its broader climate and energy goals. This requires considerable investment in the existing gas and electricity networks, with rapid development of their interconnections. In order to face these challenges, JRC research includes desktop and experimental studies on ways to integrate renewable energy sources into the power grid. It also investigates the grid interoperability with, for example ICT and transport systems. The Union list of Projects of Common Interest is updated every two years and on this ground, the JRC aims to continue supporting energy infrastructure development policies in general and smart grid deployment policies in particular.

Quick guide

To assist the development of an integrated EU energy market, every two years the European Commission adopts a list of key energy infrastructure projects - known as Projects of Common Interest (PCIs). This report presents the outcome of the evaluation of Smart Grid project proposals, carried out within the Smart Grid thematic group, to be included in the 2015 Union list of Projects of Common Interest. The assessment framework, developed by the JRC and adopted within the Smart Grid Task Force, aims to serve as guidance for project promoters to prepare their PCI proposals and for the Smart Grid thematic group to propose and review Projects of Common Interest, under the trans-European energy infrastructure Regulation.

1. INTRODUCTION

1.1. Objectives

This report presents the outcome of the evaluation of Smart Grid project proposals which has been carried out within the Smart Grid thematic group. The group comprises representatives of competent Ministries, national regulatory authorities, electricity transmission operators, project promoters, ENTSO for Electricity, the Agency, and the European Commission.

The assessment framework for Projects of Common Interest in the area of smart grids [1] has been developed within the Smart Grid Task Force[1], Expert Group on smart grid infrastructure deployment, and used as guidance for project promoters to prepare their PCI proposals and for the Smart Grid thematic group to propose and review Projects of Common Interest, under the trans-European energy infrastructure regulation (Regulation EU No. 347/2013) [2].

1.2. Background

In the context of the Commission's proposal to launch a new energy strategy "Europe 2020" and therefore promote more resource-efficient, sustainable and competitive economy, the energy infrastructure has been put at the forefront, by underlining the need to urgently upgrade Europe's networks and interconnect them at the continental level, in particular to integrate and increase the penetration of renewable energy sources.

For electricity projects falling under the categories set out in Annex II.1 of Reg. 347/2013 EU, each regional group shall be composed of representatives of the Member States, national regulatory authorities, TSOs, as well as the Commission, the Agency and the ENTSO for Electricity. The Smart Grid thematic group represents the priority thematic area on smart grids deployment, as defined in Annex I of Reg. EU 347/2013 and focuses on the adoption of smart grid technologies across the Union to efficiently integrate the behaviour and actions of all users connected to the electricity network, in particular the generation of large amounts of electricity from renewable or distributed energy sources and demand response by consumers.

In this context, PCI proposals in the area of Smart Grid shall clearly demonstrate their contribution to the policy criteria, as defined in Annex IV of the Regulation EU 347/2013, and the positive outcome of the respective cost-benefit analysis.

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1 https://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force

For smart grids projects falling under the energy infrastructure category set out in Annex II.1 (e), ranking shall be carried out for those projects that affect the same two Member States, and due consideration shall also be given to the number of users affected by the project, the annual energy consumption and the share of generation from non-dispatchable resources in the area covered by these users.

Projects of common interest falling under the categories set out in Annex II.1 (e) which also includes Smart Grid projects, shall also be eligible for Union financial assistance in the form of grants for works. Such assistance would be eligible if the project promoters can clearly demonstrate the significant positive externalities generated by the projects and their lack of commercial viability, according to the business plan and other assessments carried out, notably by possible investors or creditors or, where applicable, a national regulatory authority.

1.2.1. Eligibility requirements

Projects of common interest shall meet the following general criteria, according to the trans-European energy infrastructure regulation (Reg. EU 347/2013):

1) the project should contribute to the implementation of at least one of the energy infrastructure priority corridors and thematic areas (Annex I Reg. EU 347/2013);
2) the potential overall benefits of the project, assessed according to the respective specific policy criteria, set out in Annex IV (4) Reg. EU 347/2013, outweigh its costs, including in the longer term;
3) Project of common interest shall also meet any of the following criteria:
    - The project involves at least two Member States by directly crossing the border of two or more Member States
    - The project is located on the territory of one Member State and has a significant cross-border impact as set out in Annex IV.1
    - The project crosses the border of at least one Member State and a European Economic Area country.

Project of Common Interest shall significantly contribute to the six specific policy criteria, considered in 2) and set out in Annex IV (4) Reg. 347/2013, namely:

- **Level of sustainability**: This criterion shall be measured by assessing the reduction of greenhouse gas emissions, and the environmental impact of electricity grid infrastructure.
- **Capacity of transmission and distribution grids to connect and bring electricity from and to users:** This criterion shall be assessed by estimating the installed capacity of distributed energy resources in distribution networks, the allowable maximum injection of electricity without congestion risks in

transmission networks, and the energy not withdrawn from renewable sources due to congestion or security risks.

- **Network connectivity and access to all categories of network users**: This criterion shall be measured by assessing the methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both and the operational flexibility provided for dynamic balancing of electricity in the network.
- **Security and quality of supply**: This criterion shall be addressed by assessing the ratio of reliably available generation capacity and peak demand, the share of electricity generated from renewable sources, the stability of the electricity system, the duration and frequency of interruptions per customer, including climate related disruptions, and the voltage quality performance.
- **Efficiency and quality of service in electricity supply and grid operation**: This criterion shall be measured by assessing the level of losses in transmission and in distribution networks, the ratio between minimum and maximum electricity demand within a defined time period, the demand side participation in electricity markets and in energy efficiency measures, the percentage utilisation (*i.e.* average loading) of electricity network components, the availability of network components (related to planned and unplanned maintenance), and its impact on network performances, and the actual availability of network capacity with respect to its standard value.
- **Contribution to cross-border electricity markets by load-flow control to alleviate loop-flows and increase interconnection capacities**: This criterion shall be estimated by assessing the ratio between interconnection capacity of a Member State and its electricity demand, the exploitation of interconnection capacities, and the congestion rents across interconnections.

2. ASSESSMENT FRAMEWORK FOR PROJECTS OF COMMON INTEREST

2.1. Minimum technical requirements

As previously mentioned and in line with the requirements of Reg. EU 347/2013, a project is considered to be eligible as candidate Project of Common Interest, providing it fulfils the following criteria:

- The project is designed for equipment and installations at high-voltage and medium-voltage level designed for a voltage of 10 kV or more;
- The project involves transmission and distribution system operators from at least two Member States;

- The project area involves at least 50 000 users that generate or consume electricity or do both;
- The project covers consumption area of at least 300 GWh/year;
- The project area includes at least 20% electricity generation originating from renewable resources that are variable in nature.

2.2. Project's potential overall benefits outweigh its costs, in long term

Further to the fulfilment of the eligibility requirements, a candidate Project of Common Interest shall clearly demonstrate that the overall potential benefits brought out by the project deployment outweigh the project cost. This shall be demonstrated through the outcome of a societal cost-benefit analysis performed by the project promoters. The assessment framework for Projects of Common Interest in the area of Smart Grid [1] indicates guidelines for quantifying and monetizing potential benefits associated with smart grid projects deployment. This document shall serve as guidance to the project promoters when preparing their project proposals and assist the Smart Grid Thematic Group in reviewing and proposing Smart Grids Projects of Common Interest to be included in the second Union list of Projects of Common Interest.

2.3. Project contribution to policy criteria – via Key Performance Indicators

In addition to the positive outcome of the societal cost-benefit analysis, project proposals shall clearly demonstrate significant project contribution to the policy criteria, as set out in Annex IV of Reg. EU 347/2013. The assessment framework for Projects of Common Interest in the area of Smart Grid proposes relevant Key Performance Indicators (KPIs) for evaluation of the project contribution towards attainment of each single policy criterion, as listed below.

Policy criterion 1: Level of sustainability

KPI^{a}_{1}: Reduction of greenhouse emissions

KPI^{b}_{1}: Environmental impact of electricity grid infrastructure

Policy criterion 2: Capacity of transmission and distribution grids to connect and bring electricity from and to users

KPI^{a}_{2}: Installed capacity of distributed energy resources in distribution networks

KPI^{b}_{2}: Allowable maximum injection of electricity without congestion risks in transmission networks

KPI^{c}_{2}: Energy not withdrawn from renewable sources due to congestion or security risks

Policy criterion 3: Network connectivity and access to all categories of network users

KPI^{a}_{3}: Methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both

KPI^{b}_{3}: Operational flexibility provided for dynamic balancing of electricity in the network

Policy criterion 4: Security and quality of supply

KPI^{a}_{4}: Ratio of reliably available generation capacity and peak demand

KPI^{b}_{4}: Share of electricity generated from renewable sources

KPI^{c}_{4}: Stability of the electricity system

KPI^{d}_{4}: Duration and frequency of interruptions per customer, including climate related disruptions

KPI^{e}_{4}: Voltage quality performance

Policy criterion 5: Efficiency and service quality in electricity supply and grid operation

KPI^{a}_{5}: Level of losses in transmission and distribution networks

KPI^{b}_{5}: Ratio between minimum and maximum electricity demand within a defined time period

KPI^{c}_{5}: Demand side participation in electricity markets and in energy efficiency measures

KPI^{d}_{5}: Percentage utilisation (*i.e.* average loading) of electricity network components

KPI^{e}_{5}: Availability of network components (related to planned and unplanned maintenance) and its impact on network performances

KPI^{f}_{5}: Actual availability of network capacity with respect to its standard value

Policy criterion 6: Contribution to cross-border electricity markets by load-flow control to alleviate loop-flows and increase interconnection capacities

KPI^{a}_{6}: Ratio between interconnection capacity of a Member State and its electricity demand

KPI^{b}_{6}: Exploitation of interconnection capacities

KPI^{c}_{6}: Congestion rents across interconnections

The evaluation process follows the guidelines adopted by the Smart Grid Task Force Expert Group 4 and includes three main elements, as depicted in Figure 1. Fulfilment of the eligibility requirements is a precondition for the next steps, *i.e.* evaluation of the project contribution to the policy and economic criteria, as set out in Annex IV of Reg. EU 347/2013.

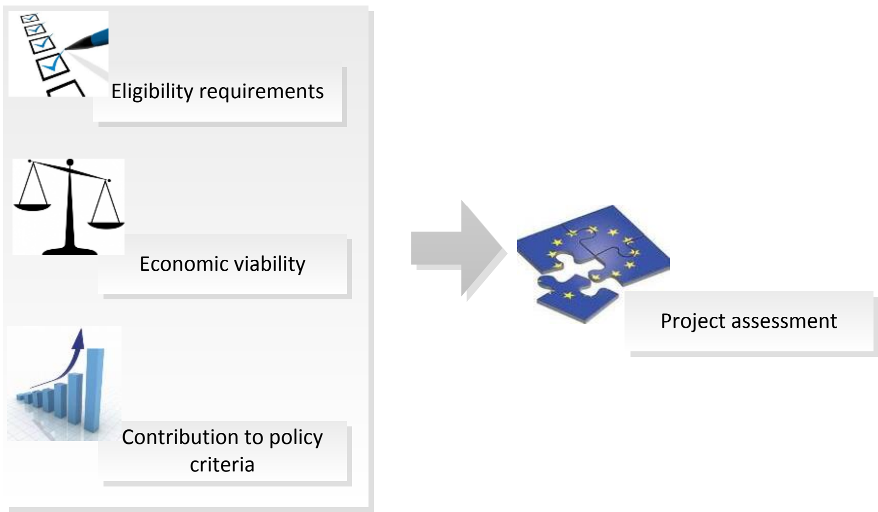

Figure 1 Overview of the evaluation process for smart grid projects of common interest

The assessment framework for smart grid candidate projects of common interests adopts a colour-coded approach for assessing project economic viability (through societal cost-benefit analysis) and project contribution to the six policy criteria, as mentioned above. Three main colours (green, yellow and red) and mixed evaluations between two colours are used, resulting in a scale of five different possible types of evaluation.

Green colour indicates assessment of positive impact with sufficient level of confidence.

Yellow colour indicates assessment of some positive impact with some confidence; however, uncertainties may persist either in the information provided or in the assumptions made.

Red colour indicates assessment of limited impact or inability of performing impact assessment due to lack of information.

3. EVALUATION OF PROJECT PROPOSALS

In line with the energy infrastructure regulation requirements and upon official request for information launched by the Commission, the following projects were submitted by 27th February 2015:

- **N**orth **A**tlanti**c** **G**reen **Z**one **(NAGZ) –** Member States involved: Ireland and Northern Ireland
- **G**rid Integration of **Re**newable **E**nergy Sources in the **N**orth **Me**diterranean (GREEN-ME) – Member States involved: France and Italy
- SINCRO.GRID – Member States involved: Slovenia and Croatia

The sections below illustrate the evaluation of the three project proposals.

3.1. North-Atlantic Green Zone (Ireland and Northern Ireland)

3.1.1. General overview

The project proposal involves the North-West area of the Republic of Ireland (IE) and the West area of Northern Ireland (UK). No interconnections with UK mainland are foreseen. Although they are two different countries, UK Northern Ireland and IE form a Single Electricity Market since 2007. The project proposal involves four promoters, namely: ESB Networks (Irish DSO and Meter Operator), Northern Ireland Electricity-NIE (DSO of Northern Ireland), EirGrid (TSO and Market Operator of IE) and System Operator Northern Ireland -SONI (TSO and Market Operator of Northern Ireland).

The project encompasses an area with exceptional wind generation capabilities whose harnessing poses significant challenges on the transmission and distribution network operation. To this end, in large part of the project area, the TSOs have to reduce the real time penetration of variable Renewable Energy Sources (RES), in particular wind generation. Experience to date made evident the need to introduce innovative technologies and advanced network operational capabilities to the system, involving all system users (generators, consumers and those that do both). The implementation of this project is expected to demonstrate on a large scale a network that can accommodate, according to the promoters, renewables close to 300% of customer demand in the zone (exceeding the national target of 40% of energy coming from RES in both, Ireland and Northern Ireland). The key towards such benefits is to leverage the current electrical and ICT infrastructure by implementing TSO-DSO and cross-border inter-operator coordination framework which will optimise the network management across the power system, and efficiently integrate demand side resources.

Main project goals:

- Mitigating the challenges presented at system level due to RES integration already reaching critical levels for system stability

- Providing variable access network capacity on distribution networks and at system level
- Improving distribution continuity and security standards
- Reducing distribution losses and delivering energy efficiencies
- Leveraging the benefits of increased cross-border co-operation and connectivity

3.1.2. Role of DSOs and TSOs

The role of the DSOs in the project area focuses on increasing the observability and controllability of the distribution Medium Voltage grid, which would result in enhanced management of the transmission grid by the TSOs. The TSOs will also participate (in collaboration with the DSOs) in reviewing the potential use of existing 110 kV interconnectors for normal operation to balance renewable generation, load and reactive power.

The project will require DSOs – TSOs co-operation in the following areas:

- Development of operational framework between DSOs and TSOs for implementing voltage and reactive power control for wind generation at both distribution and transmission network level, operating the new distribution interconnectors and frequency control measures at DSO level.
- Installation of reactive compensation resources, with optimal location points to be jointly determined by DSOs and TSOs.
- Development of market frameworks for demand side management for energy losses optimisation at both DSOs and TSOs system level and enabling growing potential of RES at both DSO and TSO system level.
- Management of cross-border flow at distribution network level
- Development of operational framework for management of future energy storage applications in the distribution and transmission systems for frequency support, and thus reducing the level of wind curtailment.

Contingency supply challenges on either side of the border at distribution level have so far been addressed in the context of isolated systems. The project proposes 5 interconnections operated by the respective DSOs with consultation and agreement with the corresponding TSOs, which will more economically and effectively address these challenges.

The TSOs have the sole responsibility for active dispatch of generation over 5MW on the power system of Ireland and Northern Ireland. With the advent of DG penetration on the distribution network, and in the absence of a comprehensive interaction framework for DG dispatch, the DSOs must reactively manage the implications of DG penetration in real time. The DSOs and TSOs would therefore need to work together to deliver a fully coordinated framework, effectively addressing generation dispatch at distribution system level.

3.1.3. Cross-border impact and added value of joint project

The project focuses on increasing the potential of existing 110 kV connections and further increasing the physical connections through cross-border co-operation at distribution level. The 110 kV interconnections between the Republic of Ireland and Northern Ireland (UK) systems which are controlled by phase shift transformers lie in the proposed North Atlantic Green Zone. These transformers were installed for emergency back-up and are currently used for limited flows (20MVA out of 90MVA total transfer capacity). Therefore, the project addresses an improved exploitation of the 110 kV interconnections for normal operation, *i.e.* in balancing renewable generation, and for optimal control of both active and reactive power across the border that would lead to increased hosting capacity of renewables in the area. To achieve this, the project promoters propose development and deployment of communication and control software between the two 110 kV interconnectors that would allow for their full exploitation through automated coordination. Potential benefits arising from improved exploitation of these interconnectors include the following:

- Increase of MW transfers (subject to considerable network capacity limits) to reduce curtailment of RES. Where greater levels of non-firm wind generation can be accommodated, this might also lead to lower network constraint payments (*i.e.* balancing costs) and lower wholesale prices for consumers.
- Provision of enhanced operational security during transmission maintenance
- Coordinated MVar dispatch to optimise voltage levels, thereby enhancing system security, and reducing losses
- Enhanced frequency control
- Use of real-time information exchange to increase interconnection capacity.

Furthermore, the project proposal notes that 'further interconnections to address capacity transfer limitations between the two jurisdictions are already planned and are being submitted for funding under the TYNDP [3] and considered as part of the Renewable Integration Development Plan (RIDP). The project promoters, however, clarified that the envisaged reduction in RES curtailment will be solely achieved through measures addressed in the specific smart grid proposal (such as frequency response and reactive power management) and not through the additional capacity considered under RIDP and TYNDP.

3.1.4. Compliance with eligibility requirements

North Atlantic Green Zone fulfils the eligibility requirements, as indicated below.

- Voltage level(s) greater than 10 kV

The project involves Medium Voltage (MV) network levels of 10 kV, 20 kV, 33 kV and 38 kV and therefore complies with this eligibility requirement.

- Number of users involved (producers, consumers and prosumers) greater than 50 000

The project covers an area with 172 972 network users involved.

- Consumption level in the project area greater than 300 GWh/year

The consumption level in the project area is 1 324 GWh/year.

- Percentage of consumption supplied from renewable resources that are variable in nature of at least 20%

The total connected wind capacity in the project area is 766 MW, which is above 300 % of the total consumption (226 MW).

- Involvement of transmission and distribution system operators of at least 2 Member States

The project involves the DSOs and TSOs of both Republic of Ireland and Northern Ireland.

3.1.5. Smart Grid dimension

The main focus of NAGZ project is to address challenges faced by the network operators in the project area due to increasing share of variable renewable energy at both distribution and transmission system levels. Deployment of innovative technologies and advanced network operational capabilities on one hand side and cross-border co-operation and market integration on the other may lead to wind curtailment reduction from 25% to 6%. In this context, NAGZ offers smart grid solutions in the following areas:

- Enhanced frequency response due to implementation of advanced anti-islanding protection schemes
- Enhanced voltage/reactive power control as a result of provision of real-time control signals (provided by fibre optic communication)
- Increased capacity due to introduction of variable access capacity and dynamic line rating
- Meeting power continuity and security standards due to deployment of advanced protection and outage detection mechanisms (ASC, FPIs and Pathfinder)
- Increased network efficiency as a result of advanced power flow monitoring (based on network sensors and near real time communication), reduced network losses (due to dynamic network sectionalisation, network voltage conversion, etc.) and consumer engagement to deliver peak demand reductions.

3.1.6. System architecture and deployed assets

NAGZ is intended to implement the following measures in order to deliver the full project benefits:

- **ICT infrastructure** – the High Voltage stations in the project zone will be connected via fibre optic network to the relevant control centres. Along with this, a method for receiving high resolution readings (higher bandwidth) and providing real time control needs to be installed for the devices on the Medium Voltage feeders. A 4G field area network will then be deployed by ESB Networks to connect all medium voltage down-line sensors and devices including reclosers, switches, voltage regulators, fault passage indicators and mobile operator communications. NIE will deploy a similar field area network using either GPRS or polled radio solutions to connect downstream 11kV network devices and generators for control and monitoring. This network will enable monitoring for local area protection schemes and remote operation of these devices, allowing for control of dynamic network operations. It will also allow higher volume data collection for network planning and post fault analysis.

- **Distribution Management System Network** – the current DMS network will integrate high speed reliable communications, full electrical models of the 38kV and 110kV systems and full deployment of network sensors into the distribution control centres and use of ICCP link to the transmission control centres to effectively and efficiently manage the system operation through:
    - Rapid post fault network sectionalisation
    - Real time network optimisation – voltage optimisation to reduce energy consumption
    - Variable tap changer set point implementation
    - Network losses optimisation
    - Reactive power management

As a result, the abovementioned DMS functionalities will enable active management of:

- MW active power outputs to the embedded generators
- MVAr reactive power outputs to the embedded generators and to the reactive power resources on the network
- Voltage set points to the embedded generators and to the voltage regulating resources on the network – tap changer, regulators
- Demand by altering network sectionalisation to actively match demand and generation curves in real time.

- **Dynamic thermal rating –** Dynamic line rating has already been trialled on specific 33kV networks in the project area of Northern Ireland and there are trials for its application on transmission connected renewables. This means that at any given time the hosting network capacity is determined through calculation of the real time network ratings based on local conditions, thus increasing the installed capacity above the firm MEC (Maximum Export Capacity) and potentially reducing the connection costs.
- **Variable wind access –** Currently the allowed level of generation installed capacity is determined based on worst case conditions, so that no voltage/thermal loading limits are violated. However, such restrictions may only be applicable at particular times, outside of which higher levels of installed

capacity may be feasible. Therefore, allowing variable wind access will result in higher wind farms capacity factors and increased installed generation capacity above the MEC, where the DSO in co-operation with the TSO will continually optimise the generation output while dynamically manage the network operation. Development of such variable access contracts will require clear and transparent operational framework in place.

- **Wind generation Volt/Var control –** Wind generation Volt/Var control will be integrated into distribution management system (DMS) tools, with active voltage management determined by the DSOs to meet expected voltage and reactive power conditions based on network and weather forecasts. Wind generation Volt/VAr control will be co-ordinated and agreed with the TSOs.

- **Storage and demand response –** Local loading conditions have a direct impact on the wind level operating at the distribution network. Storage deployment could increase the level of variable generation accepted onto the network, however due to still existing regulatory challenges, storage is not included in this proposal.

- **Reactive power management –** Voltage rise is the primary constraint on the level of distributed generation that can be safely connected to the grid. At present, generation must operate at an inductive power factor of 0.95, absorbing reactive power and thus posing challenges on the network power factor management and increasing losses. Due to the local nature of this issue, ESB Networks will install reactive compensation resources at optimal points on the distribution network to meet voltage and power factor profiles determined by the DSOs and TSOs at bulk supply points in the project area. The location and capacities of such reactive power resources will depend on the load and generation, in addition to the operational parameters and framework agreed between the TSOs and DSOs.

- **Medium voltage protection, fault isolation, location and restoration –** through:

    - **Distribution automation and remote control:** the project proposal includes number of initiatives to decrease the level of outages in the project area through: installation of 2.5 reclosers per outlet with self-healing functionality to isolate the faulted part of the network and 2.5 remote control switches per rural circuit to automatically enable further isolation of the faulted network.

- **Medium voltage arc suppression:** the project envisages deployment of ASCs at all 20 kV networks in the project area, as an innovative protection scheme; it is expected to reduce outage cost savings by 67% and average customer interruptions and number of customers impacted by almost 50%.
- **Smart fault passage indication:** the project envisages installing 3 fault current passage indicators on each MV network in the project area for providing high quality, accurate current and fault current indication directly to network operators in near real time.
- **Smart integrated fault location:** for easier fault location with near real-time notification, the MV arc suppression systems, fault passage indicators and ESB Networks Pathfinder devices have been integrated into a new deterministic method of quickly and safely locating fault sites.
- **Single Phase reclosers:** deployment of single phase reclosers will clear transient earth faults on a single phase networks, thereby isolating the impact to the minimum number of customers.

- **20 kV network conversion –** the project includes conversion of all rural MV networks (around 3000 km) from 10 kV to 20 kV, which will result in doubling network thermal capacities, halving the level of voltage drop and reducing the peak losses by 60%. This is an on-going ESBN intervention on a nationwide level and will ultimately facilitate the increased level of wind connection in the region.

- **Cross-border distribution connections** – the project proposes development of five distribution level interconnections, operated by DSOs in coordination with the TSOs. In addition to developing distribution level interconnections, there are two interconnections between the Republic of Ireland and Northern Ireland 110kV systems which are controlled by phase shift transformers. The specifications of these transformers have been carefully tailored to the network capacities on either side of the interconnection to allow for optimal control of both active and reactive power across the border. At present these interconnections are used in a limited fashion only. Nevertheless, phase shift transformers may provide efficient management of variable generation in the area, using wider operating range and settings. Therefore, such investment may effectively address the challenges of balancing renewable generation, load and reactive power on both side of the border, ultimately leveraging reliability and quality of supply.

The system and communication architecture of NAGZ project is depicted in Figure 2 and Figure 3, respectively.

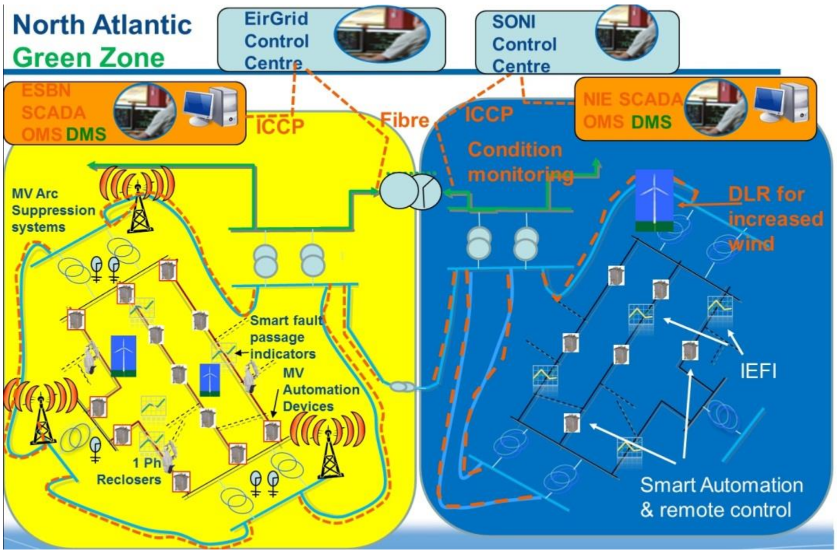

Figure 2 NORTH GREEN ZONE system architecture (Source: NAGZ promoters)

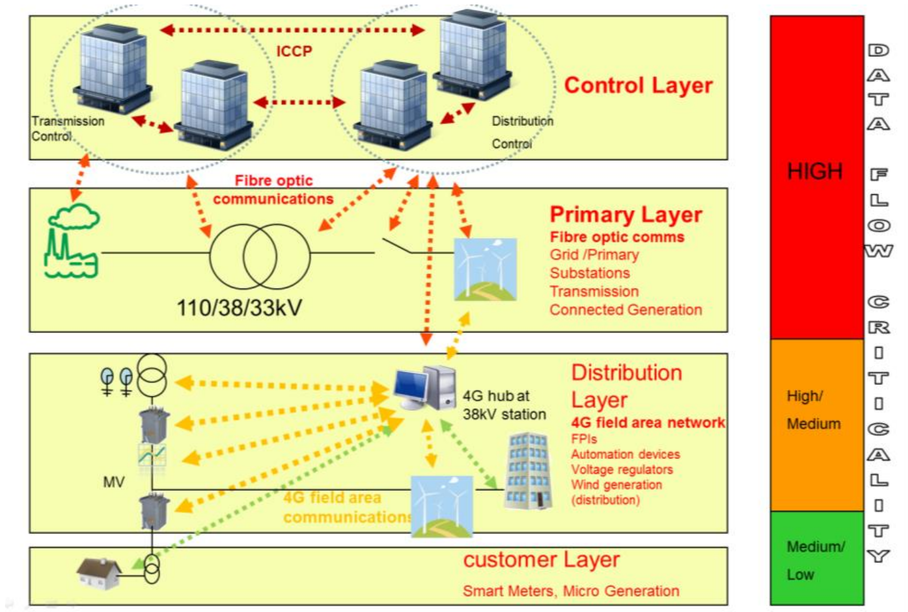

Figure 3 NORTH GREEN ZONE communication architecture (Source: NAGZ promoters)

3.1.7. Contribution to the policy criteria – evaluated through Key Performance Indicators

The NAGZ project includes the following key assumptions in the evaluation of the project impact on the six policy criteria, namely:

- NAGZ project envisages a substantial wind curtailment reduction from 25% (BaU scenario) to 6% (Smart Grid scenario, *i.e.* with the project deployment). This will ultimately lead to a sizeable reduction in the wholesale production costs as a result of avoided curtailed wind production and additional energy of replacement generation. Therefore, being the most significant benefit of the project, it is important to measure the impact if these savings do not materialise as expected. To this end, sensitivity analysis has been considered to account for factors beyond the NAGZ project's control, in which case the reduction drops to 10%, instead of 6%.

- Given the concerted efforts to incentivise and aid the delivery of wind generation in the region, 80% of the planned and contracted wind generation required nationwide to achieve Ireland's 2020 goals is expected to be delivered under the smart grid scenario (*i.e.* with NAGZ deployment), relative to the 70% assumed in the Business as Usual scenario (*i.e.* without NAGZ deployment).

- Variable access capacity of wind generation at MV network level will allow an additional 177 MW to be connected by the project deployment.

A. Level of sustainability

The project is expected to significantly contribute towards the decrease of Green House Gas (GHG) emissions, in particular CO2, due to increase in network hosting capacity for wind generation, resulting from 20 kV network conversion, dynamic sectionalisation, voltage management and frequency control, loss reduction and new variable wind connection arrangements. The project reported CO2 savings of around 300 kg/MWh and mainly as a result of:

- Energy savings due to conservation voltage reduction

- MV network loss savings due to 20 kV conversion

- MV network loss savings due to dynamic network sectionalisation

- Increased network hosting capacity due to provision of variable access at 38 kV and 110 kV network

The NAGZ project is expected to have a positive environmental impact, resulting from reduced needs for building overhead lines, due to:

- Energy efficiency increase through 20 kV conversion, dynamic sectionalisation and conservation voltage reduction

- Increased MV network capacity through conversion of over 2800 km of 10 kV network lines to 20 kV, which will more than double the network capacity to accommodate load and generation connections

- New route options for network reinforcement at MV network level with cross-border distribution interconnection, which may ultimately result in transmission network deferral
- Reduced generation investments due to improved energy efficiency
- Deployment of amorphous core transformers with significantly lower no-load loss factor (and also meeting strict noise pollution limits), in comparison with conventional transformers.

Table 1 illustrates the project impact assessment on the sustainability criterion.

Table 1 North Atlantic Green Zone: evaluation of project impact against the first policy criterion

Level of sustainability	Project impact	
KPI $^{a}_{1}$ Reduction of Green House Gas Emissions	KPI was positively assessed to 311.6 kg/MWh. NAGZ is expected to reduce the CO2 emissions, due to: • Energy savings as a result of CVR, 20 kV conversion, dynamic sectionalisation • Increased planned RES generation (relative to the BaU scenario) and additional RES connection to the 38 kV and 110 kV network due to variable access provision. Key assumption: Wind curtailment reduction from 25% (BaU) to 6% (SG scenario).	
KPI $^{b}_{1}$ Environmental impact of electricity grid infrastructure	The projects is expected to have positive environmental impact due to reduced needs of overhead lines, mainly through: • Increase of energy efficiency (via CVR, dynamic sectionalisation and 20 kV network conversion) • Increased MV network capacity through 20 kV network conversion • Transmission network and generation capacity deferral • Deployment of next generation amorphous core transformers (low noise pollution).	

B. Capacity of transmission and distribution grids to connect and bring electricity from and to users

The impact on this criterion is mainly assessed through the project contribution towards increasing hosting capacity of the distribution and transmission networks to accommodate growing amount of renewables and reduced curtailed energy that may result from congestion or security risks.

In this context, the wind generation capacity that could be injected into the existing distribution grid will be increased, owing to increase of MV network thermal capacity due to network conversion of 10 kV to 20 kV, dynamic load rating and variable wind access. The project is also expected to increase the hosting capacity of the transmission network due to cross-border integration initiatives and dynamic line rating and contribute towards reduction of wind curtailment from 25% to 6%. Table 2 depicts the evaluation of the NAGZ project impact on this criterion.

Table 2 North Atlantic Green Zone: evaluation of project impact against the second policy criterion

<table>
<tr><th>Capacity of transmission and distribution grids to connect and bring electricity from and to users</th><th colspan="2">Project impact</th></tr>
<tr><td>KPI $^{a}_{2}$ Installed capacity of distributed energy resources in distribution networks</td><td>KPI is positively assessed to 0.574. Increased DER installed capacity is expected due to:
Allowing variable access at 20 kV, 38 kV and 110 kV
Additional installed capacity of the planned and contracted DER in the region (in comparison to the BaU scenario), due to incentive mechanisms to deliver wind generation in the region
Reduced energy consumption through loss reduction and CVR).
Key assumption: Wind curtailment reduction from 25% (BaU scenario) to 6% (SG scenario).</td><td></td></tr>
</table>

Capacity of transmission and distribution grids to connect and bring electricity from and to users	Project impact	
KPI $^{b}_{2}$ Allowable maximum injection of power without congestion risks in transmission networks	A detailed quantitative assessment has not been carried out due to lack of sufficient time. However a positive Impact is expected owing to: • Replacement of existing conductors with HTLS conductors • Increased cross border capability • Dynamic line rating • Reactive power/voltage management.	
KPI $^{c}_{2}$ Energy not withdrawn from renewable sources due to congestion or security risks	KPI was positively estimated to 0.361 and 0.423 in two SG scenarios (under current wind connections and additional connections in the regions enabled by variable access, respectively). The energy consumption is also reduced through loss reduction and CVR. Key assumption: Wind curtailment reduction from 25% (BaU scenario) to 6% (SG scenario).	

C. Network connectivity and access to all categories of network users

This criterion addresses the project contribution towards facilitation and integration of demand side participation and demand management, resulting from adoption of advanced network control and monitoring mechanisms to ensure quick and reliable response from both the generation and consumption side. Nevertheless, such arrangements require development of adequate operational and market frameworks, often being beyond the control of the project promoters. Table 3 illustrates the assessment of NAGZ project on this criterion.

Table 3 North Atlantic Green Zone: evaluation of project impact against the third policy criterion

Network connectivity and access to all categories of network users	Project impact	
KPI $^{a}_{3}$ Methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	Advanced monitoring and control capabilities offered by the project will enable detailed grid information, and are expected to allow for: • A wider range of connection solutions for generators – by offering a range of variable capacity options. • More accurate determination of loss factors, both time of use and average, for demand and generation customers at different voltage levels. • Provision of ancillary services by allowing generators to contribute to system stability though reactive power supply.	
KPI $^{b}_{3}$ Operational flexibility for dynamic balancing of electricity in the network	KPI was positively estimated, assuming: • 10 % commitment of MV consumers to DSM • 20 % commitment of MV consumers to DSM • Facilitation of future storage applications, enabled by the project • Reduced peak demand, as a result of 20 kV conversion, dynamic sectionalisation and CVR.	

D. Security and quality of supply

The NAGZ project covers an area with sub-standard network availability and low loading conditions, which limits the level of demand available to balance the impact of growing penetration of renewables. Taking this into account and the increasing wind capacity in the project area, deployment of storage appears as a viable solution. NAGZ does not include storage as part of the project, nevertheless, the electrical infrastructure, communication and market arrangements, addressed by the project, will facilitate hosting of future storage applications. Table 4 depicts the evaluation outcome of the NAGZ project in respect to the fourth policy criterion.

Table 4 North Atlantic Green Zone: evaluation of project impact against the fourth policy criterion

<table>
<tr><th>Security and quality of supply</th><th colspan="2">Project impact</th></tr>
<tr><td>KPI $^{a}_{4}$ Ratio of reliably available generation capacity and peak demand</td><td>The KPI was positively estimated to 11.4%. Benefits are expected as a result of peak shaving measures, such as:
20kV conversion leading to peak loss reduction of 2292 kW.
Dynamic sectionalisation leading to peak loss reduction 371.2 kW.
CVR leading to peak reduction of 3389 kW.
Furthermore, deployment of communication and electrical infrastructure and market arrangements within the project will facilitate hosting of storage and further contribute to this KPI.

KPI was calculated only for the Irish part of the zone with the assumption that similar factors will apply to Northern Ireland.</td><td></td></tr>
<tr><td>KPI $^{b}_{4}$ Share of electricity generated from renewable sources</td><td>The KPI was positively estimated to 0.665. Increase of electricity generated from RES is expected due to:
Reduced wind curtailment from 25% to 6%.
Planned RES generation and additional RES due to variable access of wind connection to the 38 kV and 110 kV network.
Reduction of electricity consumption due to CVR, dynamic sectionalisation and 20 kV network conversion.
Key assumption: Wind curtailment reduction from 25% to 6%.</td><td></td></tr>
<tr><td>KPI $^{c}_{4}$ Stability of the electricity system</td><td>This KPI was positively assessed to 0.253 on the base of increased system stability due to reduction of wind curtailment. Time constraints did not allow for project impact evaluation on this KPI, in terms of voltage and frequency violations.

Key assumption: Reduction of wind curtailment from 25% to 6%.</td><td></td></tr>
</table>

Security and quality of supply	Project impact	
KPI $^d_4$ Duration and frequency of interruptions per customer, incl. climate related disruptions	This KPI was positively assessed. Presently there are poor continuity indexes in the region. Significant improvement is expected, due to: deployment of arc suppression coil system, distribution automation schemes and single phase reclosers (in IE). To this end, SAIDI is expected to improve by around 37% and SAIFI by around 59%.	
KPI $^e_4$ Voltage quality performance	This KPI was positively estimated with voltage complaints used as a proxy. Significant improvement, in terms of voltage violations (~35%) and THD (~30%) is expected in the IE zone due to 20 kV conversion. KPI was calculated only for the IE part of the project area.	

E. Efficiency and service quality in electricity supply and grid

This criterion addresses increase in network operation efficiency and service quality due to: 1) reduction of distribution network losses, expected to be achieved through 20 kV conversion of the 10 kV networks and dynamic sectionalisation, 2) conservation voltage reduction, 3) demand side participation and 4) provision of variable wind access. Although storage is not being deployed as part of the North Atlantic Green Zone its impact was taken into account on this criterion, as communication and energy infrastructure, and market arrangements, expected with the project deployment, will facilitate hosting of future storage. Table 5 illustrates the evaluation of the project impact on this criterion.

Table 5 North Atlantic Green Zone: evaluation of project impact against the fifth policy criterion

Efficiency and service quality in electricity supply and grid	Project impact	
KPI $^a_5$ Level of losses in transmission and in distribution networks	This KPI was positively assessed to 0.84%. Expected benefits appear due to 20 kV conversion and dynamic sectionalisation.	

Efficiency and service quality in electricity supply and grid	Project impact	
KPI $^{b}_{5}$ Ratio between minimum and maximum electricity demand within a defined time period	This KPI was positively estimated (14.5%) due to peak and valley load reductions (as a result of CVR, commitment of 10% of consumers to DSM, peak loss reduction and facilitation of future storage applications). The KPI is only assessed for the IE part of the zone with the assumption that similar factors will apply to the whole region.	
KPI $^{c}_{5}$ Demand side participation in electricity markets and in energy efficiency measures	This KPI is positively assessed as a result of assumed 10% participation of large consumers in demand response, storage and energy efficiency through CVR.	
KPI $^{d}_{5}$ Percentage utilisation (*i.e.* average loading) of electricity network components	An increase of 30% was reported as conservative estimate due to: 20 kV conversion, DTR, variable wind capacity access and enhance monitoring of equipment. Nevertheless, technical and regulatory uncertainties persist, and do not allow for more accurate quantification of the project impact on this criterion.	
KPI $^{e}_{5}$ Availability of network components (related to planned and unplanned maintenance) and its impact on network performances	Move from interval-based to condition-based maintenance has reduced the maintenance requirement by 30%. Nevertheless, the availability of distribution and transmission assets is generally very high, thus an estimate of 5% of availability improvement was reported due to implementation of condition based maintenance system.	
KPI $^{f}_{5}$ Actual availability of network capacity with respect to its standard value	Real time asset monitoring and enhanced network visibility enables maximum utilisation of assets and narrowing down contingency requirements, as a result of greater network control. Accurate quantification of the exact capacity increase has been however difficult to assess due to the scale and diversity of the NAGZ project. Thus, expected increase of 20% availability of network capacity has been communicated as a conservative estimate.	

F. Contribution to cross-border electricity markets by load flow control to alleviate loop flows and increase interconnection capacity

One of the main focuses of the NAGZ project is to develop and enhance the utilisation of the interconnection capacity in the project area, both through better exploitation of the existing 110 kV interconnectors and development of five new distribution network interconnectors, thus leveraging the existing common market in the region. Table 6 illustrates the project impact assessment on this criterion.

Table 6 North Atlantic Green Zone: evaluation of project impact against the sixth policy criterion

Contribution to cross-border electricity markets	Project impact	
KPI $^{a}_{6}$ Ratio between interconnection capacity of a Member State and its electricity demand	This KPI is positively assessed (in terms of power and energy) as a result of enhanced exploitation of the 110kV interconnectors and provision of additional 26 MVA due to deployment of five distribution network interconnectors.	
KPI $^{b}_{6}$ Exploitation of Interconnection capacities	Positive impact is expected, resulting from: • Better exploitation of the 110kV interconnections (in terms of increased average load flows) to facilitate the management of RES connection and • Deployment of five distribution lines to increase the cross-border load flow in the project area.	
KPI $^{c}_{6}$ Congestion rents across interconnections	There are no congestion rents in the area, as both sides of the border are part of a single market. However, the project is expected to have positive impact in managing future potential congestions at the interconnections that may appear due to RES increase. This impact was not assessed at this stage.	

3.1.8. Economic appraisal

The following values have been assumed for the variables used in the societal CBA:

- Demand growth: An average annual demand growth of 0% has been considered due to the current trends in the Irish load growth.

- Discount rate: A value of 4% has been used as societal discount rate according to the recommendation given in definition of an assessment framework for project of common interest in the field of smart grids[2].

- Time horizon: 20 years has been chosen as time horizon, as recommended in the assessment framework for smart grid projects of common interest.

- Energy price for losses: 47.3 €/MWh has been assumed for evaluating project impact on the level of technical losses.

- Carbon prices: 5 €/t has been assumed, as the latest carbon price in the EU Emissions Trading Scheme.

- Cost of energy not supplied: 10.898 €/kWh, provided by the Single Electricity Market Committee for the common market on the island of Ireland.

The project reports positive economic cost-benefit analysis with the main monetary benefits and costs listed below. The project also reports lack of commercial viability as a result of negative financial CBA and due to the fact that most of the benefits can be attributed to the society.

3.1.8.1. Main monetary benefits

NAGZ is expected to deliver a set of positive impacts and mainly in terms of:

- Reduced compensation costs for wind generation curtailment (56%) as a result of wind curtailment reduction from 25% to 6%

- Electricity savings (16%) due to deployment of conservation voltage reduction (estimated CVR factor equal to 0.8%)

- Reduced outage times (16%), which will result in: 1) value of lost load saved through supply continuity improvements, resulting from installation of MV arc suppression systems, single phase reclosers and distribution automation and 2) loss reduction of supplier revenue

- Reduced technical losses, as a result of system peak reduction, coming from 20 kV conversion in Republic of Ireland and dynamic sectionalisation in Republic of Ireland and Northern Ireland

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[2] https://ec.europa.eu/energy/sites/ener/files/documents/20120720_electricity_smartgridsassessment_framework_sgtf_eg4.pdf

3.1.8.2. Main costs

The main costs associated with the project deployment are:

- Fibre Optic (24%)
- Arc suppression coils (13%)
- 20 kV network conversion (12%)

3.1.8.3. Sensitivity analysis

The Net Present Value (NPV) of the project varies with variation of the following critical variables:

- **Load growth**: An annual growth rate of 0% was used in the cost-benefit analysis of the NAGZ, based on current planning policies of ESBN and NIE and reflecting the current growth trends in Ireland. Nevertheless, economic development in the region, from one hand side, and further depopulation, on the other, may lead to variation in the load growth rate. NPV remains positive under load growth variation of -2% to 2%.

- **Lower reduction in wholesale generation cost:** The project deployment is expected to lead to wind curtailment reduction from 25% to 6%, which may result in reduction in wholesale production cost since less replacement generation is required to account for the curtailed wind energy. The NPV of the project remains positive for variation of the wholesale generation cost reduction within 20%-80% and turns out to be negative by 100% of wholesale generation cost reduction, *i.e.* in case of no effect of wind curtailment reduction on the wholesale generation costs.

- **Under-performance of continuity systems:** The project proposal considers deployment of the following supply continuity systems: MV arc suppression systems, distribution automation and single phase reclosing. The NPV of the project remains positive under different percentage (0%-50%) of under-performance of these systems.

- **Variation in energy cost:** Consumer savings through energy efficiency increase (via conservation voltage reduction) and supplier revenue increase (due to reduced outages) vary with the cost of energy. Recognising the complexity of the impact that this factor may have on the project NPV (e.g. highly volatile measure given the 20 years evaluation period, interaction with factors outside the promoters control, etc.), it has been subject to sensitivity analysis. The project NPV reports positive values for variation in annual electricity prices within the range of -1% to 2%.

- **Discount rate:** The project proposal considered 4% discount rate in performing the societal cost-benefit analysis. The project NPV remains positive within a wide range of discount rate variation (6%-12%), however applying a discount rate of 10%, reduces the NPV by around 74%.

- **Less than expected load reduction due to Conservation Voltage Reduction:** Load reduction due to conservation voltage reduction is one of the main benefits of NAGZ deployment. According to ESBN trials on the impact of voltage reduction on both rural and urban load, 0.8% of load reduction has been reported for 1% voltage reduction. However, due to the wide range of factors that may affect the CVR potential (e.g. load mix change, voltage dependency in the project area, etc.), a sensitivity analysis has been performed. The project proposal reports positive NPV for CVR within the range of 0.6% to 1%.

3.1.8.4. Non-monetary benefits

The project proposal also includes a set of non-monetary impacts, such as:

- Improved availability of broadband, by deployment of optical fibre in the region, which would significantly increase the regional broadband speeds available.

- Safety increase due to deployment of advanced protection schemes, which will both reduce the number of customer interruption and increase the safety in locating network faults by the system operators.

- Public acceptance and environmental impact, by increasing energy efficiency, leveraging existing network infrastructure and reducing the need for overhead electricity lines.

- Economic benefit of improved electricity infrastructure, by delivering robust infrastructure that will attract future investments in an area with significant challenges in the economic growth.

3.1.9. Summary of evaluation

The main objectives of NAGZ project are enabling flexible operation of the distribution and transmission networks so as to facilitate greater wind generation, improve quality of supply and reduce electricity losses. The North Atlantic Green Zone is a project with clear objectives and a well-defined set of necessary inputs to achieve them.

Based on the information provided by the promoters and the respective assessment, the project meets the criteria set out by the trans-European energy infrastructure regulation and their evaluation is in line with the assessment methodology for projects of common interest in the area of smart grids.

The project proposal North Atlantic Green Zone is well articulated in its main aspects and is in line with the technical requirements. A KPI analysis and a CBA were undertaken by the project promoters and respective elements required for this assessment were in general provided. However, the indicator "efficiency and service quality in electricity supply and grid" lacked precision. Therefore, additional information and clarifications were requested to complement the project evaluation. The critical variables of the project (wind generation curtailment, load growth, generation production cost, variation in energy cost, discount rate, etc.) were selected as candidates for sensitivity analysis and the results still demonstrate positive NPV of the project. In the light of all information provided, it is assessed that the project fulfils the technical requirements and shows positive impacts against the policy (evaluated through the KPI analysis) and economic criteria (assessed via the socio-economic CBA), as outlined in Reg. 347/2013. While this project offers a positive cost benefit outcome, according to the methodology guidelines provided, this does not equate to a commercially viable project for the project promoters.

Both, the Irish regulator (CER) and the Utility Regulator of Northern Ireland (UR) have communicated a positive informal opinion on the technical apects of the NAGZ project, underlining its innovative character, which will facilitate the delivery of benefits to the end-users within a single electricity market and contribute towards the fulfilment of the national renewable energy targets. The project is also in line with the trans-European objectives since it increases the cross-border co-operation of the TSOs and DSOs of the two Member States, and improves the cross-border flow of electricity, thus increasing the efficiency and resilience of each power system.

3.2. GREEN integration of renewable energy in the north MEditerranian (Italy and France)

3.2.1. General overview

The project includes the transmission and distribution systems in the North-East of Italy and the South of France, involving three French administrative regions, namely Midi-Pyrenees, Languedoc Roussillon (LARO) and Provence Alpes Cote (PACA) and two Italian administrative regions - Piemonte and Lombardia.

The ongoing substantial increase of variable distributed generation in the project area poses new challenges on the electricity grid, not only at local level but also at system level, calling for enhanced observability, controllability and predictability of distributed generation. The project comes to address this need. It therefore includes processes such as voltage and reactive power regulation, power flow and congestion management, and load and generation forecast, aiming at a more efficient integration of RES into the network, while improving service quality and energy efficiency.

The GREEN-ME project covering an area between the North of Italy and the south of France, involves the electricity transmission and distribution systems of two bordering countries, and their respective operators: two TSOs (Terna in Italy and RTE in France) and two DSOs (ENEL Distribuzione in Italy and ERDF in France).

Main project goals:

- Enhanced management of the French/Italian cross-border capacity through better coordinated operations and new data exchanges
- Improved network observability and controllability by upgrading primary and secondary substations and installation of sensors and innovative interfaces with the producers
- Enhanced network management (voltage control, active and reactive power flow management, outage management, etc.) through adoption of innovative software tools in different TSO/DSO control centres and distribution and transmission network automation.
- Increased network hosting capacity by enhanced predictability of RES and DG, installation of dynamic thermal rating and storage in primary substations
- Increased coordination between DSOs and TSOs and knowledge sharing through development of digital databases and interfaces

- Deployment of emergency actions on generation and loads through development of selective load shedding functions.

3.2.2. Role of DSOs and TSOs

The main activities of the Italian TSO (TERNA) in the project cover the following responsibilities:

- Integration of additional information and Energy Management System functions in the central SCADA system for coordinated operation of the Italy-France interconnections
- Development and implementation of algorithms for extension of voltage and active power regulation functions in the SCADA system to the DG connected to the MV network and RES power plants directly connected to the HV network
- Installation of automation and control devices with local regulation functions in 2 transmission substations located in the GREEN-ME area
- Installation of actuators with voltage and reactive power regulation functions in 4 RES power plants located in the GREEN-ME area and directly connected to the HV network
- Installation of actuators with active power regulation functions through the interaction with the central control systems.

The activities of the French TSO (RTE) within the project are the following:

- Deployment of digital Remote Terminal Units (RTUs) in 9 HV substations
- Deployment of Dynamic Line Rating on 41 transmission lines
- Creation of a new secondary voltage control in east PACA region
- Implementation of automated constraint management in 4 HV substations
- Deployment of fault locators on 62 transmission lines
- Installation of centralized fault localization system in 2 regional control centres (Toulouse, Marseille).

The French DSO (ERDF) is responsible for:

- Installation of digital RTUs in 18 primary substations, 667 new sensors and RTUs on the network, 90 control devices at the producers interfaces and upgrade of 114 secondary substations
- Deployment of Volt-Var-Control (VVC) and Fault-Location-Isolation-Save-Restore (FLISR) self-healing functions at the Distributed Control Centres
- Development and implementation of new applications to manage network outages, data exchange between DSO/TSO and forecast of solar generation.

The main activities of the Italian DSO (Enel Distribuzione) include:

- Upgrade of 14 primary substations and 679 secondary substations with automation and control devices, RTUs, communication devices , and active OLTC management
- Upgrade of control and communication for RES above 400 kW
- Implementation of smart reactive compensation devices in 3 HV/MV substations
- Implementation of communication infrastructure
- Installation of one storage device [1MW/1MWh].

3.2.3. Cross-border impact and added value of joint project

The project area is characterised with a significant amount of intermittent RES, which calls for increased network predictability and observability. In this context, the two DSOs will implement similar technologies to provide the TSOs with enhanced information on the generation connected to the distribution network. This will ultimately result in better exploitation of the interconnection capacity and increased benefits, particularly in terms of reduced energy not supplied. Furthermore, the system for data processing can be jointly conceptualised by both DSOs, thus ensuring interoperability and replicability of the system architecture. One of the main objectives of GREEN-ME is to allow for full exploitation of the available interconnection capacity, even in periods of low consumption through controllable DG units and participation of such controllable power in provision of adequate network reserve margins.

3.2.4. Compliance with eligibility requirements

GREEN-ME project fulfils the eligibility requirements, as indicated below.

- Voltage level(s) greater than 10 kV

The project involves a network area with the following voltage levels: 10 kV, 15 kV and 20 kV.

- Number of users involved (producers, consumers and prosumers) greater than 50 000

The project area involves 702 300 users.

- Consumption level in the project area greater than 300 GWh/year

The consumption in the project area is 6648 GWh/year.

- Percentage of consumption supplied from renewable resources that are variable in nature of at least 20%

The generation level of RES variable in nature in the project area is 429.8 GWh, which represents 25% of the total consumption for the Italian part of the project zone and 1342 GWh, which is 27% of the consumption in the French part of the project area.

- Involvement of transmission and distribution system operators of at least 2 Member States

The project involves two DSOs and TSOs of Italy and France.

3.2.5. Smart Grid dimension

The following Smart Grid features have been proposed by the project:

- Integration of growing levels of Distributed Energy Resources (DER) as a result of deployment of innovative voltage control strategies, active/reactive power flow control, advanced forecast of RES generation connected to the distribution grid, use of storage in primary substation (in Italian part of the project area), network monitoring systems and ICT infrastructure.
- Automation and control of MV network as a result of automatic faults selection, control functions and data collection for local dispatching and TSO information provision, monitoring of MV circuit breakers in primary substations, deployment

of advanced protection and control strategies - new actuators and sensors (e.g. fault detectors, voltage and current sensors).

- Provision of ancillary services by the DSOs, through active/reactive power flow control and use of storage in primary substation (in the Italian part of the project area).
- Management, collection and coordination by the TSOs of ancillary services and forecast information, provided by the DSOs and RES directly connected to the HV power system.
- Integration of ancillary services and forecast information provided by the DSO with the TSO control infrastructure (SCADA and EMS), for the purpose of grid control and planning of reserve margins.

3.2.6. System architecture and deployed assets

The project proposal includes the implementation of the following functionalities (depicted in Figure 4):

- Enhanced cross-border interconnection management
    - Data exchange to perform advanced cross border flow calculation
    - Data exchange about "state of health" of system operation on both sides of France-Italy border
- Power system observability and controllability
    - Implementation of fast and accurate measurement functions
    - Active power regulation functions
    - Optimal coordinated voltage control
    - Automated management of transmission network constraints
- Transmission and distribution grid automation
    - Dynamic thermal rating
    - HV fault localization
    - Enhanced MV failure automation

- Anti-islanding on MV grids

- Emergency actions on generation and loads – Development of selective load shedding functions.

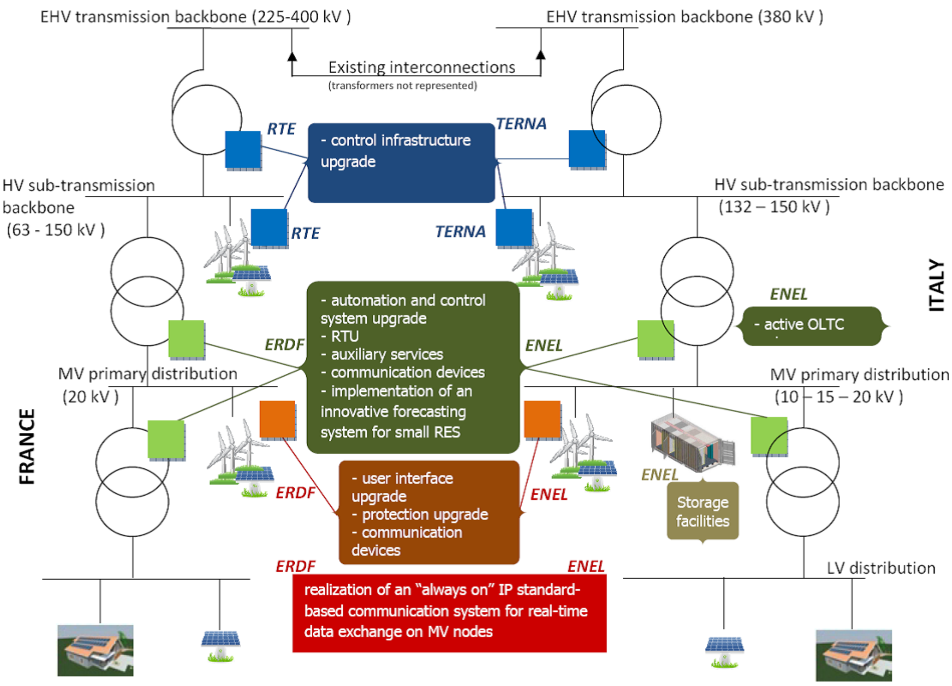

Figure 4 GREEN-ME system architecture (Source: GREEN-ME promoters)

3.2.7. Contribution to the policy criteria – evaluated through Key Performance Indicators

The sections below illustrate the project impact on the six policy criteria drafted in the EU Reg. 347/2013, evaluated through corresponding Key Performance Indicators (KPIs). Some KPIs were evaluated based on inputs coming only from one side of the project area. In such cases, it was accepted that this part of the project benefit was most relevant to the side where it was thoroughly analysed.

A. Level of sustainability

The project is expected to have positive impact on the sustainability criterion, in terms of reduced CO_2 emissions. The way this specific impact is assessed by the promoters differs between the Italian and French part of the project area. The project environmental effect, considered in terms of visual, electromagnetic impact, impact on vegetation, water, cultural heritage etc. is thoroughly analysed and positively assessed for the whole project area. Table 7 illustrates the evaluation of the project impact on the sustainability criterion, assessed through two KPIs.

Table 7 GREEN-ME: evaluation of project impact against the first policy criterion

Level of sustainability	Project impact	
KPI [a]$_1$ Reduction of Green House Gas Emissions	CO_2 reduction is expected as a result of: reduction of RES connection period and reduced generation interruption in case of maintenance (in FR) and wider diffusion of RES at distribution network level (in IT). Assumptions: • CO_2 emission rate, equivalent hours of RES production, % of increased MV hosting capacity (in the Italian part of the project area). • % RES connection period reduction, incremental RES production impacted by connection period reduction, % of generation interruption reduction and total RES impacted by the generation interruption reduction (in the FR part of the project area). The project is expected to have positive impact on this KPI; nevertheless, uncertainties still persist in the information provided.	
KPI [b]$_1$ Environmental impact of electricity grid infrastructure	The project is expected to have positive environmental impact due to reduced needs of new lines and substations to reach the same increase of hosting capacity. Qualitative analysis is performed addressing project visual impact, electro-magnetic impact, water, vegetation, fauna, cultural heritage, noise, etc. and the project is expected to have positive environmental impact due to optimisation of RES integration, reduction of new construction projects by optimising the operation of the existing network assets.	

B. Capacity of transmission and distribution grids to connect and bring electricity from and to users

The project impact on this criterion is evaluated through its contribution to the network hosting capacity increase, so as to accommodate growing penetration levels of DG and reduce RES curtailment and thus comply with the network security requirements. Table 8 illustrates the outcome of the evaluation process relative to three KPIs associated with the second policy criterion.

Table 8 GREEN-ME: evaluation of project impact against the second policy criterion

Capacity of transmission and distribution grids to connect and bring electricity from and to users	Project impact		
KPI $^{a}_{2}$ Installed capacity of distributed energy resources in distribution networks	This KPI is positively assessed. However, the methodology of assessing this KPI differs between the two project areas. In FR part of the project zone, this KPI is assessed as % of RES integration cost reduction. In the IT part of the zone, 50% increase in hosting capacity has been assessed on the base of pilot project case study. Finally the KPI value has been conservatively reduced to 25% to take into account the assumptions considered. The project is expected to have positive impact on this KPI; however, uncertainties still persist in the information provided (particularly for the French part of the project area).		
KPI $^{b}_{2}$ Allowable maximum injection of power without congestion risks in transmission networks	This KPI was not quantitatively assessed. However, qualitative arguments point out that the increase of 25% hosting capacity on MV/LV side, in the IT part of the project area, is not expected to increase the risk of congestion in the transmission grid. Improvements of RES control, proposed by the project, would, however, present an added value to the network security.		
KPI $^{c}_{2}$ Energy not withdrawn from renewable sources due to congestion or security risks	The project is expected to have positive impact in terms of avoided curtailed energy in the whole project area. On the French transmission side, the reported avoided energy not withdrawn is 7100 MWh/year, whereas on the French distribution side, this figure reaches 17300 MWh/year. In the IT part of the project area, current RES capacity of about 230 MW is not directly controllable. GREEN-ME may contribute to better control and maximise the use of RES due to set of measures (such as, control of currently non-controllable RES units by the DSO, storage deployment both at HV and MV level, etc.) The project is thus expected to have positive impact on this KPI, however, uncertainties still persist in the information provided and the assumptions made.		

C. Network connectivity and access to all categories of network users

The main project contribution to this criterion is increased operational flexibility through the installation of storage in primary substations, and DG controllability. Additionally, GREEN-ME is expected to allow for RES and DG participation in voltage regulation and network congestion management. Table 9 shows the project evaluation, in terms of two KPIs associated with this policy criterion.

Table 9 GREEN-ME: evaluation of project impact against the third policy criterion

Network connectivity and access to all categories of network users	Project impact	
KPI $^{a}_{3}$ Methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	Project promoters state that the project will encourage the evolution of regulatory framework by facilitating RES to participate in ancillary service market (for which adequate infrastructure is required). The discussion is only based for the IT side of the project area.	
KPI $^{b}_{3}$ Operational flexibility for dynamic balancing of electricity in the network	KPI was estimated to 10%, resulting from the increased storage and DG that can be modified vs. the total storage and DG connected to the distribution network. Nevertheless, the estimation of 10% only considers the contribution of PV reactive power and it addresses only the IT part of the project area.	

D. Security and quality of supply

The project is expected to deploy innovative protection and voltage control mechanisms and thus allow for full exploitation of the distribution network hosting capacity while improving continuity of supply and MV network voltage profiles. Table 10 illustrates the evaluation of the project impact on this criterion, captured through 5 KPIs.

Table 10 GREEN-ME: evaluation of project impact against the fourth policy criterion

Security and quality of supply	Project impact	
KPI $^{a}_{4}$ Ratio of reliably available generation capacity and peak demand	Positive impact is expected due to increased hosting capacity of controllable DG and storage deployment in primary substations in Italy. Nevertheless, the impact has been only assessed for the Italian part of the project area.	
KPI $^{b}_{4}$ Share of electricity generated from renewable sources	The project is expected to have positive impact on this KPI due to increase of DER hosting capacity (for the IT part of the project area).	
KPI $^{c}_{4}$ Stability of the electricity system	The project is expected to improve the controllability of DER production and deploy coordinated voltage control, thus limiting the causes of possible system instabilities, typically in terms of voltage and frequencies. However, uncertainties persist in the information provided and there is a lack of quantitative evaluation (subject to detailed simulation analysis).	
KPI $^{d}_{4}$ Duration and frequency of interruptions per customer, incl. climate related disruptions	KPI was estimated resulting in improvement of both SAIDI and SAIFI of 1-2% for the French region due to protection improvement in primary substation, and 7% for the Italian region mainly due to deployment of innovative automation technique.	
KPI $^{e}_{4}$ Voltage quality performance	KPI estimation is not provided, as estimations based on previous pilot projects are not available yet. Project promoters argue on the positive impact of the project on this KPI by linking it to KPI 2a. Increased RES capacity requires more sophisticated voltage control, which leads to enhanced voltage quality. The project is expected to optimize voltage and reactive power through enhanced network observability and enabling of automatic corrective measures.	

E. Efficiency and service quality in electricity supply and grid

The project will be making use of innovative diagnosis tools to monitor underground cables in real time. This will lead to a reduction in the number of faults and ultimately contribute to securing continuity of supply. Table 11 depicts the evaluation outcome of the project impact relative to 6 KPIs associated with this policy criterion.

Table 11 GREEN-ME: evaluation of project impact against the fifth policy criterion

Efficiency and service quality in electricity supply and grid	Project impact	
KPI $^{a}_{5}$ Level of losses in transmission and in distribution networks	Quantitative evaluation of this KPI was not provided. Promoters expect losses reduction due to better utilization of DG as additional resource able to provide ancillary services, both at system and local level. Concrete results from demo projects are not available yet.	
KPI $^{b}_{5}$ Ratio between minimum and maximum electricity demand within a defined time period	Storage in primary substations is expected to smooth peaks and level the demand curve so that the exchange energy profiles between primary substations and the rest of the grid are more predictable, especially in presence of variable RES. Estimated KPI shows a positive impact of the project (presented only for the Italian part of the project zone).	
KPI $^{c}_{5}$ Demand side participation in electricity markets and in energy efficiency measures	Quantitative evaluation of this KPI was not provided. The project will deploy additional functionalities to enable DERs to participate in voltage regulation and demand response. MV customers fed by primary substations classified as rural will participate in voltage regulation and demand response. Adequate regulatory framework should be put in place to allow demand side participation.	
KPI $^{d}_{5}$ Percentage utilisation (*i.e.* average loading) of electricity network components	The project is expected to have positive impact on this KPI due to deployment of new Volt/Var control functions, which will allow for increased integration of RES. In Italy, the project may contribute towards deferral of MV grid investment by avoiding reinforcement of primary substation to accommodate the expected increased hosting capacity of 96 MW, allowed by the project. However, positive impact with sufficient level of confidence could not be assessed.	
KPI $^{e}_{5}$ Availability of network components (related to planned and unplanned maintenance) and its impact on network performances	Quantitative evaluation of this KPI was not provided. Promoters argue on the positive impact of the project on this KPI due to deployment of predictive maintenance of MV circuit breakers, which will result in reducing interruption of electrical service, optimizing maintenance and improving asset management.	

Efficiency and service quality in electricity supply and grid	Project impact	
KPI $^{f}_{5}$ Actual availability of network capacity with respect to its standard value	Quantitative evaluation of this KPI was not provided. Some arguments on the project positive impact on this KPI have been given, such as use of phase shift transformers, dynamic line rating for the transmission system in French part of the project zone, centralised fault localisation, etc.	

F. Contribution to cross-border electricity markets by load flow control to alleviate loop flows and increase interconnection capacity

The increased predictability of RES anticipated by the project could potentially allow the TSOs to reduce the balancing reserve, and eliminate limitations on the existing interconnections. Table 12 illustrates the project impact assessment on 3 KPIs related to the sixth policy criterion.

Table 12 GREEN-ME: evaluation of project impact against the sixth policy criterion

Contribution to cross-border electricity markets	Project impact	
KPI $^{a}_{6}$ Ratio between interconnection capacity of a Member State and its electricity demand	Quantitative evaluation of this KPI was not provided. Provided information show that the project impact on this KPI is negligible, due to the fact that the project is not expected to increase the NTC nor cause significant load demand variations. However, the project will allow for 500 MW of controllable PV generators at the target year of 2030, which would result in reduction of cross-border transmission capacity limitation in the order of 1% of hourly maximum transmission capacity.	
KPI $^{b}_{6}$ Exploitation of Interconnection capacities	KPI was positively assessed. GREEN-ME project is expected to have positive impact on the transmission cross-border capacity, resulting in better NTC exploitation in the range of 0%-0.4%.	
KPI $^{c}_{6}$ Congestion rents across interconnections	Better use of NTC could contribute to alleviating price differentials between the Italian Northern Market Zone and France. However, a quantitative estimation would require detailed studies which have not been performed at this stage.	

3.2.8. Economic appraisal

The following values have been assumed and provided for the variables used in the societal CBA:

- Demand growth: An average annual demand growth of 1.1% has been considered for the project area based on the electricity demand forecast in Italy for the period 2014-2024[3] and the trend of the last 6 years in the South-East region of France[4]
- Discount rate: A value of 4% has been used as societal discount rate according to the recommendation given in the definition of an assessment framework for project of common interest in the field of smart grids [1].
- Time horizon: 15 years, considering the average lifetime of major project components
- Energy price for losses: [46 – 88] €/MWh
- CO2 emission per kWh: 0.41 ton/kWh
- CO_2 average price: 7.5 €/ton
- Average oil price: 80 €/boe
- NO_x average cost: 5700 €/ton (IT) and 7700 €/ton (FR)
- SO_2 average cost: 6100 €/ton (IT) and 8000 €/ton (FR)
- Cost of energy not supplied: 26 €/kWh.

The project reports a positive economic cost-benefit analysis with the main monetary benefits and costs listed below. The project also reports lack of commercial viability as a result of a negative financial CBA and due to the fact that most of the benefits are external and can be attributed to the society.

3.2.8.1. Main monetary benefits

- Avoided distribution network reinforcements

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[3] http://www.terna.it/default/Home/SISTEMA_ELETTRICO/statistiche/previsioni_domanda_elettrica.aspx

[4] http://www.rtefrance.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Schema_developpement/Schema_decennal_2013.pdf

- Improved operational flexibility
- Reduced outages.

3.2.8.2. Main costs

- HV/MV substations control, automation and monitoring systems
- Control and communication of RES
- MV/LV substations control, automation and monitoring system.

3.2.8.3. Sensitivity analysis

The project proposal reports the following variables, subject to sensitivity analysis:

- Discount rate: 3%, 4% and 6%. The project NPV drops by around 27% for discount rate of 6%.
- Costs variation: Total cost increase of 10% would result in project NPV decrease by around 29%.
- Network hosting capacity: Increase in network hosting capacity to accommodate 15% increase of RES (instead of the estimated 25%), would result in NPV decrease by around 6.5%.

Additional variables and their values, reported as candidates for sensitivity analysis are the following:

- Average oil price: 50 €/boe, 80 €/boe and 110 €/boe
- CO_2 average price: 5 €/ton, 7.5 €/ton, 10 €/ton
- NO_x average cost (IT): 3000 €/ton, 5700 €/ton, 8600 €/ton, 11000 €/ton and 16000 €/ton
- NO_x average cost (FR): 7700 €/ton, 12000 €/ton, 14000 €/ton and 21000 €/ton
- SO_2 average cost (IT): 4000 €/ton, 6100 €/ton, 9300 €/ton, 12000 €/ton and 18000 €/ton
- SO_2 average cost (FR): 5000 €/ton, 8000 €/ton, 12000 €/ton, 16000 €/ton and 23000 €/ton.

3.2.8.4. Non-monetary benefits

Further to the quantified benefits, the project proposal includes the following impacts that could not be (entirely) quantified and included in the KPI analysis:

- Better exploitation of FR-IT interconnection
- Quality and continuity of supply
- Provision of new services and market entry to third parties
- Dissemination of the results and standardization of solutions applicable to other areas worldwide (replicability & scalability potential).

3.2.9. Summary of evaluation

The project proposal GREEN-ME is well articulated in its main aspects and it is in line with the technical requirements. The project proposal is however, not entirely prepared in line with the guidelines presented in the assessment framework for smart grid projects of common interest. On this note, the promoters were requested additional information and clarifications to complement their project evaluation, both in the KPI analysis and the CBA. Some project impacts were evaluated based on inputs from one side of the project area. In such cases, it was accepted that this part of the project benefit was most relevant to the side where it was thoroughly analysed. The critical variables of the project (increase of hosting capacity, discount rate, CO2 emission rate, CO2 price, etc.) were selected as candidates for sensitivity analysis and the results still demonstrate positive NPV of the project. The project fulfils the technical requirements and shows positive impacts against the policy (evaluated through the KPI analysis) and economic criteria (assessed through the societal CBA). While GREEN-ME project offers a positive cost benefit outcome, the financial CBA performed by the promoters, does not indicate commercially viable project for the project proposers.

Both, the Italian regulator (AAEGSI) and the French regulator (CRE) have communicated a positive informal opinion on the technical aspects of the GREEN-ME project, underlining its innovative character, significant cross-border impact and alignment with the trans-European energy infrastructure objectives.

3.3. SINCRO.GRID (SLOVENIA AND CROATIA)

3.3.1. General overview

The project area involves the distribution and transmission network of Slovenia and Croatia, which covers the whole territory in both countries.

Flexibility deficiency in terms of voltage and frequency regulation has been recently brought to the limit, which could potentially endanger future development in the direction of renewable and dispersed generation integration. To address this issue, the current proposal focuses on voltage profile management that will allow for increased integration of renewables to the grid, while enabling secure and reliable delivery of electric power to the end-users. For this purpose, a dedicated control centre will be established to support various voltage and frequency control processes.

The project addresses the needs of the transmission system to deal with increased penetration of RES, connected both at the transmission and distribution grids, and in particular:

- The need to deal with voltage fluctuations set outside the operational limits
- Increased needs for ancillary services, especially secondary and tertiary reserve, both capacity- and energy-wise
- Increased need for primary infrastructure due to the fluctuating nature of renewable generation.

Main project goals:

- Enhanced voltage control, primarily in terms of removing overvoltages caused in periods of increased generation and low consumption. Nevertheless, low voltage problems that may evolve in the future will also be addressed
- Efficient deployment of RES in ancillary service provision in Slovenia and Croatia
- Relieving local power flows at 110 kV grid and providing alternative ancillary services (secondary reserves) in Slovenia, and consequently removing current operational deficiency caused by market price drop and closure of conventional generators
- Increasing network capacities at the transmission network by use of real-time control of the operational limits of network elements and thus allowing for capacity investment deferral

- Improving observability of the distribution network, which would facilitate transmission network operation and potentially lead to reduction of future demands for ancillary services

- Improving observability of RES operation and its impact on the transmission and 110 kV network operation at international level

- Enhanced communication platform for Demand Side Management (DSM) for tertiary reserve, thus allowing for more transparent co-operation between reserve providers and TSOs

- Increased cross-border capacity with real-time control of network operational limits.

Two TSOs (ELES in Slovenia and HOPS in Croatia) and two DSOs (SODO in Slovenia and HEP in Croatia) are involved in the project. The project is led by the TSOs since it primarily addresses problems on the transmission grid. DSOs will enhance the observability of the distribution grid by providing forecasting tools for DG generation, thus helping the TSOs in predicting any necessities for ancillary services and network operation, mainly in terms of voltage control.

Expected project impacts:

- Increased penetration of RES into the distribution and transmission grids of both Slovenia and Croatia (the project deployment allows for additional 330 MW of wind power to be installed in Croatia)

- Enhanced voltage profiles at both transmission systems of Slovenia and Croatia

- Relieved local power flows on 110 kV grid and reduced shortage of ancillary services (secondary reserve) in the range of 12 MW from battery storage and controllable DG units in Slovenia

- Enhanced utilization of existing transmission and 110 kV grid using Dynamic Thermal Rating (DTR)

- Better observability of distribution and transmission grids using advanced forecasting tools, DTR and information coupling of distribution and transmission systems

- Additional 5 MW of tertiary reserves provided by Demand Side Management by establishing a common communication platform that will allow for provision of more accurate data to the TSO.

3.3.2. Role of DSOs and TSOs

TSOs will be leading the activities, as the project primarily focuses on issues on the transmission network. DSOs will increase the observability of their grid by implementing short-term forecasting tools based on metering data, which will be used by the TSO to optimise operation and ancillary services. Some DG generation at MV distribution grid will be included in the ancillary services market in Slovenia. Wind farms in the Croatian distribution grid will be included in the voltage control mechanisms.

The project will require co-operation between DSOs and TSOs in the following domains:

- Establishment of a virtual cross-border control centre, which will require a high level of co-operation between both TSOs

- ICT connection of DSO and TSO control centres in both member states and standardised data exchange

- Development of common voltage control mechanism, including existing and new active devices at the transmission level, as well as existing active components on the distribution level with the inclusion of wind farms for coordinated voltage control at the TSOs level and between TSOs and DSOs. The project will also require co-operation between DSOs and TSOs to establish standardised data exchange and data flow from the distribution to the transmission level.

- Installation of storage units at the 110 kV substations on the MV side. The choice of optimal installation points will be jointly determined by TSO and DSO in Slovenia.

- Development of standardised communication protocols for data exchange in demand response services, which will increase DR potential for ELES’ ancillary services.

3.3.3. Cross-border impact and added value of joint project

The project area exhibits high degree of transit power flows, which in certain periods can reach more than 100% of the peak consumption in some parts of the project area. In addition to the strong transit fluctuations, increased penetration of intermittent RES lead both TSOs of Slovenia and Croatia to face similar problems related to voltage control. Each of the neighbouring TSOs conducted a separate analysis on this issue and the results revealed that at least 1350 MVar of compensation devices are needed in both countries together to solve the overvoltage problem, if addressing it separately. On the other hand, by establishing a common virtual cross-border control centre, the need for compensation devices would reduce to 1050 MVar due to coordinated actions of the neighbouring TSOs.

The geographical position of Slovenia and Croatia lies in between regions with a surplus of energy (Central Europe and the Balkans) and regions with a high deficit (Italy), which makes their transmission grid subject to very high transits of electric energy. This calls for building additional interconnections in order to serve market needs, however, it results in borders being congested most of the time. The construction of new power lines is very difficult due to problems related to spatial planning. It is therefore important to utilise the existing infrastructure to a maximum extent by implementing smart grids solutions. This requires high level of co-operation between TSOs and DSOs, and enables increasing utilisation of the existing grid while still maintaining adequate level of reliability and security of supply.

3.3.4. Compliance with eligibility requirements

SINCRO.GRID fulfils the eligibility requirements, as indicated below.

- Voltage level(s) greater than 10 kV

The project includes investments at MV network levels of 10 kV and higher (10 kV, 20 kV and 35 kV) and HV grid (110 kV and higher).

- Number of users involved (producers, consumers and prosumers) greater than 50 000

The project area involves 3 294 910 network users.

- Consumption level in the project area greater than 300 GWh/year

The consumption in the project area in 2013 amounted to 12 816 GWh in Slovenia and 16 407 GWh in Croatia, which together sums up to 29 333 GWh.

- Percentage of consumption supplied from renewable resources that are variable in nature of at least 20%

The peak demand in the project area in 2013 was 4 769 MW. The installed power of non-dispatchable renewable sources variable in nature (solar and wind) was 532 MW in Slovenia in 2013 and 555.8 MW in Croatia, which together amounts to 23 % of the peak demand. The project area also includes significant penetration level of run-of-river hydro plants, which together with the solar and wind production accounts for 29.8% of the total consumption in the project area, in terms of energy.

- Involvement of transmission and distribution system operators of at least 2 Member States

The project involves TSOs and DSOs from Slovenia and Croatia.

3.3.5. Smart Grid dimension

The main smart grid highlights of the project are:

- Deployment of dynamic line rating on highly interconnected lines with cross-border impact. Dynamic thermal rating systems increase the complexity of tasks within the control centre as more dynamic operation is introduced. The rules for system operation have to be adjusted and maintenance procedures enhanced to better manage the increased responsibilities of the field staff. New operational and market agreements have to be justified also to third parties not directly involved in this project in order to achieve an increase in transfer capacities according to ENTSO-E standards.

- Centralised voltage and reactive power control with an internationally balanced optimisation function, integrating advanced reactive sources from two power systems. Optimisation will be tailored to RES and DER operation, and will also have an impact on the operation of conventional production units.

- A virtual cross-border control centre with improved information flows, common data representation, dynamic system optimization, and common forecasting algorithms involving two TSOs and two DSOs. The forecasting algorithms will integrate the knowledge and local experience with RES and improve their predictability as regards wind, solar and small hydro production. With increased utilisation of the network, each of the operators will need to rely on the coordinated actions of the other TSO and DSOs in order to provide reliable and safe operation of the grid.

- Storage systems at the TSO-DSO interface and DG storage units replacing conventional units for active power system control and relieving local power flows. The operation of storage systems under intense power/energy conditions calls for the introduction of a predictive optimisation function that will exploit system unbalances as an energy source for active system balancing. Within the control centre, these algorithms will also need to be extended to the operation of conventional generation units under control. DG storage units will be upgraded with advanced systems of secondary reserve operation in order to optimally exploit the limited technical capabilities of the subsystems, and keep a reliable provision of ancillary services.

3.3.6. System architecture and deployed assets

The project proposal assumes deployment of the following assets:

- Virtual cross-border control centre – A joint ELES – HOPS Virtual Cross-border Control Centre (VCBCC) and corresponding infrastructure will be set up to allow for coordinated and controlled network operation and RES production at the Slovenian and Croatian HV and MV networks, as well as to allow for power system optimization in the whole control area. The VCBCC will be integrated within the existing SCADA/EMS systems on both sides (operated by ELES and HOPS) and with additional advanced tools, such as: simulation tools based on measurements and state estimator's output, advanced visualization tools and SUMO – a system for real-time and short-term forecast assessment of operational limits.

- Compensation devices – Static Voltage Compensators (SVC) with a total capacity of 1050 Mvar will be installed in the project area through coordinated approach between the two TSOs, which both face the issues of overvoltages. The results show that separate solutions (compensation in Slovenia or Croatia only) lower the voltage, but still do not solve the issue in all substations. Installing full configuration in both countries solves the issue at considerably lower cost and also leaves some operational reserve.

- Storage – The Slovenian TSO will implement 10 MW of secondary reserve from battery storage (technology to be determined at a later stage) with energy capacity of 30 MWh.

- DG units providing secondary reserve – The Slovenian TSO assume the following units to be included in provision of secondary reserve: two bio gas power plant with total installed capacity of 1.4 MW and one small hydro power plant with installed capacity of 2 MW.

- Dynamic thermal rating (DTR) – DTR will be implemented at all transmission power lines in the Slovenian transmission grid, as part of the SUMO architecture (DTR advanced system developed by ELES in partnership with research institutions and industry). The central part of the system is the SUMO BUS, which collects data from all subsystems and provides information to the operators in control centres by means of advanced visualization tools. The Croatian TSO will adopt the DTR system at the most critically loaded lines, connecting wind power plants and consumers in the coastal areas of Croatia with the mainland.

- Load and DG generation forecast – Growing penetration of renewables causes increased uncertainties for transmission system operation and consequently increased needs for ancillary services (secondary and tertiary reserve, both in terms of capacity and energy). As a result, the Slovenian DSO is developing a forecasting tool that will provide a day-ahead forecast for the whole area of Slovenia. The forecast needs to be upgraded so as to be able to provide short-term forecasts and a geographical breakdown of forecasts for specific nodes.

- ICT infrastructure – The existing ICT infrastructure needs to be upgraded in order to provide reliable data needed for the operation of the virtual cross-border control centre. According to the Slovenian TSO's preliminary analysis, an upgrade of the existing infrastructure is needed to provide infrastructure for: the virtual cross-border control centre, the DTR system, control and support of DG and demand side integration in ancillary services, storage units, and data exchange between SODO and ELES.

Figure 5 illustrates the system architecture of the SICNRO.GRID project.

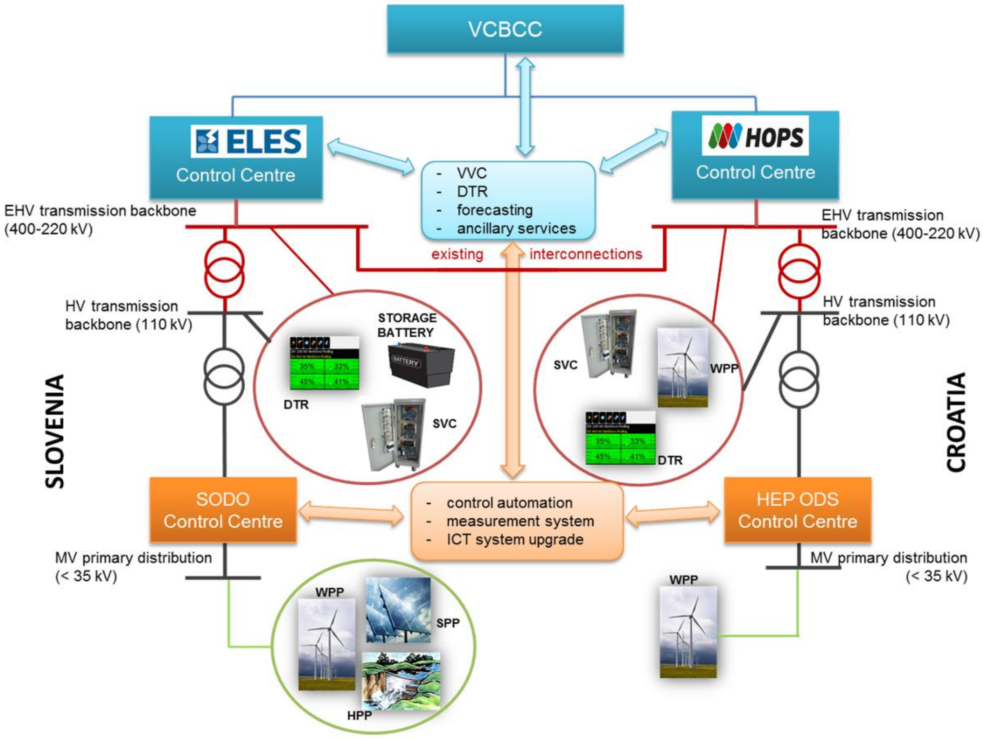

Figure 5. SINCRO.GRID system architecture (Source: SINCRO.GRID promoters)

3.3.7. Contribution to the policy criteria – evaluated through Key Performance Indicators

The sections below illustrate the project impact on the six policy criteria drafted in the EU Reg. 347/2013, evaluated through corresponding Key Performance Indicators (KPIs). Some KPIs were assessed only for one side of the project area. In such cases, it was accepted that this part of the project benefit was most relevant to the side where it was thoroughly analysed.

A. Level of sustainability

The project impact on this criterion is evaluated as expected variation of GHG emissions due to the project deployment normalised over the total energy demand of the project area. Enhanced utilisation of the existing grid assets as a result of dynamic thermal rating, and consequently deferral of future network investments may have positive environmental impact on land use, landscape changes, and visual, acoustic and electromagnetic impact. Furthermore, deployment of a battery storage system will replace the construction of a gas power plant intended to participate in the secondary control power for balancing purposes. This would result in reduced fuel consumption and GHG emissions as well as reduced environmental impact in terms of noise level. The evaluation of the project impact on this criterion is illustrated in Table 13.

Table 13 SINCRO.GRID: evaluation of project impact against the first policy criterion

Level of sustainability	Project impact	
KPI $^{a}_{1}$ Reduction of Green House Gas Emissions	SINCRO.GRID reports reduction of CO2 emissions by 11.5 t/GWh, due to: • Inclusion of additional 330 MW of wind farms in the Croatian system, resulting from increased network observability and voltage regulation • Deployment of storage units (which will replace the 30 MW gas-fired power plant) for provision of secondary reserve (performed by ELES) • 5 MW of tertiary reserve provided by DSM in Slovenia • Reduced technical losses.	
KPI $^{b}_{1}$ Environmental impact of electricity grid infrastructure	The evaluation of this KPI does not include detailed and well-argued description of the expected (positive or negative) outcomes. Nevertheless, the project is expected to have positive environmental impact due to deferred/avoided transmission grid investments, mainly resulting from: • Dynamic Thermal Rating (could defer the planned 110 kV lines Skofja Loka-Cerkno and Divaca-Koper by 10 years in short term). • Installation of storage (which will replace the 30 MW gas-fired power plant). Deferred/avoided transmission grid investments will bring positive environmental impact, in terms of land use and landscape changes, reduced/avoided visual, acoustic impact and environmental impact.	

B. Capacity of transmission and distribution grids to connect and bring electricity from and to users

This criterion evaluates the project impact in terms of additional capacity it brings that can be safely integrated into the grid. The SINCRO.GRID project mainly addresses the transmission grid since technical issues in terms of overvoltage are already present at transmission grid level and could be further challenged by the increased generation of RES. On this note, the project is expected to increase the network hosting capacity, while not compromising the safety and quality of power supply. The evaluation of the project impact on this criterion is presented in Table 14.

Table 14 SINCRO.GRID: evaluation of project impact against the second policy criterion

Capacity of transmission and distribution grids to connect and bring electricity from and to users	Project impact	
KPI $^{a}_{2}$ Installed capacity of distributed energy resources in distribution networks	This KPI was positively assessed for the whole project area. In Croatia, the current wind capacity "hard cap" of 400 MW could be increased to 800 MW due to the project deployment. From this capacity, 20 MW could be installed at distribution network level which results in KPI = 0.15%. In Slovenia there is no "hard cap" on RES. KPI is estimated on the basis of the national plan for RES integration (an additional 600 GWh of RES, in comparison to 2013). Current issues of overvoltage would prevent integration of this energy to the network in the BaU scenario, *i.e.* without SINCRO.GRID deployment. SINCRO.GRID deployment would allow for integration of this additional energy, resulting in KPI = 2.2%.	
KPI $^{b}_{2}$ Allowable maximum injection of power without congestion risks in transmission networks	Promoters have calculated the KPI based on the worst case power flow conditions. The size of the largest production unit that can be connected without risking curtailment in the pre-defined worst case scenario is 3993 MW. The size of the largest production unit that can be connected without risking curtailment under the SG conditions is 4820 MW (additional 519 MW in Slovenia and 308 MW in Croatia). The reference power load in the project area is 4769 MW. The KPI under these conditions amounts to 17.3%.	
KPI $^{c}_{2}$ Energy not withdrawn from renewable sources due to congestion or security risks	KPI was not assessed, as there is no historical data on energy curtailment (according to national regulation, the RES connected to the grid can operate at maximum capacity). Nevertheless, future deployment of increased RES may trigger overvoltage protection relays to disconnect DGs from the network for a short period of time. SINCRO.GRID assumes 719 MW of controllable wind plants in Croatia to be included in the overall voltage control mechanism. Some DG units in Slovenia will be also included in the secondary reserves.	

C. Network connectivity and access to all categories of network users

This criterion is measured through the project impact on the way network charges and tariffs are calculated for all network users. The project assumes inclusion of RES in provision of ancillary services (mainly secondary reserve), which will give information to the regulator on the way RES can contribute to ancillary services and what possible incentives would be required to stimulate such a service. Moreover, the project considers inclusion of RES in the distribution and transmission system operation, in terms of network losses optimisation and voltage regulation. This will bring an opportunity for new regulatory mechanisms for rewarding DGs participating in network operation. The project is also expected to enhance the network operational flexibility for dynamic power balancing through the increase of dispatchable capacity (DG, storage and controllable wind generation). The evaluation of the project impact on this criterion is presented in Table 15.

Table 15 SINCRO.GRID: evaluation of project impact against the third policy criterion

Network connectivity and access to all categories of network users	Project impact	
KPI $^{a}_{3}$ Methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	The project will provide the regulator with information on how RES can contribute to ancillary services (secondary reserves) and the incentives that would stimulate them to provide such services. Additionally, RES units will be included in the operation of transmission and distribution systems with the goal of optimising losses and regulating voltage. Regulatory mechanisms can be established to adequately reward participating DG by eliminating old regulatory mechanisms of Var energy penalties and introducing new ones.	
KPI $^{b}_{3}$ Operational flexibility for dynamic balancing of electricity in the network	This KPI was positively estimated at 52% as a ratio of DG and storage that can be modified vs. total storage and DG in the project area. SINCRO.GRID is expected to have positive impact on this KPI, as a result of: • Inclusion of 22 MW of storage and DG in the supply of secondary reserve in Slovenia • Connection of 719 MW wind generation to the central voltage control in Croatia, thus allowing for modification of its operation.	

D. Security and quality of supply

The project assumes to positively contribute towards security and quality of supply (as illustrated in Table 16), as a result of: 1) increase of the reliably available capacity thanks to DG and the storage inclusion in the secondary reserve, 2) increased share of RES that can be safely integrated into the system, 3) increased system stability by keeping the voltage levels within admissible limits, 4) decrease of outages stemming from TSO equipment failures, due to resolution of the overvoltage issue and 5) improved voltage quality, as a result of reduced voltage violations (in terms of overvoltages).

Table 16 SINCRO.GRID: evaluation of project impact against the fourth policy criterion

Security and quality of supply	Project impact	
KPI $^{a}_{4}$ Ratio of reliably available generation capacity and peak demand	This KPI was positively estimated to ca. 0.2% (for SI). The reliably available capacity in 2014 for BaU scenario was calculated at 2.72 GW in Slovenia and 3 GW in Croatia. SINCRO.GRID will increase the reliably available capacity by 12 MW due to inclusion of DG and storage capacity in the secondary reserve. Peak load in the project area is 4.769 MW (2013).	
KPI $^{b}_{4}$ Share of electricity generated from renewable sources	This KPI is positively assessed to 2.5% (for HR), as additional integration of 328 MW in HR is envisaged with the project. The "hard cap" for wind is 380 MW on transmission and 55 MW on distribution grid. Total consumption in the whole project area is 29 233 GWh.	
KPI $^{c}_{4}$ Stability of the electricity system	The project is assumed to have positive impact on this KPI (estimated at 99.99%) due to voltage profile improvement, resulting from deployment of compensation devices and cross-border voltage/var control algorithms in the whole project area.	
KPI $^{d}_{4}$ Duration and frequency of interruptions per customer, incl. climate related disruptions	Network reconfigurations would be required to deal with overvoltages in the project area, which on the other hand would have effect on network security (using N-1 criterion). An estimate of 50% decrease in system security due to overvoltages (calculated as period when N-1 criterion is not fulfilled) is reported in the BaU compared to the SG scenario (*i.e.* with SINCRO.GRID deployment).	
KPI $^{e}_{4}$ Voltage quality performance	The project is expected to have positive impact (estimated value of 99.99%), resulting from avoided voltage violations (hours) in the SG scenario.	

E. Efficiency and service quality in electricity supply and grid

The project is positively evaluated against this criterion in terms of project contribution towards increased efficiency of network operation and quality of electricity supply due to losses reduction, enhanced utilisation and availability of electricity network components, increased availability of network capacity, variation level between the minimum and maximum demand and demand side participation (Table 17).

Table 17 SINCRO.GRID: evaluation of project impact against the fifth policy criterion

Efficiency and service quality in electricity supply and grid	Project impact	
KPI $^{a}_{5}$ Level of losses in transmission and in distribution networks	This KPI was positively assessed to 0.05%. Expected benefits appear due to deployment of advanced voltage/var control mechanisms.	(green)
KPI $^{b}_{5}$ Ratio between minimum and maximum electricity demand within a defined time period	This KPI is assessed to 0.83%, as a result of storage and demand response (aprox. 12MW).	(green)
KPI $^{c}_{5}$ Demand side participation in electricity markets and in energy efficiency measures	This KPI is positively assessed to 0,1% due to inclusion of additional 5 MW of demand response in tertiary reserve (ELES), as a result of the ICT infrastructure enabled by the project. Also, tertiary reserve from DR in SI will be increased by 33%.	(green)
KPI $^{d}_{5}$ Percentage utilisation (*i.e.* average loading) of electricity network components	This KPI is not estimated. Dynamic thermal rating in SI deals with better utilisation of the grid and will increase the capacity of the existing transmission infrastructure and NTC values. DTR deployment in the HR part of the project is expected to bring similar results as for the SI part.	(amber)
KPI $^{e}_{5}$ Availability of network components (related to planned and unplanned maintenance) and its impact on network performances	This KPI is positively estimated on the basis of reduced average lifespan of HV equipment by 2 years in BaU scenario due to overvoltage problems (estimated average lifespan of HV equipment in SG scenario is assumed to be 40 years).	(green)
KPI $^{f}_{5}$ Actual availability of network capacity with respect to its standard value	This KPI is positively assessed (ca. 15%) due to increased network capacity in SINCRO.GRID scenario as a result of dynamic thermal rating.	(green)

F. Contribution to cross-border electricity markets by load flow control to alleviate loop flows and increase interconnection capacity

This criterion evaluates the project impact in terms of the ratio between the interconnection capacity of a Member State and its electricity demand, the exploitation of interconnection capacity and congestion rents across interconnections. The project is assumed to have a positive impact on this criterion due to increase of Net Transfer Capacity (NTC) and enhanced management of the average annual load flow passing through each interconnection within the project area. The evaluation of the project impact on this criterion is illustrated in Table 18.

Table 18 SINCRO.GRID: evaluation of project impact against the sixth policy criterion

Contribution to cross-border electricity markets	Project impact	
KPI $^{a}_{6}$ Ratio between interconnection capacity of a Member State and its electricity demand	This KPI is positively assessed to 14% for Slovenia, since the project is assumed to impact the NTC of Slovenia (increase by 400 MW[5]), as a result of dynamic thermal rating. Promoters decided to deploy DTR at the Croatian part as well, which resulted in average increase of NTC of 208 MW and KPI equal to 7%.	
KPI $^{b}_{6}$ Exploitation of Interconnection capacities	This KPI is positively assessed for the border of SI-IT to 34%; SI-AT to 14% and SI-HR to 12.99%[6], as a result of NTC increase, whereas the average load flow will not be affected by the project deployment.	
KPI $^{c}_{6}$ Congestion rents across interconnections	Promoters do not expect the project to have impact on the congestion rent. Their argument is on the value of NTC change being too small to have significant influence on the mid to long term market price formation. However, uncertainties still persist in the information provided.	

3.3.8. Economic appraisal

The following values have been assumed for the variables used in the societal CBA:

[5] The value is subject to yearly NTC assessment
[6] The values are subject to yearly NTC assessment

- Demand growth: An average annual demand growth of 2.1% has been considered, according to the last demand forecast analysis performed by ELES.
- Discount rate: A value of 4% has been used as societal discount rate according to the recommendation given in definition of an assessment framework for project of common interest in the field of smart grids [1].
- Time horizon: 15 years has been chosen as time horizon due to the lifespan of most of the investments, such as ICT equipment, DTR, etc.
- Peak load growth: 1.5% as peak load forecast has been considered according to ELES peak load forecast analysis.
- Energy price for losses: 45 €/MWh has been assumed, as current price ELES is paying for energy losses (similar situation is assumed for Croatia).
- Carbon prices: 16.5 €/t from 2020-2025, 20 €/t from 2025-2030 and 36 €/t from 2030-2035 (according to the EC reference scenario up to 2050).
- Cost of energy not supplied: 4.13 €/kWh, calculated by the regulatory energy agency of Slovenia.

The project exhibits strongly positive NPV with main benefits and costs listed below. The project also reports lack of commercial viability due to negative financial CBA and due to the fact that most of the benefits are attributed to the society.

3.3.8.1. Main monetary benefits

- Societal benefits due to increased cross-border capacity
- Reduction of GHG
- Avoided generation capacity investment for spinning reserve.

3.3.8.2. Main costs

- Compensation devices
- Storage units.

3.3.8.3. Sensitivity analysis

The following parameters are considered as candidates for sensitivity analysis, whose variation affect the CBA outcome (NPV), nevertheless, it still remains positive:

- Carbon price: 5 €/t of carbon price would lead to NPV drop by around 19%.
- Social welfare: This is the highest benefit expected by the project deployment, however, also subject to high uncertainty due to a number of highly fluctuating variables. To this end, the CBA was performed under a social welfare benefit of 0, with the project NPV dropping by around 86%.
- Investment costs: 20% increase in investment cost would lead to project NPV decrease by around 6%.
- Lower probability of outages and equipment breakdown: Zero probability of outages and equipment breakdown would result in project NPV reduction by around 9%.

3.3.8.4. Non-monetary benefits

Further to the quantified benefits, the project proposal addresses the impacts that could not be (entirely) quantified and consequently included in the KPI analysis, such as:

- Enhanced network observability (using advanced forecasting tools, DTR, etc.)
- Environmental impact due to deferred transmission lines and generation investments
- Increased quality of ancillary services, and system operation due to available data enabled by the common communication platform.

3.3.9. Summary of evaluation

The SINCRO.GRID is a project with clear objectives and a well-defined set of necessary actions to achieve them. Flexibility deficiency in terms of voltage and frequency regulation has been recently brought to the limit in the project area, which would compromise network reliability and security of supply and potentially endanger future development of renewable and dispersed generation integration. Therefore, the main project driver is enhanced voltage profile management, which will allow for increased integration of renewables, while enabling secure and reliable supply of electric power to the end-users. For this purpose, a dedicated control centre will be established to support various voltage and frequency control processes.

The project proposal is very well articulated and documented and project promoters followed to a great extent the guidelines and indicators provided by the assessment framework of projects of common interest in the area of smart grids. The critical variables of the project (social welfare benefit, carbon price, investment costs, lower probability of equipment breakdown, etc.) were selected as candidates for sensitivity analysis and the results still demonstrate positive NPV of the project. In the light of all information provided, the project fulfils the technical requirements and shows strong positive impacts against the policy (evaluated through the KPI analysis) and economic criteria (assessed via the socio-economic CBA), as outlined in Reg. 347/2013. While this project offers a positive cost benefit outcome, according to the methodology guidelines provided, this does not result to a commercially viable project for the project promoters.

Both, the energy agency of the Republic of Slovenia and the Croatian Energy Regulatory Agency (HERA) have communicated a positive informal opinion on the technical aspects of SINCRO.GRID project, underlining its innovative character, which will ensure future integration of RES (especially wind power plants) in a parallel with smooth functioning of cross-border electricity trade and a high-level operational reliability of the system. To this end, the project illustrates significant cross-border impact in an area with above-average transit flows, and as such is strongly aligned with the trans-European energy infrastructure policy objectives.

4. SUMMARY OF PROJECT PROPOSALS EVALUATION

The outcome of the overall projects' evaluation is summarised in the tables below, according to the analysis presented in the previous sections. Table 19 illustrates an overview of the projects compliance to the eligibility requirements, as stated in Reg. EU 347/2013. The penetration level of non-dispatchable resources is reported both, in terms of power and energy, except for the NAGZ project, where the energy figure was not available to the Irish DSO.

Table 19 Overview of projects compliance to eligibility requirements

Project/ Technical requirements	Voltage level	Number of users	Non-dispatchable resources	Consumption level in the project area
North Atlantic Green Zone (IE and UK-NI)	10kV, 20 kV, 33 kV & 38 kV	172 972	766 MW of connected wind (region peak demand: 226 MW)	1 324 GWh/year
	√	√	√	√
GREEN-ME (FR-IT)	10 kV, 15 kV, 20 KV	702 300	IT: 25% (429.8 GWh) and FR: 27% (1 342 GWh)	6648 GWh/year
	√	√	√	√
SINCRO.GRID (SI-HR)	10 kV, 20 kV, 35kV 110kV and 400kV	3 294 910	29.8% (5257 GWh in SI + 3534 GWh in HR)	29 233 GWh/year
	√	√	√	√

KPI ANALYSIS

Table 20 reports a summary of the project proposals assessment in the KPI analysis, in line with the policy criteria of Reg. 347/2013 Annex IV (4).

Table 20 Summary of projects assessment in the KPI analysis

CRITERIA	NORTH ATLANTIC GREEN ZONE	GREEN-ME	SINCRO.GRID
1.SUSTAINABILITY			
2. CAPACITY			
3. NETWORK CONNECTIVITY AND ACCESS			
4. SECURITY AND QUALIY OF SUPPLY			
5. EFFICIENCY IN THE GRID USE			
6. CROSS-BORDER ELECTRICITY MARKETS			

ECONOMIC ANALYSIS

Table 21 reports an overview of the economic assessment of the three project proposals, based on the information provided by the promoters.

Table 21 Summary of economic performance of projects proposals

CRITERIA	NORTH ATLANTIC GREEN ZONE	GREEN-ME	SINCRO.GRID
ECONOMIC VIABILITY			
SENSITIVITY ANALYSIS			
COMMERCIAL VIABILITY			

5. LESSONS LEARNED AND FUTURE CONSIDERATIONS

The assessment framework for Projects of Common Interest in the area of smart grids has been developed within the Smart Grid Task Force, Expert Group on smart grid infrastructure deployment and used as guidance for project promoters to prepare their PCI proposals and for the Smart Grid thematic group to propose and review Projects of Common Interest, under the trans-European energy infrastructure regulation (Regulation EU No. 347/2013).

The evaluation of smart grids candidate projects of common interest shall, therefore, follow the guidelines of the assessment framework, as a common base for project evaluation. On this note, and in order to ensure consistency throughout the process and make future evaluations easier, more straightforward, and comprehensive, some recommendations are made, as follows:

Application of common assessment framework: Each project proposal shall argue convincingly about the project contribution to the fulfilment of the policy criteria, by making reference to the corresponding KPIs. The argumentation of the project contribution to the policy criteria should be as much as possible supported by quantification of the corresponding KPIs, including clear and detailed explanation of the calculation assumptions. Likewise, each project proposal shall demonstrate that the project benefits outweigh the project costs, by performing societal cost-benefit analysis. Such analysis shall be credibly supported by numerical quantification and monetisation, including clear and detailed explanation of the calculation assumptions and qualitative appraisals of benefits that cannot be reliably monetised. During the present assessment it was noted that, often project proposals lacked transparency in the calculation method of the monetised benefits and in the assumption considered. The assessment framework for evaluation of smart grid projects of common interest proposes a number of calculation options for quantification and monetisation of project impacts, intended to facilitate the preparation of project proposals and ensure a common base for project evaluation. Project promoters are therefore strongly encouraged to closely follow these guidelines. In case the proposed calculation options are not used, alternative approaches need to be presented, sufficiently elaborated and convincingly argued.

Some of the impacts assessed via the respective Key Performance Indicators serve as basis for monetizing these impacts in the societal CBA. In this regard, one shall note that the KPI-based analysis can be seen as a complementary approach to the CBA analysis, adopted to assess quantifiable impacts that cannot be reliably monetised.

Use of a common database: Project promoters shall use a reference Commission database, whenever available (e.g. Commission reference scenario for carbon prices) in quantifying their project impacts.

Refinement of certain KPIs: As previously mentioned, the assessment framework for Projects of Common Interest in the area of smart grids defines Key Performance Indicators, related to each policy criteria, as defined in the EU Reg. 347/2013. In the light of the assessments undertaken so far it has become evident that some KPIs may require further refinement. For instance, in the case of KPI b6: "exploitation of interconnection capacities", difficulties arose when evaluating two different projects. The SINCRO.GRID project intends to increase its interconnection capacity, whereas the NAGZ project aims towards enhancing the use of the interconnection (as a result of increased load flow through the interconnector). Using the formula proposed in the assessment framework, the data from the first project will trigger a positive indicator and the second project a negative one, which may lead to a false interpretation. To this end, it is relevant to recognise the increase in the interconnection capacity exploitation as a variance in the KPI, compared to BaU scenario; this variance may result either from increased average power flow at the interconnection or increased Net Transfer Capacity.

Appraisal of qualitative impacts: The qualitative impacts of the project proposals shall refer to impacts that cannot be reliably monetised and therefore are not included in the CBA. Moreover, such impacts may be related to some KPIs, and as such shall be expressed as much as possible in physical units and considered in the overall project assessment.

References

[1] Giordano V., Vitiello S. and Vasiljevska J., "Definition of an assessment framework for Projects of Common Interest in the field of Smart Grids", JRC Science and Policy report, 2014

[2] REGULATION (EU) No 347/2013 on guidelines for trans-European energy infrastructure, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:115:0039:0075:en:PDF

[3] ENTSO-E, "Ten-Year Network Development Plan", last report available at: https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202014/141031%20TYNDP%202014%20Report.pdf

List of abbreviations and definitions

ASC	Arc Suppression Coil
BaU	Business as Usual
CAPEX	Capital Expenditures
CBA	Cost Benefit Analysis
CCTV	Closed-Circuit TV
CER	Commission for Energy Regulation
CVR	Conservation Voltage Reduction
DCC	Distribution Control Centre
DER	Distributed Energy Resources
DMS	Distribution Management System
DR	Demand Response
DSM	Demand Side Management
DSO	Distribution System Operator
DTR	Dynamic Thermal Rating
EG	Expert Group
EMS	Energy Management System
ENTSO	European National Transmission System Operators
ESBN	Electricity Supply Board Networks
FOR	Facilitation Of Renewables
FPI	Fault Passage Indicator
FR	France
GHG	Green House Gas
GPRS	General Packet Radio Service
HR	Croatia
HTLS	High Temperature Low Sag
HV	High Voltage
ICCP	Inter-Control Centre Protocol

ICT	Information and Communications Technology
IE	Republic of Ireland
IT	Italy
KPI	Key Performance Indicator
kV	Kilo Volt
MEC	Maximum Export Capacity
MS	Member State
MV	Medium Voltage
MVA	Mega Volt Ampere
MW	Mega Watt
NI	Northern Ireland
NIE	Northern Ireland Electricity
NPV	Net Present Value
NTC	Net Transfer Capacity
OLTC	On-line Tap Changer
OMS	Outage Management System
PCI	Projects of Common Interest
PV	Photovoltaic
RES	Renewable Energy Sources
RIDP	Renewable Integration Development Plan
RoCoF	Rate of Change of Frequency
RTU	Remote Terminal Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SG	Smart Grid
SI	Slovenia
SONI	System Operator Northern Ireland

SVC	Static Var Compensator
THD	Total Harmonic Distortion
TLC	Telecommunication
TSO	Transmission System Operator
UK	United Kingdom
VVC	Volt-Var Control

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