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Identification of projects of common interest in the priority thematic area of smart grids deployment

Evaluation of candidate projects under EU Regulation 347/2013 on trans-European energy infrastructure

Vasiljevska, J., Flego, G.

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Contact information
Name: Julija Vasiljevska
Address: European Commission, Joint Research Centre, P.O. box 2, 1755 ZG, Petten, Netherlands
Email: julija.vasiljevska@ec.europa.eu
Tel.: +31 224565141

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Contents

Abstract

The document presents the outcome of the evaluation process of candidate projects of common interest in the priority thematic area of smart grids deployment, as set out in Regulation (EU) No 347/2013. The evaluation follows the guidelines of the *Assessment framework for projects of common interest in the field of smart grids — 2017 update* developed by the Joint Research Centre (JRC) and adopted within the smart grid priority thematic group.

The report aims to assist the smart grid priority thematic group in proposing projects of common interest in the area of smart grids deployment to be included in the fourth Union list of projects of common interest.

Authors

Julija Vasiljevska, Gianluca Flego

Executive summary

Policy context

This report supports the implementation of the European Union (EU) Regulation on guidelines for trans-European energy infrastructure (Regulation (EU) No 347/2013) and in particular the assessment of candidate projects of common interest (PCIs) in the priority thematic area of smart grids deployment. Projects of common interest are energy infrastructure projects, which are essential to complete the European internal energy market and to meet the EU's energy policy objectives of affordable, secure and sustainable energy.

Projects of common interest may benefit from accelerated planning and permit granting, a single national authority for obtaining permits, improved regulatory conditions, lower administrative costs owing to streamlined environmental assessment processes, increased public participation through consultations and increased visibility to investors.

To obtain the status of PCI, a project must have a significant impact on the energy markets and market integration in at least two EU countries, increase energy market competition and contribute to the EU's energy security, competitiveness and climate goals by diversifying energy sources and integrating renewables. The selection process gives preference to projects in priority corridors and areas, as identified in the Trans-European Networks for Energy (TEN-E) strategy, in which smart grids deployment is identified as one of the 12 priority infrastructure corridors and thematic areas.

Once a project is assigned the status of PCI, it is also eligible for Union financial assistance in the form of grants for works or grants for studies. Such assistance could be granted 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.

This report is intended to assist the smart grid priority thematic group (comprising Member States, national regulatory authorities, electricity transmission system operators (TSOs), electricity distribution system operators (DSOs), project promoters, the European Network of Transmission System Operators for Electricity (ENTSO-E), the Agency for Cooperation of Energy Regulators (ACER) and the European Commission) in selecting projects of common interest in the priority thematic area of smart grids deployment to be included in the fourth Union list of projects of common interest.

Key conclusions

The report presents the outcome of the evaluation process of candidate projects of common interest in the priority thematic area of smart grids deployment based on the *Assessment framework for projects of common interest in the field of smart grids — 2017 update* (Vasiljevska and Gras, 2017) developed by the Joint Research Centre (JRC) and adopted within the smart grid priority thematic group.

Six candidate projects have been submitted to the Commission and evaluated accordingly, namely the Again COnnected Networks (ACON) project (Member States: Czechia and Slovakia), CrossFlex project (Member States: Estonia and Finland), Danube InGrid project (Member States: Hungary and Slovakia), Data Bridge project (Member States: Denmark, France, Estonia, Latvia, Lithuania and Finland), Smart Border Initiative (SBI) project (Member States: Germany and France) and SINCRO.GRID project (Member States: Croatia and Slovenia).

All six project proposals were analysed and assessed based on the information provided by the project promoters and with regard to both the project's compliance with the general criteria laid out in Article 4(1) of Regulation (EU) No 347/2013, and the evaluation of the project's contribution to the smart grid specific criteria of Article 4(2) of the same regulation. All six project proposals were evaluated in accordance with the following steps: (1) verification of the project's compliance with the priority thematic area of smart grids deployment; (2) verification of the project's economic viability by conducting a societal cost-benefit analysis in which the overall projects' benefits are assessed according to the six specific criteria outlined in Article 4(2)(c) of the regulation and against a set of key performance indicators (KPIs) set out in Annex IV(4) to the regulation; and (3) involvement of at least two Member States in the project by directly crossing the border of two or more Member States or at least one Member State and a European Economic Area country or, alternatively, the project being located in the territory of one Member State and having a significant cross-border impact.

Although the projects significantly differ in scope, objectives and stage of development, they are all driven by the current and future regional needs and they recognise and build on the increased value of a joint approach.

The ACON project, notwithstanding the conventional elements proposed in the project, includes technologies and solutions necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation). The ACON project demonstrates a significant cross-border dimension by directly involving DSOs from two Member States as project promoters and also two TSOs expected to benefit from more efficient and reliable operation of the distribution networks in the project area. In this respect, the project complies with Article 4(1)(c)(i) of the regulation. The ACON project demonstrates a significant contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the project's societal cost-benefit analysis.

The CrossFlex project builds its scope and objectives on the system needs in the project area to increase security and stability by enabling flexibility resources (renewable energy sources and demand response) connected to both the distribution and transmission networks to provide system services. Therefore, the project includes technologies and solutions necessary for the priority thematic area of smart grids deployment. The CrossFlex project capitalises on existing infrastructure — high-voltage direct current (HVDC) systems owned by TSOs from two Member States directly involved in the project — with the aim of increasing their utilisation to support provision of flexibility services while facilitating growing penetration of renewable energy sources. In this respect, the CrossFlex project demonstrates a strong cross-border dimension and thus complies with Article 4(1)(c)(i) of the regulation. The CrossFlex project, notwithstanding its early stage of development, demonstrates a significant contribution to the six smart grid specific criteria outlined in Article 4(2)(c) of the regulation.

The Danube InGrid project includes smart grid solutions to significantly improve distribution system observability and remote controllability and enable provision of flexibility services for system support while increasing network hosting capacity for distributed energy resources. Furthermore, the detailed system state information enabled by the project is to be shared across borders in real time, or close to real time, allowing much closer coordination in the operation of the two neighbouring distribution systems. This will facilitate the development of dynamic pricing and enable active consumer participation through demand response and installation of distributed generation. The InGrid project directly involves DSOs from two Member States and two TSOs, which also stand to benefit from more efficient network management, and their involvement is essential to make the most of the project's potential. Therefore, the InGrid project both complies with Article 4(1)(c)(i) of the regulation and it proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation). The Danube InGrid project demonstrates a significant contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the project's societal cost-benefit analysis.

The Data Bridge project aims to support data access and data exchange as vital elements in enabling effective EU market integration and provision of flexibility services across borders. In this light, the project includes smart grid solutions to efficiently integrate the behaviour of all users connected to the electricity network and allow cross-border data exchange. The project currently involves six participating EU countries and, more specifically, five TSOs and three DSOs, with the strong probability of involving other EU TSOs and DSOs in the near future and in long-term replication of the project's solution across the EU. In this regard, the Data Bridge project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation) and is also compliant with general criterion (i) of Article 4(1)(c) of the regulation. Notwithstanding the uncertainties regarding the evaluation of the project's contribution to the specific policy criteria of the regulation, which are mainly associated with the early stage of the project's development, the Data Bridge project not only demonstrates strong potential to fulfil the policy criteria but also appears highly relevant to the development of the EU internal energy market.

The SBI project presents an innovative approach to addressing common cross-border energy challenges in the project area by integrating the electricity grid with electric mobility and district heating and cooling systems, and exploiting the flexibilities of both the electric mobility and the heating systems to optimise the development and operation of the distribution electricity networks in the project area. Specifically, the SBI project aims to develop a cross-border data management system and common standards for optimisation of the cross-border electricity distribution systems using smart grid solutions. Therefore, the SBI project complies with general criterion (i) of Article 4(1)(c) of the regulation and proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation). The SBI project is currently in its study phase and despite the uncertainties in the information provided and the assumptions made, it demonstrates a positive contribution to the six smart grid specific criteria outlined in Article 4(2)(c) of the regulation.

The SINCRO.GRID project is a mature project with clear objectives and a well-defined set of necessary actions to achieve these objectives. It is driven by existing challenges, mainly related to voltage and frequency regulation at the transmission network level. The SINCRO.GRID project develops (among other elements) a virtual cross-border control centre to effectively support various voltage and frequency control processes and enhance voltage profiles in the project area while enabling increased integration of RES and secure and reliable supply of electric power to end-users. The SINCRO.GRID project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation) and complies with criterion (i) as well as criterion (ii) of Article 4(1)(c) of the regulation. The SINCRO.GRID project demonstrates a significant positive contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the societal cost-benefit analysis.

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. 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, information and communication technology (ICT) and transport systems. Since the establishment of the first Union list of projects of common interest in 2013, and every second year, the JRC supports the implementation of the EU regulation on guidelines for trans-European energy infrastructure in the priority thematic area of smart grids deployment. Since 2015, the JRC has also supported the implementation of the regulation in the energy infrastructure priority corridors of electricity and gas and, this year, also in the priority thematic area of cross-border carbon dioxide networks.

Quick guide

To assist the development of an integrated EU energy market and ensure fulfilment of the EU's policy objectives of affordable, secure and sustainable energy, every 2 years the European Commission adopts a list of key energy infrastructure projects known as PCIs. This report presents the outcome of the evaluation process of candidate PCIs in the TEN-E priority thematic area of smart grids deployment to be included in the 2019 Union list of projects of common interest. The evaluation process relies on a thorough analysis of the information provided by the project promoters in the submitted project proposals, following the *Assessment framework for projects of common interest in the field of smart grids — 2017 update* (Vasiljevska and Gras, 2017).

1. Introduction

1.1. Objectives

This report presents the outcome of the evaluation of smart grid project proposals submitted under the priority thematic area of smart grids deployment. The assessment was carried out within the smart grid priority thematic group ([1]) and in line with the 2017 Joint Research Centre (JRC) assessment framework (Vasiljevska and Gras, 2017), which is intended to guide project promoters in preparing their project proposals.

The JRC assessment framework closely follows the requirements put forward in Regulation (EU) No 347/2013 on guidelines for trans-European energy infrastructure ([2]), hereinafter referred to as 'the regulation'. It builds on a methodological approach for verification of a project's compliance with the general criteria laid out in the regulation (Article 4) and in the evaluation of the project's contribution to the smart grid specific criteria of Article 4 of the regulation and in line with Annex IV (4) to the regulation.

The regulation identifies 'smart grids deployment' as one of its 12 priority infrastructure corridors and thematic areas, with the objective to adopt 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 (DER), and demand response by consumers. In this context, Article 2(7) of the regulation defines a smart grid as 'a network efficiently integrating the behaviour and actions of all users connected to it — generators, consumers and those that do both — in order to ensure an economically efficient, sustainable electricity system with low losses and high quality and security of supply and safety'. In addition, point (1)(e) of Annex II to the regulation identifies a smart grid infrastructure as 'any equipment or installation, both at transmission and medium voltage (MV) distribution level, aiming at two-way digital communication, real-time or close to real-time, interactive and intelligent monitoring and management of electricity generation, transmission, distribution and consumption within an electricity network'.

The report aims to assist the smart grids priority thematic group in proposing projects of common interest (PCIs) in the area of smart grids deployment to be included in the fourth Union list of projects of common interest.

1.2. Policy context

To facilitate the development of an integrated European Union (EU) energy market, since 2013 and every 2 years, the European Commission draws up a list of key energy infrastructure projects, known as projects of common interest, essential for meeting the EU's energy policy objectives of affordable, secure and sustainable energy.

Projects of common interest must meet the following general criteria, according to Article 4(1) of the regulation.

a) The project must be necessary for at least one of the energy infrastructure priority corridors and areas.

b) The potential overall benefits, assessed according to the six specific policy criteria outlined in Article 4(2)(c) of the regulation, outweigh its costs, including in the longer term.

c) The project will either involve at least two Member States by directly crossing the border of two or more Member States or cross the border of at least one Member State and a European Economic Area country; alternatively, it will be located in the territory of one Member State and have a significant cross-border impact ([3]).

In the context of point b) above, each project's benefits are to be assessed by conducting a societal cost-benefit analysis (CBA) and according to the six policy criteria of Article 4(2)(c), namely:

- integration and involvement of network users with new technical requirements with regard to their electricity supply and demand;
- efficiency and interoperability of electricity transmission and distribution in day-to-day network operation;

([1]) The smart grid priority thematic group addresses the priority thematic area of smart grids deployment (Annex I(4) to the regulation) and includes representatives of Member States, national regulatory authorities, electricity transmission operators, project promoters, the European Network of Transmission System Operators for Electricity, the ACER and the European Commission.

([2]) http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:115:0039:0075:en:PDF.

([3]) Cross-border impact as set out in point (1)(e) of Annex IV to the regulation.

- network security, system control and quality of supply;
- optimised planning of future cost-efficient network investments;
- market functioning and customer services;
- involvement of users in management of their energy usage.

Moreover, for smart grid projects, i.e. projects falling under the energy infrastructure category set out in point 1(e) of Annex II, each specific policy criterion mentioned above is to be evaluated against a set of KPIs ([4]), namely:

- **KPI_1** – reduction of greenhouse emissions;
- **KPI_2** – environmental impact of electricity grid infrastructure;
- **KPI_3** – installed capacity of distributed energy resources in distribution networks;
- **KPI_4** – allowable maximum injection of electricity without congestion risks in transmission networks;
- **KPI_5** – energy not withdrawn from renewable sources due to congestion or security risks;
- **KPI_6** – methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both;
- **KPI_7** – operational flexibility provided for dynamic balancing of electricity in the network;
- **KPI_8** – ratio of reliably available generation capacity and peak demand;
- **KPI_9** – share of electricity generated from renewable sources;
- **KPI_{10}** – stability of the electricity system;
- **KPI_{11}** – duration and frequency of interruptions per customer, including climate-related disruptions;
- **KPI_{12}** – voltage quality performance;
- **KPI_{13}** – level of losses in transmission and distribution networks;
- **KPI_{14}** – ratio between minimum and maximum electricity demand within a defined time period;
- **KPI_{15}** – demand side participation in electricity markets and in energy efficiency measures;
- **KPI_{16}** – percentage utilisation (i.e. average loading) of electricity network components;
- **KPI_{17}** – availability of network components (related to planned and unplanned maintenance) and its impact on network performances;
- **KPI_{18}** – actual availability of network capacity with respect to its standard value;
- **KPI_{19}** – ratio between interconnection capacity of a Member State and its electricity demand;
- **KPI_{20}** – exploitation of interconnection capacities;
- **KPI_{21}** – congestion rents across interconnections.

According to the regulation, each regional and thematic group is to assess each project's contribution to the implementation of the same priority corridor or area in a transparent and objective manner and this assessment shall lead to a ranking of projects for the internal use of the group. Nevertheless, for smart grid projects falling under the energy infrastructure category set out in point 1(e) of Annex II, ranking is to be carried out only for those projects that affect the same two Member States, and due consideration must also be given to the number of users affected by the project, the annual energy consumption and the proportion of generation from non-dispatchable resources in the area covered by these users.

Projects of common interest may benefit from accelerated planning and permit granting, a single national authority for obtaining permits, improved regulatory conditions, lower administrative costs owing to streamlined environmental assessment processes, increased public participation through consultations and increased visibility to investors.

Once a project is assigned the status of project of common interest, it will also be eligible for Union financial assistance in the form of grants for works or grants for studies. Such assistance can be granted if the project

([4]) The KPIs are derived from the criteria of point (4) of Annex IV: level of sustainability; capacity of transmission and distribution grids; network connectivity; security and quality of supply; efficiency and service quality; and contribution to cross-border electricity markets.

promoters can clearly demonstrate the significant positive externalities generated by the project and its 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. Priority thematic area of smart grids deployment

The priority thematic area of smart grids deployment supports EU efforts to reach the EU's binding goal of 32 % renewables by 2030, which intrinsically calls for increase in the EU cross-border capacity necessary to effectively integrate renewable energy sources (RES) into the European energy infrastructure. This means that more and more RES need to be included in providing system support services, for example frequency control services from wind farms and energy storage (Wind Europe, 2017).

Moreover, to enable a competitive and properly functioning electricity market (and flexibility service market), clear rules on data access, exchange and management need to be put in place. Furthermore, some European countries will need to join forces to develop harmonised processes and functionalities to ensure interoperable data exchange and energy services across borders ([5]). This points to the need to bundle the efforts of various bodies, such as transmission system operators (TSOs), distribution system operators (DSOs), customers and industry, in the value chain of innovation. The TSO/DSO interface remains one of the key areas of future investments to increase system observability and enhance the deployment of new services that ensure overall system security. As today's markets do not support data sharing with market participants or service providers that are not legally based in the same country as the data hub, smart grid projects of common interest may also facilitate the cross-border exchange of data and energy services and contribute towards increased capacity flows across borders and more efficient use of the electricity interconnectors.

In the light of the above, smart grid investments under this priority thematic area are tightly linked with (1) the regional system needs to efficiently operate and plan the distribution and transmission networks given the growing penetration levels of RES and (2) the need to ensure a competitive and properly functioning integrated energy market. Such investments could entail optimisation of the use of existing infrastructure and joint planning of cross-border regional investment needs, cross-border sharing of flexibility and integration of different infrastructures (electricity, heat, gas, etc.).

With this in mind, smart grid projects of common interest appear vital with a view to reaching the EU energy and climate targets. Large differences between national energy infrastructures would prevent businesses and consumers from reaping the full benefits of integrated markets and smart grids, and would threaten cross-border trade and cooperation across national borders. In this view, the regulation on the trans-European energy infrastructure remains an essential instrument in supporting the development and installation of cross-border smart grid infrastructure.

([5]) http://eu-sysflex.com/.

2. Evaluation of project proposals

According to the energy infrastructure regulation requirements and on an official request for information launched by the Commission, six project candidates under the priority thematic area of smart grids deployment were submitted to the Commission by 7 March 2019:

- Again COnnected Networks (ACON) — Member States involved: Czechia and Slovakia;
- Cross-border flexibility (CrossFlex) — Member States involved: Estonia and Finland;
- Danube InGrid — Member States involved: Hungary and Slovakia;
- Data Bridge — Member States involved: Denmark, France, Estonia, Latvia, Lithuania and Finland;
- Smart Border Initiative (SBI) — Member States involved: Germany and France;
- SINCRO.GRID — Member States involved: Croatia and Slovenia.

Although the projects significantly differ in scope, objectives and stage of development, they are all driven by the current and future regional needs and they recognise and build on the increased value of a joint approach.

In general, all project proposals revolve around current/future system needs, such as:

- increase in network operational efficiency — for example by improving distribution network observability and controllability or sectoral integration (e.g. electrification of transport or interaction with the heating sector);
- increase in system security and stability while also enabling growing RES integration — by facilitating provision of ancillary services to both TSOs and DSOs and from resources connected to the distribution network and across borders;
- market integration — integration of retail and wholesale markets and also flexibility service markets across borders.

The sections below illustrate the evaluation of the project proposals.

2.1. Again COnnected Networks (Czechia and Slovakia)

2.1.1. General overview

The ACON project is built around the need to significantly improve the efficiency of the distribution networks in the project area while strengthening cooperation between Czechia and Slovakia and contributing to the territorial cohesion of the region of eastern Europe. The project aims to leverage the use of existing cross-border connections at distribution network level (at 110 kV and 22 kV) and further enhance network security by strengthening these interconnections and developing new ones. In this context, the project combines smart grid and conventional infrastructure investments, both necessary for strengthening the network operational security. Current 110 kV and 22 kV cross-border connections at distribution network level are mainly used in non-standard operational situations, whereas future regional needs of growing RES integration would lead to increased inter-regional flows in the distribution networks and thus challenge network security and quality of supply. The smart grid elements in the project include smart metering and control functionalities, mainly installed at MV and high-voltage (HV) distribution network levels; nevertheless, some of the equipment will also be installed at a low-voltage (LV) network level.

The ACON project brings together a total of four entities: E.ON Distribuce (DSO in Czechia), Západoslovenská distribučná (DSO in Slovakia), ČEPS (TSO in Czechia) and Slovenská elektrizačná prenosová sústava (SEPS) (TSO in Slovakia). The two DSOs take the primary responsibility for the project activities and act as project promoters, whereas the TSOs play a supporting role in regard to the far-reaching use of the information flow and associated impact on their networks.

Main project goals:

- improvement of distribution and transmission network operational efficiency;
- enhancement of network security and quality of supply;
- enablement of growing penetration levels of RES in the region;
- leverage of the benefits of increased cross-border cooperation and connectivity.

Expected impacts:

- increased market competition in the project area;
- increased distribution network reliability and quality of supply;

- greater energy input (increased number of consumers and RES grid connections);
- strengthened connection at DSO level between the two Member States.

The ACON project was included in the third Union list of projects of common interest and in 2018 has also been granted financial support from the Connecting Europe Facility (CEF) in the form of a grant for works.

2.1.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

The ACON project involves DSOs from two Member States responsible for carrying out the project's investments at either side of the project area. At its current stage, the project is mainly developed at the distribution network level; nevertheless, the project's impact is also expected and demonstrated at the transmission network level. In addition, the project has a direct impact on the cross-border capacity of the Member States involved, as it includes distribution network cross-border connections at 110 kV and 22 kV network levels. Smart grid elements deployed in the project area would enable cross-border data exchange and lead to an increase in the regular operational capacity of the cross-border interconnections. This would ultimately facilitate utilisation of different flexibility services for enhanced network reliability and quality of supply. Based on these arguments, the project complies with Article 4(1)(c)(i) of the regulation.

2.1.3. Project's necessity for the priority thematic area of smart grids deployment

The ACON project mainly involves investments at HV and MV distribution network levels, aiming to support integration of all users connected to the grid and facilitate growing penetration of RES. This entails adoption of smart grid technologies to efficiently integrate the behaviour and actions of all users connected to the electricity network and, as a result, increase the generation of renewable and distributed energy sources as well as facilitate demand response. Smart grid technologies addressed in the project allow improved network observability and control, and ultimately lead to enhanced network operational efficiency and higher quality and security of supply.

The ACON project is mainly driven by the current and future needs of the distribution networks in the project area, and therefore the DSOs of both Member States are the main project promoters. Nevertheless, the project is expected to have a positive impact on the transmission networks of both Member States, as increased network observability and control enabled by the ACON project would lead to better management of the power flows in the distribution networks and consequently power flows coming from the distribution into the transmission networks. In addition, demand-side management (DSM) solutions enabled by the ACON project, as well as future use of dynamic tariffs, could lead to a new type of ancillary services provided to the TSOs. In this regard, the project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

2.1.4. Compliance with the energy infrastructure category of Annex II(1)(e) to the regulation

The ACON project involves infrastructure investments mainly installed at the medium- and high-voltage distribution levels, providing two-way digital communication of meter data in real time, or close to real time, thus enabling interactive and intelligent monitoring and management of electricity network assets and consumption. To this end, the project includes investments in the energy infrastructure category of Annex II(1)(e) to the regulation.

Some of the main infrastructure investments addressed by the ACON project are the following:

- Smart grid technologies including a new substation dispatching control and protection system — installation of new local advanced supervisory control and data acquisition (SCADA), voltage regulation, remotely controlled transformation stations, installation of smart switchers (reclosers) and locators on the MV power lines, intelligent algorithms for automation, etc.
- Smart communication and control technologies, including smart metering devices — optic wires, high-speed power line carrier (PLC) communication, new network dispatching model, etc.
- Modernisation of current cross-border MV and HV power lines — installation of automated remote controls for MV power lines and distribution transformer stations, deployment of optic wires for real-time or close to real-time data communication on the current network status, looping and cabling of MV power lines, etc.
- Construction of new cross-border distribution network interconnections and a 110/22 kV transformer station with the aim of improving network operational efficiency, security and quality of supply, and increasing network capacity while accommodating future needs of all network users.

2.1.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The benefits of the ACON project are assessed according to the specific policy criteria outlined in Article 4(2)(c) of the regulation and captured by a set of 21 key performance indicators derived from the criteria presented in Annex IV(4) to the regulation. The ACON project promoters elaborate on the project's impact on each of the six specific criteria, selecting a set of KPIs to better capture this impact against a specific criterion.

Tables 1-6 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach to evaluate the project's contribution to each specific criterion (Vasiljevska and Gras, 2017). In addition, each project's impact has been assessed in view of the following two scenarios: business as usual (BaU), i.e. without implementation of the project; and a smart grid (SG) scenario, i.e. with implementation of the project.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

The project is expected to effectively accommodate growing integration of distributed RES and involve controllable load in the provision of more efficient distribution network operation. To this end, the promoters selected the following KPIs in addressing the project's impact on this criterion (Table 1).

Table 1. ACON: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_7: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to significantly increase the operational flexibility of the electricity network for dynamic balancing as a result of effective integration and involvement of network users in managing their load. This could lead to an increase in integration of distributed RES. The ACON promoters report and demonstrate a significant increase in the operational flexibility of the network and therefore positively quantify this KPI.	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	The ratio between the minimum and maximum electricity demand within a defined time period is expected to decrease as a result of better involvement of network users (and their controllable load) in network management. In terms of data information and promotion of dynamic tariffs, the proposed project solution is expected to facilitate demand-side management and reduce the difference between P_{max} and P_{min}. Based on this expectation, this KPI is positively assessed for the whole project area.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The promoters report an increase in distribution and transmission network efficiency (and consequently a reduced level of network losses) due to increased network monitoring and control and demand-side participation enabled by the project, which in turn would lead to a reduced environmental impact.

In this respect, the promoters selected the KPIs presented in Table 2 to capture the project's impact on this specific criterion.

Table 2. ACON: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_1$: reduction of greenhouse gas emissions	The project is expected to increase distribution and transmission network efficiency (e.g. lower network losses) owing to increased network observability and controllability, increased RES and effective demand-side management enabled by the project' solutions. The ACON promoters positively quantify this KPI and report a reduction of greenhouse gas (GHG) emissions owing to the project's deployment.	
KPI$_2$: environmental impact of electricity grid infrastructure	Enhanced network management and control enabled by the implementation of the project could lead to a reduced need to build overhead lines and, as a result, reduce the environmental impact of such grid infrastructure. Furthermore, the ACON project proposes replacement of certain overhead power lines with underground cables, thus reducing the long-term environmental impact in terms of visual impact, soil occupation, threat to endangered animal species, etc.	
KPI$_3$: installed capacity of distributed energy resources in distribution networks	Enhanced network management and control capabilities (e.g. innovative voltage regulation algorithms, reactive power management, innovative grid protection/monitoring) enabled by the ACON project would allow increased DER capacity that can be safely integrated in the distribution grids. The ACON promoters report an increase in the network hosting capacity for DER and positively assess this KPI.	
KPI$_{13}$: level of losses in transmission and distribution networks	The ACON promoters acknowledge the challenges in estimating the future value of losses owing to the smart grid elements deployed in the project; nevertheless, the promoters expect a reduction in network losses due to the enhanced network management introduced by the project. As the ACON project is developed mainly at the DSO level, this KPI is evaluated with respect to the level of distribution network losses. The promoters demonstrate a positive impact of the project on this KPI by calculating the relative difference in distribution network losses between the BaU and SG scenarios.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

The promoters expect a positive project impact on this KPI due to enhanced network management and control using advanced network reconfigurations and voltage regulation at the substations and provision of new types of ancillary services enabled by the project. In addition, extension of the 110 kV cross-border interconnection line and deployment of a new 22 kV line would allow enhanced network control and management and ultimately growing levels of DER.

The following KPIs (Table 3) are selected by the promoters to address the project's contribution to the third specific criterion.

Table 3. ACON: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_4$: allowable maximum injection of power into transmission networks without congestion risks	The ACON project mainly addresses the distribution network and in this case the KPI indicates the increased distribution network hosting capacity in the project area, thus allowing an increase in DER in the region without compromising the operation of the transmission network. The ACON promoters positively quantify this KPI as a result of an increase in the distribution network hosting capacity due to extension of the 110 kV line and deployment of the new 22 kV line. Moreover, the smart grid elements deployed within the project would allow enhanced network control and management and ultimately growing levels of DER.	

KPI_8: ratio of reliably available generation capacity and peak demand	The ACON project is expected to increase the reliably available generation capacity owing to enhanced network management and control, and lower peak demand as a result of demand-side management and introduction of dynamic tariffs. The reliably available capacity is the part of net generating capacity actually available to cover the peak load (ENTSO-E, 2009) and as such is an indicator of the system's adequacy. As the ACON project mainly addresses the distribution network level, the promoters use an alternative approach and positively quantify this KPI as network capability to accommodate more renewable energy owing to better operational management and consequently lower the difference between the P_{min} and P_{max}.	
KPI_{10}: stability of the electricity system	The promoters report a positive impact on this KPI in terms of quality of supply, as the ACON project can better deal with possible under-/overvoltage situations using advanced network reconfigurations and voltage regulation at the substations and provision of new types of ancillary services (e.g. DSM) while enabling the connection of more new network users. The KPI is, however, not quantified at this stage of the project's development.	
KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The ACON project is expected to increase network reliability via various smart grid elements deployed in the project (voltage regulation, remotely controlled transformation stations, installation of smart switchers and locators on the MV power lines, etc.). The promoters positively quantify the project's impact on both reliability indices, the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), thus bringing significant benefits to both the customers and the DSOs (in terms of avoided costs for repairs and service interventions).	
KPI_{12}: voltage quality performance	The promoters report a positive impact on this KPI in terms of voltage line violations (over a pre-defined period of time) defined in accordance with the EN 50160 standard. The KPI is quantified as a reduced number of voltage line violations over a period of 1 year owing to project deployment.	
KPI_{20}: exploitation of interconnection	As the project mainly addresses the distribution network level, the promoters estimate this KPI as an increase in the MV cross-border capacity due to modernisation and installation of new MV cross-border lines along with deployment of smart grid elements in the project area. As a result, the exploitation of the distribution interconnection will increase as well; however, more reliable assessment of this KPI cannot be quantified at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The promoters expect a positive impact of the project on this specific criterion as increased data availability related to network operation and maintenance enabled by the project would lead to optimised planning of network investments. Moreover, a higher-percentage utilisation of electricity network components would potentially lower the cost of distribution network management and ultimately enhance planning of future cost-efficient network investments.

In this respect, the promoters capture the project's impact on this criterion using the following KPIs (Table 4).

Table 4. ACON: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The promoters expect a positive impact on this KPI due to increased distribution network capacity and improved network stability enabled by the project. This would ultimately lead to enhanced utilisation of the TSO-DSO interface in terms of power flows coming from the transmission network and an increase in the lifetime and reliability of network components and equipment at the TSO-DSO interface. Notwithstanding the expected positive impact of the project, this KPI is not quantified at the current stage of the project's deployment.	
KPI_{17}: availability of network components (related to planned and unplanned maintenance) and its impact on network performance	The project is expected to have a positive impact on this KPI, as the increased data availability related to network operation and maintenance enabled by the project will lead to optimised planning of network investments. The implementation of smart grid capabilities will allow condition-based maintenance and ultimately reduce the mean time between network failures (as a result of optimal loading conditions of network components) and the mean time to repair (as a result of faster fault identification). The KPI is positively quantified using existing network failure reports from both DSOs and expected improvements based on similar pilot projects.	
KPI_{18}: actual availability of network capacity with respect to its standard value	The promoters select the actual availability of network capacity to address the project's impact on future cost-efficient investment. In this context, the ACON project is expected to increase the network capacity with respect to its nominal value as a result of the extension and enhancement of the 110 kV line and deployment of a new 22 kV cross-border interconnection. As the ACON SG project is developed mainly at the DSO level, the project's impact on this KPI is positively assessed owing to the installation of a new cross-border interconnection line at the distribution network level, new substations and smart grid elements.	

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

The project would enable increased involvement of end-users (both consumers and prosumers) in effective management of grid operation, which is critical for market functioning and the introduction of new customer services. In addition, increased physical cross-border interconnection is expected to have a positive impact on the market development in the project area.

Table 5 illustrates the KPIs selected to address the project's impact on the fifth specific criterion.

Table 5. ACON: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_5: energy not withdrawn from renewable sources due congestion or security risks	The promoters use this KPI to capture the project's impact on this specific criterion, as involvement of end-users (both consumers and prosumers) in effective management of the grid operation is critical for retail market functioning and the introduction of different customer services. In this regard, the ACON project is expected to reduce the amount of renewable energy not withdrawn owing to network congestion or security risks as a result of the increase in controllable load subject to demand-side management. At this stage of the project's development, promoters do not expect RES curtailment; therefore, the KPI is quantified as potential increase in RES without congestion/security risks, as a result of growing controllable load, subject to demand-side participation.	

KPI_6: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	The ACON project is expected to make available a more granular array of information, which will allow better allocation of electricity costs between different network users. Such information typically includes automatic and (close to) real-time energy consumption and/or generation data and detailed analysis of consumer/prosumer data in the form of clear tables and graphs used for customer energy bills. Furthermore, this amount of information and detail would further promote the introduction of dynamic tariffs and potentially engage end-users in more effective management of their energy consumption. Finally, more detailed information flows would allow regulators to assess RES contribution in provision of ancillary services to both DSOs and TSOs and move the market forward for new customer services.	
KPI_{19}: ratio between interconnection capacity of a Member State and its electricity demand	The promoters use this KPI to capture the project's impact on the fifth specific criterion, as cross-border interconnections and cross-border cooperation have a critical impact on market functioning. An increase in the physical cross-border interconnection enabled by the ACON project is expected to have a positive impact on market development in the project area. Since the ACON project is mainly developed at the distribution network level, this positive impact is quantified as an increase in the distribution network net transfer capacity (NTC) resulting from modernisation of the existing cross-border lines and installation of new 110 kV and 22 kV lines. In addition, deployment of smart grid elements on both sides of the border would allow integration of additional DER and enable ancillary services available to the DSO. This KPI is positively quantified as the increase in the ratio of interconnection capacity at distribution network level and energy demand in the project area. However, the impact on the ratio of total interconnection capacity in each Member State and their energy demand is expected to be limited.	
KPI_{21}: congestion rents across interconnections	A well-interconnected energy market must provide sufficient capacity to all market participants and, in this regard, the level of congestion rents strongly affects the functioning of the market itself. This KPI cannot be assessed at this stage of the project's development, as currently no congestion rents apply across the interconnection at the DSO level. Nevertheless, the promoters expect a lower probability/frequency of distribution network congestion owing to the project deployment.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

The ACON project is expected to increase the involvement of end-users in more effective management of their energy usage (through demand-side participation and energy efficiency measures) and consequently enable an increase in the proportion of electricity generated from RES.

Table 6 presents the KPIs, selected by the promoters, for addressing the ACON project's contribution to this specific criterion.

Table 6. ACON: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_9: share of electricity generated from renewable sources	The promoters choose this KPI to address the project contribution to the sixth specific criterion, as the proportion of electricity generated from RES is expected to increase owing to more effective involvement of end-users in the management of their energy usage. The promoters positively quantify this KPI owing to increased RES connections in the project area enabled by the smart grid elements	

	introduced by the project.	
KPI15: demand-side participation in electricity markets and in energy efficiency measures	This KPI is closely linked to the involvement of users in effective management of their energy usage. In this respect, the ACON project is expected to increase the load participating in demand-side management and energy efficiency measures in comparison with the BaU scenario. The KPI is therefore positively quantified using available data from the dispatch centres of both DSOs for the BaU scenario and an expected increase in additional sources subject to DSM coming from similar pilot projects in the region for the SG scenario.	

Source: Own elaboration, 2019.

2.1.5.1. Economic appraisal

The following section presents the societal benefits of the ACON project in monetary terms along with the total cost (capital and operational expenditure), as communicated by the promoters. Furthermore, economic indicators such as the net present value (NPV), the internal rate of return (IRR) and the benefit/cost (B/C) ratio are used to verify whether or not the overall project's benefits outweigh the project's costs and therefore the project complies with the second general criteria of the regulation (Article 4 1 (b)).

The promoters assumed the following values as variables used in the societal CBA:

- **demand growth**: an average annual demand growth of 0.56 % has been assumed for the project area;
- **discount rate**: a value of 4 % has been used as societal discount rate (Vasiljevska and Gras, 2017);
- **time horizon**: 25 years has been chosen as time horizon (as the project also considers traditional investments);
- **peak demand reduction**: 31.5 MW has been assumed for the project area owing to expected peak load shift;
- **electricity price for losses**: EUR 27/MWh and EUR 32/MWh for Czechia and Slovakia, respectively;
- **electricity market price**: EUR 52.9/MWh ([6]);
- **cost of energy not supplied**: EUR 6 550/MWh and EUR 9 010/MWh for Czechia and Slovakia, respectively ([7]);
- **carbon prices**: EUR 47.6/t (European Commission, 2011);
- **fuel prices**: EUR 1.3/l.

The project reports a positive outcome in the societal CBA. The main monetary benefits and costs are listed below.

2.1.5.2. Main monetary benefits

The ACON project is expected to deliver a set of positive impacts and in that respect the following monetised benefits are communicated by the project promoters:

- reduced operation and maintenance costs;
- reduced cost of equipment breakdowns;
- deferred distribution capacity investments due to consumption reduction;
- deferred distribution capacity investments due to peak load shift;
- reduced electricity technical losses;
- electricity savings due to consumption reduction;
- electricity savings due to peak load transfer;
- increased value of service due to reduced outage times;

(6) http://www.eex.com/.
(7) https://www.sciencedirect.com/science/article/pii/S2214629617301184.

- recovered revenue due to reduced outages;
- reduced CO_2 emissions due to reduced losses;
- reduced CO_2 emissions due to wider diffusion of low-carbon generation sources;
- reduced fossil fuel usage;
- reduction in electricity interruption costs for households;
- prevention of blackouts and brownouts, etc.

2.1.5.3. Main costs

The current estimated project costs are based on the CEF energy application submitted during the second call for submissions, in September 2018, where the project's costs correspond to the project's duration period 2018-2024. In this PCI application, the promoters report some minor adjustments in the costs based on additional sub-activities, such as cyber and physical security of the smart grid infrastructure and of the energy-dispatching centre planned for the period of 2025-2027.

The main costs associated with the project deployment are:

- smart technologies related to a new substation dispatching control and protection system (remote control, cabling, voltage regulation, intelligent metering system, smart distribution board, reclosers, platform for demand-side management, etc.);
- smart technologies related to communication and network management, including smart meter devices (new dispatching model, optic wires, smart meter devices, high-speed PLC communication, intelligent algorithms for network management, etc.);
- modernisation of the current cross-border MV and HV power lines and construction of new cross-border distribution interconnectors to increase network capacity for new network users, remove undervoltage situation, etc.

2.1.5.4. Sensitivity analysis

The NPV of the project changes as the following critical variables are adjusted to account for the worst-case scenario:

- **decrease in outage time:** lowering the benefit of reduced outage time by 50 % diminishes the project's NPV by EUR 18.8 million;
- **peak demand reduction**: lowering the value of assumed peak demand reduction owing to both energy savings and peak load shifting by 50 % diminishes the project's NPV by EUR 18.6 million;
- **consumption reduction:** lowering the benefit of consumption reduction by 50 % diminishes the project's NPV by EUR 5.8 million;
- **CO_2 price:** lowering the CO_2 by 50 %, diminishes the NPV by EUR 5.3 million.

The promoters report that even in the constructed worst-case scenario, where most salient benefits and variables (e.g. consumption reduction, decrease in outage time, reduced equipment breakdown, peak demand reduction, energy market price, wholesale margin difference between peak and non-peak generation and CO_2 price) are reduced by 50 % at once, the expected NPV is kept positive, while the B/C ratio is still marginally above 1 (1.03).

2.1.5.5. Additional non-monetary benefits

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

- reduced air pollutant emissions (dust particles, SO_x, NO_x and CO) due to reduced line losses;
- reduced air pollutant emissions (dust particles, SO_x, NO_x and CO) due to wider diffusion of low-carbon generation sources;
- reduced soil occupation;
- lower threat to animal species;
- reduced visual impact.

2.1.6. Summary of the ACON project's evaluation

The ACON project builds its scope on the need to significantly improve the efficiency of the distribution networks in the project area while increasing the cross-border capacity at the DSO level. It capitalises on existing cross-border distribution network interconnections (currently used only for non-standard operational activities) and proposes further enhancement of these interconnections by deployment of smart grid solutions. In addition, the project includes installation of additional 22 kV and 110 kV cross-border lines necessary for addressing current and future grid stability and reliability issues given growing levels of RES. Notwithstanding these conventional investments necessary to support the energy needs in the project area, the ACON project mainly involves smart grid technology and solutions and, as a result, it proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

The project mainly addresses a geographical region covering the electricity distribution network of both countries. In this sense, it directly involves DSOs from two Member States; the two TSOs involved in the project are also expected to benefit from more efficient and reliable operation of the distribution networks in the project area. The cross-border dimension also includes deployment of cross-border connection of two-way real-time or close to real-time digital communication allowing interactive and intelligent monitoring and management of the electricity network through better involvement of network users in the management of their energy usage. This would ultimately create favourable conditions for utilisation of demand-side flexibility and development of innovative customer services. In this respect, the project complies with Article 4(1)(c)(i) of the regulation. In addition, the project demonstrates a significant contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the project's societal CBA.

2.2. Cross-border flexibility — CrossFlex project (Estonia and Finland)

2.2.1. General overview

The project's overall aim is to support RES integration and increase security of supply in mainland Finland, the Åland Islands and Estonia by cross-border provision of flexibility services provided by distributed generation (DG) connected to both distribution and transmission networks. This is driven by the growing need for flexibility services in the Nordic countries due to an expected lack of inertia adequacy in the long term. In addition, the long-term objective of the Åland Islands is to use 100 % renewable energy, which makes the provision of flexibility services to and from the neighbouring countries a highly valuable resource to improve the overall efficiency and feasibility of that objective.

In this sense, the CrossFlex project addresses system needs for increased flexibility in the project area by using existing infrastructure: high-voltage direct current (HVDC) systems and DG. More specifically, it focuses on the coordination of flexibility resources (i.e. DG) and the HVDC system, which is vital for the provision of cross-border capacity for flexibility services.

The CrossFlex project builds on the results of various ongoing smart grid projects and initiatives in the project area addressing present and future flexibility needs; therefore, a number of flexibility resources are expected to be implemented based on a newly developed portfolio of flexibility needs and services. In addition, the existing HVDC control systems will be modified to allow cross-border provision of at least some of these services.

The CrossFlex project involves TSOs from two Member States, namely Fingrid and Kraftnät Åland from Finland and Elering from Estonia.

Main project goals:

- accelerate the integration of renewable generation and cost-effective energy system operation in Finland and Estonia;
- enable cross-border flexibility;
- maximise the utilisation of flexibility resources for power system needs at both the distribution and transmission levels;
- extend the possibilities to provide fast reserve services across borders using HVDC systems;
- identify technical requirements (including validation and information exchange) for both distributed flexibility resources and HVDC control systems;
- support the development of a flexibility platform under the ongoing Horizon 2020 project INTERRFACE and enhance its capability to better support the cross-border flexibility features in the project area.

Expected impacts:

- improved requirements facilitating provision of a wide portfolio of flexibility services to strengthen the business cases related to flexibility resources investments at local, regional and cross-border levels;
- measures to support integration of RES into distribution and transmission networks with new flexibility features;
- increased utilisation of HVDC systems, specifically ÅlLink and EstLink 1 interconnectors;
- increased robustness against unintentional islanding of Åland;
- increased availability of flexibility services essential to facilitate power balance management as well as management of the power system under abnormal network operation;
- implementation of flexibility services required to achieve a 100 % renewable energy island.

2.2.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

The project aims to address the system needs for increased flexibility services provided by distributed energy resources and using existing HVDC interconnectors. At present, a major portion of the cross-border capacity in the Nordic countries has been implemented using HVDC, and the project promoters expect an increasing need for cross-border provision of flexibility services necessary to enable integration of a large amount of RES and increase the security of supply in the project area.
The CrossFlex project involves TSOs from two Member States, responsible for carrying out the project's investments at either side of the project area. The project also involves DSOs as well as investors of flexibility resources in the project. In this respect, there are ongoing calls for partners in Finland and Estonia, which are expected to be finalised by the end of May 2019, and additional partners are expected to be selected by the end of June 2019.
The project builds on existing outputs from various smart grid projects with scopes driven by not only current but also future system flexibility needs to identify the type of flexibility services and associated resources providing such services. Currently, the HVDC interconnector EstLink 1, owned by the Finnish and Estonian TSOs, is also used for the provision of frequency control service across the Finnish-Estonian border. The aim of the project is to further increase the utilisation of the HVDC interconnectors in the project area to widen and strengthen the portfolio of flexibility services. In addition, provision and procurement of flexibility services across borders would also support the long-term target of the Åland Islands of using 100 % renewable energy. Therefore, one of the key objectives of the project is to modify the existing HVDC control systems to allow provision of flexibility services across borders.
In this regard, the project complies with Article 4(1)(c)(i) of the regulation.

2.2.3. Project's necessity for the priority thematic area of smart grids deployment

The CrossFlex project builds its scope and objectives on recent smart grid pilots and research and development (R&D) projects, and in particular on enabling flexibility resources needed to support system security and management of the distribution and transmission networks in mainland Finland, Estonia and the Åland Islands. The outputs of these recent pilots and R&D projects are used to develop various use cases for flexibility services as well as technical specifications for the implementation of a selected number of DER. Furthermore, the project aims to study, design and implement the required flexibility features of the existing HVDC systems to facilitate provision of flexibility services across borders. This entails adoption of smart grid technologies to efficiently integrate the behaviour and actions of all users connected to the electricity network, to increase the generation capacity from renewable and distributed energy sources and facilitate demand response.

The current project proposal includes five use cases, which have been identified based on pilots and on the focus areas of R&D activities in the Finland-Estonia-Åland region, namely:

- RES integration;
- security of supply at remote regions or energy communities;
- e-mobility/e-ferries;
- sensitive loads in the process industry;
- local optimisation of customer energy costs, e.g. shopping centres.

The first two use cases (the cases with the highest regional potential in Finland and Estonia) have been used by the promoters in demonstrating the project's contribution to the smart grid specific criteria of the regulation.

2.2.4. Compliance with the energy infrastructure category of Annex II(1)(e) to the regulation

The CrossFlex project involves infrastructure investments mainly installed at the transmission and medium- and high-voltage distribution levels. These investments enable interactive and intelligent monitoring and management of electricity network assets and consumption, and integrate the behaviour of both generators and consumers. To this end, the project's investments comply with the energy infrastructure category of Annex II(1)(e) to the regulation.

The main infrastructure assets addressed by the CrossFlex project are the following:

- **Cross-border transmission capacity enhancement** — cross-border investments (HVDC upgrades and modifications):
  - control and protection upgrade extended with new control features of the EstLink 1 HVDC interconnector (connecting Finland with Estonia);
  - control and protection modifications of the EstLink 2 HVDC interconnector (connecting Finland with Estonia);
  - control and protection modifications of the Åland HVDC interconnector (connecting Åland with mainland Finland);
  - yearly operational cost of the HVDC systems.
- **DSO-level flexibility investments:**
  - energy storage capacity (around 25 MW capacity);
  - improvements to substation automation equipment;
  - dynamic line rating equipment;
  - yearly operational cost of the energy storage capacity.
- **Development of a flexibility market** — integration of flexibility market platforms and integration of flexibility assets to this market platform, etc.

2.2.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The promoters demonstrate the project's impact on the smart grid specific criteria in reference to four building blocks necessary to (1) develop and implement the flexibility platforms, (2) identify the technical requirements, (3) integrate the flexibility resources to the platforms and (4) facilitate the provision of flexibility services across the borders. The four building blocks are the following:

- cross-border investments (HVDC upgrades and modifications) — 100-300 MW additional cross-border capacity expected to be allocated for flexibility and 30-150 MVar for voltage control as a result of enhanced possibility for more flexibility services (also to be provided simultaneously);
- development of flexibility market platforms and integration of flexibility resources to these platforms;
- deployment of flexibility resources (battery energy storage system (BESS) or BESS combined with either small-scale pumped hydro storage or small-scale power-to-gas plant) and DSO investments (e.g. substation automation, dynamic thermal rating (DTR)) — in the use case 'RES integration', 10-25 MW storage capacity and 5-25 MVar reactive power and voltage control capacity;
- deployment of flexibility resources (BESS or high-power uninterrupted power supply (UPS) equipment or, alternatively, combination of BESS and small-scale power-to-gas plant) and DSO investments (e.g. substation automation, DTR, etc.) — in the use case 'security of supply', 0-10 MW storage capacity and 0-10 MVar reactive power and voltage control capacity.

The promoters elaborate on the project's impact on each of the six specific criteria, selecting a set of KPIs to better capture the project's impact against a specific criterion. The project's impact is mainly evaluated by performing a qualitative assessment, since the actual capacity, technical characteristics and exact location of these investments are not known at this stage of the project's development. As a result, uncertainties remain in the assumptions made and the estimation approach for most of the evaluated impacts presented below.

Table 7-12 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach (Vasiljevska and Gras, 2017) to evaluate the project's contribution to each specific criterion. In addition, each project's impact has been assessed in view of the following two scenarios: a BaU scenario, i.e. without deployment of the project, and an SG scenario, i.e. with implementation of the project.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

The CrossFlex project is expected to increase the number of network users integrating flexibility resources by developing a wide portfolio of flexibility products and enabling a cross-border flexibility market. The promoters demonstrate the project's contribution to the first policy criterion by making reference to a set of chosen KPIs as listed in Table 7.

Table 7. CrossFlex: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_3: installed capacity of distributed energy resources in distribution networks	The promoters expect a significant positive impact of the project on this KPI, as the further development of flexibility platforms will facilitate the provision of services required to support RES integration, both at the distribution level and at the transmission network level. In addition, deployment of additional flexibility resources (e.g. battery storage) will further support the integration of RES.	
KPI_4: allowable maximum injection of electricity without congestion risks in transmission networks	The promoters report and demonstrate moderate to significant contribution of the project to this KPI as a result of: • development of flexibility platforms, which is expected to facilitate provision of services required to support RES integration; • integration of additional flexibility resources in the use case 'RES integration', which will facilitate a wide range of services and therefore support RES integration while safeguarding the system security; • enhanced voltage quality and reduced power interruptions due to deployment of flexibility resources to avoid costly power interruptions of industrial processes.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The promoters report a significant positive impact of the project on this KPI due to: • development of flexibility platforms which facilitate provision of services supporting RES integration; • deployment of flexibility resources in the use cases 'RES integration' and 'security of supply', which will increase the available capacity for flexibility services and consequently contribute to a reduction in the amount of renewable energy curtailed due to congestion or security risks.	
KPI_9: share of electricity generated from renewable sources	The promoters argue for a significant positive impact of the project on this KPI, as it supports provision of flexibility services, which is vital for increased penetration of intermittent RES. Moreover, additional storage deployment and capacity for voltage control and reactive power will further support RES integration and allow the owners of flexibility resources to make additional revenues from flexibility provision.	

KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The project is likely to have a moderate to significant positive impact on this KPI owing to the following aspects of the project. • Coordination of the control features of the HVDC and the DER for provision of flexibility services may help to avoid large-scale network outages and consequently reduce the network restoration time. • Further development of flexibility platforms will facilitate provision of flexibility services to also manage disturbance and emergency operational network conditions at local and regional levels. • Installation of additional flexibility resources will avoid costly interruptions in industrial processes. This benefit depends on the location of the industrial site and the sensitivity of the process. The promoters report estimation of the average number of annual interruptions and the range of its monetary value. In this regard, the impact has been assessed as positive; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI_{12}: voltage quality performance	Voltage quality performance can be assessed by keeping track of short interruptions, voltage dips, flicker, supply voltage variation and harmonic distortions. The promoters report a moderate to significant positive impact on this KPI as a result of the following: • further development of the market for flexibility services; • technical requirements set up at the planning stage of the project to enhance users' voltage quality and reduce power interruption using active voltage control, UPS features, reactive power support, etc. Nevertheless, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The promoters expect a moderate to significant positive impact of the project on this KPI, as it enables a wide portfolio of flexibility services. Therefore, it allows users to offer their capacity for different markets, which in turn would result in an increase in assets utilisation.	
KPI_{21}: congestion rents across interconnections	The project is expected to have a moderate to significant positive impact on this KPI owing to: • the potential of the HVDC systems to allow network users to provide services for cross-border congestion management; • further development of flexibility platforms, which will allow network users to benefit from the up- and down-regulation required to manage potential transmission network congestion. Nevertheless, the impact of the project on this KPI cannot be assessed with a sufficient level of confidence at the current stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The CrossFlex project aims to develop solutions to facilitate the coordination of measures to respond to different system needs at both the distribution (network congestion, voltage profiles, etc.) and transmission network (balancing, frequency reserves, system security and stability, etc.) levels, thereby increasing network operational efficiency. The promoters demonstrate the project's contribution to the second policy criterion by making reference to a set of chosen KPIs as listed in Table 8.

Table 8. CrossFlex: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_{7}$: operational flexibility provided for dynamic balancing of electricity in the network	The promoters report a moderate to significant positive impact of this KPI, as the project's scope is to leverage technologies facilitating the provision of flexibility services to the transmission and distribution networks as well as supporting the integration of RES.	
KPI$_{13}$: level of losses in transmission and distribution networks	The project is expected to contribute to more efficient use of existing network components, which would ultimately result in energy loss reduction. On the other hand, however, increased utilisation of HVDC systems and utilisation of power electronic interfaces of flexibility resources will probably increase total network losses. Therefore, a greater impact cannot be assessed at the current stage of the project's development.	
KPI$_{16}$: percentage utilisation (i.e. average loading) of electricity network components	The promoters report a moderate to significant positive impact of the project on this KPI as a result of the following: • Further development of flexibility platforms to facilitate the interoperability of transmission and distribution in day-to-day operation. • Increase in allocated capacity for flexibility services (frequency containment reserve for normal operation (FCR-N), frequency controlled disturbance reserve (FCR-D) and firm frequency response (FRR)). The promoters argue for a significant potential for increase in allocated capacity on the EstLink 1 interconnector, which could reach up to 50 % of EstLink 1's total capacity; however, the actual energy transfer is expected to increase by up to 25 % of the allocated capacity. Deployment of flexibility resources in the use cases 'RES integration' and 'prevention of power supply interruption' will increase the available capacity for flexibility services at the transmission and distribution network levels, and therefore increase network utilisation.	
KPI$_{20}$: exploitation of interconnection capacities	The promoters report a moderate to significant positive impact of the project on this KPI as a result of: • upgrade and modification of the HVDC systems to enable increased provision of cross-border flexibility services — the promoters envisage a significant increase in the utilisation of the currently underutilised EstLink 1 (up to three times the present level); • further development of the flexibility platforms to facilitate the interoperability of transmission and distribution in day-to-day operation.	
KPI$_{21}$: congestion rents across interconnections	The project is expected to have a moderate to significant positive impact on this KPI owing to: • the possibility of HVDC systems to allow network users to provide services for cross-border congestion management; • further development of flexibility platforms, which will allow network users to benefit from up- and down-regulation required to manage potential transmission network congestion.	

	Nevertheless, the impact of the project on this KPI cannot be assessed with a sufficient level of confidence at the current stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

One of the CrossFlex project's objectives is to define technical requirements for implementation of a wide portfolio of flexibility services essential to enhance future network security and quality of supply. The promoters demonstrate the project's contribution to the third policy criterion by making reference to a set of chosen KPIs as listed in Table 9.

Table 9. CrossFlex: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_8: ratio of reliably available generation capacity and peak demand	The ratio between the reliably available generation capacity and the peak demand is representative of the system's adequacy. The promoters report a moderate to significant positive impact of the project on this KPI for the following reasons: • Further development of flexibility platforms would facilitate demand-side management as a source of flexibility. • The installed flexibility resources deployed in the project would increase the available short-term capacity and, in addition, the RES integration facilitated by these resources would further increase this ratio. However, owing to low availability of solar and wind energy during peak demand periods in Finland, this development is expected to result in a relatively minor increase. Uncertainties persist in the information provided owing to the insufficient maturity of the project, and thus a more reliable impact cannot be assessed at the current stage of the project's development.	
KPI_{10}: stability of the electricity system	The promoters demonstrate a moderate to significant positive impact on this KPI due to the following: • improved capabilities of HVDC converters to provide different frequency and voltage control services as well as network restoration support under contingencies and special operating conditions; • further development of flexibility platforms to facilitate the availability of flexibility services dealing with disturbance and emergency operational network conditions at local and regional levels; • installation of additional capacity of flexibility resources with reactive power capability and effective coordination with the HVDC system, which may facilitate provision of flexibility services across the border (voltage and reactive power control, fast frequency reserve, potential system protection schemes, etc.) and thus enhance local and regional network stability. Nevertheless, more reliable assessment, in terms of voltage and frequency instabilities, in both SG and BaU scenarios cannot be performed at the current stage of the project's development.	
KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The project is likely to have a moderate to significant positive impact on this KPI owing to the following aspects of the project: • Coordination of the HVDC and the DER control features may help to avoid large-scale network outages and consequently reduce network restoration time. • Further development of flexibility platforms will facilitate provision of flexibility services to also manage disturbance and	

	emergency operational network conditions at local and regional levels. • Installation of additional flexibility resources will avoid costly interruptions in industrial processes. This benefit depends on the location of the industrial site and the sensitivity of the process. The promoters report estimation of the average number of annual interruptions and the range of its monetary value. In this regard, the impact has been assessed as positive; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI$_{12}$: voltage quality performance	The promoters report a moderate to significant positive impact of the project on this KPI due to the following: • Further development of flexibility platforms, which will support the deployment of flexibility resources with capability to improve voltage quality. • Deployment of additional flexibility resources (e.g. local energy storage) as auxiliary power in case of grid disconnection of wind power sites (especially those located in remote areas). • Installation of additional flexibility resources to avoid costly interruptions in industrial processes. This benefit depends on the location of the industrial site (how prone it is to disturbances) and the sensitivity of the process. The promoters provide estimates for the average number of annual interruptions and the range of their monetary values. • Improved voltage capability of HVDC converters to facilitate network management under outages and contingencies, which is expected to nearly double the already very fast voltage control available in Finland. The benefits in the short term are considered limited; however, in the long run, and in conjunction with the phase-out of rotating machines of CHP power plants, the impact is expected to increase significantly. Nevertheless, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI$_{18}$: actual availability of network capacity with respect to its standard value	The promoters expect a minor to moderate positive impact of the project on this KPI mainly owing to further development of flexibility platforms, which can facilitate the provision of services for network contingency management and ultimately improve the availability of the network capacity. In addition, the upgrade and modification of HVDC systems may have an impact on the reliability of the HVDC systems. However, more reliable assessment of the project on this KPI cannot be performed at the current stage of the project's development.	
KPI$_{20}$: exploitation of interconnection capacities	The project is likely to contribute to better exploitation of the interconnection capacities in the project area as a result of: • HVDC upgrade and modifications to allow more capacity allocation for flexibility services, also enabling provision of several services simultaneously and increasing the number of available services. In addition, the project focuses on the coordination of HVDC control and the activation of flexibility resources to avoid congestion. The capacity of the HVDC interconnectors to provide simultaneous services is expected to increase by one third on average, whereas the total number of available services is expected to increase by 50 %. • Further development of flexibility platforms to allow cross-border flexibility provision.	

	• Additional installation of flexibility resources, which will result in increased available capacity for provision of flexibility services.	(green)

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The CrossFlex project aims to define technical requirements for development of a wide portfolio of flexibility services, which would also facilitate the creation of business cases for various flexibility providers. Moreover, these technical requirements could support the development of tools to allow flexibility service to be part of network-planning practices. The promoters demonstrate the project's contribution to the fourth policy criterion by making reference to a set of chosen KPIs as listed in Table 10.

Table 10. CrossFlex: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_3: installed capacity of distributed energy resources in distribution networks	The promoters expect a significant positive impact of the project on this KPI, as further development of flexibility platforms will facilitate the provision of services required to support RES integration in both the distribution and transmission networks. Moreover, deployment of additional flexibility resources (e.g. battery storage) will further support the integration of RES.	(green)
KPI_4: allowable maximum injection of electricity without congestion risks in transmission networks	The promoters report and demonstrate a moderate to significant contribution of the project to this KPI as a result of: • development of flexibility platforms, which is expected to facilitate provision of services required to support RES integration; • enhanced voltage quality and reduced power interruptions due to deployment of flexibility resources to avoid costly power interruptions of industrial processes.	(green)
KPI_{12}: voltage quality performance	The promoters report a moderate to significant positive impact of the project on this KPI due to the following: • Further development of flexibility platforms, which will support the deployment of flexibility resources with the capability to improve voltage quality. • Deployment of additional flexibility resources (e.g. local energy storage) as auxiliary power in case of grid disconnection of a wind power site (especially those located in remote areas). • Installation of additional flexibility resources to avoid costly interruptions in industrial processes. This benefit depends on the location of the industrial site (how prone it is to disturbances) and the sensitivity of the process. The promoters report estimates for the average number of annual interruptions and for the range of their monetary values. • Improved voltage capability of HVDC converters to facilitate network management under outages and contingencies, which is expected to nearly double the already very fast voltage control available in Finland. The benefits in the short term are considered limited; however, in the long term, and jointly with the phase-out of rotating machines of CHP power plants, the impact will increase significantly. Nevertheless, uncertainties persist in the information provided owing to the insufficient maturity of the project.	(yellow)
KPI_{17}: availability of network components (related to planned and	The promoters report no or an insignificant impact of the project on this KPI.	(red)

unplanned maintenance) and its impact on network performances		

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

The CrossFlex project aims to develop a cross-border flexibility market and therefore expand the amount of resources providing flexibility services. This would ultimately enable better market functioning and enhanced customer services. The promoters demonstrate the project's contribution to the fifth policy criterion by making reference to a set of chosen KPIs as listed in Table 11.

Table 11. CrossFlex: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse emissions	The promoters demonstrate a moderate to significant positive impact on this KPI due to the following aspects of the project: • HVDC upgrade and modifications, which will facilitate the cross-border flexibility service market and also provide incentives to invest in flexibility resources across borders; • further development of flexibility platforms, which will facilitate the development of the flexibility service market and create favourable business opportunities for investments in flexibility resources as one of the main drivers to promote RES integration; • deployment of additional flexibility resources and associated flexibility services in the use case 'RES integration', which will accelerate further integration of RES. However, a more reliable assessment cannot be performed at the current stage of the project's development owing to uncertainties in the assumptions made (e.g. type of flexibility resources to be deployed).	
KPI_2: environmental impact of electricity grid infrastructure	The project will probably have a significant environmental impact, as the project's main scope is to take full advantage of the technical capabilities of flexibility resources to accelerate the integration of renewables. Nevertheless, a greater impact, in terms of possible areas of environmental impact (land use, landscape change, visual and acoustic impact, etc.), cannot be assessed at the current stage of the project's development.	
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure for generators, consumers and those that do both	The promoters report a moderate to significant positive impact of the project on this KPI due to the following: • HVDC upgrade and modifications for cross-border flexibility service provision, which will support the development of common methods and practices to manage both local/regional and cross-border issues. • Further development of flexibility platforms, which are vital to the development of a functioning flexibility market. The implementation and integration of flexibility resources will strongly promote development and implementation of methods and mechanisms related to the provision of flexibility services. Nevertheless, a more reliable assessment, in terms of new information that can be measured and collected when the project is deployed, and its use in defining more accurate methods of allocating costs, cannot be performed at the current stage of the project's development.	

KPI$_{19}$: ratio between interconnection capacity of a Member State and its electricity demand	The promoters report no direct impact on this KPI, as the project does not lead to capacity increase. A minor positive impact can be expected owing to possible improvements in the reliability of the cross-border connections.	
KPI$_{20}$: exploitation of interconnection capacities	The project is likely to contribute to better exploitation of the interconnection capacities in the project area as a result of the following: • HVDC upgrade and modifications to allow more capacity allocation for flexibility services, enabling provision of several services simultaneously and increasing the number of available services. In addition, the project focuses on the coordination of HVDC control and the activation of flexibility resources to avoid congestions. The capacity of the HVDC interconnectors to provide simultaneous services is expected to increase on average by one third, whereas the total number of available services is expected to increase by 50 %. • Further development of flexibility platforms to facilitate cross-border flexibility provision. • Additional installation of flexibility resources, which will result in increased available capacity for provision of flexibility services.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

The CrossFlex project includes development of a flexibility platform through which network users (e.g. through aggregators) could provide various system services across borders.

The promoters demonstrate the project's contribution to the sixth policy criterion by making reference to a set of chosen KPIs as listed in Table 12.

Table 12. CrossFlex: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_{14}$: ratio between minimum and maximum electricity demand within a defined time period	The project is expected to have a significant positive impact on this KPI, as its main objective is to enhance the technical capabilities of flexibility resources and, as a consequence, accelerate the possibilities for these resources to provide a wide variety of services for the needs of the transmission and distribution system operators as well as network users. Still, uncertainties persist in the information provided and, therefore, a more reliable assessment cannot be performed at the current stage of the project's development.	
KPI$_{15}$: demand-side participation in electricity markets and in energy efficiency measures	The promoters expect a moderate to significant positive impact of the project on this KPI owing to the following aspects of the project: • further development of flexibility platforms, which will facilitate demand-side management as a source of flexibility; • HVDC upgrade and modifications to facilitate a larger market for flexibility service provision; • deployment of additional flexibility resources to facilitate provision of flexibility services and avoid costly interruptions of industrial processes by enabling industrial consumers to not only improve the performance of their processes using smart grid technology but also provide flexibility services. Still, a more reliable assessment cannot be performed at the current stage of the project's deployment owing to uncertainties related to the	

	amount of load participating in demand-side management, type of flexibility resources deployed, etc.	

Source: Own elaboration, 2019.

2.2.5.1. Economic appraisal

One of the main objectives of the project is to take full advantage of the possibilities provided by the existing HVDC systems in the project area and technologies of flexibility resources essential for cost-efficient RES integration. The project demonstrates potential for significant positive effects, including the following:

- provision of balancing and frequency (containment reserves, fast reserves, etc.) services;
- congestion management;
- system security (e.g. support for network restoration) and security of supply;
- reduction of costs related to power interruptions;
- integration of renewable generation;
- reactive power management and voltage control.

Nevertheless, a societal CBA cannot be reliably performed at the current stage of the project's development, mainly owing to the following aspects communicated to the Commission until 15 May 2019:

- the actual flexibility investments and investors are still not known;
- the actual DSOs and related investments are still not known;
- the complete list of use cases for the whole project area, which reflects the system/market needs of the project region, is shortly to be defined.

The promoters expect to conduct a more reliable assessment of the societal CBA by the end of June 2019, once the representative and scalable use cases and core flexibility investments are identified and the project consortium completed.

2.2.5.2. Main monetary benefits

The CrossFlex project is expected to deliver a set of positive impacts and in that respect the following monetised benefits have been communicated by the project promoters:

- socioeconomic benefit due to replacement of fuels required for generation of heat;
- energy trading by flexibility owners;
- provision of balancing services by the flexibility owners.

Other expected positive impacts, which have not been quantified at the current stage of the project's development, are the following:

- provision of flexibility products such as firm frequency response (FFR), frequency controlled disturbance reserve (FCR-D) and frequency containment reserve for normal operation (FCR-N) by the flexibility owners;
- provision of congestion management services;
- management of interruptions, reactive power and voltage control;
- support for network restoration;
- increased security of supply.

2.2.5.3. Main costs

The main costs associated with the project deployment are as follows:

- **Cross-border transmission capacity enhancement** — cross-border investments (HVDC upgrades and modifications):
  - control and protection upgrade extended with new control features of the EstLink 1 HVDC interconnector;
  - control and protection modifications of the EstLink 2 HVDC interconnector;

- control and protection modifications of the Åland HVDC interconnector;
- yearly operational cost of the HVDC systems.

- **DSO-level flexibility investments:**
    - energy storage capacity (around 25 MW capacity);
    - improvements to substation automation equipment;
    - dynamic line rating equipment;
    - yearly operational cost of the energy storage capacity.
- **Development of a flexibility market** — integration of flexibility market platforms, integration of flexibility assets to the market platform, etc.

2.2.5.4. Additional non-monetary benefits

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

- great replicability potential in the region — as the CrossFlex project is driven by fast integration of RES in Finland and Estonia, one of the project's aims is to identify investments with great replicability in the region.
- synergy with the INTERRFACE Horizon 2020 project — the INTERRFACE project aims to develop possible concepts and rules for flexibility markets, whereas the CrossFlex project facilitates the deployment of flexibility platforms along with integration of various flexibility resources and a wide portfolio of flexibility services.
- enhanced DSO-TSO cooperation — the CrossFlex project involves TSOs, DSOs and DER owners in the whole process from the revision of the technical requirements of flexibility resources to the integration of these resources into the flexibility platforms.
- technological innovation — several R&D projects have been addressing the development of specific flexibility services and the CrossFlex project goes one step further to widen the portfolio of available services in line with current and future system needs. The integration of flexibility services to flexibility platforms is expected to generate technological innovation.
- promotion of a 100 % renewables-based energy system.
- promotion of solidarity, etc.

2.2.6. Summary of the cross-border flexibility project's evaluation

The CrossFlex project builds on current and future system needs in the project area, i.e. increased system security and stability, while supporting growing penetration of RES. The project capitalises on the results from various ongoing smart grid projects and initiatives in the project area as a starting point to identify present and future system flexibility needs and build system services around those needs. The CrossFlex project is unique, as it addresses system needs for increased flexibility by using existing infrastructure — HVDC systems and DG — to better facilitate the provision of system services across borders, thus increasing utilisation of the HVDC interconnectors (owned by the participating TSOs) and ultimately enabling integration of growing penetration levels of RES. Given this, the project complies with Article 4(1)(c)(i) of the regulation.

The project builds its scope and narrative on recent smart grid pilots and R&D projects, and in particular on enabling flexibility resources (i.e. DG) connected to both the distribution and transmission network to support system security and management of various network operational conditions in Estonia, mainland Finland and the Åland Islands. Furthermore, the promoters develop project's use cases for the flexibility services addressed in the project as well as for the technical specifications of selected DER. This entails adoption of smart grid technologies to efficiently integrate the behaviour and actions of all users connected to the electricity network and, thus, increase the generation of renewable and distributed energy sources and facilitate demand response. As a result, the project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation) with investments in accordance with the energy infrastructure category of Annex II(1)(e) to the regulation.

The CrossFlex project is in an early stage of development, which poses some challenges to the evaluation of the project's contribution to the specific policy criteria of the regulation and particularly the quantification and monetisation of the project's impacts. The challenges are mainly associated with a lack of definite use cases and a final list of project partners and associated flexibility investments, as communicated by the promoters until 15 May 2019. In view of these arguments, a quantitative societal CBA could not be performed at the current stage of the project's development. Therefore, the promoters demonstrate the project's contribution to the policy criteria of Article 4 of the regulation by performing a qualitative assessment of the project's impact and referring to the two use cases with great potential in Finland and Estonia, mentioned in Section 2.2.3, and the associated possible flexibility investments. Notwithstanding these challenges, the promoters convincingly argue for the project's significant contribution to the specific criteria of the regulation, and the project demonstrates strong potential for the fulfilment of the policy criteria of Article 4(2)(c) of the regulation.

2.3. **Danube InGrid** (Hungary and Slovakia)

2.3.1. General overview

The Danube project chiefly aims at enhancing cross-border coordination of electricity network management, with a specific focus on smartening data collection and exchange. The importance of the project for the Member States involved (Hungary and Slovakia) is highlighted by the fact that the leading participant on the Slovak side is the largest DSO, Západoslovenská distribučná (ZSD), while the TSOs involved (SEPS for Slovakia and MAVIR for Hungary) are key players in the project, the first by actively implementing its own investment and the second as a supporting organisation for the involvement of the country's DSO. The project primarily leverages physical interconnection already existing at the high-voltage level. Technically, the project primarily consists of the enlargement and smartening of the networks' substation infrastructure and installation of remote control, data collection and exchange, and fault detection instruments. In particular, this involves technical modernisation of 150 existing transformer stations through installation of metering and communication devices and of automatic on-load tap changers (OLTCs). The project also includes installation of an optical fibre infrastructure for improved management of the MV network, construction of two new smart substations in Slovakia (with a capacity of 400/110 kV and 110/22 kV, respectively) and of numerous micro substations ([8]) at HV/MV level, including smart meters, a geographic information system (GIS) and a SCADA system.

Main project goals:

- promote flexibility, resilience and security of the electricity system;
- facilitate customer connectivity to the electricity system to reduce barriers to entry and increase competitiveness of the electricity market;
- improve residential and business welfare through more dependable and secure electricity supply;
- lessen environmental damage through better air and climate;
- deepen European economic and electricity market integration.

Expected impacts:

- substantially enhance data collection, exchange and processing capabilities (especially forecasting) to enable stronger collaboration on efficient network management;
- foster greater RES integration as well as deployment of electro-mobility;
- introduce the capability of remote infrastructure monitoring and management for faster detection and resolution of infrastructure failures;
- promote cross-border know-how (and more broadly technological) sharing and diffusion;
- increase the network capacity (especially for connection of RES generation) through construction of smart substations;
- diminish losses through improved grid (especially voltage) management.
- improve system reliability parameters (System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI)).

2.3.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

The project takes place on the territory of two neighbouring Member States (Slovakia and Hungary), each featuring a key DSO as central participant and project promoter. An equivalent role is played by SEPS

([8]) Smaller substations installed more densely at MV network level.

(Slovakia's TSO) owing to its direct involvement in infrastructure investment, while the Hungarian TSO MAVIR will act as a project partner through gathering and sharing of knowledge and experience.

The construction of monitoring, remote control and communication technology, including optical fibre-based cables for real-time information exchange, will enable cross-border data processing at the DSO level to allow much deeper interaction in the joint management of the network through the operation of a dedicated shared information technology (IT) platform to be used for various systems (e.g. network topology program based on a geographic information system and energy management system (EMS) SCADA). This will foster the intensified exploitation of the physical interconnection infrastructure currently existing at the TSO level, even though cross-border interconnection capacity is not directly addressed by the project. Furthermore, the greater availability and exchangeability of information on the status of the electricity system will lead to the construction of a joint data repository storing technical and non-technical data. This will permit deeper analysis of system state patterns and further promote efficient network management, with the final goal of (on the one hand) improving the system's RES accommodation capacity and (on the other) enhancing service continuity, quality and resilience.

In this regard, the data exchange and joint network management character of the project clearly displays a cross-border dimension affecting two Member States, to comply with Article 4(1)(c)(i) of the regulation.

2.3.3. Project's necessity for the priority thematic area of smart grids deployment

The Danube project's key investments primarily aim to tighten inter-DSO collaboration linkage and, through this channel, support the integration of customers with different technical requirements (consumers/prosumers, DG, etc.). This necessitates deployment of smart grid technologies to enable higher degrees of network observability and management.

The project is founded on detailed studies carried out on the development of smart grids in Slovakia, especially as enablers of higher integration of electro-mobility, demand response and DG (possibly through aggregators) into the system, as well as on the impact of undergrounding, fault localisation and advanced distribution system operation methods on enhancement of service quality (as measured for example through lower SAIDI and SAIFI values) in both Slovakia and Hungary.

These aspects and background highlight the project's potential in promoting the modernisation of cross-border electricity system operation in the area and make it necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

2.3.4. Compliance with the energy infrastructure category of Annex II(1)(e) of the regulation

The project enables two-way digital communication through the installation of several smart grid elements, including:

- construction of an optical fibre network for HV and MV grid management;
- installation of smart metering devices;
- metering and fault detection to remotely operated pole-mounted switches.

Better monitoring and control of the grid is a central objective of the project. This is made possible through a number of key pieces of infrastructure, including:

- modernisation of the technology of 150 existing transformer stations;
- new SCADA systems and implementation of cybersecurity measures involving SCADA analytical algorithms;
- voltage and current metering devices with communication;
- installation of a new, modern GIS system with large capacity and smart functionalities.

The following newly constructed facilities allow the interactive management of electricity generation, transmission, distribution and consumption:

- smart 400/110 kV substation;
- smart 110/22 kV substation;
- micro substations;
- automatic tap changer MV/LV transformers.

The project can therefore clearly be assessed as complying with the criteria for the energy infrastructure category of Annex II(1)(e) to the regulation.

2.3.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The benefits of the Danube InGrid project are evaluated by the promoters according to each of the specific criteria in Article 4(2)(c) of the regulation and based on a selection from the 21 key performance indicators, derived from the criteria presented in Annex IV(4) to the regulation.

Tables 13-18 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach (Vasiljevska and Gras, 2017) to evaluate the project's contribution to each specific criterion. In addition, each project's impact has been assessed in view of the following two scenarios: a BaU scenario, i.e. without deployment of the project, and an SG scenario, i.e. with implementation of the project.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

The project is expected to accelerate integration of RES and demand response owing to the automatic control and metering system enabled by the project, which in turn would allow more efficient distribution network management.

The promoters demonstrate the project's contribution to the first policy criterion by making reference to a set of chosen KPIs as listed in Table 13.

Table 13. Danube InGrid: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse gas emissions	The promoters demonstrate a positive impact on this KPI due to the following aspects of the project: • increased automatic control and metering system, allowing more efficient distribution network management, thus leading to a decrease in network losses, relief of network congestion and a reduction in the need for redispatching and ultimately in the fossil generation (overall capacity and especially peak power); • more effective deployment of demand side, which will accelerate further integration of RES.	
KPI_7: operational flexibility provided for dynamic balancing of electricity in the network	The promoters report and demonstrate the project's positive impact on this KPI as a result of an increase in the remotely available capacity which can be utilised for balancing the distribution network. This is expected to take place owing to an increase in demand response, which will allow growing integration of RES while securing the grid stability (capability of automatic disconnection and reconnection of RES).	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	Flexibility resources and peak shaving are fostered by this project through advanced meter management (AMM), demand response and adjustments in consumption patterns due to the potential introduction of new dynamic tariffs. As a consequence, the project is expected to have a positive impact on this KPI, which is assessed through elaboration of data provided by the DSOs' dispatching centres.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The project's main investments focus on enhancement of network management and control capabilities (e.g. innovative voltage regulation algorithms, availability of new flexibility resources, innovative grid protection/monitoring), which is expected to greatly improve network operational efficiency. The promoters demonstrate the project's contribution to the second policy criterion by making reference to a set of chosen KPIs as listed in Table 14.

Table 14. Danube InGrid: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_2: environmental impact of electricity grid infrastructure	Enhanced network management and control enabled by the project deployment could reduce the need to build overhead lines and, in that respect, reduce the environmental impact of grid infrastructure. Furthermore, the Danube project proposes replacement of certain overhead power lines with underground cables, thus reducing the long-term environmental impact in terms of visual impact, soil occupation, threat to endangered animal species, etc. Reductions in GHG emissions are associated with reductions in other pollutants. The promoters make an effort to quantify this based on standard industry correlations.	
KPI_3: installed capacity of distributed energy resources in distribution networks	Enhanced network management and control capabilities (e.g. innovative voltage regulation algorithms, availability of new flexibility resources, innovative grid protection/monitoring) enabled by the Danube InGrid project would allow increased DER capacity to be safely integrated in the distribution grids. The project promoters report an increase in the network hosting capacity for DER through a positively assessed KPI.	
KPI_{13}: level of losses in transmission and in distribution networks	The InGrid promoters acknowledge the challenges in estimating the future value of losses owing to the smart grid elements deployed in the project; nevertheless, the promoters expect a reduction in network losses due to improved network management introduced by the project. As the InGrid SG project is developed mainly at the DSO level, this KPI is evaluated with respect to distribution network losses. Based on consideration of the impact of new elements in the grid, the promoters calculate a net decrease in losses as a relative change in respect of the BaU scenario. This is based on both the positive expected effect of new cabling, grid optimisation and installation of new equipment (lowering the losses) as well as the increased number of elements and equipment, which in itself may lead to an increase in network losses.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

The project aims to enhance the distribution network observability and controllability owing to the advanced meter management (AMM) elements brought in by the project, which in turn would also enable integration of higher levels of DER into the system. The promoters demonstrate the project's contribution to the third policy criterion by making a reference to a set of chosen KPIs as listed in Table 15.

Table 15. Danube InGrid: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_4: allowable maximum injection of power without congestion risks in transmission networks	The InGrid project mainly addresses the distribution network and in this case the KPI indicates the increased distribution network hosting capacity in the project area, thus allowing an increase in DER in the region without compromising the operation of the transmission network. The InGrid promoters positively quantify this KPI as a result of an increase in the distribution network hosting capacity due to the installation of smart elements and smart distribution stations in the grid. The enhanced observability and controllability of the grid enabled by AMM elements in the project would allow improved network management and, ultimately, higher levels of DER in the system.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The project promoters assess this KPI indirectly through the increase in flexible resources in the system. Smart grid elements should enable demand response participation, hence increase balancing possibilities and ultimately induce higher hosting capacity for intermittent RES. In this regard, the Danube InGrid project is expected to lower the amount of renewable energy not withdrawn as a result of network congestion or security risks owing to an increase in controllable load subject to demand-side management. At this stage of the project's development, promoters do not expect RES curtailment and therefore the KPI is quantified as potential increase in RES without congestion/security risks, as a result of growing controllable load, subject to demand-side participation.	
KPI_8: ratio of reliably available generation capacity and peak demand	Analogous to the ACON project, the InGrid project's promoters use an alternative approach for measuring this KPI as network capability to accommodate more renewable energy owing to better operational management, increased demand response and introduction of dynamic tariffs, consequently lowering the difference between the P_{min} and P_{max}. Therefore, this KPI is positively quantified.	
KPI_{10}: stability of the electricity system	This KPI is assessed indirectly as closely correlated with three other indicators: SAIDI/SAIFI reduction (**KPI_{11}**), voltage quality performance (**KPI_{12}**) and availability of network components and their impact on network performance (**KPI_{17}**). Nevertheless, more accurate assessment cannot be provided at this stage of the project's development.	
KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The KPI is expected to improve thanks to better monitoring and remote control capabilities enabled by the project. The project's promoters demonstrate its well-quantified impact on this KPI, based on previous feasibility studies and pilot projects.	
KPI_{12}: voltage quality performance	Voltage quality improvement is expected to improve thanks to better monitoring and management capabilities. The project's promoters demonstrate its positive impact on this KPI and quantify it based on a solid methodology and parameters provided by DSO statistics.	
KPI_{20}: exploitation of interconnection capacities	The project is not expected to physically increase the transfer capacity of any interconnection at transmission network level but rather reduce the load on the interconnectors via construction of a new 400/110 kV substation in the Slovak part of the project. This will result in an increase in capacity and security of supply at the distribution network level and ultimately allow increased load flow on the TSO interconnectors and available cross-border transfer capacity. The project's promoters positively quantify this KPI; nevertheless,	

	uncertainties persist in the assumptions made.	

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The project is expected to increase the availability of the network components, mainly owing to the higher availability of data related to network maintenance and in particular to the increased capability for remote fault detection and resolution. It will also lead to greater grid utilisation and thereby bring new possibilities to future cost-efficient network planning. The promoters demonstrate the project's contribution to the fourth policy criterion by making reference to a set of chosen KPIs as listed in Table 16.

Table 16. Danube InGrid: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The promoters expect a positive impact on this KPI due to increased distribution network capacity and improved network stability enabled by the InGrid project. This would ultimately lead to enhanced utilisation of the TSO-DSO interface in terms of power flows coming from the transmission network and increase the lifetime and reliability of network components and equipment at the TSO-DSO interface. Notwithstanding the expected positive impact, this KPI is not quantified at the current stage of the project's development.	
KPI_{17}: availability of network components (related to planned and unplanned maintenance) and its impact on network performances	The project is expected to have a positive impact on this KPI, first and foremost thanks to the increased capability for remote fault detection and resolution. The indicator is positively quantified based on assumptions and parameters imputed through pilot projects, feasibility studies and expert judgement.	
KPI_{18}: actual availability of network capacity with respect to its standard value	The actual availability of network capacity is assumed to increase thanks to the project owing to the smartening of substation infrastructure. In particular, new micro substations and MV/LV OLTC transformers on Hungarian side will for instance secure an increase in network capacity by 251 MW. Similar to the ACON project, the InGrid project's promoters positively quantify this indicator by referring to the possible usage of each network element (as a percentage of its nominal capacity) in both BaU and SG scenarios.	

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

The Danube InGrid project will provide more granular information on the energy consumption/generation, which would promote introduction of dynamic tariffs and engage end-users in more effective management of their energy consumption. This would in turn facilitate the provision of ancillary services to both DSOs and TSOs and move the market forward for new customer services. The promoters demonstrate the project's contribution to the fifth policy criterion by making reference to a set of chosen KPIs as listed in Table 17.

Table 17. Danube InGrid: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI6: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	The Danube InGrid project is expected to provide a more granular array of information to better allocate the electricity costs among different network users. Such information typically includes automatic and (close to) real-time energy consumption and/or generation data, detailed analysis of consumer/prosumer data in the form of clear tables and graphs used for customer energy bills, etc. Furthermore, this level of detail would further promote introduction of dynamic tariffs and potentially engage end-users in more effective management of their energy consumption. Finally, more detailed information flows would allow regulators to assess RES contribution in provision of ancillary services to both DSOs and TSOs and move the market forward for new customer services.	
KPI19: ratio between interconnection capacity of a Member State and its electricity demand	Cross-border interconnection capacity per se is not expected to rise owing to the project; however, better handling of consumption and generation at the distribution grid level will allow less utilisation of transmission-distribution transformation and hence of the transmission network infrastructure. As a consequence, the ratio between available interconnection capacity and electricity demand will probably rise.	
KPI21: congestion rents across interconnections	The indicator cannot be computed owing to the absence of congestion rents in the area involved (no interconnection at the DSO level). However, the project will lead to better utilisation of the existing infrastructure and, specifically, less exploitation of the transmission network, fostering greater price alignment between neighbouring price zones. Nevertheless, this KPI cannot be quantified at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

One of the project's main objectives is to increase the network hosting capacity for RES and, therefore, it also focuses on integration of flexibility resources (e.g. demand response) along with more effective grid management. The promoters demonstrate the project's contribution to the sixth policy criterion by making reference to a set of chosen KPIs as listed in Table 18.

Table 18. Danube InGrid: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI9: share of electricity generated from renewable sources	The promoters choose this KPI to address the project contribution to the sixth specific criterion, as the proportion of electricity generated from RES is expected to increase owing to more effective grid-balancing management and by tapping into enabled additional flexibility resources (including end-user involvement through demand response). The promoters positively quantify this KPI owing to increased RES connections in the project area enabled by the smart grid elements introduced in the project.	
KPI15: demand-side participation in electricity markets and in energy efficiency measures	This KPI is closely linked to the involvement of users in effective management of their energy usage. In this respect, the Danube InGrid project is expected to increase the amount of load participating in demand-side management and energy efficiency measures in comparison with the BaU scenario. The KPI is therefore positively quantified using available data from the dispatch centres of both DSOs	

	for the BaU scenario and plans for additional demand-side management resources and legislative requirements for the SG scenario.	

Source: Own elaboration, 2019.

2.3.5.1. Economic appraisal

The following section presents the societal benefits of the Danube InGrid project in monetary terms along with the total cost (capital and operational expenditure) as communicated by the promoters. Furthermore, economic indicators such as the NPV, the IRR and the B/C ratio are used to verify whether or not the overall benefits outweigh the project's costs and therefore the project complies with the second general criteria of the regulation (Article 4(1)(b)).

The promoters assumed the following values as variables used in the societal CBA:

- **demand growth:** an average annual demand growth of 1.45 % has been assumed for the project area;
- **discount rate:** a value of 4 % has been used as societal discount rate (Vasiljevska and Gras, 2017);
- **time horizon:** 25 years has been chosen as the time horizon (as the project also considers traditional investments);
- **peak demand reduction:** 89.78 MW has been assumed for the project area owing to expected peak load shift;
- **electricity market price:** EUR 52.9/MWh ([9]);
- **cost of energy not supplied:** EUR 7 470/MWh and EUR 9 010/MWh for Hungary and Slovakia, respectively ([10]);
- **carbon prices:** EUR 47.6/t (European Commission, 2011);
- **fuel prices:** EUR 1.3/l.

The project reports a positive outcome in the societal CBA. The main monetary benefits and costs are listed below.

2.3.5.2. Main monetary benefits

The Danube InGrid project is expected to deliver a set of positive impacts and in that respect the following monetised benefits are communicated by the project promoters:

- reduced operational and maintenance cost;
- deferred distribution capacity investments;
- reduced electricity technical losses;
- reduced outage times;
- reduced CO_2 emissions and reduced fossil fuel usage;
- estimated reduction in electricity interruption costs;
- prevention of blackout;
- prevention of brownout;
- reduction of air pollution (particulate materials, NO_x, SO_2).

2.3.5.3. Main costs

The project is in preparatory phase; therefore, cost estimations are mainly based on expert assessment of similar projects and on the current project plan under supervision by independent consultancies.

The main costs associated with the project deployment are:

- construction of new DSO and TSO smart substations;

([9]) http://www.eex.com/.
([10]) https://www.sciencedirect.com/science/article/pii/S2214629617301184.

- construction of new smart grid micro substations;
- smart lines and installations with communication devices and optical fibres;
- an IT-based system for the smart management of the grid including automated metering.

2.3.5.4. Sensitivity analysis

The NPV of the project changes with variation of the following critical variables:

- **peak demand reduction:** lowering the value of the assumed peak demand reduction by both energy savings and peak load shifting by 40 % lowers the project NPV by EUR 19.9 million;
- **decrease in outage time:** lowering the value of the assumed decrease in outage time by 40 % lowers the project NPV by EUR 13.4 million;
- **estimated percentage of consumption reduction with SG scenario:** lowering the percentage of consumption reduction by 40 % lowers the project NPV by EUR 13.4 million;
- **CO_2 price:** decreasing carbon prices by 40 % lowers the NPV by EUR 4.3 million.

The promoters report that even in the constructed worst-case scenario, where all benefit reductions are slashed by 40 % at once, the expected NPV is positive, while the benefit/cost ratio is still marginally above 1 (1.01).

2.3.5.5. Additional non-monetary benefits

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

- reduced air pollutant emissions (dust particles, SO_x, NO_x and CO) due to reduced line losses;
- reduced air pollutant emissions (dust particles, SO_x, NO_x and CO) due to wider diffusion of low-carbon generation sources;
- reduced soil occupation;
- lower threat to animal species;
- reduced visual impact.

2.3.6. Summary of the Danube InGrid project's evaluation

The Danube InGrid project aims to significantly improve the efficiency of (especially distribution system) operation services through increased availability of flexibility resources to allow better balancing, safer grid management, higher voltage quality, shorter and less frequent interruptions, lower RES curtailment and lower line congestion, all while increasing the network's hosting capacity with respect to intermittent RES and DG in particular. This is obtained through the installation of new smart facilities, especially the construction of two new smart substations (400/110 kV and 110/22 kV, respectively), multiple micro substations, automatic tap changer MV/LV transformers and remote fault detection systems. This allows radical improvement of the observability and remote controllability of the system.

This wealth of new and detailed system state information made available to each DSO is to be shared across borders in real time, or close to real time, through modern optical fibre communication technology also installed as part of the project, enabling much closer coordination in the operation of distribution systems. TSOs also stand to benefit from more efficient network management and clearly need to be well involved to fully tap into the project's potential. This will also build a shared data repository to be exploited for analysis of typical system conditions and their efficient management. Customers will also be incentivised towards more active participation through facilitated demand response and DG installation, potentially also through enabled dynamic pricing developments. Therefore, the InGrid project both complies with Article 4(1)(c)(i) of the regulation and proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

The Danube InGrid project demonstrates a significant contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the project's societal CBA. Remarkably, this holds even in the worst-case scenario, with 40 % lower benefits constructed for sensitivity analysis purposes.

2.4. **Data Bridge** (Estonia, Finland, France, Latvia, Lithuania and Denmark)

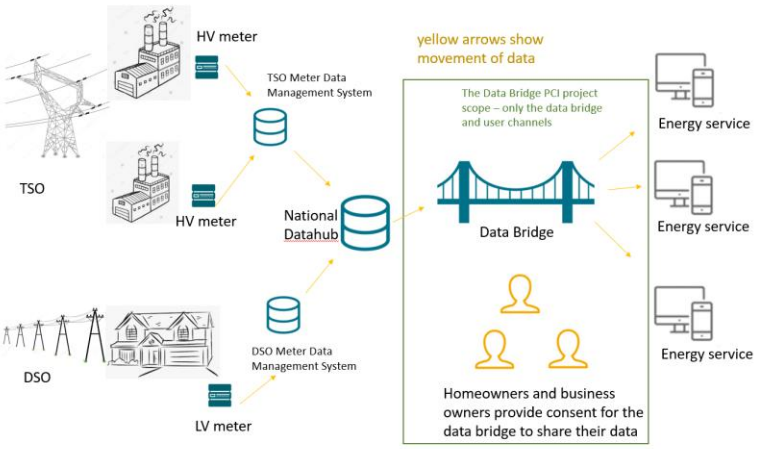
2.4.1. General overview

The Data Bridge project makes a direct reference to Article 23 of the Clean Energy Package, in which EU Member States are required to ensure that consumers can access and share their energy data. Therefore, its main objective is to build a common European Data Bridge platform, which will enable integration of different data types (smart metering data, network operational data, market data, etc.) with the far-reaching goal of covering the territory of all EU Member States. Therefore, the project promoters seek to develop scalable and replicable solutions, which will reduce costs and avoid duplication of investments across EU Member States. Such solutions will address the needs and interests of multiple stakeholders, for instance:

- **consumers —** by providing access to better and more personalised energy services and control over their data (who uses the data, for what purpose, etc.);
- **energy suppliers —** by providing easier access to metering data in new operating markets, thus creating a level playing field with the other incumbents;
- **energy services companies (aggregators, companies providing monitoring services, financial services, etc.) —** by enabling access to metering data for providing various services to the consumers;
- **DSOs, TSOs —** by enabling increased system flexibility.

The primary focus of the Data Bridge project is to integrate different national smart meter data hubs. In case of absence of a national data hub, the Data Bridge platform is envisaged to connect to the meter data management systems of the TSOs and DSOs (Figure 1).

Figure 1. Illustrative description of the Data Bridge project



Source: Data Bridge project promoters

Main project goals:

- integration of European energy markets by ensuring interoperability of different data types (e.g. smart meter data from LV and MV/HV network levels, sub-meter data, network operational data, market data, etc.) between a variety of stakeholders (e.g. system operators, market operators, flexibility providers, suppliers, energy service companies (ESCOs), end-customers, etc.);
- integration of retail energy markets in Europe by ensuring interoperability of smart meter data, thus reducing the cost for energy suppliers to operate in new regions;
- facilitate TSO-DSO cooperation on data interoperability by bringing different companies together in a project of common interest, benefiting grid operators, energy companies and consumers;
- ensure compliance with the General Data Protection Regulation (GDPR) and the Clean Energy Package provisions by providing the necessary tools to grid companies to access smart meter data of all European consumers and to energy consumers to access and share their energy data;
- ensure that consumers benefit from increased choice and better energy services arising out of increased competition.

Expected impacts:

- growing flexibility resources for grid operation and planning;
- enhanced energy efficiency services for the final consumers;
- lower energy price for the final consumers;
- increased participation of prosumers in energy markets.

2.4.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

Integration of the retail energy market necessitates interoperability of smart metering data and making these data accessible on consumer's consent to any third party, including across borders. One of the main objectives of the project is to ensure interoperability across different data hubs, where TSOs and DSOs, responsible for the processing and management of smart metering data in the participating countries, interface with the Data Bridge platform, which enables energy suppliers, aggregators and other service providers to access data from a single application programming interface.

Therefore, one of the project's objectives is the development of solutions for increased data sharing across borders and for provision of ancillary services (congestion management at both, the transmission and distribution levels, balancing, emergency reserves, etc.) as a response to different TSOs/DSOs flexibility needs, thus resulting in cross-border data and capacity exchange.

Possible cross-border data exchange could include between:

- data exchange platforms (e.g. national data hub or TSO/DSO meter data management system) in countries A and B;
- a data exchange platform (e.g. national data hub or TSO/DSO meter data management system) in country A and a network operator (TSO and/or DSO) in country B;
- a data exchange platform (e.g. national data hub or TSO/DSO meter data management system) in country A and a third party (e.g. flexibility provider) in country B;
- a data exchange platform (e.g. national data hub or TSO/DSO meter data management system) in country A and a customer (consumer/prosumer) in country B.

Such data exchange would also introduce the possibility of analysing synergies from both consumers' meters and network operational data as well as from cross-sectoral data exchange (electricity, gas, heat, transport, telecommunications, etc.) by making these data available to interested parties via a single Data Bridge platform (one-stop-shop principle).

The project currently involves six EU countries, and more specifically five TSOs, i.e. Elering (EE), Fingrid (FI), RTE (FR) ([11]), AST (LV) Energinet (DK) and three DSOs, i.e. Elektrilevi (EE), AS (LV) and ESO (LT). Furthermore, the project foresees the involvement of other EU TSOs and DSOs in the near future and, in the long term, aims to replicate the project's solution across the EU.

In view of the above, the Data Bridge project appears compliant with criterion (i) of Article 4(1)(c) of the regulation.

2.4.3. Project's necessity for the priority thematic area of smart grids deployment

The purpose of the Data Bridge project is to facilitate better integration of network users by giving them the ability to gain control over data access and therefore choose among different RES producers and demand response service providers. On the other hand, the project also enables easy data access under consumer consent to third parties (e.g. demand response providers and RES producers). This increases market competition by reducing barriers and integrating EU energy markets. Furthermore, the project's solution brings down costs, since flexibility providers and RES producers will make use of the Data Bridge platform instead of building their own data management systems. In this context, the project seeks to efficiently integrate the behaviour and actions of all users connected to the electricity network, and as a result increase the generation of renewable and distributed energy sources, and facilitate demand response.

Moreover, the cross-border data exchange enabled by the project is expected to open up possibilities for providing different energy services, managing energy supply contracts, providing easy access to information on energy suppliers and ESCOs, managing the portfolio of services, etc., regardless of the country in which the

([11]) The French TSO has only an advisory role in the project.

provider is located. This would provide new business opportunities to power supply and energy service companies.

2.4.4. Compliance with the energy infrastructure category of Annex II(1)(e) to the regulation

The Data Bridge project's interfaces are installed at TSO or DSO premises (transmission and medium-voltage distribution levels), providing two-way digital communication of meter data in real time, or close to real time, enabling energy service companies to provide interactive and intelligent monitoring and management of electricity assets and consumption to better integrate the behaviour of users (both generators and consumers). To this end, the project's investments are in line with the energy infrastructure category of Annex II(1)(e) to the regulation.

2.4.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The promoters assess the benefits of the Data Bridge project according to the specific criteria outlined in Article 4(2)(c) of the regulation, captured by a set of 21 key performance indicators derived from the criteria presented in Annex IV(4) to the regulation. The project promoters argue for the project's impact on each of the six specific criteria by selecting a set of KPIs to better capture the project's impact against a specific criterion.

One of the main objectives of the Data Bridge project is to enable integration of energy markets, which will facilitate the integration and involvement of different network users. The promoters demonstrate the project's contribution to the first policy criterion by making reference to a set of chosen KPIs as listed in Table 19.

Table 19-24 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. For most of the KPIs, uncertainties persist either in the information provided or in the assumptions made, which is associated not only with the early stage of the project's development but also with the lack of similar pilot projects and studies in EU, which could have served as reference material to support the project's development. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach (Vasiljevska and Gras, 2017) to evaluate the project's contribution to each specific criterion. In addition, each project's impact has been assessed in view of the following two scenarios: a BaU scenario, i.e. without deployment of the project, and an SG scenario, i.e. with implementation of the project.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

One of the main objectives of the Data Bridge project is to enable integration of energy markets, which will facilitate the integration and involvement of different network users. The promoters demonstrate the project's contribution to the first policy criterion by making reference to a set of chosen KPIs as listed in Table 19.

Table 19. Data Bridge: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_3: installed capacity of distributed energy resources in distribution networks	The project is expected to have a positive impact on this KPI as a result of the following: • increased demand response and flexibility services due to easier data access and increased data sharing; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology ([12])); • increased and enhanced energy efficiency services. The promoters demonstrate a positive impact of the project on this KPI by referring to various studies in the UK and the USA as well as to successful business models in the region relying on smart metering data access and data sharing.	(green)
KPI_6: methods adopted to calculate charges and tariffs, as well as	The project is likely to have a positive impact on this KPI as a result of a growing number of providers of demand response and flexibility services. In addition, the project would allow more informed decision-	(green)

([12]) https://wepower.network/.

their structure for generators, consumers and those that do both	making for the grid operators with regard to grid developments, whereas the regulators would have more information about the potential of market-based solutions versus grid investments.	
KPI$_{7}$: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to data access and increased data sharing; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as existing successful business models in the region relying on data access and data sharing.	
KPI$_{12}$: voltage quality performance	Voltage quality performance can be assessed by keeping track of short interruptions, voltage dips, flicker, supply voltage variation and harmonic distortions. The project is likely to contribute to improved voltage quality as a result of flexibility services enabled by the project (e.g. reactive power for voltage control). However, a greater impact cannot be assessed with a sufficient level of confidence owing to significant lack of information at the current stage of the project's development.	
KPI$_{15}$: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to data access and increased data sharing; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contract and blockchain technology); • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA and also existing successful business models in the region relying on smart metering data access.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The Data Bridge project is expected to contribute to improved network efficiency and interoperability owing to increased demand response and provision of flexibility services. The promoters demonstrate the project's contribution to the second policy criterion by making reference to a set of chosen KPIs as listed in Table 20.

Table 20. Data Bridge: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse emissions	The project is expected to contribute to reduced GHG emissions as a result of: • peak load reduction and fossil fuel displacement owing to increased demand response and provision of flexibility services enabled by the project; • increased proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services leading to reduced electricity consumption; • growing end-user awareness of energy and climate issues leading to an increase in the number of prosumers, etc.	
KPI_4: allowable maximum injection of electricity without congestion risks in transmission networks	The promoters report a positive impact of the project in terms of increased maximum power injection without congestion risk in the transmission networks as a result of local power production and consumption and less reliance on the transmission grid. The promoters make an effort to quantify this impact by making reference to the investment figures of a UK TSO related to congestion reduction. However, uncertainties remain in the assumptions made and in the calculation method used.	
KPI_7: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to data access and increased data sharing enabled by the project; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as existing successful business models in the region relying on smart metering data access.	
KPI_9: share of electricity generated from renewable sources	The promoters demonstrate an increase in the proportion of electricity generated from RES owing to: • less RES curtailment due to demand response and provision of flexibility services enabled by the project; • innovative financing solutions for RES (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues leading to an increased number of prosumers and demand response and flexibility services thanks to increased transparency enabled by the Data Bridge platform, etc.	

KPI$_{13}$: level of losses in transmission and distribution networks	The promoters make an effort to quantify the project's contribution to reduced network technical losses as a result of load factor reduction coming from increased grid flexibility. However, significant uncertainties remain in the assumptions made and the calculation method used for calculating this benefit. Therefore, a greater impact cannot be reliably reported at this stage of the project's development owing to a significant lack of information.	
KPI$_{15}$: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to data access and increased sharing of data; • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as existing successful business models in the region relying on smart metering data access.	
KPI$_{16}$: percentage utilisation (i.e. average loading) of electricity network components	The promoters expect enhanced network utilisation as a result of increased flexibility brought about by the project. The promoters make an effort to positively quantify this benefit by making reference to a study performed in the UK that reports better-targeted investments as a result of increased grid flexibility. However, a greater impact, in terms of better use of the existing grid's assets, cannot be assessed with a sufficient level of confidence at this stage of the project's development, as significant uncertainties persist in the calculation method reported as well as in the assumptions made.	
KPI$_{17}$: availability of network components (related to planned and unplanned maintenance) and its impact on network performances	The promoters expect a positive impact of the project on this KPI due to better data analytics enabled by the project, thus resulting in better planning of network maintenance. Nevertheless, a greater impact, in terms of reduced mean time between failures and mean time to repair, cannot be assessed with a sufficient level of confidence at this stage of the project's development.	
KPI$_{18}$: actual availability of network capacity with respect to its standard value	The promoters expect a positive impact of the project on this KPI owing to increased flexibility and increased availability of network components as a result of enhanced data analytics. Nevertheless, a greater impact, in terms of actual availability of network capacity in selected lines or network cross-sections compared with their nominal capacity, cannot be assessed with a sufficient level of confidence at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

The Data Bridge project is expected to increase the network security and quality of supply as a result of increased data access and data sharing. This will result in increased network operational flexibility owing to integration of demand response and flexibility services. The promoters demonstrate the project's contribution to the third policy criterion by making reference to a set of chosen KPIs as listed in Table 21.

Table 21. Data Bridge: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The project is expected to reduce the energy not withdrawn from RES as a result of congestion or security risks owing to enhanced consumption of power at the local level. The promoters report a positive quantified impact on this KPI. Nevertheless, uncertainties persist in the calculation method used and in the assumptions made, largely stemming from the lack of data at this stage of the project's development as well as the lack of insights from similar pilot projects/studies in the EU.	
KPI_7: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to increased data access and data sharing enabled by the project; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI_{10}: stability of the electricity system	The promoters expect an increase in frequency and voltage stability due to the larger number of available reserves brought in by the project. In this regard, the promoters make an effort to quantify this benefit by making reference to **KPI_7**. Nevertheless, a greater impact, in terms of voltage and frequency instabilities under a set of specified contingency scenarios, cannot be assessed with a sufficient level of confidence at this stage of the project's development.	
KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The promoters expect a positive impact of the project on this KPI due to better data access enabled by the project, leading to faster response times and reduced frequency of interruptions. Nevertheless, a greater impact cannot be assessed at this stage of the project's development owing to uncertainties in the calculation method used and the assumptions made. Moreover, these uncertainties relate to the lack of data/insights from similar studies/pilots in the project area and in the EU, so that promoters needed to make reference to studies performed in the USA (which, despite some common drivers, refer to different boundary conditions, such as grid characteristics, load and RES growth, etc.).	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	The promoters argue for a positive impact of the project on this KPI by referring to the demand and generation flexibility potential enabled by the project. The promoters also make an effort to positively quantify this impact; nevertheless, uncertainties remain in the assumptions made (using data/insights from a study performed in the USA, which, despite some common drivers, refers to different boundary conditions, such as grid characteristics, load and RES growth, etc.).	

KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to data access and increased sharing of data; • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI_{17}: availability of network components (related to planned and unplanned maintenance) and its impact on network performances	The promoters report a positive impact of the project on this KPI due to better data analytics enabled by the project, thus resulting in better planning of network maintenance. Nevertheless, a greater impact, in terms of reduced mean time between failures and mean time to repair, cannot be assessed with a sufficient level of confidence at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The Data Bridge project will contribute to optimised network planning and more cost-efficient network investments owing to enhanced data access and data sharing, which would facilitate the integration of demand response and flexibility services. The promoters demonstrate the project's contribution to the fourth policy criterion by making reference to a set of chosen KPIs as listed in Table 22.

Table 22. Data Bridge: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_2: environmental impact of electricity grid infrastructure	The promoters report a positive impact of the project on this KPI due to investments in grid assets avoided as a result of the flexibility and increased demand response enabled by the project. In this regard, the promoters refer to a study performed in the UK that also indicates that the savings from generation avoided significantly outweigh the costs of deploying storage and demand response. Nevertheless, a greater impact, in terms of possible areas of environmental impact (land use, landscape change, visual and acoustic impact, etc.), cannot be assessed at the current stage of the project's development.	
KPI_3: installed capacity of distributed energy resources in distribution networks	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to increased data access and data sharing; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as existing successful business models in the region relying on smart metering data access.	

KPI$_5$: energy not withdrawn from renewable sources due to congestion or security risks	The project is expected to reduce the energy not withdrawn from RES as a result of congestion or security risks owing to enhanced consumption of power at the local level. The promoters report a positive quantified impact on this KPI. Nevertheless, uncertainties persist in the calculation method used and in the assumptions made, largely stemming from a lack of data at this stage of the project's development as well as a lack of insights from similar pilot projects/studies in the EU.	
KPI$_7$: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to increased data access and data sharing enabled by the project; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI$_8$: ratio of reliably available generation capacity and peak demand	The promoters argue for the project's positive impact on this KPI due to expected reduction in the peak load by making reference to **KPI$_{15}$**. Nevertheless, uncertainties remain in the quantification of this impact, mainly in the assumptions made and the calculation approach used.	
KPI$_{14}$: ratio between minimum and maximum electricity demand within a defined time period	The promoters argue for a positive impact on this KPI by referring to the demand and generation flexibility potential enabled by the project. The promoters also make an effort to positively quantify this impact; nevertheless, uncertainties remain in the assumptions made (using data/insights from a study performed in the USA, which, despite some common drivers, refers to different boundary conditions, such as grid characteristics, load and RES growth, etc.).	
KPI$_{15}$: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to increased data access and data sharing; • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access. Nevertheless, uncertainties persist in the assumptions made and the calculation method used.	
KPI$_{16}$: percentage utilisation (i.e. average loading) of electricity network components	The promoters expect enhanced network utilisation as a result of increased flexibility brought in by the project. The promoters make an effort to positively quantify this benefit by making reference to a study performed in the UK, which reports better targeted investments as a result of increased grid flexibility. However, a greater impact, in terms of better use of existing grid assets, cannot be assessed with a sufficient level of confidence at this stage of the project's development, as high levels of uncertainty persist in the calculation method reported as well as in the assumptions made.	

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

Increased data access and data sharing enabled by the project would facilitate the development of flexibility services, and thus contribute to better market functioning and customer services. The promoters demonstrate the project's contribution to the fifth policy criterion by making reference to a set of chosen KPIs as listed in Table 23.

Table 23. Data Bridge: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse emissions	The project is expected to contribute to reduced GHG emissions as a result of: • peak load reduction and fossil fuel displacement owing to increased demand response and provision of flexibility services enabled by the project; • increased proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services leading to reduced electricity consumption; • growing end-user awareness of energy and climate issues leading to an increased number of prosumers, etc.	(green)
KPI_3: installed capacity of distributed energy resources in distribution networks	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to increased data access and data sharing; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	(green)
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The project is expected to reduce the energy not withdrawn from RES as a result of congestion or security risks owing to enhanced consumption of power at the local level. The promoters report a positive quantified impact of the project on this KPI. Nevertheless, uncertainties persist in the calculation method used and in the assumptions made, largely stemming from a lack of data at this stage of the project's development as well as a lack of insights from similar pilot projects/studies in the EU.	(amber)
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure for generators, consumers and those that do both	The project is likely to have a positive impact on this KPI as a result of a growing number of providers of demand response and flexibility services. In addition, the project would allow more informed decision-making by the grid operators with regard to grid developments, whereas the regulators would have more information about the potential of market-based solutions versus grid investments.	(green)

KPI$_7$: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to increased data access and data sharing enabled by the project; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI$_8$: ratio of reliably available generation capacity and peak demand	The promoters argue for a positive impact of the project on this KPI due to an expected reduction in the peak load by making reference to **KPI$_{15}$**. Nevertheless, uncertainties remain regarding the quantification of this impact, mainly regarding the assumptions made and the calculation approach used.	
KPI$_9$: share of electricity generated from renewable sources	The promoters demonstrate an increase in the proportion of electricity generated from RES owing to: • less RES curtailment due to demand response and provision of flexibility services enabled by the project; • innovative financing solutions for RES (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues leading to an increased number of prosumers and demand response and flexibility services thanks to increased transparency enabled by the Data Bridge platform, etc.	
KPI$_{10}$: stability of the electricity system	The promoters expect an improvement in frequency and voltage stability due to a larger number of available reserves brought in by the project. In this regard, the promoters make an effort to quantify this benefit by making reference to **KPI$_7$**. Nevertheless, a greater impact, in terms of voltage and frequency instabilities under a set of specified contingency scenarios, cannot be assessed with a sufficient level of confidence at this stage of the project's development.	
KPI$_{12}$: voltage quality performance	Voltage quality performance can be assessed by keeping track of short interruptions, voltage dips, flicker, supply voltage variation and harmonic distortions. The project is likely to contribute to improved voltage quality as a result of flexibility services enabled by the project (e.g. reactive power for voltage control). However, a greater impact cannot be assessed with a sufficient level of confidence owing to a significant information shortage at the current stage of the project's development.	
KPI$_{14}$: ratio between minimum and maximum electricity demand within a defined time period	The promoters argue for a positive impact of the project on this KPI by referring to the demand and generation flexibility potential enabled by the project. In addition, the promoters make an effort to positively quantify this impact; nevertheless, uncertainties remain in the assumptions made (using data/insights from a study performed in the USA, which, despite some common drivers, refers to different boundary conditions, such as grid characteristics, load and RES growth, etc.).	

KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have a positive impact on this KPI due to the following: • increased demand response and flexibility services due to increased data access and data sharing; • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI_{19}: ratio between interconnection capacity of a Member State and its electricity demand	This KPI serves the purpose of assessing the minimum interconnection capacity necessary to ensure that, if significant events affect one country/zone's electricity supply, at least 10 % of the demand can be met through imports (European Commission, 2002). The promoters make an effort to quantify the project's impact on this KPI by making reference to a study performed in the UK in which deployment of interconnectors is analysed as a potential source of flexibility. Nevertheless, the assessment must not be limited to deployment of new interconnectors but should also take into account the increase in the net transfer capacity (NTC) across the existing interconnectors. It is likely that better-integrated markets owing to the Data Bridge platform would have a positive impact on both the deployment of new interconnectors and the increase in the NTC. Nevertheless, uncertainties remain in the assumptions made and the calculation method used, so a greater impact cannot be assessed with a sufficient level of confidence at this stage of the project's development.	
KPI_{20}: exploitation of interconnection capacities	The promoters expect a positive impact of the project on this KPI, as closer market coupling (day-ahead market, intraday market) would lead to better exploitation of the interconnectors. In addition, reserves would be increasingly provided by resources across the border so that TSOs could also rely more on system services from neighbouring countries. The promoters make an effort to positively quantify this impact; however, uncertainties persist in the assumptions made and the assessment approach used.	
KPI_{21}: congestion rents across interconnections	The promoters make an effort to quantify the impact of the project on this KPI by linking to **KPI_{19}** and **KPI_{20}**. Nevertheless, uncertainties remain in the calculation method and the assumptions made; therefore, a greater impact cannot be assessed with a sufficient level of confidence at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

Increased data access and data sharing enabled by the project allows greater involvement of network users in management of their energy usage. The promoters demonstrate the project's contribution to the sixth policy criterion by making reference to a set of chosen KPIs as listed in Table 24.

Table 24. Data Bridge: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse emissions	The project is likely to contribute to reduced GHG emissions owing to: • peak load reduction and fossil fuel displacement owing to increased demand response and provision of flexibility services enabled by the project; • increased proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services leading to reduced electricity consumption; • growing end-user awareness of energy and climate issues leading to an increase in the number of prosumers, etc.	
KPI_3: installed capacity of distributed energy resources in distribution networks	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to data access and increased sharing of data; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The project is expected to reduce the energy not withdrawn from RES as a result of congestion or security risks owing to enhanced consumption of power at the local level. The promoters report a positive quantified impact of the project on this KPI. Nevertheless, uncertainties persist in the calculation method used and in the assumptions made, largely stemming from data shortage at this stage of the project's development as well as from a lack of similar pilot projects/studies in the EU.	
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure for generators, consumers and those that do both	The project is likely to have a positive impact on this KPI as a result of growing number of providers of demand response and flexibility services. In addition, the project would allow more informed decision-making by grid operators with regard to grid developments, whereas regulators would have more information about the potential of market-based solutions versus grid investments.	
KPI_7: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to have a positive impact on this KPI owing to: • increased demand response and flexibility services due to increased data access and data sharing enabled by the project; • a higher proportion of RES as a result of increased data access and data sharing (e.g. WePower using smart contracts and blockchain technology); • growing end-user awareness of energy and climate issues and therefore willingness to participate in providing flexibility services thanks to increased transparency enabled by the Data Bridge platform. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	

KPI_8: ratio of reliably available generation capacity and peak demand	The promoters argue for a positive impact of the project on this KPI due to an expected reduction in the peak load by making reference to KPI_{15}. Nevertheless, uncertainties remain in the quantification of this impact, mainly in the assumptions made and the calculation approach used.	
KPI_{12}: voltage quality performance	Voltage quality performance can be assessed by keeping track of short interruptions, voltage dips, flicker, supply voltage variation and harmonic distortions. The project is likely to contribute to improved voltage quality as a result of flexibility services enabled by the project (e.g. reactive power for voltage control). However, a greater impact cannot be assessed with a sufficient level of confidence owing to a significant lack of information at the current stage of the project's development.	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	The promoters argue for a positive impact of the project on this KPI by referring to the demand and generation flexibility potential enabled by the project. In addition, the promoters make an effort to positively quantify this impact; nevertheless, uncertainties remain in the assumptions made (employment of data and insights from a study performed in the USA, which, despite some common drivers, refers to different boundary conditions, such as grid characteristics, load and RES growth, etc.).	
KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to have positive impact on this KPI due to the following: • increased demand response and flexibility services due to increased data access and data sharing; • increased and enhanced efficiency services. The promoters demonstrate a positive impact by referring to various studies in the UK and the USA as well as to existing successful business models in the region relying on smart metering data access.	
KPI_{19}: ratio between interconnection capacity of a Member State and its electricity demand	This KPI serves the purpose of assessing the minimum interconnection capacity necessary to ensure that, if significant events affect one country/zone's electricity supply; at least 10 % of the demand can be met through imports (European Commission, 2002). The promoters make an effort to quantify the project's impact on this KPI by making reference to a study performed in the UK in which deployment of interconnectors is analysed as a potential source of flexibility. Nevertheless, the assessment must not be limited to deployment of new interconnectors but should also take into account the increase in the net transfer capacity (NTC) across the existing interconnectors. It is likely that better integrated markets owing to the Data Bridge platform would have a positive impact on both the deployment of new interconnectors and the increase in the NTC. Nevertheless, uncertainties remain in the assumptions made and the calculation method used so that a greater impact cannot be assessed with a sufficient level of confidence at this stage of the project's development.	

Source: Own elaboration, 2019.

2.4.5.1. Economic appraisal

The following section presents the societal benefits of the Data Bridge project in monetary terms along with the total cost (capital and operational expenditure), as communicated by the promoters. Furthermore, economic indicators such as the NPV, the IRR and the B/C ratio are used to verify whether or not the overall project' benefits outweigh the project's costs and, therefore, whether or not the project complies with the second general criteria of the regulation (Article 4(1)(b)).

The promoters assumed the following values for the variables used in the societal CBA.

- **Demand growth:** electricity generation has been relatively stable over the last decade in the region and the promoters expect this trend to continue during the lifetime of the project, whereas the effects of electrification will be felt only after the time horizon of the project's CBA. Therefore, the promoters account for 0 % demand growth in their project's CBA.
- **Discount rate:** a value of 4 % has been assumed for the societal discount rate (Vasiljevska and Gras, 2017).
- **Time horizon:** considering the large amount of information and communication technology (ICT)-based investments in the project, the promoters report a time horizon of 15 years.
- **Number of start-ups per participating country** enabled by the project: one new start-up per country per year.
- **Average economic value created per start-up:** EUR 5 million.
- **Average electricity price in the project area:** EUR 40/MWh.
- **CO_2 price:** EUR 40/t.
- **Technical network losses in the project area:** 10 %.

Owing to the insufficient level of project maturity, the CBA of the Data Bridge project was affected by several uncertainties both in the calculation approach and in the assumptions made. These are mainly associated with the early stage of the project's development and the lack of similar pilots/studies in Europe, meaning that the promoters could only refer to studies performed in the USA and Canada. Nevertheless, the promoters put great effort into demonstrating the significant contribution of the project to the policy specific criteria mentioned in Article 4 of the regulation.

The project reports positive outcomes in the societal CBA. The main monetary benefits and costs are listed below.

2.4.5.2. Main monetary benefits

The Data Bridge project is expected to deliver a set of positive impacts and in that respect the following monetised benefits are communicated by the project promoters:

- increased economic activity and additional employment thanks to innovation;
- deferred distribution capacity investments;
- deferred transmission capacity investments;
- reduced electricity technical losses;
- electricity cost savings;
- reduced CO_2 emissions and fossil fuel usage;
- deferred data access platform investments.

2.4.5.3. Main costs

The main costs associated with the project deployment are:

- purchase of Estfeed ([13]) licences;
- installation of central component servers capable of managing 100 million metering points;
- improving the user experience (automating the interfacing process, better support for user channels, including mobile platforms, websites, etc.);
- interfacing the Data Bridge with other platforms;
- software investments per partner to build the prerequisite data hub;

([13]) https://elering.ee/en/smart-grid-development.

- management change within each organisation to join the Data Bridge platform;
- software and hardware investments per partner to join the Data Bridge platform.

2.4.5.4. Sensitivity analysis

The NPV of the project changes with variation of the following critical variables:

- discount rate;
- number of start-ups created per year per participating country;
- economic value of average start-up;
- consumption reduction from consumer awareness;
- per cent of consumers who obtain information about energy usage thanks to the Data Bridge;
- energy efficiency market share increase owing to Data Bridge;
- reduced CO_2 emissions due to wider diffusion of low-carbon generation sources;
- deferred transmission investments;
- deferred distribution investments;
- reduced technical losses;
- cost of within-country Data Bridge platform (if the project does not succeed as a PCI, each Member State would need to build their own platform);
- number of countries that would need to duplicate the Data Bridge infrastructure if the project does not succeed as a PCI (France, Latvia, Lithuania, Finland);
- CO_2 price (EUR 40/t, EUR 20/t and EUR 60/t as medium, low and high values, respectively);
- number of promoter countries.

The promoters report that even in the worst-case scenario, where the variables (CO_2 price and number of created start-ups) used for the most salient benefits (value of reduced CO_2 emissions and increased economic activity) diminish by 50 % and 70 %, respectively, the project's NPV is still kept positive and the B/C ratio is 1.21.

2.4.5.5. Additional non-monetary benefits

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

- consumer inclusion and empowerment;
- employment;
- social acceptance;
- enabling new services and applications and market entry to third parties;
- time used/saved by consumers and network users;
- dissemination of the project's results.

2.4.6. Summary of the Data Bridge project's evaluation

The Data Bridge project is unique, as its main focus is on data access and data exchange as a vital element in enabling effective EU market integration and facilitating provision of flexibility resources across borders. In this light, the project aims to integrate data hubs of both DSOs and TSOs, thus also including end-users' smart metering data. As a result, it involves and efficiently integrates the behaviour of all users connected to the electricity network and allows cross-border data exchange, which is central to the development and operation of flexibility markets, and the project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

One of the project's objectives is to develop solutions for increased data sharing across borders and also for provision of ancillary services (congestion management at both the transmission and distribution network levels, balancing, emergency reserves, etc.) as a response to different TSO/DSO flexibility needs, thus resulting in cross-border data and capacity exchange. The project currently involves six participating EU countries and, more specifically, five TSOs and three DSOs, with the strong probability of involving other EU TSOs and DSOs in the near future and, in the longer term, replicating the project's solution across the EU.

In this regard, the Data Bridge project appears compliant with criterion (i) of Article 4(1)(c) of the regulation.

The Data Bridge project mainly includes investments at the transmission and medium-voltage distribution levels, providing two-way digital communication of meter data in real time, or close to real time, that enables interactive and intelligent monitoring and management of electricity assets and consumption to better integrate the behaviour of users (both generators and consumers). As a result, the project's investments comply with the energy infrastructure category of Annex II(1)(e) to the regulation.

The project is in its early stages of development, which poses some challenges in the evaluation of the project's contribution to the specific policy criteria of the regulation and particularly on the quantification and monetisation of the project's impacts. In addition, uncertainties, both in the approach to calculation and in the assumptions made, stem from a lack of similar pilots/studies in Europe, meaning that promoters could only refer to studies performed in the USA and Canada. Despite these challenges, the promoters convincingly argue for the project's contribution to the specific policy criteria of the regulation.

Last but not least, the Data Bridge project not only demonstrates strong potential to fulfil the policy criteria of Article 4(2)(c) of the regulation but also appears highly relevant to the development of the EU internal energy market.

2.5. Smart Border Initiative (Germany and France)

2.5.1. General overview

The Smart Border Initiative (SBI) project is a cross-border energy optimisation project, which originates from the need for more balanced and resilient energy systems at local level. Driven by practical needs and highlighting the added value of a regional project, the SBI offers an integrated approach of cross-border distribution network optimisation, smart mobility solutions and multi-energy subsystems, with the aim of improving energy efficiency, security of supply and network resilience in the project region. In this context, the German Energy Agency (DENA) with the support of Tilia (14) has decided to launch a common initiative to develop the SBI project. The project addresses the cross-border region of Saarland-Lorraine (south-west Germany and north-east France) and it involves DSOs and TSOs from Germany (Energis Netzgesellschaft and Amprion, respectively) and France (Enedis and RTE, respectively) among other market players (technology manufacturers, consultancies, etc.). The SBI project is composed of three closely interconnected modules, as follows.

1. **Joint optimisation of the cross-border electricity distribution system** — this project module focuses on optimising the development and operation of the electricity distribution systems in the project area through improved balancing of local generation and consumption at DSO level and integration and use of flexible resources.
2. **Smart mobility and integration into the smart grid (implementation of a vehicle-to-grid interface)** — this module aims to develop and operate electric vehicle (EV)-charging infrastructure in the project area, considering electricity network constraints and the development and adoption of a smart and low-carbon strategy for cross-border mobility (including a cross-border mobility platform for various mobility services, e.g. location and availability of parking and charging infrastructure).
3. **Energy efficiency and sector integration (developing an interface to add energy efficiency and sector integration measures to the smart grid)** — this module aims to develop integrated local energy systems, leveraging the integration of different energy sectors (heating, cooling and electricity); more particularly, it focuses on the development of an interface with the DSO for provision of flexibility services, RES management, etc.

Increased proportions of distributed non-dispatchable RES along with growing demand for electric vehicle charging in the project area pose significant challenges to the electricity system operation in the region. To this end, the project envisages the development of a cross-border smart grid mechanism for joint monitoring and steering of network components to enhance the operation of the distribution grids in the project area while increasing transmission and distribution network capacity. The mechanism also includes definition of coordination procedures between the parties involved (DSOs, TSOs, aggregators, flexibility owners, etc.), technical procedures for monitoring and control of the flexibility options, and algorithms to ensure optimal use

(14) http://www.tilia.info/.

of these options while making use of a common data management system (including relevant information on the grid status on either side of the border).

In addition, a cross-border interconnector at the DSO level is envisaged based on the identification of existing and future grid challenges in the project region and subject to internal CBA of the project, to be finalised by the end of 2019.

Finally, flexibilities provided by modules 2 and 3 will respond to the network challenges identified and further contribute to network optimisation while allowing higher levels of RES penetration.

Main project goals:

- optimisation of the energy system in the region covered by the project by utilising cross-border synergies and integrating the electricity grid planning and operation with the planning and operation of smart e-mobility, energy efficiency and sector-coupling concepts;
- enhancement of network security, reliability and quality of supply;
- enablement of growing penetration levels of RES in the region;
- increased system operational efficiency as a result of joint cross-border systemic approach;
- development of a market for provision of flexibility services.

The project is currently in its study phase, to be finalised by the end of 2019. In the course of this phase, an analysis was carried out to narrow down the four pre-selected locations as possible project areas with regard to existing facilities and network capacities, grid congestions and flexibility potential. Finally, two locations out the four have been selected as a potential project area. Further analyses, including the assessment of possible interconnector technologies and their exact location, will focus on these two cross-border areas.

The SBI project was granted the status of project of common interest in 2017 and as a result it was included in the third Union list of projects of common interest. The project has been also granted financial support from the CEF in the form of a grant for studies. The study phase started in May 2018 and it is planned to be finalised by the end of 2019. It includes selected activities from all three modules with the aim of further developing the project concept and paving the way for the implementation phase. The final result of the study phase will be a CBA, which will take into account all quantitative and qualitative inputs collected during this phase. Depending on the outcome of the CBA, the project will proceed to the final investment decision phase.

2.5.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

The main idea of the SBI project revolves around development of optimised cross-border electricity distribution systems driven by regional needs and objectives, and integrating electrical mobility, energy efficiency and heating systems. The project intends to develop a cross-border data management system for efficient operation of the regional smart grid and a cross-border interconnection at the distribution network level. It also aims to develop joint standards for the development of a mechanism for optimisation of the cross-border electricity distribution systems to ensure interoperability, connectivity and ultimately functionality of the systems and technologies in the smart grid environment. For this purpose, the project aims to develop a cross-border data management system (as part of module 1) based on a set of communication and coordination measures between (1) the DSOs, for operation and maintenance of the distribution network cross-border line, (2) the aggregators and DSOs, for utilisation of flexibility options with respect to market signals and network requirements, and (3) the DSOs and TSOs, with regard to market coupling and network operation in the cross-border region.

In the context of the above, the project addresses the cross-border region of two Member States and complies with criterion (i) of Article 4(1)(c) of the regulation.

2.5.3. Project's necessity for the priority thematic area of smart grids deployment

The SBI project includes various smart grid elements with a strong cross-border regional focus, covering the region of Saarland-Lorraine (south-west Germany and north-east France). The smart grid dimension is mainly addressed in the first module of the project, which aims to optimise the development and operation of the distribution networks in the cross-border area, but using flexibility resources (EVs, district heating and cooling, buildings, etc.) provided by the three modules. Module 1 includes development of a cross-border data management system, whereas modules 2 and 3 focus on development of interfaces for smart mobility and multi-energy sector coupling, respectively, for enabling provision of flexibility services for efficient network operation and for management of growing levels of non-dispatchable RES. In this context, the project centres on a strong cross-border dimension, which enables the DSOs to jointly address some of the current challenges in the region and beyond by efficiently integrating the behaviour and actions of all users connected to the electricity network. As a result, the project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

2.5.4. Compliance with the energy infrastructure category of Annex II(1)(e) of the regulation

The SBI project mainly involves investments at MV and HV distribution network levels, providing two-way digital communication in real time, or close to real time, enabling interactive and intelligent monitoring and management of electricity assets and consumption to better integrate the behaviour of users (both generators and consumers). To this end, the project's investments are in line with the energy infrastructure category of Annex II(1)(e) to the regulation.

The main infrastructure assets addressed by the SBI project are the following.

- **Development of a cross-border data management system able to monitor and optimise in real time the operation of the cross-border smart grid —** selection of necessary data and interfaces to allow the efficient operation of the distribution networks in the cross-border region; implementation of a common online data management platform and information flow; definition and set-up of communication and coordination measures for coordination activities between different parties (e.g. DSOs and DSOs, DSOs and aggregators, DSOs and TSOs), etc.
- **Deployment of a cross-border interconnection at the MV distribution network level —** subject to planning, implementation study and internal CBA to be finalised by the end of the study phase (end of 2019).
- **Development of a compatible smart grid mechanism —** allowing efficient use of flexibility options with regard to different possible use cases (critical network operational conditions, electricity market, integration of centralised versus decentralised energy storage, etc.). Moreover, it defines the coordination procedures between the parties involved (DSOs, TSOs, aggregators, flexibility owners, etc.), technical procedures for monitoring and control of flexibility options, possibilities for efficient integration of DSO interconnectors in the existing market coupling, etc.
- **Development of EV- and hydrogen-charging infrastructure on both sides of the border and their integration into a back-end system —** such infrastructure addresses preparation of a detailed charging development plan, including location, number of charging stations, placement and grid connection, based on observed cross-border vehicle traffic in the region and on distribution network constraints. The back-end system will be accessible from both sides of the border and will provide user-friendly solutions to resolve roaming issues for charging, billing and paying. To this end, the project aims to upgrade the existing charging infrastructure in the project area, namely as follows:
  - update and digitalisation of existing charging stations to future-related standards to allow integration of the existing infrastructure into the back-end system;
  - implementation of new charging infrastructure with an initial estimate of ca 25 fast charging stations (50 kW, triple charger), ca 25 normal charging stations (22 kW), ca 50 private charging stations (< 11 kW), etc.
- **Development of smart mobility solutions and services —** the project includes development of solutions for cross-border roaming services, EV incentive possibilities, provision of flexibility services to the DSO and app-based solutions for further provision of e-mobility services to the customers (e.g. location of vacant charging stations).
- **Development of central cross-border mobility platform —** this platform will integrate different mobility services in the project area and thereby provide EV users with the following information: navigation, locations for parking and charging, e-tickets for public transport, traffic, weather, etc. In addition, this information will encourage public authorities to take further action for smart and sustainable mobility (e.g. e-buses, hydrogen mobility).
- **Deployment of energy data management system in industrial companies, local municipalities, social housing, etc., for provision of demand response/flexibility —** the efficiency potential of each residential, industrial or commercial site will be used to optimise the distribution network operation and energy consumption in the region. The deployment of this asset will be aligned with the joint optimisation of the cross-border distribution systems (module 1).

- **Setting up the interface links between the different project modules** — the smart grid system addressed in module 1 is intended to make use of the flexibility potential proposed in modules 2 and 3. To this end, the project includes development of interface links between the modules and, more specifically, assessment of the flexibility potential of modules 2 and 3 and their integration into the smart grid design of module 1; definition of the nature of the heat-electricity link in local subsystems and its integration into smart grid monitoring; definition of data sharing modes with municipal utilities and other players; coordination of cross-border smart grid and heating grids planning and the planning of local energy efficiency programmes, etc.

2.5.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The benefits of the SBI project are assessed according to the specific criteria outlined in Article 4(2)(c) of the regulation, captured by a set of 21 key performance indicators derived from the criteria presented in Annex IV(4) to the regulation. In this context, the SBI project promoters argue for the project's impact on each of the six specific criteria, selecting a set of KPIs to better capture the project's impact against a specific criterion.

Table 25-30 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach (Vasiljevska and Gras, 2017) to evaluate the project's contribution to each specific criterion. In addition, each project's impact has been assessed in view of the following two scenarios: a BaU scenario, i.e. without deployment of the project, and an SG scenario, i.e. with implementation of the project.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

The SBI project creates favourable conditions for integration and involvement of different network users with new technical requirements, such as flexible loads coming from EVs, heat pumps users, buildings and industries, etc. through provision of user-friendly solutions and services (e.g. roaming, smart charging, etc.) and adoption of energy data management systems for industries, local municipalities, social housing, etc.

In this context, the promoters address the project's impact on the first specific criterion using the KPIs indicated in Table 25.

Table 25. SBI: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_4: allowable maximum injection of power without congestion risk in transmission networks	The project is likely to have a positive impact on this KPI as a result of cross-border optimisation of the distribution networks in the project area. The promoters expect no increase in back-feed flows from DSOs to TSOs if additional production units connect to the distribution network. This KPI is, however, not quantified at this stage of the project's development.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The promoters expect no increase in curtailed RES compared with the BaU scenario, owing to the currently low level of RES and no distribution network limitations. Nevertheless, growing RES penetration levels and large-scale adoption of e-mobility in the future may pose significant challenges to the operation of the electricity network. In this context, the project is expected to have a positive impact as a result of cross-border optimisation of the distribution networks in the project area and the creation of favourable conditions for provision of flexibility services. Nevertheless, a quantification of this KPI is not provided at this stage of the project's development.	
KPI_9: share of electricity generated from renewable sources	The promoters expect an increase in the proportion of electricity generated from RES due to the optimisation of the distribution networks in the project area and the integration and involvement of end-users in provision of flexibility services. As a result, based on previous smart grid projects (GRID4EU and Smart Country), the promoters expect a 20 % increase in RES capacity that can be safely	

	integrated into the system.	
KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to increase the demand-side participation of flexible loads and, as a result, the promoters expect a positive impact of the project on this KPI, referring to the flexibility associated with industrial load and EV users. The promoters provide an estimation of such a positive impact under the following assumptions: (1) in the BaU scenario there is no flexibility coming from EVs and limited industrial load flexibility and (2) in the SG scenario the EVs can provide flexibility as long as they are connected to the charging infrastructure. Nevertheless, uncertainties persist in the information provided and in the assumptions made. Therefore, more accurate assessment of this KPI cannot be performed at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The SBI project is expected to increase the distribution and transmission network operational efficiency and interoperability as a result of the following activities enabled by the project: development of a cross-border smart grid mechanism to enhance the operation of the distribution networks on both sides of the border; application of common technical standards to allow interoperability, connectivity and functionality of the technologies and systems in the project area; optimisation of the development and operation of EV-charging infrastructure considering electricity grid constraints and roaming services to customers across the border; coordination of planning and operational procedures of the electricity distribution networks and the electrical mobility, energy management and power-to-heat solutions; etc. In this context, the promoters address the project's impact on the second specific criterion using the KPIs indicated in Table 26.

Table 26. SBI: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_{13}: level of losses in transmission and distribution networks	The promoters expect an increase in the absolute value of losses due to greater utilisation of the DSO assets enabled by the project. This increase will, however, be offset by a relative increase in the RES connected to the distribution network. Nevertheless, quantified estimation of this KPI cannot be provided at this stage of the project's development.	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The average loading of electricity network components is expected to increase (e.g. increased average loading at transformer level due to higher RES infeed). At the same time, the joint optimisation of the distribution network enabled by the project will contribute to more efficient loading of electricity network elements. The quantitative estimation of this KPI requires specific simulation studies, which cannot be provided at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

The project addresses this criterion by making reference to the following tasks proposed by the project: cross-border matching of supply and demand and provision of more efficient compensation of regional imbalances (e.g. efficient multi-energy subsystems), and active management of feed-in and flexible load to maintain grid stability and allow efficient integration of RES, etc. To this end, RES penetration level can be significantly increased without compromising the network's security of supply. In addition, the promoters stress the need to analyse the extent of these benefits at the expense of higher network utilisation rates, which may result in higher network losses.

The promoters address the project's impact on the third specific criterion using the KPIs indicated in Table 27.

Table 27. SBI: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_4$: allowable maximum injection of power without congestion risk in transmission networks	The project is likely to have a positive impact on this KPI as a result of cross-border optimisation of the distribution networks in the project area. The promoters expect no increase in back-feed flows from DSOs to TSOs if additional production units connect to the distribution network. This KPI is, however, not quantified at this stage of the project's development.	
KPI$_5$: energy not withdrawn from renewable sources due to congestion or security risks	The promoters expect no increase in RES curtailment compared with the BaU scenario owing to the currently low level of RES and no distribution network limitations. Nevertheless, growing RES penetration levels and large-scale adoption of e-mobility in the future may pose significant challenges to the operation of the electricity network. In this context, the project is expected to have a positive impact as a result of cross-border optimisation of the distribution networks in the project area and creation of favourable conditions for provision of flexibility services. Nevertheless, a quantification of this KPI is not provided at this stage of the project's development.	
KPI$_9$: share of electricity generated from renewable sources	The promoters expect an increase in the proportion of electricity generated from RES due to optimisation of the distribution networks in the project area and involvement of end-users in provision of flexibility services. As a result, based on previous smart grid projects (GRID4EU and Smart Country), the promoters expect a 20 % increase in RES capacity that can be safely integrated into the system.	
KPI$_7$: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to increase the network operational flexibility for dynamic balancing as a result of an increase in the controllable capacity coming from EVs, loads subject to demand-side management, etc. However, the exploitation of such flexibility will also depend on the market rules in place, which are beyond the control of the project promoters. As the project aims to optimise the development and operation of the distribution networks in the cross-border area using different flexibility resources (EVs, district heating and cooling, energy efficiency in buildings, etc.), a positive impact can be assessed with a sufficient level of confidence.	
KPI$_8$: ratio of reliably available generation capacity and peak demand	The promoters expect a significant increase in this KPI due to an increase in generation capacity and lower peak demand (as a result of DSM, e-mobility, etc.). However, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI$_{10}$: stability of the electricity system	The promoters report a positive impact of the project on this KPI as a result of the more robust network structure introduced by the project as well as the integration and optimisation of the local energy system. Nonetheless, as the project's impact on this KPI would also depend on the ultimate decision regarding deployment of a MV interconnection and its capacity (subject to the CBA outcome), a greater impact cannot be reliably assessed at this stage of the project's development.	
KPI$_{11}$: duration and frequency of interruptions per customer, including climate-related disruptions	The promoters report an expected decrease in SAIDI and SAIFI due to the more robust distribution network structure enabled by the project and based on similar studies in the project region. In this regard, a positive impact has been assessed; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	

KPI$_{12}$: voltage quality performance	The promoters expect a positive impact of the SBI project on this KPI as a result of the more robust distribution network structure enabled by the project even in the presence of growing RES penetration levels. In this regard, a positive impact has been assessed; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI$_{14}$: ratio between minimum and maximum electricity demand within a defined time period	The project is envisaged to have a positive impact on this KPI due to increased controllable load, subject to demand-side participation, which would ultimately result in a smaller difference between the minimum and maximum electricity demands. In this context, the promoters report a value of 10 % for the peak load reduction by making reference to similar projects.	
KPI$_{17}$: availability of network components (related to planned and unplanned maintenance) and its impact on network performance	The project is expected to minimise the effects of component failures and unavailability owing to enhanced observability and control of the distribution networks in the project area. The promoters also relate this KPI to an expected increase in network reliability (decrease in SAIDI and SAIFI). The KPI is, however, not quantified at this stage of the project's development.	
KPI$_{18}$: actual availability of network capacity with respect to its standard value	The promoters expect a positive impact of the project on this KPI due to the increased network monitoring and steering capabilities and the possible deployment of a MV network interconnection. Nevertheless, a greater impact of the SBI project on this KPI cannot be assessed with a sufficient level of confidence at this stage of the project's deployment, as the impact would also depend on the ultimate decision regarding the installation of a MV interconnection.	

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The promoters address the project's impact on this criterion by making reference to the following activities of the project: coordination of the planning and operation procedures of the distribution networks with the planning and operation of electrical mobility, energy management and power-to-heat solutions; integration of co-generation facilities, heat pumps and thermal storage to efficiently manage variable non-dispatchable RES; efficient planning of the design and location of future EV and hydrogen charging infrastructure, etc.

The following KPIs (Table 28) have been selected to address the project's impact on the fourth specific criterion.

Table 28. SBI: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_{3}$: installed capacity of distributed energy resources in distribution networks	Enhanced distribution network operation and management enabled by the SBI project are expected to significantly increase the installed DG capacity and enable DG connection at an earlier stage than in the BaU scenario. This will in turn incentivise DG deployment in areas where it has not been viable before. In this respect, promoters estimate a 20 % increase in installed DG capacity compared with the BaU scenario based on previous pilot projects (GRID4EU and Smart Country).	
KPI$_{4}$: allowable maximum injection of power without congestion risk in transmission networks	The project is likely to have a positive impact on this KPI as a result of the cross-border optimisation of the distribution networks in the project area. The promoters expect no increase in back-feed flows from DSOs to TSOs if additional production units connect to the distribution network. This KPI is, however, not quantified at this stage of the project's development.	

KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The promoters expect no increase in RES curtailment compared with the BaU scenario, owing to the currently low level of RES and no distribution network limitations. Nevertheless, growing RES penetration levels and large-scale adoption of e-mobility in the future may pose significant challenges to the operation of the electricity network. In this context, the project is expected to have a positive impact as a result of the cross-border optimisation of the distribution networks in the project area and the creation of favourable conditions for provision of flexibility services. Nevertheless, a quantification of this KPI is not provided at this stage of the project's development.	
KPI_{12}: voltage quality performance	The promoters expect a positive impact of the SBI project on this KPI as a result of the more robust distribution network structure enabled by the project, even in the presence of growing RES penetration levels. In this regard, a positive impact has been assessed; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

The SBI project largely addresses development of markets for innovative customer services, such as smart charging options for EV users, provision of information on energy consumption for demand response, development of cross-border roaming services for EV charging and provision of flexibility services to the DSOs.

In this regard, the promoters address the project's impact on the fifth specific criterion using the KPIs indicated in Table 29.

Table 29. SBI: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse emissions	The promoters report an expected reduction of GHG emissions due to increase in the proportion of EV and energy savings (through energy efficiency and energy sector coupling) enabled by the project. The KPI is, therefore, positively quantified.	
KPI_2: environmental impact of electricity grid infrastructure	The project is likely to have a positive impact on this KPI, as it will reduce the need for constructing additional distribution network assets. As a result, the promoters expect noise reduction and a reduced visual impact as well as a reduced impact on vegetation and fauna.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	The promoters expect no increase in RES curtailment compared with the BaU scenario, owing to the currently low level of RES and no distribution network limitations. Nevertheless, growing RES penetration levels and large-scale adoption of e-mobility in the future may pose significant challenges to electricity network operation. In this context, the project is expected to have a positive impact as a result of the cross-border optimisation of the distribution networks in the project area and the creation of favourable conditions for provision of flexibility services. Nevertheless, a quantification of this KPI is not provided at this stage of the project's development.	
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	Valuable information on the demand response potential from EV users and residential/industrial customers enabled by the project would facilitate provision of adequate incentives for network users providing flexibility. Such incentives could also be provided through network tariffs. In addition, the cross-border nature of the SBI project would require coordination of the two network tariff systems so that contradictory incentives are avoided. The project's results could lead	

	to recommendations on effective and ineffective incentives under different conditions, especially in view of the necessary harmonisation of the tariff systems.	
KPI_{11}: duration and frequency of interruptions per customer, including climate-related disruptions	The promoters expect a decrease in SAIDI and SAIFI due to the more robust distribution network structure enabled by the project and based on similar studies in the project region. In this regard, a positive impact has been assessed; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI_{12}: voltage quality performance	The promoters expect a positive impact of the SBI project on this KPI as a result of the more robust distribution network structure enabled by the project, even in the presence of growing RES penetration levels. In this regard, a positive impact has been assessed; however, uncertainties persist in the information provided owing to the insufficient maturity of the project.	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The average loading of electricity network components is expected to increase (e.g. increased average loading at transformer level due to greater RES infeed). At the same time, the joint optimisation of the distribution network enabled by the project will contribute to more efficient loading of electricity network elements. Quantitative estimation of this KPI requires specific simulation studies, which cannot be provided at this stage of the project's development.	
KPI_{19}: ratio between interconnection capacity of a Member State and its electricity demand	The promoters expect an increase in the interconnection capacity at the MV level due to the potential deployment of physical cross-border distribution network interconnection. Nevertheless, the project's impact on this KPI would also depend on the final decision regarding installation of such interconnection and its capacity and, therefore, a greater impact cannot be reliably assessed at this stage of the project's development.	
KPI_{20}: exploitation of interconnection capacities	The deployment of a cross-border data management system enabled by the project is expected to optimise the operation of the distribution networks in the project area and contribute to better exploitation of the existing interconnection capacities. Moreover, the potential installation of an additional MV cross-border interconnector (subject to the CBA outcome) could further increase the value of this KPI. However, a more accurate estimate of the project's impact on this KPI cannot be provided at this stage of the project's development.	
KPI_{21}: congestion rents across interconnections	Currently, congestion rents take place at high-voltage level. The possible deployment of the MV cross-border interconnector would increase the cross-border energy trade and potentially have an impact on congestion rents. Nevertheless, a greater impact cannot be reliably assessed at this stage of the project's development, as it would also depend on the final decision regarding installation of such interconnection and its capacity.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

The SBI project is envisaged to contribute positively to the fulfilment of this criterion by empowering various customers (EV users, residential/industrial load subject to DSM, etc.) to monitor, manage and control their electricity consumption and by the integration and involvement of different network users in more efficient and sustainable operation of the distribution networks in the project area, etc.

The promoters address the project's impact on this specific criterion using the KPIs indicated in Table 30.

Table 30. SBI: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to increase the demand-side participation of flexible loads and, as a result, the promoters expect a positive impact of the project on this KPI, referring to the flexibility associated with industrial load and EV users. The promoters provide an estimation of the positive impact under the following assumptions: (1) in the BaU scenario there is no flexibility coming from EVs and limited industrial load flexibility and (2) in the SG scenario the EVs can provide flexibility as long as they are connected to the charging infrastructure. Nevertheless, uncertainties persist in the information provided and in the assumptions made and, therefore, more accurate assessment of this KPI cannot be performed at this stage of the project's development.	
KPI_3: installed capacity of distributed energy resources in distribution networks	Enhanced distribution network operation and management enabled by the SBI project is expected to significantly increase the installed DG capacity and enable DG connection at an earlier stage than in the BaU scenario, which in turn will incentivise DG deployment in areas where it has not been viable before. In this respect, promoters estimate a 20 % increase in installed DG capacity compared with the BaU scenario, based on previous pilot projects (GRID4EU and Smart Country).	
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	Valuable information on the demand response potential from EV users and residential/industrial customers enabled by the project would facilitate provision of adequate incentives for network users providing flexibility. Such incentives could also be provided through network tariffs. In addition, the cross-border nature of the SBI project would require coordination of the two network tariff systems so that contradictory incentives are avoided. The project's results can lead to recommendations on effective and ineffective incentives under different conditions, especially in view of the necessary harmonisation of the tariff systems.	

Source: Own elaboration, 2019.

2.5.5.1. Economic appraisal

The SBI project is in its study phase and therefore some project parameters (exact project location, deployment of a cross-border MV interconnector, etc.) are still to be defined by the end of the project planning phase.

The choice of these parameters is subject to studies, including a CBA to estimate the costs and benefits of different possible project realisations and ensure that the project's costs do not outweigh the total benefits. As the SBI project has not reached a sufficient level of maturity, a quantitative CBA could not be reliably carried out at this stage of the project's development, and the economic appraisal of the project's costs and expected benefits is demonstrated in qualitative terms.

The main monetary benefits and costs of the project are listed below.

2.5.5.2. Main monetary benefits

The SBI project is expected to deliver a set of positive impacts. In this respect the following benefits (expressed qualitatively) are communicated by the project promoters:

- deferred or optimised distribution capacity investments at HV/MV substations and MV network levels as a result of better integration of DER/RES and cross-border optimisation of the EV-charging infrastructure;
- optimised DER/RES integration to support the implementation of 2020/2030 RES targets on both sides of the border;

- increased energy savings through energy efficiency and energy sector coupling, which may also result in reduction of network technical losses;
- optimised planning of a number of charging stations as a result of roaming management solutions and services, interoperability of technology, etc.;
- reduction of LV network reinforcement costs as a result of optimisation of the EV-charging infrastructure and processes;
- increased penetration level of EVs;
- additional environmental benefits (reduction of SO_x, NO_x emissions, air quality, etc.).

2.5.5.3. Main costs

The main costs associated with the SBI project deployment are:

- development and operation of distribution grid optimisation — smart grid taking into account the specificities of the cross-border region (module 1 of the project);
- deployment of MV cross-border interconnector (final decision is subject to internal CBA to be finalised by the end of 2019);
- development, implementation and testing of a cross-border mobility platform, addressed in module 2 of the project;
- development of a cross-border smart charging infrastructure (module 2);
- conception and definition of data, stakeholders and requirements of the energy management system, addressed in module 3 of the project;
- identification and analysis of the flexibility potential in module 3 of the project and its link with the smart grid of module 1;
- development of a cross-border data management system;
- project design and management, etc.

2.5.5.4. Additional non-monetary benefits

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

- **enhanced consumer awareness and market participation** — the SBI project is expected to play a significant role in empowering customers to take an active role in more efficient network operation, incentivising their behavioural impact on the cost of electricity and promoting the creation of innovative market mechanisms for new energy services, such as energy efficiency and demand response, etc.;
- **increased social awareness and acceptance** — the project aims to create public awareness of the project, keep up the public interest in the project and motivate people to take part (online and offline communication on the process to connect new installation to the smart grid, building up an open data platform, user experience reports, etc.);
- **exchange of best practices** — the project results would enable sharing of good practices among local energy shareholders across the Franco-German border;
- **provision of attractive service to daily commuters in the project area** — the mobility platform developed in the project is expected to facilitate the use of individual and public modes of transportation in the project area;
- **project replicability potential** — the most adequate and cost-effective smart grid technologies and tools with respect to the regional/cross-border characteristics will be identified, which may serve as a basis for public/private decision-making and assist the development of other cross-border projects.

2.5.6. Summary of the SBI project's evaluation

The Smart Border Initiative project capitalises on cross-border cooperation in one of the Franco-German regions, exploiting strong regional and integrated approaches of several energy modules with the aim of achieving the energy transition objectives set in both Member States while effectively addressing the Energy Union's goals.

In this context, the project presents an innovative approach to addressing common cross-border energy challenges in the project area by integrating the electricity grid with electric mobility and district heating and cooling systems, and exploiting the flexibilities of both the electric mobility and the heating systems to optimise the development and operation of the distribution electricity networks in the project area. To this end, it includes a variety of participants, among which are French and German DSOs, TSOs, regional and local authorities, technology providers, research centres and other relevant local bodies working in the field of energy and electric mobility.

The project addresses a cross-border region of two Member States by developing a cross-border data management system for efficient operation of the regional smart grid and potentially a cross-border interconnection at distribution network level (final decision subject to internal CBA). It also aims to develop common standards for development of a mechanism for optimisation of the cross-border electricity distribution systems to ensure the interoperability, connectivity and ultimately functionality of the systems and technologies within the smart grid environment. Therefore, the SBI project complies with criterion (i) of Article 4(1)(c) of the regulation and proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

The project is currently in its study phase and as a result some project parameters (exact project location, installation of a cross-border MV network interconnector, etc.) are still to be defined by the end of the project planning phase. Moreover, as the project has not yet reached a sufficient level of maturity, a quantitative societal CBA could not be performed. Consequently, the economic appraisal of the project's expected benefits is demonstrated in qualitative terms. Notwithstanding the uncertainties in the information provided and the assumptions made, the project already demonstrates potential for a positive contribution to the six smart grid specific criteria outlined in Article 4(2)(c) of the regulation.

2.6. SINCRO.GRID (Slovenia and Croatia)

2.6.1. General overview

The SINCRO.GRIDS project builds on the flexibility deficiency in the area in terms of voltage and frequency regulation, which could potentially endanger future development of renewable energy in the region. The project addresses the distribution and transmission network of Slovenia and Croatia, therefore covering the territory of both countries.

To address this issue of flexibility need, the project proposal focuses on voltage profile management that will allow increased integration of renewables in the grid while enabling secure and reliable delivery of electric power to the end-users. For this reason, a dedicated control centre will be established to support various voltage and frequency control processes.

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

- the need to deal with voltage fluctuations outside of the operational limits;
- the increased need for ancillary services, especially secondary and tertiary reserve both capacity- and energy-wise;
- the 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 by periods of increased generation and low consumption; nevertheless, low-voltage problems that may develop 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 level (operated by the TSOs in both Member States), 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 network elements operational limits, thus allowing 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;

- enhanced communication platform for demand-side management for provision of tertiary reserve, thus allowing more transparent cooperation 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 anticipate 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 an additional 330 MW of wind power to be installed in Croatia);
- enhanced voltage profiles of transmission systems of both 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 utilisation of existing transmission and 110 kV grid using DTR;
- better observability of distribution and transmission grids using advanced forecasting tools, DTR and information coupling of distribution and transmission systems;
- additional capacity for tertiary reserves provided through demand-side management by establishing a common communication platform that will allow provision of more accurate data to the TSO.

The SINCRO.GRID project was granted the status of project of common interest for the first time in 2015 and then again in 2017. As a result, the project was part of both the second and third Union lists of projects of common interest. In 2016 and 2018, the project was also granted financial support from the CEF in the form of a grant for works for phase 1 and phase 2 of the project, respectively.

2.6.2. Compliance with the general criteria of Article 4(1)(c) of the regulation

The SINCRO.GRID project deals with the flexibility deficiency needs in the project area in terms of voltage control by deploying a virtual cross-border control centre (VCBCC) for coordinated optimisation of the voltage profile on either side of the border. This control centre will be established as a joint ELES-HOPS application to allow coordinated and controlled centralised representation of RES production and system variables of Slovenian and Croatian HV and MV networks as well as to enable power system optimisation in the whole control area. Furthermore, the project focuses on increasing cross-border capacities by means of installing real-time control of operational limits of network elements (dynamic line rating). To this end, the project complies with criterion (i) of Article 4(1)(c) of the regulation.

2.6.3. Project's necessity for the priority thematic area of smart grids deployment

The project area exhibits a high degree of transit power flows, which in certain periods can reach more than 100 % of the peak consumption in some parts of the electricity networks. In addition to the strong transit fluctuations, increased penetration levels of intermittent RES cause TSOs in both Slovenia and Croatia to face similar problems related to voltage control. As a result, 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 across both countries to solve the overvoltage problem if they are addressing it separately. On the other hand, establishing a common virtual cross-border control centre would reduce the need for compensation devices to 1050 Mvar owing to the coordinated actions of neighbouring TSOs.

Both Slovenia and Croatia are located 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 not only calls for additional interconnections to serve market needs but also results in borders being congested most of the time. Solutions such as construction of new power lines are often challenged by issues related to spatial planning; therefore, it is essential to utilise the existing infrastructure to the maximum extent possible by implementing smart grids solutions. This requires a high level of cooperation between TSOs and DSOs, which will enable increased utilisation of the existing grid while maintaining an adequate level of reliability and security of supply. As a result, the project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation).

2.6.4. Compliance with the energy infrastructure category of Annex II(1)(e) to the regulation

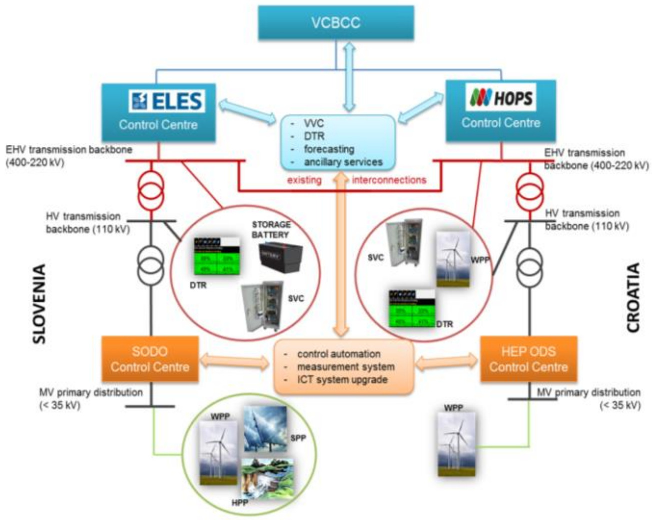
The SBI project mainly involves investments at the transmission and MV (≥ 10 kV) and HV (≥ 110 kV) network levels in Slovenia and Croatia, providing two-way digital communication in real time, or close to real time, enabling interactive and intelligent monitoring and management of electricity assets and consumption to better integrate the behaviour of users (both generators and consumers). To this end, the project's investments are in line with the energy infrastructure category of Annex II(1)(e) to the regulation.

The main infrastructure assets deployed in the SINCRO.GRID project are the following.

- **Virtual cross-border control centre —** a joint ELES-HOPS VCBCC and corresponding infrastructure will be set up to allow coordinated and controlled network operation and RES production at the Slovenian and Croatian HV and MV networks as well as power system optimisation in the whole control area. The VCBCC will be integrated within the existing SCADA system/EMSs on both sides of the border (operated by ELES and HOPS) and with additional advanced tools, such as simulation tools based on measurements and state estimator's output, advanced visualisation tools and SUMO — a system for real-time and short-term forecast assessment of the network operational limits.
- **Compensation devices —** static var compensators with a total capacity of 1050 Mvar will be installed in the project area through a coordinated approach between the two TSOs, which both face the issue of overvoltage. The results show that separate solutions (compensation in Slovenia or Croatia separately) lower the voltage but 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 (Li-Ion technology) with energy capacity of 30 MWh.
- **DG units providing secondary reserve —** the Slovenian TSO assumes the following units to be included in provision of secondary reserves: two biogas power plants with a total installed capacity of 1.4 MW and one small hydropower plant with an installed capacity of 2 MW.
- **DTR —** DTR will be implemented at all transmission power lines in the Slovenian transmission grid as part of the SUMO architecture (a 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 visualisation 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 RES causes increased uncertainties for transmission system operation and consequently an increased need for ancillary services (secondary and tertiary reserves in terms of both 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 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 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 2 illustrates the system architecture of the SINCRO.GRID project.

Figure 2. SINCRO.GRID system architecture



Source: SINCRO.GRID promoters

2.6.5. Project contribution to the smart grid specific criteria (Article 4(2)(c) of the regulation)

The benefits of the SINCRO.GRID project are assessed according to specific criteria outlined in Article 4(2)(c) of the regulation and captured by a set of 21 key performance indicators derived from the criteria presented in Annex IV(4) to the regulation. In this context, the SINCRO.GRID project promoters elaborate on the project's impact on each of the six specific criteria, selecting a set of KPIs to better capture the project's impact against a specific criterion.

Policy criterion 1: integration and involvement of network users with new technical requirements with regard to their electricity supply and demand

The project will allow additional DG and RES to be connected to the transmission and distribution networks while ensuring a higher level of security of supply and reducing environmental impact (in terms of greenhouse gas (GHG) emissions). The promoters select the following KPIs (Table 31) to capture the project's impact on this criterion.

Tables 31-36 below depict the selected KPIs for capturing the project's impact against each specific criterion and the estimation approach used. Depending on the present uncertainties in the information provided by the promoters and the assumptions made, the JRC has used a colour-coded approach (Vasiljevska and Gras, 2017) to evaluate the project's contribution to each specific criterion. In addition, each project's impact has been assessed in view of the following two scenarios: a BaU scenario, i.e. without deployment of the project, and an SG scenario, i.e. with implementation of the project.

Table 31. SINCRO.GRID: evaluation of project impact against the first specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_1: reduction of greenhouse gas emissions	The project is expected to reduce CO_2 emissions owing to the following activities: • increased network observability and voltage regulation, which would result in an additional 330 MW of wind power connection in the Croatian transmission and distribution system; • deployment of storage units, which will replace the 30 MW gas-fired power plant for provision of secondary reserve in Slovenia; • provision of DSM for tertiary reserve in Slovenia; • reduced technical losses, etc. In this regard, the promoters report positive quantification of this KPI.	

KPI_9: share of electricity generated from renewable sources	The promoters report a positive assessment of this KPI in terms of percentage variation in the proportion of electricity generated from RES that can be safely integrated into the system in both the SG and BaU scenarios. The KPI is positively quantified based on additional renewable energy (676 GWh per year) that can be safely integrated into the grid as a result of project deployment.	
KPI_{10}: stability of the electricity system	One of the main objectives of the SINCRO.GRID project is to solve overvoltage problems in the project area. In this context, the promoters assess this KPI in terms of improvement of transmission network voltage profiles as a result of deployment of compensation devices and inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control algorithms. As a result, the promoters report a positive assessment of this KPI.	

Source: Own elaboration, 2019.

Policy criterion 2: efficiency and interoperability of electricity transmission and distribution in day-to-day network operation

The project is envisaged to increase the level of RES that can be safely integrated into both the distribution and transmission networks. This would require stronger cooperation between the DSOs and the TSOs on either side of the project border. In addition, more efficient operation of both the distribution and transmission networks is expected owing to the inclusion of DG and storage in the provision of ancillary services and increased exploitation of the interconnection capacities in the project area.

The KPIs presented in Table 32 address the project's impact on the second specific criterion.

Table 32. SINCRO.GRID: evaluation of project impact against the second specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_3: installed capacity of distributed energy resources in distribution networks	The promoters expect a positive impact of the project on this KPI, as the project will allow installation of an additional 310 MW and 20 MW of wind power in the Croatian transmission and distribution systems, respectively. In the Slovenian part of the project, the KPI is estimated on the basis of the national plan for RES integration (an additional 600 GWh of RES, predominantly connected to the distribution network), as the project promoters have no control over the location and additional capacity of DG installed in the grid. Current overvoltage issues would prevent integration of this additional RES in the network in the BaU scenario and, in this regard, the project plays a key role in enabling connection of additional DG into both distribution and transmission network. The KPI is, therefore, positively quantified.	
KPI_5: energy not withdrawn from renewable sources due to congestion or security risks	There is no historical data on energy curtailment in the project area, as, in accordance with the national legislation in Slovenia and Croatia, all 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. In this regard, the project is expected to reduce possible curtailed renewable energy in the future as a result of enabling 719 MW of controllable wind units in Croatia included in the voltage control mechanism and an additional 12 MW of battery storage and DG in Slovenia providing secondary reserves.	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	This KPI is positively assessed owing to additional capacity of storage and demand response (ca 12 MW) enabled by the project, which would result in lowering the difference between the P_{max} and P_{min}.	

KPI$_{20}$: exploitation of interconnection capacities	The project is expected to increase the average net transfer capacity (NTC) in the project area owing to deployment of dynamic thermal rating. Assuming that the average load flow would not be affected by the project deployment, the KPI is positively assessed for the interconnections between Slovenia and Italy (direction from Slovenia to Italy) and Austria and Slovenia (direction from Austria to Slovenia). The promoters report hardly any congestion at the interconnector between Slovenia and Croatia. Nevertheless, the project's deployment is expected to increase NTC at this border by 15 %, thus contributing to the positive quantification of this KPI.	

Source: Own elaboration, 2019.

Policy criterion 3: network security, system control and quality of supply

The promoters expect a positive project impact on this specific criterion (mainly in terms of improved voltage profiles) as a result of inclusion of storage and DG units in provision of secondary reserve, deployment of dynamic thermal rating, etc. Therefore, the project facilitates growing penetration levels of RES that can be safely integrated into the grid.

The following KPIs (Table 33) have been selected to address the project's impact on this specific criterion.

Table 33. SINCRO.GRID: evaluation of project impact against the third specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI$_{4}$: allowable maximum injection of power into transmission networks without congestion risks	The promoters report a positive impact of the project on this KPI as a result of additional capacity from RES that could be safely integrated into the distribution and transmission network. In this context, the KPI is positively assessed based on the worst-case power flow conditions and the size of the largest production unit that can be connected to the grid without risking generation curtailment in both the BaU and SG scenarios.	
KPI$_{6}$: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	The project is expected to provide additional information to the regulator on the way RES can contribute to the provision of ancillary services (secondary reserves) and the incentives that would stimulate them to provide such services. Moreover, RES units will be included in the operation of the 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 reactive energy penalties and introducing new ones.	
KPI$_{7}$: operational flexibility provided for dynamic balancing of electricity in the network	The project is expected to increase the operational flexibility for dynamic network balancing. In this respect, the promoters assess this KPI as a ratio of DG and storage that can be modified versus total storage and DG in the project area. The promoters demonstrate a positive impact on this KPI due to inclusion of 22 MW of storage and DG in the supply of secondary reserve in Slovenia and connection of 719 MW wind generation to the central voltage control in Croatia.	
KPI$_{10}$: stability of the electricity system	One of the main objectives of the SINCRO.GRID project is to solve overvoltage problems in the project area. In this context, the promoters assess this KPI in terms of improvement of transmission network voltage profiles as a result of deployment of compensation devices and inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control algorithms. As a result, the promoters report a positive assessment of this KPI.	
KPI$_{11}$: duration and frequency of interruptions per	Presence of overvoltages in the project area may lead to equipment failure and, consequently, higher outage probability. The promoters argue that, owing to the nature of the project (overvoltages mainly	

customer, including climate-related disruptions	occurring at the transmission network level), the SAIDI and SAIFI are not the most adequate indicators to represent the issue at stake. To this end, the promoters demonstrate the project's impact on this KPI by taking into account only network outages caused by failures of transmission network equipment. An estimated 50 % decrease in system security due to overvoltages (calculated as the period when N-1 criterion ([15]) is not fulfilled) is reported in the BaU compared with the SG scenario.	
KPI$_{12}$: voltage quality performance	The promoters assess the project's impact on this KPI in terms of the reduced number of hours of voltage violations as a result of project deployment. In this regard, the project is expected to have a positive impact (estimated value of 99.99 %) as a result of the deployment of compensation devices and the inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control algorithms in the whole project area.	
KPI$_{14}$: ratio between minimum and maximum electricity demand within a defined time period	This KPI is positively assessed owing to additional capacity of storage and demand response (ca 12 MW) enabled by the project, which would result in lowering the difference between the P_{max} and P_{min}.	
KPI$_{16}$: percentage utilisation (i.e. average loading) of electricity network components	Dynamic thermal rating in Slovenia contributes to better utilisation of the grid and, therefore, DTR is expected to increase the capacity of the existing transmission infrastructure and the net transfer capacity (NTC) values. However, the promoters expect that the physical cross-border flow will remain the same using the phase-shift transformers, as the current physical cross-border flows already exceed the NTC value. Similar results are also expected for the Croatian part of the project. Nevertheless, the project is expected to increase the utilisation of the internal electricity network components as a result of increased levels of network observability and controllability. Still, uncertainties persist in the assessment of this KPI at the current stage of the project's development, as it is very much dependent on future network operation conditions and grid development.	
KPI$_{17}$: availability of network components (related to planned and unplanned maintenance) and its impact on network performances	This KPI is positively assessed on the basis of an estimated 2-year reduction in the average lifespan of HV equipment due to overvoltage problems in the BaU scenario, whereas the average lifespan of HV equipment is reported to be 40 years. In this context, the SINCRO.GRID solutions addressing overvoltage issues are expected to increase the availability of transmission network components by 2 years.	

Source: Own elaboration, 2019.

Policy criterion 4: optimised planning of future cost-efficient network investments

The project is expected to optimise the planning of future cost-efficient network investments as a result of increased security of supply, increased network efficiency and increased network utilisation and net transfer capacity (NTC), which would in turn postpone some transmission network investment.

In addition, the implementation of the project would possibly affect the level of losses in the grid and consequently have an impact on the future grid development. As one of the main goals of the project is solving the overvoltage issue in the project area, deployment of compensation devices and an advanced voltage-var control (VVC) mechanism may potentially increase the total energy losses.

The promoters choose the following KPIs (Table 34) to address the project's impact on this criterion.

([15]) The rule according to which the elements remaining in operation within a TSOs control area after occurrence of a contingency are capable of accommodating the new operational situation without violating operational security limits (https://docstore.entsoe.eu/data/data-portal/glossary/Pages/home.aspx).

Table 34. SINCRO.GRID: evaluation of project impact against the fourth specific criterion

Selected KPIs	Calculation approach and impact evaluation
KPI$_2$: environmental impact of electricity grid infrastructure	The project is expected to have a positive environmental impact as a result of deferred/avoided transmission grid investments, mainly resulting from dynamic thermal rating (estimated deferral of the planned Skofja Loka-Cerkno and Divaca-Koper 110 kV lines by 10 years) and installation of storage (which will replace the 30 MW gas-fired power plant). In this context, deferred/avoided transmission grid investments would have a positive environmental impact in terms of land use and landscape changes and reduced/avoided visual and acoustic impacts.
KPI$_5$: energy not withdrawn from renewable sources due to congestion or security risks	There are no historical data on energy curtailment in the project area, as, according to the national legislation in Slovenia and Croatia, all 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. In this regard, the project is expected to reduce possible curtailed renewable energy in the future as a result of enabling 719 MW of controllable wind units in Croatia included in the voltage control mechanism and an additional 12 MW of battery storage and DG in Slovenia providing secondary reserves.
KPI$_8$: ratio of reliably available generation capacity and peak demand	The SINCRO.GRID project is expected to increase the reliably available capacity by 12 MW owing to inclusion of DG and storage capacity in the secondary reserve in Slovenia. Therefore, the promoters demonstrate a positive assessment of this KPI for the Slovenian part of the project area.
KPI$_{10}$: stability of the electricity system	One of the main objectives of the SINCRO.GRID project is to solve overvoltage problems in the project area. In this context, the promoters assess this KPI in terms of the improvement of transmission network voltage profiles as a result of the deployment of compensation devices and of the inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control algorithms. As a result, the promoters report a positive assessment of this KPI.
KPI$_{11}$: duration and frequency of interruptions per customer, including climate-related disruptions	The presence of overvoltages in the project area may lead to equipment failure and, consequently, higher outage probability. The promoters argue that, owing to the nature of the project (overvoltages mainly occurring at transmission network level); the SAIDI and SAIFI are not the most adequate indicators to represent the issue at stake. To this end, the promoters demonstrate the project's impact on this KPI by taking into account only network outages caused by failures of transmission network equipment. An estimated 50 % decrease in system security due to overvoltages (calculated as the period when N-1 criterion([16]) is not fulfilled) is reported in the BaU compared with the SG scenario.
KPI$_{12}$: voltage quality performance	The promoters assess the project's impact on this KPI in terms of reduced number of hours of voltage violations as a result of the project deployment. In this regard, the project is expected to have a positive impact (estimated value of 99.99 %) as a result of the deployment of compensation devices and the inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control

([16]) The rule according to which the elements remaining in operation within a TSOs control area after occurrence of a contingency are capable of accommodating the new operational situation without violating operational security limits (https://docstore.entsoe.eu/data/data-portal/glossary/Pages/home.aspx).

	algorithms of the whole project area.	
KPI_{13}: level of losses in transmission and distribution networks	The promoters report an expected increase in the network losses of 0.07 % for the following reasons: • installation of reactive power compensation devices will solve the voltage problem; however, on the other hand, they will probably increase peak losses by 2.4 MW; • around 10 % of energy is expected to be lost in the charging/discharging cycle of the battery; • the advanced VVC mechanism is also expected to increase losses by 1 MW on average in each system, thus increasing energy losses by 17.520 MWh (calculated using a load flow analysis for typical grid situations).	
KPI_{14}: ratio between minimum and maximum electricity demand within a defined time period	This KPI is positively assessed owing to the additional capacity of storage and demand response (ca 12 MW) enabled by the project, which would result in a smaller difference between the P_{max} and P_{min}.	
KPI_{16}: percentage utilisation (i.e. average loading) of electricity network components	The dynamic thermal rating installed in Slovenia contributes to better utilisation of the grid. Therefore, DTR is expected to increase the capacity of the existing transmission infrastructure and the NTC values. However, promoters expect that the physical cross-border flow will remain the same using the phase-shift transformers, as the current physical cross-border flows already exceed the NTC value. Similar results are also expected for the Croatian part of the project. Nevertheless, the project is expected to increase the utilisation of the internal electricity network components as a result of an increased level of network observability and controllability. Still, uncertainties persist in the assessment of this KPI at the current stage of the project's development, as it is very much dependent on future network operation conditions and grid developments.	
KPI_{21}: congestion rents across interconnections	The expected increase in NTC enabled by the project would probably have an impact on the congestion rents and consequently on the income from cross-border capacity auctions of the neighbouring TSOs. Based on the promoters' previous experience, the increase in NTC will be followed by a decrease in auction prices; however, the net effect of the income coming from such auction in the whole project area would be close to zero. Still, the promoters are not able to provide a more accurate estimation at this stage of the project's development.	

Source: Own elaboration, 2019.

Policy criterion 5: market functioning and customer services

The project is expected to increase the number of new participants in the ancillary services market, thus potentially reducing the costs of secondary reserve while ensuring a higher level of security of supply. The project would also enable increased demand response participation in the provision of tertiary reserve. In addition, increased network capacity along with higher NTC values will further facilitate market integration and enable new market services.

The promoters use the following KPIs (Table 35) to capture the project's impact on this specific criterion.

Table 35. SINCRO.GRID: evaluation of project impact against the fifth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_6: methods adopted to calculate charges and tariffs, as well as their structure, for generators, consumers and those that do both	The project is expected to provide additional information to the regulator on the way RES can contribute to the provision of ancillary services (secondary reserves) and the incentives that would stimulate them to provide such services. Moreover, 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 reactive energy penalties and introducing new ones.	
KPI_{10}: stability of the electricity system	One of the main objectives of the SINCRO.GRID project is to solve overvoltage problems in the project area. In this context, the promoters assess this KPI in terms of improvement of transmission network voltage profiles as a result of deployment of compensation devices and inclusion of controllable RES (e.g. wind farms) in the cross-border voltage/var control algorithms. As a result, the promoters report a positive assessment of this KPI.	
KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to increase the demand-side participation, particularly in provision of tertiary reserve in Slovenia. Currently, 15 MW of demand response capacity participate in provision of tertiary reserve to the Slovenian TSO. Implementation of the communication platform at the DSO level would facilitate data exchange between demand response providers and the DSO/TSO to account for additional capacity of demand response available to the DSO/TSO. In this regard, the KPI is positively assessed for the whole project area; in particular, the amount of demand response capacity participating in the tertiary reserve in Slovenia is expected to increase by 33 %.	
KPI_{18}: actual availability of network capacity with respect to its standard value	The dynamic thermal rating proposed in the project would contribute to better network utilisation and lead to increased availability of network capacities. As a result, the promoters demonstrate a positive assessment of this KPI.	
KPI_{19}: ratio between interconnection capacity of a Member State and its electricity demand	The promoters expect an increase in the average NTC (considering the average NTC at each interconnector in the project area) as a result of the dynamic thermal rating addressed in the project. Therefore, the KPI is positively quantified for either side of the border in the project area.	
KPI_{20}: exploitation of interconnection capacities	The project is expected to increase the average NTC in the project area owing to the deployment of dynamic thermal rating. Assuming that the average load flow would not be affected by project deployment, the KPI is positively assessed for the interconnections between Slovenia and Italy (from Slovenia to Italy) and Austria and Slovenia (from Austria to Slovenia). The promoters report hardly any congestion at the interconnector between Slovenia and Croatia; nevertheless, project deployment is expected to increase NTC at this border by 15 %, thus contributing to the positive quantification of this KPI.	

Source: Own elaboration, 2019.

Policy criterion 6: involvement of users in management of their energy usage

The project is expected to contribute to this specific criterion by involving additional network users in provision of tertiary reserve through demand response. In this respect, the promoters select the following KPIs (Table 36) to address the project's impact on this criterion.

Table 36. SINCRO.GRID: evaluation of project impact against the sixth specific criterion

Selected KPIs	Calculation approach and impact evaluation	
KPI_{15}: demand-side participation in electricity markets and in energy efficiency measures	The project is expected to increase demand-side participation, particularly in the provision of tertiary reserve in Slovenia. Currently, 15 MW of demand response capacity participate in the provision of tertiary reserves to the Slovenian TSO. Implementation of the communication platform at the DSO level would facilitate data exchange between demand response providers and the DSO/TSO and thus account for additional capacity of demand response available to the DSO/TSO. In this regard, the KPI is positively assessed for the whole project area; in particular, the amount of demand response capacity participating in the tertiary reserve in Slovenia is expected to increase by 33 %.	

Source: Own elaboration, 2019.

2.6.5.1. *Economic appraisal*

The following section presents the societal benefits of the SINCRO.GRID project in monetary terms along with the total cost (capital and operational expenditure) as communicated by the promoters. Furthermore, economic indicators such as the NPV, the IRR and the B/C ratio are used to verify whether or not the overall benefits outweigh the project's costs and therefore the project complies with the second general criteria of the regulation (Article 4 (1) (b)).

The project's promoters have performed a societal CBA and the following variables have been reported.

- **Demand growth:** an average annual growth in demand of 2.1 % has been reported, according to the last demand forecast analysis performed by ELES. A similar situation applies in Croatia.
- **Discount rate:** a value of 4 % has been assumed for the societal discount rate, in keeping with the recommendation given in the JRC assessment framework for projects of common interest in the field of smart grids (Vasiljevska and Gras, 2017).
- **Time horizon:** a time horizon of 15 years has been chosen, owing to the lifespan of most of the investments, such as ICT equipment and DTR.
- **Peak load growth:** a forecast of 2 % peak load growth has been considered, in accordance with ELES's peak load forecast analysis. A similar situation applies in Croatia.
- **Carbon prices:** EUR 16.5/t from 2020-2025, EUR 20/t from 2025-2030 and EUR 36/t from 2030-2035, according to the Commission reference scenario up to 2050 (European Commission, 2011).
- **Cost of energy not supplied:** EUR 4.13/kWh, calculated by the regulatory energy agency of Slovenia.

The project's economic assessment presents a strongly positive outcome of the societal CBA, with the main benefits and costs listed below.

2.6.5.2. *Main monetary benefits*

SINCRO.GRID is expected to deliver a set of positive impacts and in that respect the following monetised benefits are communicated by the project promoters:

- reduction of GHG (as calculated in **KPI_1** and using the carbon price provided in the Commission reference scenario up to 2050);
- avoided cost of purchasing capacity for secondary reserve (due to an additional 2 MW of DG and 10 MW of storage deployed within the project);
- avoided generation capacity investment for spinning reserve (due to avoided cost of building a combined cycle gas turbine for provision of secondary reserve);
- deferred transmission investment (due to the deployment of dynamic thermal rating, which would increase the transmission network capacity by 15 %);
- financial benefits due to increased cross-border capacity (as a result of dynamic thermal rating deployment and consequently increase in NTC);

- societal benefits due to increased cross-border capacity (between Slovenia and Italy and between Slovenia and Austria)
- reduced cost of equipment breakdowns (due to resolution of the overvoltage issue in the project area);
- increased value of service (total reduced energy not served as a result of lower HV equipment failure, reduced outages, etc.);
- decreased amortisation value due to longer lifespan of equipment;
- decreased cost of purchasing reactive power from generation units (due to adoption of reactive power compensation devices).

2.6.5.3. Main costs

The main costs associated with project deployment are:

- installation of compensation devices;
- deployment of storage units for secondary regulation;
- deployment of virtual cross-border control centre;
- adoption of advanced dynamic thermal rating;
- project coordination;
- personnel cost, insurance and DTR licensing cost.

2.6.5.4. Sensitivity analysis

The following parameters are reported as critical and as a result made subject to sensitivity analysis.

- **NTC values:** no increase in NTC value would drop the NPV by 62 %; a large increase in NTC value (of 250 MW at the border with Italy and 150 MW at the border with Austria) would lead to the NPV increasing by 87 %.
- **Carbon price:** use of EUR 6.2/t over the whole operating period would lead to a 28 % drop in the NPV; use of EUR 36/t over the whole operating period would lead to a 19 % increase in the NPV.
- **Discount rate:** an increase in the discount rate to 5.5 % would lower the NPV by 13.4 %.

2.6.5.5. Additional non-monetary benefits

In addition to the quantified benefits, the project proposal addresses further impacts that could not be (entirely) quantified and consequently included in the KPI analysis, such as the following.

- **Increase in the macro-regional security of supply** — the increased security of supply addressed in the project is expected to have a positive impact on a wider regional level, since the project area hosts major transit flows from eastern to western Europe. The project also adds value to an adequately functioning EU internal electricity market by increasing the potential for transit flows without the need for new interconnections. As a consequence, it improves the energy system efficiency and resilience and the renewable energy potential in the region.
- **Solidarity with other countries** — all neighbouring countries in the region are expected to benefit from improved quality of supply enabled by the project, which is becoming more important as RES penetration levels grow. In addition, adequately addressing overvoltage and congestion issues in the project area would allow cross-border flow from southeastern to western Europe to be increased, which would therefore facilitate renewable energy developments in the Balkans.
- **Technological innovation with replication potential** — the project demonstrates high replication potential; other southeastern European and central eastern European TSOs may learn from the systemic approach addressed in the project with a view to implementing similar technology building blocks.

2.6.6. Summary of the SINCRO.GRID project's evaluation

The SINCRO.GRID is a mature project with clear objectives and a well-defined set of actions necessary to achieve these objectives. It is driven by challenges related to voltage and frequency regulation in the project area, mostly present at the transmission network level. As a result, network reliability and security of supply could be threatened, as well as the future development of renewable and DG integration. Therefore, the project's main idea revolves around development of a VCBCC to effectively support various voltage and frequency control processes and enhance voltage profiles in the project area (both Member States) while enabling increased integration of RES and secure and reliable supply of electric power to the end-users. The advanced algorithms for VVC optimisation, the integration of secondary reserves and the advanced real-time operation of the grid using DTR proposed by the project would require a high level of coordination at the TSO-TSO and TSO-DSO interfaces and, consequently, the deployment of a communication platform for standardised data exchange. To this end, the SINCRO.GRID project proves necessary for the priority thematic area of smart grids deployment (point 4(10) of Annex I to the regulation) and it complies with criterion (i) of Article 4(1)(c) of the regulation.

The project proposal is very well articulated and documented and the 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 (Vasiljevska and Gras, 2017). The SINCRO.GRID project demonstrates a significant positive contribution to the six smart grid specific criteria outlined in Article 4(2) of the regulation and a positive outcome in the project's societal CBA.

3. Summary of the projects' evaluation

The outcome of the projects' overall evaluation is summarised in the tables below, in line with the analysis presented in the previous sections. Table 37 illustrates an overview of the projects' compliance with the requirements of Article 4 of the regulation, namely (1) the project's necessity for the thematic area of smart grids deployment, (2) the project's compliance with the general criteria under Article 4(1)(c) and (3) a positive outcome in the societal CBA — the project's overall benefits outweigh the project's costs by significantly contributing to the six policy criteria of Article 4(2)(c).

Table 37. Overview of projects' compliance with the general criteria of the regulation (Article 4)

Project name	Necessity for the smart grids deployment thematic area	Compliance with the criteria of Article 4(1)(c)	Positive outcome in the societal CBA
ACON	✓	✓	✓
CrossFlex	✓	✓	Not available (NB: positive contribution to the specific policy criteria — Table 38)
Danube InGrid	✓	✓	✓
Data Bridge	✓	✓	✓
Smart Border Initiative	✓	✓	Not available (NB: positive contribution to the specific policy criteria — Table 38)
SINCRO.GRID	✓	✓	✓

Source: Own elaboration, 2019.

In addition, Table 38 illustrates the overall assessment related to the contribution of each project proposal to the six smart grid specific criteria outlined in Article 4(2)(c) of the regulation, evaluated using the KPIs indicated in Annex IV(4) to the regulation and based on the information provided by the promoters.

Table 38. Overall project contribution to the smart grid specific criteria

Policy criteria	ACON	Cross Flex	Danube InGrid	Data Bridge	SBI	SINCRO. GRID
Integration and involvement of network users with new technical requirements with regard to their electricity supply and demand	[green]	[green]	[green]	[green]	[yellow]	[green]
Efficiency and interoperability of electricity transmission and distribution in day-to-day network operation	[green]	[yellow]	[green]	[yellow]	[yellow]	[green]
Network security, system control and quality of supply	[green]	[yellow]	[green]	[yellow]	[yellow]	[green]
Optimised planning of future cost-efficient network investments	[green]	[yellow]	[green]	[yellow]	[yellow]	[yellow]
Market functioning and customer services	[yellow]	[yellow]	[yellow]	[yellow]	[yellow]	[green]
Involvement of users in management of their energy usage	[green]	[yellow]	[green]	[yellow]	[green]	[green]

Source: Own elaboration, 2019.

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List of abbreviations

ACER	Agency for Cooperation of Energy Regulators
ACON	Again COnnected Networks
AMM	advanced meter management
BAU	business as usual
B/C	benefit/cost
BESS	battery energy storage system
CBA	cost-benefit analysis
CEF	Connecting Europe Facility
DER	distributed energy sources
DG	distributed generation
DSM	demand-side management
DSO	distribution system operator
DTR	dynamic thermal rating
EMS	energy management system
ENTSO-E	European Network of Transmission System Operators for Electricity
ESCO	energy service company
EV	electric vehicle
FCR-D	frequency controlled disturbance reserve
FCR-N	frequency containment reserve for normal operation
FFR	firm frequency response
GDPR	General Data Protection Regulation
GHG	greenhouse gas
GIS	geographic information system
HV	high voltage
HVDC	high-voltage direct current
ICT	information and communication technology
IRR	internal rate of return
IT	information technology
KPI	key performance indicator
LV	low voltage
MV	medium voltage
NPV	net present value
NTC	net transfer capacity
OLTC	on-load tap changer
PCI	project of common interest
PLC	power line carrier
R&D	research and development
RES	renewable energy sources
SAIDI	System Average Interruption Duration Index

SAIFI	System Average Interruption Frequency Index
SBI	Smart Border Initiative
SCADA	supervisory control and data acquisition
SEPS	Slovenská elektrizačná prenosová sústava
SG	smart grid
TEN-E	Trans-European Networks for Energy
TSO	transmission system operator
UPS	uninterrupted power supply
VCBCC	virtual cross-border control centre
VVC	voltage-var control

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