OSMOSE

OPTIMAL SYSTEM-MIX OF FLEXIBILITY SOLUTIONS FOR EUROPEAN ELECTRICITY

Impact analysis of the performed field tests and exploitation

D6.6

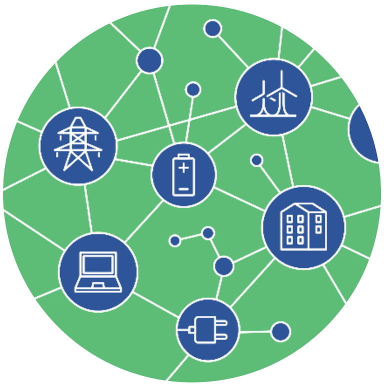

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Table of content

List of figures

List of tables

Executive summary

The document focuses on the analysis of technological and economic impacts of the proposed flexibility integration and support services developed within the OSMOSE WP6 demonstration "Near real-time cross-border energy market". The work concerns the Task 6.7 – Impact analysis and interoperability – and focuses on the outputs of WP6: the Energy Management Platform and the FlexEnergy Market Platform, implemented during the project lifecycle. The structure of the document is: i) identification of technological and economic impacts; ii) technical barriers for scaling and replication; iii) interoperability for replication and standardization; iv) WP6 exploitation plan.

Starting from the demonstration tests performed in Task 6.6, this deliverable extrapolates the technological and economic impacts of WP6 results. Indeed, the FlexEnergy Market is a business opportunity for flexibility providers that could take advantage of new optimization chances, gained in different ways. In our pilot market we investigated three ways to increase flexibility opportunities. All they have in common is that they can be exploited near-to-real time. In our case, the flexibility optimization was provided from hydro producers in the following ways:

1. Unused flexibility from ancillary services: when a unit, eligible for providing ancillary services, was not selected for such service, it can offer this remaining flexibility on FlexEnergyMarket.
2. Energy obtained while self-balancing a portfolio of power plants: the difference between forecasted and realized production from non-dispatchable Renewable Energy Source (RES) power plants (e.g., run-on-river hydropower plants (HPPs) is assessed near-to-real time and balanced via a conventional HPP, which then offers the accumulated differences on FlexEnergy Market.
3. Energy or flexibility obtained while optimizing the production of the commercial created schedule during the intraday process. The flexibility could be gained either because of a technical optimal schedule or from not fully used flexibility for intraday market.

On the other hand, the FlexEnergy Market represents an opportunity for increasing the grid efficiency. In fact, the optimization platform selects the bids in such a way that maximizes the exchanges of energy while respecting technical limits of the transmission network. A qualitative costs benefits analysis for both TSOs and FlexEnergy providers is provided in Chapter 2. It includes the social welfare preliminary assessment and the "Value proposition Canvas" as a business tool used to provide the main benefits of the technologies from the potential customers point of view. The analysis has also shown the difficulty to quantify such an increase in profit being dependent on the liquidity of this new cross-border market and on the volume exchanged on the platforms. However, the customers expect an impact in reducing the balancing costs and improving the whole power system performance by adopting the platforms, without further costs related to their use.

Chapter 3 addresses the barriers to scaling up and replicate the WP6 demo solution. Scalability and Replicability factors are introduced according to the main features of WP6 demo.

Scalability addresses the possibility to add more units to the existing portfolio of units (Slovenia) or to increase the number of flexibility units (Italy) made available by a FlexEnergy provider that is, to extend the portfolio of a producer over the market areas. In terms of adding new units in the flexibility portfolio (Slovenian case), this could have an impact on the performance of the bidding process: if units are dependent between each other, the relation between the units should be considered since it has an impact on increased complexity of the model which in turn extends the calculation time. Regarding the possibility to increase the number of flexibility units (Italian case) made available by a Flexibility Provider, this could have an impact also on the FlexEnergy Bid Calculation Module (FEB-CM) for the exploitation of unselected automatic frequency restoration reserve (aFRR) and also on the FEB Creator Tool (FEB-CT). Both software tools were developed according to the specific WP6 demo requirements and some minor adaptions could be necessary in order to address new flexibility units. The same applies for the FEB-CM INDRES relying on a nowcasting model, which must be specifically developed for each target power plant. The computational time could be a barrier also in the optimisation process since the increasing amount of relevant data (e.g., the number of flexibility units which participate in the Market) affects the computational time required by the Optimisation Platform (OPT) for processing all relevant data, selecting FEBs and providing the activation signal for FlexEnergy providers. It is important to underline that from the performance point of view, the demo tests have proved that the computational time of both bidding and optimisation process is in line with the demo expectation. However, adding new flexibility units could raise the necessity to improve the computational time; this could be addressed increasing the hardware capability of the server where the software is running and it could be useful to enhance the software libraries as well.

Technical barriers have also been analysed: they are mainly related to the current infrastructure of both TSO and FlexEnergy Provider and how it should be upgraded in order to be compliant to the demo requirements, mainly with regard to the interoperability aspect and to the activation process. Starting from the approach adopted in the demo, the standardization of activation signal which can be used or by ancillary services or by wholesale power market activities is proposed. This would result in a real value for flexibility units since a qualification for ancillary services would mean also a qualification for flexibility wholesale power markets and vice versa. Moreover, another aspect to consider is that flexibility units need to comply with the market participation prerequisite (defined in Deliverable 6.3), i.e., to be capable of being remotely controlled; if any unit is qualified for aFRR provision, it is automatically qualified for participating in FlexEnergy Market. Moreover, as with any other new market, a FlexEnergy provider willing to participate should review its internal bidding and results-dispatching processes in order to integrate it with the new FEM workflow. On the TSO side, an integration of the Italian regulation from the Regulation Authority (*Autorità di Regolazione per Energia Reti e Ambiente* - ARERA) (1) will be necessary to allow the scalability of the proposed Market from Demonstrator to real operational market, covering the entire Country and extending to borders with other TSOs.

Replicability in the context of WP6 addresses the possibility to replicate the demonstrated FEM for different flexibility technologies and for new, other market areas, involving the participation of more TSOs. This is possible as long as TSOs provide the needed data such as snapshots of their grid and properly address the overall data exchanged procedure; it is important that

TSOs integrate or prepare the activation signal to activate flexibility units. Moreover, according to the FEM design, there are no limitations for different technologies of flexibilities to be used. This means that every controllable power unit: hydro and thermal power plants, concentrated solar power plants, even photovoltaic and wind power plants could be able to provide flexibility. Batteries or technologies like P2X, where power is converted to other forms of energy like pressurized air or kinetic energy (flywheels), can be also employed. There are also no limitations for the aggregators to generate FEBs from aggregated loads as long as the unit or units used in FEM can be activated quickly, as defined in Deliverable D6.3 (3). Therefore, replicating the WP6 Demo in other contexts poses no major issues; as for the scalability, flexible units must be eligible to provide aFRR and the interoperability between TSO and FlexEnergy provider has to be taken into account. Technical barriers from TSO perspective are transmission capacities as the leftover of the imbalance netting between the countries. Moreover, it is recommended the usage of ECCo SP platform and the revision and standardization of data flows inside the TSO environment. The cyber security policies must be upgraded for the third-party access as well.

The interoperability, that is addressed in Chapter 4, is about:

1. the capacity of the two WP6 platforms to exchange and make use of information;
2. the ability to exchange data between TSO and flexibility units in the activation process.

Regarding the first point, the approach adopted for the demo, based on the sFTP protocol, has allowed achieving the expected results, however some improvements are suggested to make more efficient and secure the process of exchanging data and therefore for allowing a successful replication.

It is important to underline that the adoption of FlexEnergy Market (FEM) into a real world involves also some changes in the current regulation framework; for example, the Regulation on Wholesale Energy Market Integrity and Transparency (REMIT) (2) should be overviewed for operation near-to-real-time and the FEB xml schema defined in the context of the Project should be adopted. Another aspect is that, from the technical point of view, FlexEnergy market is similar to the aFRR balancing market; indeed, an analysis on the potential integration of FlexEnergy Market and aFRR balancing market was provided in deliverable D6.1 (3). It is important to enable parallel functioning of FlexEnergy market and aFRR process so that the latter will not cause the sub optimal solution in each of the processes. Focusing on the standardized interfaces which will enable seamless replication on the top of other TSO control systems, the network data preparation process should be improved with the production of a unique regional Common Grid Model (CGM); in this way, the inconsistency between input formats and time of delivery of individual grid models (IGMs) from TSOs should be avoided.

The last chapter is dedicated to the exploitation of the WP6 results. Here, the SWOT analysis – acronym of Strengths, Weaknesses, Opportunities and Threats - has been used as a suitable tool for synthesizing the main advantages and drawbacks of the technologies. The SWOT sums up the aspects described in the deliverable, distinguishing them in internal and external factors. The “Strengths” box lists the features of the platforms that should be mainly promoted in the OSMOSE exploitation plan, whereas the “Weaknesses” identify the aspects of the technologies that should be improved, such as the technical and computational barriers already identified. On the other hand, SWOT reports the external factors (“Opportunities” and

"Threats") that can have an impact on the success of the technologies, such as a further penetration of RES, which could be an opportunity for increasing the value of the flexibility of the plants, or the regulatory aspects, which in case of real operation should be adequate. Moreover, the chapter provides an overview of the actions that the WP6 partners would undertake together for maximizing the exploitations of the achieved results and their individual exploitation plans. In this section, the partners of the WP6 had the opportunity to describe the results they intend to exploit and the approach to use.

List of acronyms and abbreviations

In the following table are listed the acronyms and abbreviations used in this document.

Acronym	Meaning
ACE	Area Control Error
aFRR	Automatic frequency restoration reserve
API	Application Programming Interface
ARERA	*Autorità di Regolazione per Energia Reti e Ambiente* (Italian Regulatory Authority for Energy, Networks and Environment)
BESS	Battery Energy Storage System
CA	Consortium Agreement
CB	Critical Branches
CGM	Common Grid Model
CO	Critical Outages
D	Deliverable
ECCo SP	ENTSO-E's Connectivity and Communication Service Platform
EBGL	Electricity Balancing Guideline
ebIX	european forum for energy business Information Exchange
EFET	European Federation of Energy Traders
EN4M	Electricity Network for Market
EMP	Energy Management Platform
ENTSO-E	European Network of Transmission System Operators for Electricity
E&CM	Energy and Commodity Management Italy
FEB	FlexEnergy Bid
FEB-AM	FEB Activation Module (FEB-AM),
FEB-CT	FEB Creator Tool
FEMP	FlexEnergy Market Platform
FEBPP	FEB pre-processing and merge
FEB-CM	FlexEnergy Bid Calculation Modules
FEM	FlexEnergy Market (Place). Novel near to real-time cross-border flexibility market
GME	*Gestore Mercati Energetici* (Italian Power Exchange)
GSK	Generation Shift Key
GUI	Graphical User Interface
HEMRM	Harmonised Electricity Market Role Model

HPP	Hydro Power Plant
ICCP	Inter-control Center Communication Protocol
IGCC	International Grid Control Cooperation
IGM	Individual Grid Models
IN	Imbalance Netting
INDRES	Integration of Non-Dispatchable RES
ITA	Italy
KPI	Key performance indicators
MARI	Manually Activated Reserves Initiative
MSD	*Mercato Servizi di Dispacciamento* (Italian Ancillary Services Market)
OPT	Optimisation Platform
O&M	Operation and maintenance
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
REMIT	Regulation on Wholesale Energy Market Integrity and Transparency
RES	Renewable Energy Source
RoR	Run-of-River hydro power plant
sFTP	Secure File Transfer Protocol
SDAC	Single-Day Ahead Coupling
SGAM	Smart Grid Architecture Model
SLO	Slovenia
SOGL	System Operation Guideline
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TERRE	the Trans-European Restoration Reserves Exchange
TSO	Transmission System Operator
WP	Work Package

1 Introduction

This deliverable focuses on the analysis of technological and economic impacts of the proposed flexibility integration and support services; it provides also information about the exploitation of the WP6 results. The output of the WP6 involves the implementation of two platforms, as deeply described in D6.3 (4) and D6.4 (5), that are the Energy Management Platform (EMP), for the calculation and creation of FlexEnergy Bids and making them available on local and cross-border (regional) markets, and the FlexEnergy Market Platform (FEMP), able to manage the cross-border exchange capability in real-time. Among the topics of this document, there is the identification of the main technical barriers for scaling and interoperability as well as the issues for replication and standardization. A section is dedicated to the economic impact of the platform for the main stakeholders detected.

1.1 Structure of the Document

The report is structured as follows:

- Chapter 2 concerns the technological and economic impacts of the WP6 results.
- Chapter 3 provides an analysis of the application and technical barriers identified in the context of the WP6 demo concerning both scalability and replicability.
- Chapter 4, starting from the technical barriers identified in chapter 3, provides an assessment of interoperability issues for replication and standardization addressed to the WP6 outcomes.
- Chapter 5 introduces the exploitation, exclusively addressed to the WP6 results.
- Chapter 6 is dedicated to the general conclusions of the whole document.

2 Technological and economic impacts

This chapter is focused on the technological and economic impacts of the WP6 results.

Section 2.1 provides information about the technological and economic impacts of the proposed flexibility integration and flexibility support services for the demonstration tests performed on Task 6.6. Demonstrations tests were defined in D6.4 (5) and their results are provided in D6.5 (6). Section 2.2 is dedicated to the cost-benefit analysis for WP6 potential customers and a detailed analysis is reported in its sub-paragraphs.

2.1 Impact analysis for the performed tests

Flexibility is a hot topic for the power system of the future. While talking about the flexibility, one usually thinks of fast responsive storage such as batteries. Conventional sources of flexibilities like HPPs are often left out, mostly because their speed is not competitive with one from batteries. On the other hand, for the flexibility of the future, most of the flexibility is still locked within demand response.

Many projects address the potential of demand response and aggregators, and a lot of projects involve new storage devices such as batteries, but not many projects address the flexibility that could still be gained from HPPs.

Flexibility from HPPs in OSMOSE WP6 was identified in three ways:

1. Unused flexibility from ancillary services: when a unit, eligible for providing ancillary services, was not selected for such service.
2. Energy obtained while compensating the difference between forecasted and realized production near-to-real time from run-on-river HPP via a conventional HPP in the same portfolio or balance group. The accumulated differences from run-on-river HPP can be offered as a FlexEnergy Bid (FEB) on FlexEnergy Market.
3. Energy or flexibility obtained while optimizing the production of the commercial created schedule during the intraday process. The flexibility could be gained either because of a technical optimal schedule or from not fully used flexibility for intraday market.

The above-described sources of flexibility optimization create business opportunities to improve the economics of flexible units. This gives a new possibility to FlexEnergy providers to use their unit on the wholesale power market. The demonstrated pilot market is a step towards a pan-European near-to-real time market as it accepts flexibility bids (FlexEnergy Bids, FEBs) minutes prior delivery and it activates them considering the parts of the transmission grid that is affected by the activation (observation area).

The demonstrated flexibility market creates real possibilities for energy to be exchanged beyond the commercial congestions since it exchanges the energy based on the real-time data from the transmission network. Considering that intermittent power sources could be balanced via flexible units and balanced energy can be exchanged in a controlled manner on the market, such market creates the possibility to reduce the overall balancing costs through an optimal use of the different flexibility options.

During the project, HPPs were used as flexibility source but there are no limitations for any other kind of flexibility unit to participate in the proposed near-to-real time flexibility market. Any unit that is eligible or suitable for provision of automatic Frequency Restoration Reserve (aFRR) can be used on the proposed flexibility market.

For the demonstration test, data (FlexEnergy Bids, grid snapshots and bid activation list) was exchanged via Secure File Transfer Protocol (sFTP) - a sFTP server was arranged on ELES environment - and activation was carried out using Inter-control Center Communication Protocol (ICCP protocol), where the signal was in the group of slow signals. The performed tests proved that for the implementation of the market, sFTP is too slow and a proposed alternative could be, for example, ENTSO-E's Connectivity and Communication Service Platform (ECCo SP) which is accepted by ENTSO-E. Indeed, ECCo SP platform is already in use for the purpose of aFRR, which, in the sense of functionalities, is similar to the proposed pilot market. During the demo test, the activation signal was treated as a measurement that was updated every 10 seconds. aFRR channel between TSOs and FlexEnergy providers was not used because it was not possible to test it within production environments, but for the real operation a parallel environment similar to aFRR should be created to improve the performance of the activation.

All the performed open and closed-loop test and, in the end, also the proof of concept demonstration, show that it is possible to calculate, create and activate FEBs and exchange them also over the borders of market areas. This is possible due to the novel approach of bids activation based on the close-to-real time network snapshots and an optimization platform that checks the activation of the bids and network constraints every 5 minutes. From the technological perspective, many available tools and approaches, from linear optimization, real time data acquisition, Inter-Control Center Communications Protocol (ICCP) protocol, state variables, nodal network model, were used in an innovative way that enables a near-to-real time cross-border exchange of FlexEnergy. This sets path for further near-to-real time market development, where bids can be created and activated automatically, which could be the first step towards a pan-European FlexEnergy peer-to-peer exchange. Such close-to-real time cross-border FlexEnergy exchange can be used by flexibility providers to create added value to their flexibility units, no matter of the technology that provides the flexibility. All of the three above mentioned approaches can create additional revenue streams by providing flexibility on a new market segment of the wholesale market.

Units that are eligible to provide ancillary services, especially aFRR, and are not participating or selected in the ancillary services can use this market to create arbitrages between different market time periods. In this way, they can shift the energy from one time period to another and sequentially provide better liquidity in time periods where electricity is scarce or abundant. This, of course, not only impacts bid-ask spread but can also decrease the price of energy when there is a lack of it.

When talking about shifting the energy from one market time period to another, this can be done also inside portfolios, where portfolio operators can, using nowcasting principles from WP6, balance their intermittent sources via a controllable unit and then create a FEB to put this energy on the market in a controllable way and avoid imbalances. Avoiding imbalances always means adding economic value.

In the end, economic value can also be created after the technical optimization of the finally defined commercial schedule. If the operator of the portfolio realizes that there is still flexibility left, they can put it on the novel market.

2.2 Costs benefits analysis

This section introduces the methodology that was applied in order to provide considerations about the economic impact of WP6 outcome and, therefore, for addressing the costs benefits analysis reported in paragraph 2.2.3. The methodology that was conceived by ENG and was applied in Task 6.6 is the following:

1. Identification and description of the WP6 potential stakeholders.
2. Selection of the Value proposition Canvas (7) as a business tool used for pointing out the main benefits and drawbacks of the platforms implemented in the WP6 by comparing their features with the needs identified for and by their customers. This business tool, indeed, is composed of two parts: the customer profile and the value map. The customer profile is about the description of the customer's needs and expectation; the value map lists the products and services which the value proposition is built on.
3. Collection and analysis of feedback from WP6 potential stakeholders by means of a questionnaire. This questionnaire was conceived by ENG, and it is provided as Annex A: questionnaire template
4. Provision of the Value proposition Canvas (7) for WP6 potential stakeholders. This is a precondition for the definition of costs benefits analysis and the SWOT analysis that is reported in section 5.2.

Regarding the first step, TSOs and FlexEnergy providers (producers, consumers and prosumers) have been identified as stakeholders and customers of WP6 platforms. Both TSOs and FlexEnergy providers of the Consortium have been actively involved in filling in the questionnaire. Answers provided by ELES as TSO and HDE, ENEL and HSE as FlexEnergy provider are available in subsections of Annex A. The answers have been analysed by ENG and the Value proposition Canvas was defined for both TSOs and FlexEnergy providers. Indeed, through the questionnaire, the partners had the possibility to provide their considerations on different aspects of the technologies as drawbacks, opportunities, potential risks, and costs considerations.

The Value proposition Canvas addresses not only the customers' functional and financial gains but also the social benefits; for this reason, the following subsection is dedicated to a social welfare preliminary assessment. Indeed, a specific KPI "Generated social welfare" was defined in D6.4 (5) for this purpose.

2.2.1 Social welfare preliminary assessment

As described in D6.5 (6), the generated social welfare of the demonstration has been evaluated to 20k€, over two test sessions, for a total of 30 days periods on standard business hours between 3 producers representing a very small amount of the total capacity of the system.
Matches up to10 MW, for a maximum price spread of 150 € has been assessed during this period. The generalization of this value to an annual basis and for the size of the Italian and Slovenian power system would lead to an order of magnitude of 1M€ per year. This value is very low compared to other power markets. This value should increase with the penetration of renewables in power system increasing the need for almost real-time flexibility.
In general, when taken into account optimal cross-border potential of the left over imbalance netting over cross-border between Italy and Slovenia, the total theoretical potential is roughly estimated at about 50 MW. From the Slovenia perspective on the other cross-border points the exchange potential is as follows: Slovenia-Austria 50 MW, Slovenia-Croatia 300-400 MW and Slovenia-Hungary (when connected) 300-400 MW.

2.2.2 Value proposition Canvas

As anticipated in the previous section, the Value proposition Canvas (Figure 1) is a business tool composed of two parts: the **Customer Profile**, in which the needs of the customer are fully described, and the **Value Proposition** reporting the value proposition of the product/service tailored for that customer.

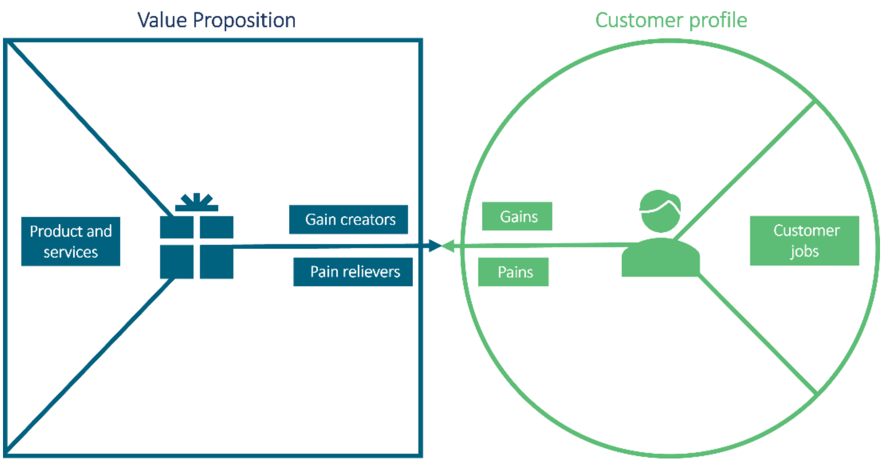

Figure 1: Value proposition Canvas template

Beyond describing the type of product/service proposed, the value proposition square defines the gains created, and the pains relieved by it. The customer profile circle contains a brief description of the identified customers, the gains that they could obtain using the service/product offered, and which are the pains they could overcome through it.

In the context of the OSMOSE project, the Value proposition Canvas is used for pointing out the main benefits, and eventually the drawbacks, of the platforms implemented in the WP6 by comparing their features with the needs of TSOs and FlexEnergy providers that were identified as stakeholders and potential customers. In the following sections, the Value proposition

Canvas is reported for FlexEnergy providers and TSOs in order to provide considerations about the main benefits of WP6 output.

2.2.2.1 FlexEnergy providers

Figure 2 shows the Value proposition Canvas for FlexEnergy providers. The content of the two blocks (Value Proposition and Customer profile) is extensively reported in the sections below where each label is fully described.

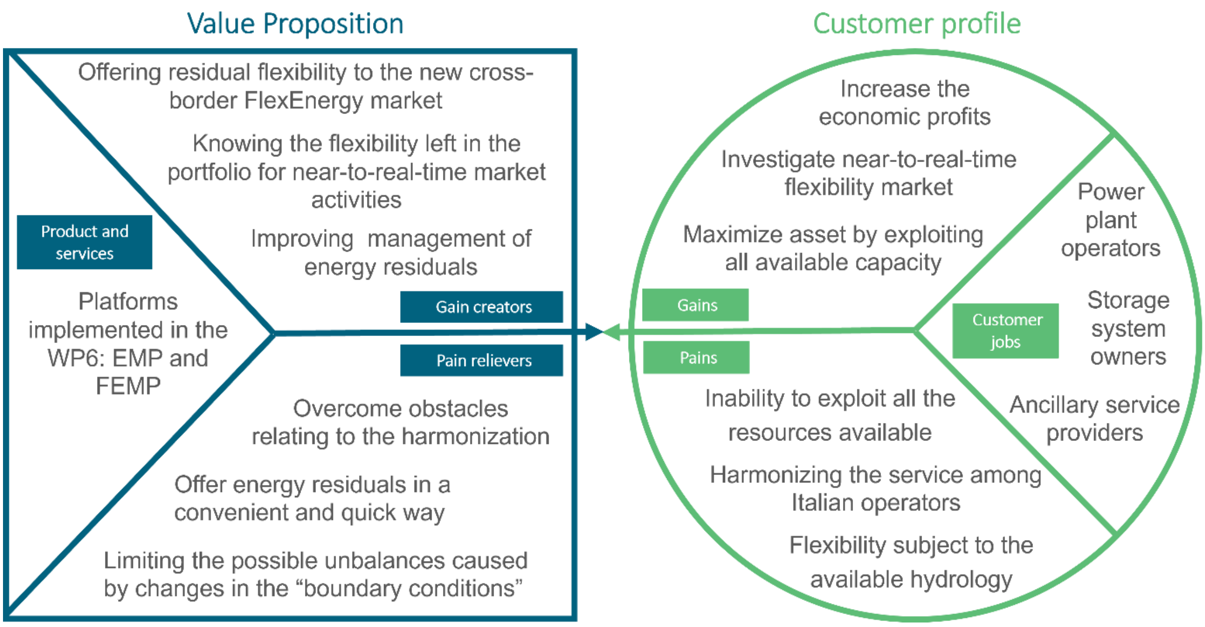

Figure 2: Value Proposition Canvas for FlexEnergy providers

Customer profile - Customer jobs

FlexEnergy provider is a definition used for identifying operators of power plants able to provide flexibility services. This includes storage system owners as well as ancillary service providers to the TSOs. In general, FlexEnergy market is not limited to traditional power plant operators but can be used by any market participant, which meets the technical requirements to participate in the market. This role in the project is covered by HSE, HDE and ENEL:

- HSE is the largest power plant owner and operator of Slovenia; it also provides ancillary services and its production units are managed as a "portfolio".
- ENEL is the largest power plant owner and operator of Italy; it also provides ancillary services. Currently, in Italy, the portfolio management of production units is not allowed; each power plant is thus managed individually, i.e., internal balancing between different plants is not allowed. ENEL's hydropower plant of Soverzene is involved in the Project, which focuses on the residual amount of flexibility not reserved by the TSO.
- HDE is the third hydroelectric producer in Italy; it also provides ancillary services. As in the case of ENEL, it is not allowed to manage its production units as a portfolio. HDE's hydropower plant of S. Massenza is involved in the Project, which focuses on the residual amount of flexibility not reserved by the TSO and on the possibility of further

integrating non-dispatchable RES through internal re-dispatching (when it will be allowed).

Customer profile - Gains

This section indicates the gains, which the customers expect in their ordinary work and what they would improve for increasing their business. The "gains" identify those benefits and results that a customer would like to obtain in its job by adopting a new service or product. In this context, the section reports the potential advantages that a customer could achieve using the solutions implemented in the WP6.

A FlexEnergy provider, as any actor present on a competitive market, aims to increase its economic profits. The answers to the questionnaire filled in by the FlexEnergy providers (HSE, HDE and ENEL) have highlighted the importance for each company of maximizing their assets and the financial results. Starting from ENEL, this company would like to actively participate in the flexibility market with its available production units and maximize the asset by exploiting all available capacity. HSE is investigating the potential of a near-to-real time wholesale flexibility market where the company provides buy and/or sell FEBs; lastly, HDE expects to increase the economic profits because of the price of energy traded on such close-to-delivery markets is expected to be higher than the current markets. This should be even more true considering the further penetration of RESs that are expected to increase the value of the flexibility of the plants able to guarantee it. Summarising, since from the FlexEnergy providers perspective it is important to increase its competitiveness in the provision of flexibility services, the exploitation of the OSMOSE platforms could allow a better integration of RESs while improving the current management of energy residuals.

Customer profile - Pains

The pains are the negative experiences and, more in general, the risks that the customers deal with during the ordinary course of their job. A pain that the FlexEnergy providers want to overcome is the inability to exploit all the resources available, which brings the risk to obtain a lower profit compared to the potential one. Indeed, in some cases, there is a residual flexibility that FlexEnergy providers cannot exploit, and this implies a loss of profit. Focusing on the WP6 demonstrator, ENEL has identified issues in the harmonisation of the implemented bidding process with the flexibility services that are usually offered by Italian operators to the Italian electricity market. Indeed, FEBs are computed taking into account the remaining market opportunities consisting in the Production Units availability not exploited by any other market nor by the provision of aFRR. HSE has explained that, since the flexibility is provided from run-on-river HPPs, it is subject to the available hydrology. Likewise, HDE partner has pointed out that possible unbalances caused by changes in the "boundary conditions" may occur, i.e., in the case of HPP, an unexpected weather evolution.

Value proposition - Product and services

The value proposition of the OSMOSE WP6 is the delivery of two platforms, which operate simultaneously at the national and cross-border market**:** the **Energy Management Platform** and the **FlexEnergy Market Platform.** Both platforms have been deeply described in D6.3 (4) and D6.4 (5); as a reminder, a recap is also provided in this document.

The **Energy Management Platform** (EMP) aims to calculate, create, and submit the FEBs on local and cross-border (regional) markets. It is made up of:

- The FEB Calculation Modules (FEB-CMs). They are responsible for identifying the market opportunities or unused flexibilities in terms of power/ energy and related price (buy and sell) in a possible timeslot for bidding. Bids are calculated according to the specific market and the optimisation strategies that differ between Slovenia and Italy. Indeed, FEB-CMs can differ from one FlexEnergy provider to another, and three FEB-CMs have been developed addressing the three different market strategies: exploitation of unselected aFRR, integration of RES (FEB-CM INDRES) and portfolio optimisation.

- FEB Creator Tool (FEB-CT). It is responsible for FEB editing and submission and for showing information about the FEBs selection or rejection. Indeed, FEBs are generated by the FEB-CMs and then are refined by the FlexEnergy provider who evaluates the possibility of participating in the FlexEnergy Market (FEM), taking the final decision on both quantity and price. Moreover, using this tool, each FlexEnergy provider can submit FEBs to the FEM Platform in order to be processed. The outcome of this process is shown to the FlexEnergy provider through the Graphical User Interface (GUI) of the FEB-CT so that he is informed about its FEBs being selected or not.

The **FlexEnergy Market Platform** (FEMP) is responsible for managing the cross-border exchange capability in real-time; it is composed of the following modules:

- Electricity Network for Market (EN4M). It is a platform for real-time preparation of network data - snapshot models provided from state estimators from each TSO every 5 or 15 minutes - and automatic creation of merged real-time regional model and lists of Critical Branches/Critical Outages (CB/COs).

- FEB pre-processing and merge (FEBPP). It is responsible for performing the quality check of FEB. Following this, valid FEBs are merged into a single file that is the input of the Optimisation Platform (OPT). It is also included the FEB Activation Module (FEB-AM), which activates selected bids and monitors their activation.

- Optimisation Platform (OPT). It selects the FEB that will be activated and provides the activation signal for the FlexEnergy providers.

Therefore, one of the main benefits of WP6 outcome is the opportunity for the FlexEnergy providers to assess the unused flexibility and to offer it on the FEM. As anticipated in section 2.1, this flexibility can come from either re-dispatching inside the portfolio, balancing of renewables via a “controllable” power plant or exploiting unused resources of ancillary services. In HSE opinion, among the modules/tools provided by the platforms, FEB-CM for portfolio optimisation is the most useful since it contains a unit-based representation of the portfolio of units operating in the Slovenian market. Likewise, ENEL considers the FEB-CM for the exploitation of unselected aFRR a useful tool because it is able to identify the remaining market opportunities, namely the quantity (power) to bid to the FEM. From HDE point of view, the two most useful features are the possibility of fully exploiting the flexibility offered by dispatchable power plants, as also pointed out by ENEL, and the possibility of better integrating non-dispatchable RES in the Energy Market. In fact, the FEB-CM INDRES allows to nowcast the power produced by such plants, which can be valorised through a market such as the FEM.

All FlexEnergy providers consider the FEB-CT a valuable product since it allows them to perform the bidding process and to know if their FEBs have been accepted or not in the FEM.

Value proposition - Gain creators

The section "gain creators" of the Value proposition describes how the product/service offers customer gains. The aim of this section is to explicitly outline benefits provided by the offer. In OSMOSE, it explains what the FlexEnergy providers expect to reach adopting the WP6 solution.

As mentioned in the section "Gain" of the "Customer profile", customers need to increase profits, eventually obtain social gains, save costs, and improve the functional utility. Thanks to the functionalities implemented by EMP and FEMP, FlexEnergy providers have the opportunity to participate in the FEM with their generation units improving the current management of energy residuals. The energy that is not reserved by the TSOs is offered to the new cross-border FEM, thus allowing maximizing the asset by exploiting all the available capacity.

From the HSE point of view, the main benefit is to have a tool which indicates how much energy (flexibility) is still left in the portfolio for near-to-real time market activities. This information is also useful for covering the outages inside the portfolio. For HDE, the WP6 solution provides a better optimization of the energy not used in the previous sessions of the Italian Ancillary Services Market (MSD) (8) or whose availability could not be forecasted earlier.

Value proposition - Pain relievers

"Pain relievers" describes how product/service alleviates specific customer issues. In particular, the section explains how WP6 platforms intend to reduce the "pains" identified for the "customer profile". First of all, the WP6 outcome allows overcoming obstacles relating to the harmonization of the flexibility services provided by the Italian operators. As pointed out by ENEL, the OSMOSE EMP allows quickly identifying the residual energy and, therefore, to offer it in a convenient and rapid way on the FEM since it is a novel near-to-real time cross-border flexibility market. Moreover, HDE has explained that operating in near-to-real time markets may help in optimizing the energy not used in the previous MSD market sessions as well as limiting the possible imbalances caused by changes in the "boundary conditions". HSE has pointed out that the flexibility is provided from the HPP and it is subject to the available hydrology. However, even if the hydrology is too high or too low, there is little space for flexibility which can be exploited by the WP6 outcomes.

2.2.2.2 TSO

Figure 3 shows the Value proposition Canvas for the TSOs. Similarly, to the previous section, the Value proposition and the Customer profile are fully described.

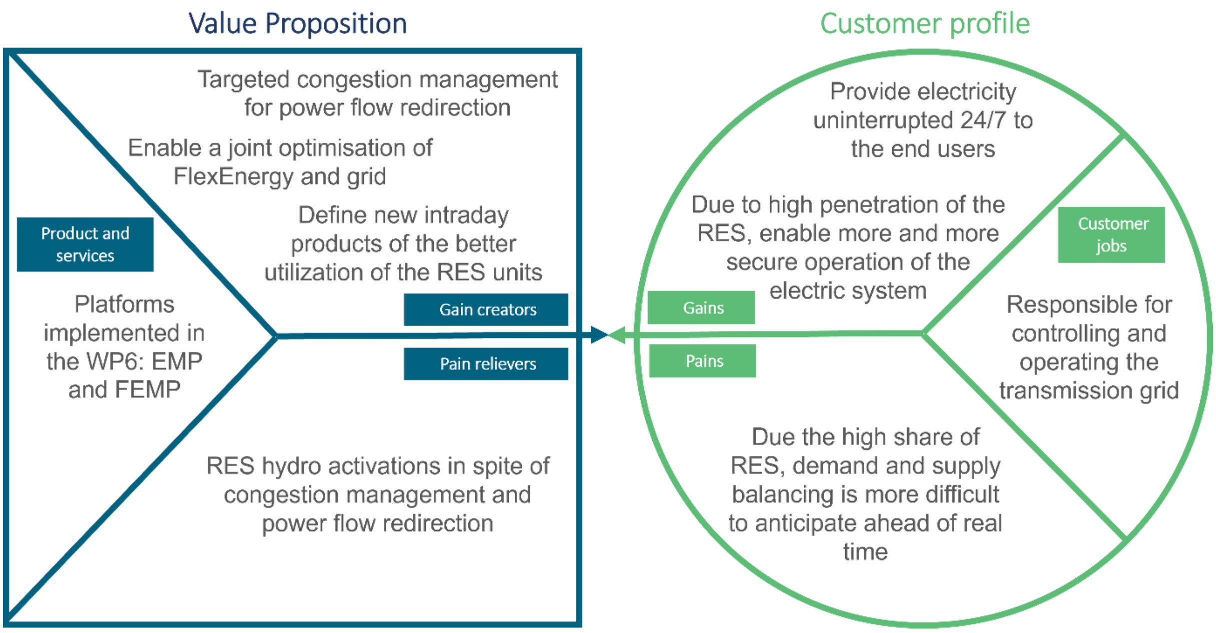

Figure 3: Value Proposition Canvas for TSOs

Customer profile - Customer jobs

The TSO is responsible for controlling and operating the transmission grid, this usually comprises the voltage levels of 220 kV and 380 kV in Europe. The TSO activity includes monitoring and control of the current grid topology and the voltage in all parts of the transmission grid (9). ELES, as Slovenian TSO, has the task of offering safe and reliable operation of Slovenia's electric power transmission system. The same goal is for TERNA working on the Italian transmission grid.

Customer profile - Gains

The main goal that a TSO as ELES aims to achieve is to provide electricity uninterrupted 24/7 to the end users/consumers. Furthermore, due to the high penetration of the RES in the European Network of Transmission System Operators for Electricity (ENTSO-E) (10) interconnection, the TSO wants to ensure both secure operation of the electric system in the future and affordable electricity supply, goals which are more and more challenging.

Customer profile - Pains

Due to the higher and higher share of the RES in the ENTSO-E interconnection, the demand and supply balancing is more difficult to anticipate ahead of real time. This phenomenon, which is also aggravated by unforeseeable stochastic events, is evaluated as a pain to alleviate.

Value Proposition - Product and services

The product reported in the Value proposition Canvas for TSOs (Figure 3) is still represented by the two platforms EMP and FEMP as well as in Figure 2: Value Proposition Canvas for FlexEnergy providers. The difference is that, in this case, the graph refers to those features and characteristics of the two platforms evaluated as the most valuable for the TSOs. Indeed, all the software modules of the FEMP are considered useful and innovative for ELES, especially the EN4M tool, which will be used in upcoming projects due to the observability of the grid and forming a common grid model. Moreover, in ELES opinion, the developing of the platforms like FEMP is crucial for the European green transition in the light of RES integration in the grid and the provision of ancillary services for TSO.

Value Proposition - Gain creators

There are many benefits, which can be achieved using EMP and FEMP platforms as pointed out by the TSOs of the Consortium:

- Defining new intraday products of the better utilization of the RES units such as congestion management services, the optimal use of non-dispatchable RES units for ancillary services.
- Performing a targeted congestion management for power flow redirection: the observable common grid model that is achieved through the topology data and the power flow calculations allows redirecting energy flows in the grid and, therefore, to release overloaded parts of the grid.
- Setting the foundation for a novel usage of the transmission grid by using near-to-real time grid snapshots which enables to exchange the energy (flexibility) securely also beyond current commercial congested borders. This is done also by considering Generation Shift Keys (GSK) as an important parameter of FEB.

Value Proposition - Pains relievers

With the mechanism developed within OSMOSE WP6, the TSOs would like to gain the insights, how can be influenced on the targeted cross-border exchanges of the RES hydro activations in spite of congestion management and power flow redirection.

2.2.3 FlexEnergy Providers and TSOs costs benefit analysis

This section gives an overview of costs benefits provided by the WP6 demonstrator to the two main customers, identified as FlexEnergy providers and TSOs. This analysis is done taking into account possible social benefits, functional and financial advantages tied to the use of EMP and FEMP platforms. As mentioned, the definition of the Value proposition Canvas, for both FlexEnergy provider and TSO, is useful for understanding the main benefits related to the WP6 platforms operation.

Starting from the FlexEnergy providers, the WP6 platforms aim to increase their economic profit since more optimization opportunities beyond the current Italian and Slovenian markets are offered. However, quantifying such increase in profit is not easy because it depends on the liquidity of this new market and only some assumption can be done. Indeed, the economic advantages are strictly determined by the volume exchanged on the platforms: if the quantity of optimized energy is significant, then social benefits, such as a lower cost of energy for the system, can be obtained. Functional advantages, i.e., a higher share of non-dispatchable RES that can be integrated in the energy system can also be achieved. On the one hand, a large part of EMP could provide economic advantages when used in a market closer to real-time. About this point, when intraday markets, especially the cross-border part of them, are close almost one-hour prior delivery, flexibility providers cannot achieve big advantages.

As mentioned in section 2.2.2.1, the computation of the residual energy that the FlexEnergy providers can offer to the FEM by means of FEBs is one of the main features offered by the WP6 EMP. This represents a benefit for a FlexEnergy provider that is interested in increasing its economic profit because the price of energy traded on such close-to-delivery markets is expected to be higher than the current markets. Thus, benefits are expected to come from the increased availability of energy exchange opportunities for flexibility resources allowed by the FEM. Supposing every FEB has a fair price, an exchange of the FlexEnergy could result in financial gains. HSE has observed that if these FEBs come from balancing inside the portfolio due to the difference between “forecasts” and “nowcasts” there are other benefits too. Such benefits are reducing the imbalances of the portfolio and transformation of this energy into energy that can put on the market in a controllable way, for example, FEB could be based on an open contract principle since at FEM, if a bid is accepted, it does not mean that it will be fully utilised in its entire quantity. This also has an impact on the balancing costs that could be decreased. Indeed, the portfolio management can minimize the imbalances and improve the whole power system performance.

Focusing on possible costs, HSE has explained that, for the Slovenian case, EMP is tailor-made since it was developed according to the needs of the FlexEnergy providers involved in the project: this means that some extra effort should be put in extending the EMP since every producer has its own platform. In addition, the FEB-CM INDRES needs to be tailored for the specific case because it is based on a machine learning nowcasting model. However, once developed, HDE - the Italian FlexEnergy provider - does not expect any cost to change by using the two platforms. As explained in its questionnaire, once the technology to exploit such close-to-delivery service is deployed, the company does not expect further costs related to its use. In other words, the use of the platform can be integrated in the company’s standard workflow without any other additional cost and, according to HDE point of view, an increase in revenue is foreseeable. Indeed, the benefits are expected to be greater than the initial deployment costs because the platforms allow to participate in a new market and to increase the profitability of the assets. A risk is related to a possible little liquidity on such a market platform. ENEL has pointed out that to guarantee flexibility services, a hydroelectric power plant must necessarily be running, otherwise the FlexEnergy provider would not be able to provide it. In this specific case, the associated costs are those related to the management of the system itself and to the need to program the unit in service. The same approach can be applied regardless of the technology used for the service provision. Costs could be reduced by using faster and more flexible resources such as the Battery Energy Storage Systems (BESSs) which guarantee much faster entry into service times. On the other hand, the BESS represents a cost for the FlexEnergy providers, which is proportional to the unit cost of the storage (measured €/kWh) multiplied by the energy involved (kWh). A BESS can imply a power conversion system as well; the sum of the storage unit cost and the power conversion system cost provides the total cost, which can be divided for the storage capacity for obtaining the cost of the system in €/kW (11).

From the TSOs point of view, the integration process of the WP6 software tools into the TSO environment will bring benefits, especially using the EMP and FEMP platforms. Indeed, the platforms will surely provide economic advantages when implemented in real operation together with market products. In ELES opinion, some costs could be related to the adoption of ECCo SP platform, which is accepted by ENTSO-E and provides key advantages such as security, reliability, and portability. The sFTP protocol was selected in the WP6 demo as protocol for FEMP operation data exchange since at the time of the platforms development the ECCo SP was not yet adopted in Italy. Moreover, when the technologies and products (software and hardware) will reach TRL 9, they will significantly reduce the investments costs in the reinforcement of the TSO's globally.

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3 Barriers to scaling up and replicate the WP6 demo solution

This chapter provides an analysis of the barriers identified in the context of the WP6 demo concerning scalability and replicability; both are therefore contextualised according to the main features provided by the WP6 demo. The analysis, carried out on possible barriers to scaling and replicate the WP6 demo solutions, focuses on both applications and technical aspects. Applications aspects are strictly related to the availability and the amount of data to be processed (e.g., number of critical outages/ branches and the number of FEBs) since it has an impact on the computational time of the main algorithms and processes. Technical barriers are mainly related to the characteristics of flexibility units and to the activation process. Details are provided in the following subsections.

3.1 Scalability

Scalability in the context of WP6 addresses the possibility to add more units to the existing portfolio of units (SLO) or to increase the number of flexibility units (ITA) made available by a Flexibility Provider; that is, to extend the portfolio of a producer over the market area.

Based on the experiences from the project, no or few HPP is the same. Most were built decades ago and were tailored to specific locations, needs and technologies at the moment of construction. For example, HPP Soverzene (ITA) was built between 1942 and 1951, HPP Santa Massenza (ITA) was built between 1948 and 1957, while HPP Vuzenica (SLO) was built between 1947 and 1957. In particular, HSEs portfolio consists of power plants that were built in different periods and have unique characteristics; this is important in the context of the mathematical models, especially concerning the parameters used in FEB-CM for portfolio optimisation. Indeed, these parameters were tailored to the specific power plant, and they are difficult to be used with other HPPs in general terms. Of course, hydraulic principles are the same, but some very specific approximations and simplifications had to be done in order to speed up the calculation process.

In terms of adding new flexibility units to the calculation, there could be different approaches:

1. units are independent between each other, such as HPPs that are hydraulically independent or one HPP and one battery which is not connected to the power plant. In this case, adding new units is a modelling challenge while the calculation of FEB might be speeded up with parallel calculation;
2. units are dependent between each other, such as units on the same river, a battery that might be used to relieve HPP generators, etc. In this case, the relation between the units should be considered since it has an impact on increased complexity of the model which in turn extends the calculation time.

In case of flexibilities from load aggregates, i.e., different loads that aggregate in the same virtual unit, statistical models should be used to ensure that the assessed flexibility will be available. If the model is complex, also in terms of considerations of different limitations per each load (activation time, time between activations, etc.), the computational time could increase. So, in terms of scalability for addition of new units in the flexibility portfolio and the challenge to calculate FEB fast enough, the performance requirement cannot be overlooked. In case of HSE, where FEBs were calculated from flexibility not used in current markets, the calculation took approximately one minute or less. Thus, different computational approaches should be used, based on the properties of flexibility sources.

Regarding the possibility to increase the number of flexibility units (ITA) made available by a Flexibility Provider, this could have an impact also on the FEB-CM for the exploitation of unselected aFRR and also on the FEB-CT. Both software tools were developed according to the specific WP6 demo requirements and some minor adaptions could be necessary in order to address new flexibility units. The FEB-CM INDRES, on the other hand, relies on a nowcasting model which must be specifically developed for each target power plant. In fact, regardless of the nowcasting technology (Deep Learning, etc...), the model has to fit the physical system to be nowcasted. In the case of the FEB-CM developed for the demo, a machine learning model was developed and trained on historical data of the considered Run-of-River hydro power plant (Ala HPP).

From the performance point of view, the demo tests have proved that the computational time for FEB calculation time and submission is in line with the demo expectation. However, adding new flexibility units could raise the necessity to improve the computational time; this could be addressed increasing the hardware capability of the server where the software is running.

A similar argument could be made for the Optimisation Platform developed by RTE since a computational barrier could limit the current scalability potential. In fact, the number of critical outages and critical branches, the number of flexibility units which participate in the Market, the size of the considered network and the quantity of distributed bids through GSK heavily affects the computational time required for the optimization. During the demo, the overall computational time remained low because the area was reduced from pan-European to an observation area where the exchange of flexibility affects the grid operation. This observation area was limited to Northern Italy, West part of France, Croatia, Hungary, Austria and Slovenia. In a similar way, increasing the number of FEBs affects the computational time of optimization algorithm, which selects the FEBs. In case of a pan-European operation of the market, the optimization level can be compared to the one used in Single-Day Ahead Coupling (SDAC) (12). In order to address this computational barrier, multiple possible solutions were identified:

- increase the computational efficiency of the algorithm and optimization model (through software and libraries enhancements).
- Increase the hardware capacities, i.e., the computing power and/or the RAM size. If the RAM size is enough, it would also be possible to keep all data for calculations there, instead of loading and saving from the HDD – this would save some other time.
- Test the Power Transmission Distribution Factors formulation in the Optimal Power Flows, rather than relying on standard equations.

Summarising, the computational time could be considered as a potential barrier for scaling up the demo. However, the solution developed for the project is feasible to scale-up adding more hardware resources to cope with a potential increase of workload.

Focusing on technical barriers for scaling, these are mainly related to the current infrastructure of both TSO and FlexEnergy provider and how it should be upgraded to be compliant with the demo requirements, mainly with regard to the interoperability aspect and to the activation process. In order to have clear understanding of the work done please reference to D6.3 and D6.5, especially on chapter 6 of D6.5 where additional tuning of the work described in D6.3 in presented.

3.1.1 Technical barriers

The Demonstrator of WP6 was set up in a real environment but, since it was a test, it was decided to initially explore FEM as a mechanism separated from aFRR. This means no full integration with all other market mechanisms existing at national and EU level. Such approach enables to isolate the FEM experiment and to provide a neutral analysis, prior of considering any further integration. In fact, even though producers included the workflow required for FEM in their standard workflow, TSOs could not fully integrate the market platform in the currently running market and dispatching system. This was due to operational reasons since, in the pilot project in the real environment, TSOs still have the responsibility to maintain all the security measures of the grid. Therefore, the pilot tests including the closed-loop demonstration were performed with supervision of TSOs, which enabled a security measure in terms of monitoring the pilot and possible stop of the pilot tests.

Regarding the activation process, the choice of using the already available technology of aFRR mechanism for the demo has proved successful. In fact, establishing a parallel aFRR-like channel between TSOs and FlexEnergy providers guaranteed real-time activation without the need of developing new systems. Anyway, different approaches were adopted on Slovenian and Italian side to implement the activation channel: in the first case, the interoperability between ELES and HSE was achieved using the production aFRR channel in which two new measurement signals were introduced. On the contrary, in the Italian side it was not reasonable to insert the activation signal into the real production channel of aFRR; it was decided to exploit the aFRR system creating a new channel for testing purpose. More in detail, on Slovenian side of the demo, a measurement signal was interpreted as an activation signal. In this way, the set-point type of signal was bypassed. The only reason for such decision lied in the optimization of the cost since for multiple set-point signals a major upgrade of the production SCADA on both TSO and FlexEnergy provider side would be needed but little benefit would be created by this. However, for a real operation a set-point like signal would be the right approach since the changes in the signals are instantaneous and TSO can easily check the difference between the base power and activation signal. On the Italian side of the demo, a set-point signal was used. This was possible because the units participating in the demo had the possibility to switch to TSO's testing environment; so, they were able to prove that such activation mechanism is feasible.

Regardless of the two solutions, the complete integration with existing market and dispatching platforms at EU level is required for real life operation and scalability of the proposed system. In addition, it will be necessary to evaluate the integration of FlexEnergy Management Platform with upcoming projects such as PICASSO (13) and MARI (14). It should be noted that PICASSO and MARI are ancillary services projects, while OSMOSE WP6 focuses on a wholesale power market. The integration here is meant as a standardization of activation signals that can be used or by ancillary services or by wholesale power market activities. This would result in a real value for flexibility units since a qualification for ancillary services would also mean a qualification for flexibility wholesale power markets and vice versa. The integration of FlexEnergy Market with existing market and balancing platforms is further addressed in section 4.1.1

Summarising, in case of adding more units to the portfolio (SLO) or new flexibility units (ITA), the interoperability between TSO and FlexEnergy provider is a topic that has to be dealt with, because some adaptions are needed from both sides in order to properly address the activation process. Moreover, the prerequisite for exploiting the cross-border capabilities of FEM is that a flexibility unit should be located, in topological grid terms, not far from the border of interest; the exact distance depends on the transmission grid characteristics. Nevertheless, units could exchange energy also just inside the same country; so, the distance from the border is not truly a barrier to scalability since FEMP is not limited to cross-border trading. In fact, it can be also used inside the same market (Country) or even region if the limits of the grid are respected. At this point, it is worth mentioning that OPT selects FEBs aiming at an optimal operation of the grid, which means that FEBs activation could also reduce congestions. Moreover, another aspect to consider is that flexibility units need to comply with the market participation prerequisite (defined in Deliverable 6.3), i.e., to be capable of being remotely controlled. If any unit is qualified for aFRR provision, it is automatically qualified for participating in FEM. The protocol for communicating the activation orders to the unit can be any protocol agreed between the FlexEnergy provider and the relevant TSO. TSOs receive the activation commands from the Market Platform via ICCP and forward them to the flexibility units by means of the agreed protocols. Moreover, as with any other new market, a FlexEnergy provider willing to participate should review its internal bidding and results-dispatching processes in order to integrate it with the new FEM workflow.

On the TSO side, an integration of the Italian regulation from the Regulation Authority (*Autorità di Regolazione per Energia Reti e Ambiente* - ARERA) (1) will be necessary to allow the scalability of the proposed Market from Demonstrator to real operational market, covering the entire Country and extending to borders with other TSOs.

3.2 Replicability

Replicability in the context of WP6 addresses the possibility to replicate the demonstrated FEM for different flexibility technologies and for new, other market areas, involving the participation of more TSOs. An active participation from TSOs is necessary since they should continuously provide snapshots of their grid to EN4M, the OSMOSE platform for real-time preparation of network data, and integrate or prepare the activation signal to activate flexibility units. While providing snapshots should not be a major issue since the participating TSOs - ELES, RTE and TERNA - were able to provide them without significant issues, the preparation of the activation mechanism could be challenging. As mentioned in the previous section, in WP6 demo two different approaches were used, but for a wider participation one unified approach should be considered; this would also simplify the whole FEM implementation.

According to the FEM design, there are no limitations for different technologies of flexibilities to be used. The demo was performed using both run-of-the-river hydropower plants and large conventional hydropower plants. Flexibility for FEM could be exploited by every controllable power unit: hydro and thermal power plants, concentrated solar power plants, even photovoltaic and wind power plants in case they are able to provide flexibility. Batteries or technologies like P2X, where power is converted to other forms of energy like pressurized air or kinetic energy (flywheels), can be also employed. There are no limitations also for the aggregators to generate FEBs from aggregated loads. The only important thing is that the unit or units used in FEM can be activated quickly, as defined in Deliverable D6.3. So, while power plants are in offline mode, e.g., gas turbines during shut-down periods, they are not considered for FEB creation, since they need some time to reach the generation mode.

Regarding the replication of the flexibility assessment that can be exploited by FEM, it can be calculated in different ways, based on the technology that is used to create FEBs. For example, if batteries are used, their capacity should be considered both in terms of power and energy that can be exploited. The same is with any other flexibility source: the important thing is that the operator develops tools that enable him to calculate how much power can be used, in which direction, for how long, how quick can the power exchange be and where in the network this flexibility is (i.e., connection node). Once all those parameters are calculated, they should be put in the XML format proposed for FEBs.

Summarising, it is possible to replicate the FEM to other market areas as long as TSOs provide the needed data and the overall data exchanged procedure is properly addressed. Any flexibility technology could be integrated, if its relevant flexibility parameters and boundaries can be properly calculated.

Replicability also means replicating the pilot novel market to different related scenarios of flexibility. Such scenarios would be:

- Self-balancing of portfolios/balance groups, as demonstrated by HDE using nowcasting to estimate imbalances in production from RoR HPP close-to-real time and then balance through a conventional HPP. In terms of replicability, any non-dispatchable RES could be re-dispatched together with any flexibility source, e.g., wind power parks or photovoltaic systems together with batteries.
- All cases where flexibility units are eligible to provide ancillary services, but they are not participating because of economic reasons. These units could exploit the value of their remaining flexibility to increase their income.
- Where long-term assessment of transmission capacities in both inter and intra market areas is used, new opportunities for increasing the grid usage or reduce the congestions can be created by introducing the proposed market. Opportunities are created since flexibility operators might identify new flexibility potential closer-to-real time rather than assessing it hours before.

Key message of replicability can be derived from HDE/HSE case and ENEL case:

- the energy difference between nowcasting and intraday scheduling can be balanced via a flexibility source which transforms intermittent energy into standardized market product (FEB).
- Units, that were not selected in the ancillary balancing process for various reasons, can trade their flexibility (exchange the energy) via novel FEM.

The usage of novel approach of bid activation based on the current status of the grid instead of on a few days old available transmission capacities just adds value to the scenarios described above.

In the following section, technical barriers for replicating the demo solution are addressed.

3.2.1 Technical barriers

Replicating the WP6 Demo in other contexts poses no major issues. As for the scalability, flexible units must be eligible to provide aFRR and the interoperability between TSO and FlexEnergy provider has to be taken into account. Indeed, the protocols for communicating the activation orders to the units must be agreed between the FlexEnergy providers and the relevant TSOs. This is worth mentioning, even if it is not a real barrier. In Demo tests, IEC 60.870.104 was selected. Also, the communication protocol between TSOs and the Market Platform must be agreed; the ICCP that was selected for the Demo is also used by ENTSO-E for aFRR which makes it an obvious choice for the novel FEM. ICCP supports categorization of signals. The category of the signal depends on the usage or purpose of the signal. Some signals carry the information of a measurement, while others carry the information about a request, e.g., activation, and are treated as fast signals. For the pilot, the configuration of the signal was done in a way that the activation signal was put in the category of measurements. The main difference between the two categories is the frequency of the signal updates. Activation signals are almost instantaneous, while the measurements category is updated every 10 seconds. This was done due to the simplification and testing purpose of the market. For the real market operation, the signal for the activation of FEB should be put in the category of activation signals which are updated every two seconds.

Technical barriers from TSO perspective are transmission capacities as the leftover of the imbalance netting between the countries. Moreover, it is recommended the usage of ECCo SP platform and the revision and standardization of data flows inside the TSO environment. Finally, cyber security policies must be upgraded for the third-party access.

4 Interoperability for replication and standardization

This section, starting from the technical barriers identified in chapter 3, provides an assessment of interoperability issues for replication and standardization addressed in the WP6 demo. The standardization is addressed giving space to the main directives, guidelines and protocols concerning this topic. Moreover, guidelines on how the interoperability can be improved are provided.

4.1 Interoperability assessment

The interoperability is a relevant topic affecting the potential replicability of the WP6 platform solution. In this context, the interoperability is:

- the capacity of the two WP6 platforms (EMP and FEMP) to exchange and make use of information;
- the ability to exchange data between TSO and flexibility units in the activation process.

Starting from the first point, in the demo, the communication between EMP and FEMP is based on the sFTP protocol. A sFTP server was arranged on ELES environment and folders for exchanging data were created according to a specific access policy. Consequently, software components belonging to the two platforms have implemented a specific mechanism for reading and writing data in these folders. This mechanism was useful for delivering the demo but the session tests demonstrated that it is necessary to speed up the bidding process, especially if the amount of exchanged data increases. For this reason, as already pointed out in deliverable D6.4 (5), the adoption of ECCo SP (ENTSO-E's Connectivity and Communication Service Platform) is recommended. Moreover, for the Demo Tests, the FEMP was deployed on ELES environment but in real operation the former could be run by an EU power or flexibility exchange platform like the *Gestore Mercati Energetici* (GME) (8) in Italy or the Slovenian BSP *SouthPool Energy Exchange* (15). Both are actors on the Market like and should be in charge of sending the activation signals to relevant TSOs.

Regarding the interoperability between TSO and flexibility units, this is about how the activation process is performed when FEBs are accepted on FlexEnergy Market. A different arrangement was done for the demo: the ICCP protocol was adopted in Slovenia but it could not be possible to use the aFRR activation signal. Indeed, the production aFRR channel was used but it was necessary to introduce two new measurement signals, one signal was used for activation and the other for the feedback. The first signal was interpreted as activation signal since inside one aFRR channel there can be only one activation signal but multiple "measurements" signal. Another possibility could be to replicate the aFRR channel for market (FlexEnergy market) activities but this would mean an upgrade on both sides (TSO, providers). The activation on the Italian side was done using the aFRR signal but a new channel for testing purpose was created.

Summarising, the interoperability, as it was addressed in the demo, has allowed achieving the expected results; however, some improvements are needed in order to extend the WP6 solution to other markets and countries for allowing a successful replication. In the following sections, the integration of the FlexEnergy Market with the current regulatory framework is addressed along with the standardized interfaces.

4.1.1 Integration of FlexEnergy Market with existing market and balancing platforms

The implementation of FlexEnergy Market into a real-world market requires an integration of the current regulatory framework. To this purpose, the following changes are proposed.

In general, it should be allowed to operate near-to-real-time cross-border market and bidding processes at least 15 minutes prior delivery time. The Regulation on Wholesale Energy Market Integrity and Transparency (REMIT) (2) should also be taken in account for operation near-to-real-time. If the outage of an element has to be published before the creation of FEB or of the network model, this introduces a delay in the near-to-real-time process. Any delay reduces the optimization opportunities for the FEM participants with respect to other already existing markets.

Then, the bid definition used for FEBs should be allowed. The bid structure already allows different technologies through gradient, power and energy constraints. Another aspect is that, as opposed to standard Day-Ahead and Intraday Markets, FEBs are based on open-contract principles. This means that, even if a FEB is accepted by the platform, it does not mean that it will be *fully* utilised, i.e., in its entire quantity. This principle is used to allow the market to stop exchanging if a network element becomes critically loaded. It is an important difference with respect to the current practice of closed contracts on wholesale markets, especially on power exchanges. The open contract principle introduces flexibility but at the same time it introduces complexity for settlement. Involved TSOs should, at the end of delivery day, create activation reports, which should be submitted to the power exchange. Based on these reports, power exchange can settle activated FlexEnergy quantity for each FlexEnergy provider. Settlement process can be the same as used in day-ahead and intraday markets.

To address non-dispatchable RES based on the concept of FEB-CM INDRES, portfolio bidding should be also allowed in wholesale electricity markets. In fact, in some countries which participate in the demo (e.g., Italy), only unit-based bidding is allowed; this prevents FEM to rely on portfolio bidding as well.

Furthermore, it should also be considered that available cross-border transfer capacities are not calculated anymore but are subject to the market optimization, where FlexEnergy exchange is maximized until technical limits are reached.

Finally, the FlexEnergy market platform should be run by an already established energy exchange platform and not by a TSO. This is a suggestion in order to speed up the whole process since energy exchanges have already a lot of infrastructure that can be used, especially concerning the settlement.

Another aspect is that, from the technical point of view, FlexEnergy market is similar to the aFRR balancing market; indeed, an analysis on the potential integration of FlexEnergy Market and aFRR balancing market was provided in deliverable D6.1 (3).

It is important to enable parallel functioning of FlexEnergy market and aFRR process so that the latter will not cause the sub optimal solution in each of the processes. The testing of the platform was performed separating the two markets to exploit a clear nodal representation and to allow more relaxed calculation (no dependence on real time Area Control Error). The drawbacks of the separation are the challenging interchange of information among the two real time markets and the knowledge of the real situation in the network.

Focusing on the short-term electricity markets like the Balancing Market, the Electricity Balancing Guideline (EBGL) approved by the European Commission (16) establishes the principles, market rules and proposals, which need to be followed, implemented or developed in order to address and integrate the balancing market. Balancing market means the entirety of institutional, commercial and operational arrangements that establish market-based management of balancing. The EBGL aims at creating a market where countries can share the resources used by their TSOs to make generation equal demand, always. Moreover, the EBGL is also about allowing new players such as demand response and renewables to take part in this market. The Balancing Guideline should help increase security of supply, limit emissions and diminish costs to customers (16). On the other hand, the System Operation Guideline (SOGL) (17) provides the necessary technical framework for the development of cross-border balancing markets, such as the structure and operational rules of load frequency control, the quality criteria and targets, the dimensioning, exchange, sharing and distribution of reserves as well as monitoring system. The four complementary forms of coordinated balancing identified by the SOGL guidelines are: imbalance netting, exchange of balancing energy, exchange of balancing capacity, sharing of reserves. Moreover, the European implementation projects addressing the Electricity Balancing Guideline are the following:

- the International Grid Control Cooperation (IGCC) (18) for the establishment of the European Imbalance Netting (IN) Platform;
- the Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (PICASSO) (13) for the establishment of the European aFRR-Platform;
- the Manually Activated Reserves Initiative (MARI) (14) for the establishment of the European mFRR-Platform;
- the Trans-European Restoration Reserves Exchange (TERRE) (19) for the establishment of the European RR-Platform.

The FlexEnergy market can be correlated to the close to real-time aFRR market, implemented by the PICASSO platform. PICASSO builds further on the work done in a regional project called EXPLORE (European X-border Project for LOng-term Real-time balancing Electricity market design) (20), a joint initiative of the TSOs of some European countries. The main objectives of PICASSO are to design, implement and operate an aFRR platform based on the TSO-TSO model, thereby enhancing economic and technical efficiency within the limits of system security.

Integrating the FlexEnergy market with aFRR would allow for increased liquidity, direct coordination of two real time activation process and a single bidding process and time window. However, this integration requires the inclusion of ACE in the Control layer, which is possible only if its calculation time would be short enough to accommodate timely reaction to the correction ACE signal. Moreover, the ACE should be turned from zonal to nodal demand bid, adding uncertainty at FlexEnergy market grid representation. It is evident that the integration of FlexEnergy market with the upcoming PICASSO platform is possible but requires further improvements and research to ensure a safe and optimal system operation.

4.1.2 Standardized interfaces

This section provides an overview of standardized interfaces, which will enable seamless replication on the top of other TSO control systems. As anticipated in the previous section, the possibility to replicate the OSMOSE platform to other countries involves an active participation of TSOs, mainly in the provision of relevant data such as the grid snapshots. Indeed, the first step in the network data preparation process is the collection and validation of individual grid models (IGMs) of different formats for the purpose of creating a regional Common Grid Model (CGM) by merging these input files. This process is triggered every 5 minutes, and involves the IGMs of:

- ELES (snapshot of Slovenia, Croatia, Hungary, Austria, and close neighbouring nodes in the observability area) in raw format,
- TERNA (snapshot of Northern Italy) in UCT format,
- RTE (snapshot of France) in UCT format and
- Swissgrid (snapshot of Switzerland – provided via ELES) in UCT format.

The ELES+ SN model is provided every 5 minutes with a delay of 30-60 seconds, while TERNA and RTE models are provided with a 15-minute resolution and a delay of up to 150 seconds.

Inconsistency between input formats and time of delivery can cause discrepancies in the created Common Grid Model (CGM) and different fall-back procedures had to be implemented in EN4M software to avoid such a situation. In addition, the process of validation and conversion of input data among different formats requires some time and every second is valuable in this close-to-real time market. The best solution for the real FlexEnergy market would be the production of a unique regional CGM directly from a common regional state estimator. Alternatively, each TSO should create its SN model in the same and compatible format (UCT or CGMES) and deliver it with the shortest possible delay (up to 30 sec). Such standardized input files would ensure a quicker, stable, and more reliable network creation process and resulting CGM that is used for network representation in the optimization process.

Another important aspect to consider is how relevant data are exchanged inside and between TSOs; indeed, some requirements for message integration service have to be taken in accounts like the secure message exchange and the guaranteed security and access control. Based on business requirements, the following services were deployed to facilitate OSMOSE project message integration:

- SSH File Transfer Protocol (sFTP Server)
- file system-based user authorization and access privileges

However, possible enhancements of the real-life OSMOSE platform integration service deployment are suggested, like the adoption of ECCo SP Service platform to enhance security and reliable data delivery.

4.2 Blueprints and guidelines

Beyond the barriers to scaling up and replicating explained in chapter 3, the proposed FlexEnergy Market can be exploited as follows by any flexibility unit, regardless of its technology and geographical location. Of course, the unit must be connected to a grid node in a market area covered by FEM and it must meet the eligibility requirement reported in D6.3 (i.e., be capable of closed loop control). In the future, it is expect a variety of possible flexibility units: not only conventional power plants, like HPP, but also batteries, units like P2X or some other technologies that are now on laboratory-level solutions.

To exploit the proposed FEM, these technologies must be modelled in a FEB-CM. FEB-CMs developed for the demo are based on the functional requirements of Italian and Slovenian scenario; this means that a new FlexEnergy provider coming from a different country could have the necessity to develop its own FEB-CMs. In any case, the FEB submission can be done exploiting the FEB-CT. The only requirement is that FEBs are compliant to the xml format defined in D6.3.

In case of a FEB-CM for portfolio optimization, like in the case of HSE, the new flexibility units must be mathematically modelled in an optimizer using e.g., linear programming. In case of a FEB-CM for unused aFRR, as in the Italian scenario, the CM must be adapted to process the relevant files: market outcomes and TSO’s reservations, technical data of flexibility units, etc. In fact, the number and layout of these files may differ from one TSO to another. In case of a FEM-CM addressing non-dispatchable RES through nowcasting, as INDRES, a specific nowcasting model must be developed and trained on the considered unit; no restrictions apply to the nowcasting technology (i.e. deep learning). A general guideline for the development of an effective FEM-CM is the following:

1. Get all the relevant technical parameters of the new unit that is willing to participate to FEM. They are both those to be indicated in each FEB and those to be used as input for the CM; they can be fixed (e.g., ramping time, GSK) or variable (e.g., min and max power, energy capacity). The variable parameters required as input by the FEB-CM should be automatically updated in near-real time.
2. If the unit addressed by the FEB-CM is not the one that participate in FEM, all relevant parameters of the latter have to be retrieved as well. In fact, if a unit is not eligible for participating in FEM, as in the case of a non-dispatchable RES, it shall be included in a portfolio with at least one flexibility unit that can participate in FEM. All quantities to be bidden in FEM must be “transferred” from the non-eligible unit to the participating unit, by means of a virtual redispatch of portfolio. This means that, e.g., if a non-eligible unit is willing to sell on FEM, the sell FEB must be submitted form the eligible unit. Therefore, also the technical parameters of the latter are required to compile the FEB.
3. Create the calculation engine of the FEB-CM. This can be a nowcasting model or a mathematical model of the portfolio. E.g., in the latter case, the model links the unit to other portfolio units through an objective function of linear programming.

The aforementioned software components (including the calculation engine) can be developed as a stand-alone application or integrated in the EMP. In the first case, it could be useful the implementation of a mechanism to automatically upload FEBs in the EMP through Web Service or API request.

The FEB-CM should automatically retrieve all input data and run the calculation model each time an update of the available flexibility estimation is needed. This can be done on a time basis or on a condition basis. E.g., a nowcasting model could run each 15 minutes to always provide the most accurate forecast to update or correct the market schedule. A FEB-CM for unused aFRR, on the other hand, could be automatically run only when the unit is not selected by the TSO for the provision of ancillary services.

Once the FEB-CM is developed, the last step needed to adopt the proposed FEM is to integrate the FEM outputs so that each Flexibility Providers is able to understand the results of the market .A possible advancement could be the integration of EMP with each producer's IT systems. This could be achieved with the development of proper communication mechanism based on API or REST services.

Finally, for a better integration of the market with the bidding system already in use by FlexEnergy providers, an upgrade of EMP to support bidding via ECCo SP would be needed. In fact, some TSOs already use this protocol to communicate with market participants. Moreover, as mentioned in 2.1, ECCo SP has some advantages over sFTP:

- Security – Only recipient of the message can read the message content. The sender of any message can be unambiguously verified.
- Reliability – The message delivery is guaranteed.
- Integration – The ECP functionality for sending and receiving messages can be integrated with wide variety of technologies (e.g. Kafka, AMQP, FTP, SFTP and WS).
- Standard – ECP is the implementation of ENTSO-E MADES standard, which defines the technical aspects of communication between entities in the energy sector.
- Transparency – Any message transported by ECP can be tracked down to gather trustworthy information about the state of delivery.
- Portability – The ECP can be installed on most of widely-used operation systems.

5 WP6 exploitation plan

Exploitation means *"the use of results in further research activities other than those covered by the action concerned, or in developing, creating and marketing a product or process, or in creating and providing a service, or in standardisation activities*" (21). Accordingly, with the Horizon 2020 approach, maximising research results through dissemination and exploitation activities is a fundamental step in the project lifecycle. In the project activity, this means optimising the adoption of new knowledges and stimulating collaboration among partners and actors who could benefit of the project results.

This chapter introduces the individual exploitation plan of the partners involved in the WP6 and the exploitation plan landscape dedicated to the entire WP6 results. In order to identify the best exploitation strategy, the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis (22) has been used as a suitable tool for synthesizing the main strengths and weaknesses as well as opportunities and threats of the WP6 outcomes.

It is noteworthy to clarify that the following sections are exclusively addressed to the WP6 outcomes, not to the whole project results. The exploitation strategy of the entire OSMOSE project, indeed, will be reported in deliverable D8.7 "Final exploitation plan of the project's results".

5.1 Exploitation plan landscape

This section aims to provide an overview of the exploitation plan of the platforms implemented in the context of the WP6. Although each partner has given an analysis of how it intends to exploit its individual WP6 results (section 5.3), some guidelines for an overall plan are desirable for maximizing the impact of the work carried out. The project partners can decide, indeed, to exploit the results themselves or facilitate the exploitation by others; to facilitate this process, they could make results available under open licenses.

The exploitation could also be occurred by some smaller partners groups, which share the implementation of specific tools or modules (i.e., FEB-CM developed by HDE and FBK) and they can decide to continue their collaboration after the end of the project for achieving a commercial solution. Noteworthy, the project encourages the collaboration among European partners and feeds the synergies, which are valuable resources in promoting internationalization.

For all the partners, know-how and methodologies achieved in the WP6 context will be a starting point for other research activities and, eventually, for business ones, especially activities focussed on flexibility solutions for the decarbonisation of industry and power sector. The partners involved intend to collaborate on exploiting the results publishing scientific papers, which disseminate the potentiality of the results obtained. The exploitable outcomes of the WP6 could be presented during conferences and workshops concerning the balancing markets of the European power system. The intention is especially to present the results to an audience interested in software tools able to exploit the residual flexibility, close to real-time, not used by the national TSOs. Great attention will be given in identifying contexts in which stakeholders, who could make use of results, operate.

The most interesting aspect advanced by the OSMOSE project is the creation of a new market (cross-border market). The prototype implemented in the WP6 could be used for developing similar solutions not only addressed to the Italian-Slovenian cross-border market but to other neighbouring countries. With this auspice, the partners could provide consultancy services to actors involved in these potential markets, providing knowledges and open-source material produced in the context of the project.

Although the partners did not show the interest in doing that for now, in the future they could plan to collaborate with the aim of commercializing the developed platforms. The software tools could be launched, after a re-engineering phase, through the foundation of a spin-off or a start-up company. In the meantime, they could patent the results, maintain the copyleft licenses and propose the arguments for the PhD thesis in order to continue the research work done until now.

5.2 SWOT

SWOT analysis (22) provides a recap of the main aspects of the platforms, broadly described in the previous paragraphs and in the questionnaires in Annex A, with the aim of pointing out the features and potential risks to take into account for the WP6 exploitation plan.

The analysis distinguishes internal and external factors tailored on the OSMOSE WP6 solution. Strengths and weaknesses are considered endogenous variables that are an integral part of the platforms and on which it is possible to directly act. Opportunities and threats, instead, collect variables external to the system but which could affect it. Moreover, strengths and weaknesses relate primarily to the present, while opportunities and threats relate to the future, which can be addressed for favourable changes.

Figure 4 shows the SWOT analysis for the OSMOSE WP6 outcomes. The matrix briefly reports the aspects, which are described later.

Strengths

- Knowing and offering the residual flexibility - not reserved by the TSO - on the market in a convenient and rapid way
- Working efficiently near-to-real time markets
- Limiting imbalances and contributing to reduce congestions in the grid
- Allowing a better integration of non-dispatchable RESs
- Enabling a joint optimisation of FlexEnergy and grid
- Performing the bidding process
- Knowing accepted and not accepted FEBs on the market
- Exploiting flexibility by every controllable power unit

Weaknesses

- Computational barrier limits current scalability potential
- Technical barriers make it difficult to integrate the market platform in the currently running market and dispatching system
- sFTP protocol should be upgraded with ECCo SP platform and an upgrade of EMP to support bidding via this protocol would be needed.
- Frequency of the activation signal (every 10 sec), used for the pilot, is not suitable for the near-to-real time operation

Opportunities

- Creation of energy cross-border markets in other market areas where the TSOs have the opportunity to provide the needed data.
- A further penetration of RESs with a consequent enhancing value of flexibility of the plants able to guarantee it and a decreasing of balancing costs
- Integration of FEMP into upcoming projects
- Implementation of a WebService for allowing Italian operators to interact with TERNA systems
- Adoption of available technology of aFRR mechanism

Threats

- Low liquidity on such a market platform
- Incorrect incomes prevision due to the complexity in quantifying profits
- Regulatory aspects such as "access policies"
- Complexity for settlement introduced by the open contract principle

Figure 4: SWOT analysis for WP6 outcomes

<u>Strengths</u>

The first square of the SWOT matrix reports the factors identified as strengths for the WP6 outcomes. From the exploitation point of view, these features of FEMP and EMP are ones that have to be mainly promoted in the dissemination and exploitation activities.

The use of the platforms can increase the FlexEnergy providers profits by exploiting the residual flexibility. Indeed, the solution allows these market actors to offer the residual flexibility on the market in a convenient and rapid way. The platforms allow knowing the amount of energy still left in the FlexEnergy providers portfolio for near-to-real time market activities. The opportunity of working near-to-real time markets may help in optimizing the energy not used in the previous market sessions and limiting the possible imbalances caused by changes in the "boundary conditions". Moreover, thanks to the information of the residual flexibility for near-to-real time market activities, the use of the platforms might cover the outages inside the FlexEnergy providers portfolio.

FlexEnergy providers, through the questionnaire circulated, have pointed out not only the opportunity to fully exploit the flexibility offered by dispatchable power plants but also a better integration of the non-dispatchable RESs in the energy market; indeed, more generally, the solution allows an optimization of the energy not used in the MSD sessions. Moreover, from their point of view, the ability to perform the bidding process and to know the accepted/not accepted FEBs on the FEM is an added value of the FEB-CT.

A better utilization of RES units is evaluated as an advantage from the TSOs point of view as well as the use of the OPT, which could contribute to reduce congestions in the grid and avoid grid reinforcement, providing substantial savings for the TSOs. Furthermore, the use of the near-to-real time grid snapshots can enable to exchange the flexibility securely also beyond current commercial congested borders.

As demonstrated by the demo, there are no limitations for different technologies of flexibilities: flexibility for FEM could be exploited by every controllable power unit (i.e., hydro and thermal power plants, concentrated solar power plants, photovoltaic and wind power plants) which provides a further technology advantage.

Weaknesses

The weaknesses section identifies the aspects of the WP6 outcomes that should be improved.

According to what is reported in strengths box, although FEB-CM for portfolio optimisation works efficiently for near-to-real time actions, for safety reasons more market time units should be considered for the calculation, but this has an impact on the overall computational time. Indeed, if the number of flexibility sources in the portfolio is increased, then the computational time is increased as well, and this could lower the performance of the FEB-CM for portfolio optimisation. In this regard, there are different options that could be evaluated for overcoming this issue such as increasing the computational efficiency of the optimization algorithm and/or the hardware capacities or testing the Power Transmission Distribution Factors formulation in the Optimal Power Flows.

From a technical point of view, TSOs could not fully integrate the market platform in the current running market and dispatching system due to operational reasons. Moreover, the use of sFTP protocol, currently adopted for the implementation of the FEM, is considered a drawback since it should be substituted with ECCo SP platform which is already used by some TSOs for communicating with market participants. ECCo SP is accepted by ENTSO-E and provides key advantages in terms of security, reliability standard and so on. For a better integration of the market with the bidding system already in use by FlexEnergy providers, an upgrade of EMP to support bidding via ECCo SP would also be needed.

For communicating the activation orders between the FlexEnergy providers and the relevant TSOs, an activation signal was introduced as a measure in the pilot. The frequency of the activation signal, currently used for the pilot, is not suitable for the near-to-real time operation, and it should be enhanced from every 10 seconds to every 2 seconds.

Opportunities

Opportunities refer to favourable external factors that could give advantages in the future use of the platforms. An example is represented by the list of changes in the regulation framework proposed in the section 4.1.1 which aims to implement the FEM in the future. The creation of a new market (energy cross-border market), in which the solution proposed by the WP6 could be applied, might not be limited to the Italian-Slovenian energy cross-border market but replicated in other contexts with different types of flexibility units or between other neighbouring countries. In this regard, any flexibility technology could be integrated if its relevant flexibility parameters and boundaries can be properly calculated. Concerning the replicability of the FEM in other market areas, it is just influenced by two factors: the possibility of the TSOs to provide the needed data, and the overall data exchanged procedure to be properly addressed.

Due to a further penetration of RESs, an enhancing of the value of the flexibility of the plants able to guarantee it, and then of the profits, would be observed. This increase of profits could provide a generation of functional and social benefits and, in view of the market growth, a decrease of balancing costs.

OSMOSE could evaluate the integration of FEMP with the upcoming projects PICASSO (13) and MARI (14). Noteworthy, the integration would be limited at the standardization level of the activation signal since PICASSO and MARI are ancillary services projects, while OSMOSE focuses on a wholesale power market.

In the light of the experience carried out in the pilot, the use of available technology of aFRR mechanism would be advisable since it would guarantee a real-time activation and a distinction of the ancillary services from the wholesale market. The analysis of the ENEL questionnaire has pointed out a potential improvement of the technology, circumscribed to the Italian operator, based on the development of services for interacting with TERNA systems. ENEL has proposed the implementation of a Web Service, which could allow two different advantages: first, the operator could download the results of the market directly from TERNA as do with the other market results; second, TERNA could know the results of the market in order to download the useful data automatically.

<u>Threats</u>

Threats include everything that can negatively affect the use of the WP6 outcomes. The section is useful for pointing out possible risks and issues tied to the platforms operation in order to prevent them or take corrective actions. This box of the matrix reports factors like a possible little liquidity on such a market platform and an incorrect incomes prevision due to the complexity in quantifying profits. Other threats concern the regulatory aspects such as "access policies”, which in case of exercise should be adequate; concerning the Italian market, for example, an integration of the Italian regulation from ARERA (1) will be necessary.

The analysis has brought out an issue concerning the open contract principle. The FEM, indeed, was defined as an open contract market, which is different from the current practice of closed contracts on wholesale markets. The open contract principle, applied in the FEM, if on one hand introduces flexibility, on the other introduces complexity for settlement because it requires that the TSOs submit activation reports at the end of the delivery day to the power exchange.

5.3 Individual exploitation plan

The individual exploitation plan of the partners involved in the WP6, concerning the WP results, is provided in the tables below which are declined based on the core business of each company.

Table 1: ELES individual exploitation plan

Partner	Sistemski operater prenosnega elektroenergetskega omrežja ELES, d.o.o.
Organisation profile	State owned company-public service
Strategic focus areas	The key activity and mission of the ELES company is the safe and reliable operation of Slovenia's electric power transmission system, which we provide 24/7 throughout the year.
How is OSMOSE project relevant to your organisation	ELES is the WP6 leader and one of the founders of the FEM concept integration into the real IT environment of TSO business together with all partners of the WP6. We believe that the results of the project will highlight the development of the intraday flexibility products of the RES for the better utilisation of the existing transmission infrastructure as well as the improvement of the ancillary services portfolio in the future for the TSO's and DSO's.
What content could be exploited?	Design and functional specifications for the SW integration in the TSO IT environment and future recommendations for the cyber security topics of the products. Integration of the FEM platform with SCADA system. Closed loop tests experience and findings related with activation signal and ICCP protocol use. The importance of the Common Grid Model and use of the state estimator data for observability and security analysis as well as the optimization of the targeted activations of the selected RES units with locations data and technical constraints of the topology of the grid. The use of the sFTP protocol regarding the operation of the FEM platform and future upgrades with ENTSO E ECCo SP platform. FlexEnergyBid as the future market product and reshaping the energy markets close to real time with flexibility and utilisation of the RES and infrastructure.
Approach to exploitation	Conferences, BRIDGE events, new projects-EU horizon, pilot projects with TRL 8, publications, etc.

Table 2: ENEL individual exploitation plan

Partner	Enel Produzione S.p.A. (ENEL)
Organisation profile	Enterprise
Strategic focus areas	Producer and Flexibility provider
How is OSMOSE project relevant to your organisation	The Energy and Commodity Management Italy (E&CM) business line operates on all spot energy markets as a single dispatching user for the entire Enel group. The experience gained in OSMOSE will be useful for participating in the new market.
What content could be exploited?	The knowledge, methodologies, and requirements used in the development of the WP6 could be exploited when the market starts.
Approach to exploitation	The selection criteria of the unit interested in the project can be reused to identify the production units that will be able to participate in the new market Similarly, the requirements provided for the development of the software solution used for participation will be reused to implement a similar solution in the biding platform that is used in Enel's Dispatching Operation Center.

Table 3: ENG individual exploitation plan

Partner	Engineering, Ingegneria Informatica S.p.A. (ENG)
Organisation profile	Enterprise
Strategic focus areas	Software and IT Services
How is OSMOSE project relevant to your organisation	ENG has a dedicated business unit for the Smart Energy & Utilities market and has also developed its own software suite for the Utilities market. OSMOSE project results can be considered a significant know-how for the R&D lab to be further exploited by the Smart Energy & Utility Business Unit.
What content could be exploited?	The modules FEB-CM, FEB-CT and FEBPP, implemented in the WP6 context, together with the immaterial assets, such as knowledges, methodologies, requirements etc., could be exploited.
Approach to exploitation	The modules developed by ENG in the WP6 of OSMOSE could be directly exploited by developing innovative solutions for flexibility providers starting from prototypes released during the research project, or indirectly, by showing, to properly identified customers, the results of the research activity in order to prove the attention of ENG toward the innovative solutions. Even though the second approach could seem a simple “marketing” action, customers are usually reassured by knowing that their IT supplier continuously investigates innovative technologies. The Smart Energy & Utilities portfolio of ENG, managed by a specific business unit, includes companies that operate in the local market and that could be interested in using the proposed modules. Moreover, thanks to the increased know-how and competences, ENG could exploit the WP6 OSMOSE outcomes by offering improved consultancy services to current and new clients about flexibility integration and flexibility support services.

Table 4: EKC individual exploitation plan

Partner	Electricity Coordinating Center Ltd (EKC)
Organisation profile	Enterprise
Strategic focus areas	Consulting and software
How is OSMOSE project relevant to your organisation	EKC develops software solutions for the analyses of power systems and electricity markets, which are widely used across the Continental Europe, as well as in several national and regional projects. Software demonstration platform for real time assessment of available cross-zonal capabilities for energy exchanges (EN4M) improved EKC spectrum of software tools in the field of electric power systems, related to the network models processing, load flow and transmission capacity calculations.
What content could be exploited?	The modules for creation of regional CGM, conversion of AC model to DC with losses and Presolve module implemented in the WP6 context, together with the immaterial assets, such as knowledges, methodologies, requirements etc., could be exploited.
Approach to exploitation	The modules developed by EKC in the WP6 of OSMOSE could be directly integrated with existing software solutions developed by EKC and used as a prototype to present results of research and gained knowledge to the properly identified customers. They can additionally be improved and used as a prototype for further development. Also, knowledge and experience obtained during this research activity will be exploited in EKC for new software solutions and improvement of the consulting services.

Table 5: FBK individual exploitation plan

Partner	Fondazione Bruno Kessler (FBK)
Organisation profile	Research and Technology Organisation
Strategic focus areas	Energy, Artificial Intelligence
How is OSMOSE project relevant to your organisation	FBK with its Center for Sustainable Energy supports the development and adoption of zero-emission solutions for the production, distribution and storage of energy that enable the decarbonisation of our society. OSMOSE project will be an important milestone for FBK since the large-scale project demos concern the identification and management of flexibilities in the power system required to enable the energy transition.
What content could be exploited?	The FEB Calculation Module (FEB-CM) for integration of non-dispatchable RES, implemented in WP6, together with the know-how, methodologies and requirements could be exploited.
Approach to exploitation	The nowcasting models included in FEB-CM for non-dispatchable run-on-the-river plants are case-specific but can be adapted to other situations or plants. These tools could be exploited in future R&D projects and customized based on possible requirements from flexibility providers in specific consultancies. Moreover, the know-how and competences developed during the OSMOSE project, enable FBK to provide better services to industry partners focusing on flexibility solutions for the decarbonisation of industry and power sector.

Table 6: HDE individual exploitation plan

Partner	Hydro Dolomiti Energia s.r.l. (HDE)
Organisation profile	Enterprise
Strategic focus areas	Hydropower production
How is OSMOSE project relevant to your organisation	HDE is a major Italian hydroelectric producer. The ongoing energy transition to a greener and cleaner EU energy system requires huge changes in the electricity sector and in the management models of power plants; being an active player in the transition means investing in R&D to anticipate, participate and promote those changes. OSMOSE Project goes in this direction and represents a valuable occasion for HDE to develop the required know-how and expertise.
What content could be exploited?	The Calculation Module (FEB-CM) INDRES, implemented for WP6, together with immaterial assets, such as knowledges, methodologies, requirements etc., could be exploited.
Approach to exploitation	HDE intends to exploit both methodologies and results developed during OSMOSE. Also, the network of contacts with the other EU partners (TSOs, producers, service companies, research institutions), created during the common work for the project, is a valuable resource in promoting internationalization. More in detail, the main result HDE is focusing on for exploitation is the FEB Calculation Module (FEB-CM) INDRES. This software, developed together with other partners, allows the "Integration of Non-Dispatchable Renewable Energy Sources" in FlexEnergy Market (a novel energy market addressed by WP6) by means of machine learning-based nowcasting. To demonstrate the concept, the model was created and trained on one of the major HDE's run-of-the-river hydropower plants, selected as target. The know-how acquired in developing the artificial neural networks calculation engine for nowcasting is already being adapted and exploited for existing electricity

	markets, allowing to reduce the imbalances in power production from non-dispatchable RES.

Table 7: HSE individual exploitation plan

Partner	Holding Slovenske elektrarne, d.o.o. (HSE)
Organisation profile	Enterprise
Strategic focus areas	Power producer, supplier and trading company
How is OSMOSE project relevant to your organisation	HSE is the biggest power producer and main ancillary services provider in Slovenia. To maintain its leading position, HSE looks for new, innovative ways, both products and services, that can be offered on the wholesale and ancillary services market. OSMOSE, with its near-to-real time FlexEnergy market is a promising way to add value to the flexible production portfolio.
What content could be exploited?	FEB-CM for portfolio optimisation could be further developed to be used in a real environment to suit intraday re-dispatching operations and improve efficiency and flexibility of portfolio. Knowledge about future market design gives an insight to what could the near-to-real time market look like and what challenges it presents.
Approach to exploitation	FEB-CM could be further developed in both terms of GUI and mathematics to suit intraday needs. Since the model is tailored to HSE production portfolio, it is very specific and difficult to apply on other portfolios however the approach described in D6.3 - Report on Software demonstration platform development - could be used by anyone. In addition to that, the idea to continuously optimize the portfolio with the goal do maximize the flexibility and revenues can also be applied by other flexibility providers. On the other hand, the experiences and findings gained from the Demo test can be applied to shape the near-to-real time markets of the future. Such information is highly important for any market participant, who wants to anticipate changes and prepare itself for them. Power market of the future will be even closer to real time so experiences from demo are of high importance.

Table 8: RTE individual exploitation plan

Partner	Réseau de Transport d'Electricité (RTE)
Organisation profile	Public Organisation
Strategic focus areas	Transmission System Operator
How is OSMOSE project relevant to your organisation	As a Transmission System Operator, RTE has for mission to improve the efficiency of the power system while ensuring its security. OSMOSE project is at the core of our mission in order to work the optimization of the flexibilities offered by power system stakeholders.
What content could be exploited?	The content that could be exploited are mainly immaterial assets such as knowledge, methodologies, requirements, feedbacks from stakeholders and tests results.
Approach to exploitation	The balancing markets of the European power system is under strong evolutions related to Network Codes requirements and Clean Energy Package for all Europeans. Investigations of new solutions regarding the utilization of flexibilities close to real time, the possible coordination schemes between TSO, the requirements of bid providers and obstacles are of strong interest for the public discussion. It also makes possible to trigger innovation

	in this field to design future market design with a real proof of concept linked to a demonstrator. Moreover, it allows us to use optimization procedures and methodologies for our internal tools and bring feedbacks from a large-scale experiment saving time, hurdles and finally costs.

6 Conclusion

This deliverable provides an analysis of technological and economic impacts of the proposed flexibility integration and support services. Technical barriers for scaling and replicate the technologies developed in the WP6 are identified and some guidelines are reported as well. The document provides the impact analysis of the performed field tests and considerations related to interoperability issues, standardization guidelines and exploitable results. The dissertation starts from the costs benefits analysis of the two platforms for the management and the processing of the FlexEnergy bids in the FlexEnergy cross-border market. In order to collect information necessary for filling in this section, ENG circulated a questionnaire among TSOs and Flexibility providers of the Consortium. The elaboration of the partners answer has pointed out the economic advantages and technical issues of the WP6 outcomes. All the partners agree in the expectation of increasing revenues using the platforms and in benefits due to working close-to-real-time and to assess the unused flexibility. At the same time, the profits estimation is strictly determined by the volume exchanged on the platforms, thus, quantifying such profits is not easy since it depends on the liquidity of this new market. The Flexibility providers do not expect further costs tied to the use of the platforms and foreseen an increase of the revenues. The TSOs expect substantial savings within the grid reinforcement and utilization of the existing power transmission infrastructure.

This deliverable also describes standardization procedures and guidelines that have to be considered to effectively introduce the platforms in the market. ELES as TSO has highlighted the importance of using of ECCo SP, recognized by ENTSO-E, in substitution of sFTP, currently used by the OSMOSE platforms. Flexibility providers have provided specific guidelines for adapting the proposed solution to a variety of different storage technologies mainly focusing on the development of an effective FEM-CM.

The last chapter is dedicated to the exploitation plan limited to the WP6 results. The contribution of all partners has been essential for providing the individual exploitation plans, relating to the single business of the Consortium partners, and the overall exploitation plan for which the cooperation of the partners is expected. The analysis has pointed out the importance of the tools which allow to work near-to-real time and the opportunity to integrate the platforms in other cross-border markets. This represents a great opportunity for the European market since the system could be replicated in similar circumstances in Europe.

7 Annex A: questionnaire template

7.1 Introduction to the questionnaire

7.1.1 Questionnaire Purpose

In order to collect the information necessary for filling the section 2.2 “Cost benefits analysis” of D6.6, ENG kindly asks the partners **ELES, TERNA ENEL, HSE** and **HDE** to provide their contribution answering the questions below, **taking in mind that the answers will be used for providing considerations about the economic impact of WP6 output**.

7.1.2 Relation to D6.6

Section 2.2 of D6.6 “Costs benefits analysis” will report the Value proposition Canvas and the Costs and benefits analysis for TSO and Flexibility providers.

The Value proposition Canvas is a business tool that will be used for pointing out the main benefits and drawbacks of the platforms implemented in the WP6 by comparing their features with the needs identified for and by their customers. (TSOs and Flexibility providers). This business tool, indeed, is composed of two parts (Figure 5): the customer profile, in which the needs of the customer are described, and the value proposition, that reports the value proposition tailored for that customer.

Section 2.2 will also provide a Costs & benefits analysis from the customers points of view, still relating to the solution developed in the WP6. Thus, the survey contains questions referring to the costs and benefits expected by the partners in using the technology.

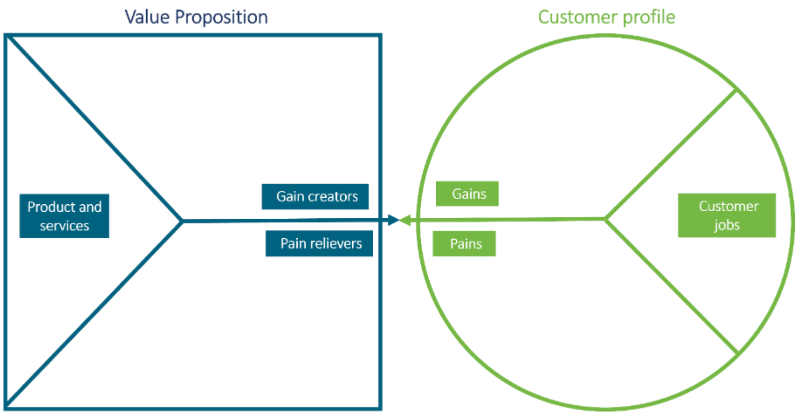

Figure 5: Value proposition Canvas template

7.1.3 WP6 output: FEMP and EMP

The output of the WP6 involves the implementation of two platforms:

- The Energy Management Platform (EMP), for the calculation and creation of FlexEnergy Bids and making them available on local and cross-border (regional) markets.

- The FlexEnergy Market Platform (FEMP), able to manage the cross-border exchange capability in real-time.

The EMP is made up of:

- The FlexEnergy Bid Calculation Modules (FEB-CM) which can differ from one FEB provider to another.
- FEB Creator Tool (FEB-CT) which accepts the FEB-CM results and creates different FEBs.

The FEMP is made up of three modules:

- Electricity Network for Market (EN4M) is a platform for real-time preparation of network data (snapshot models provided from state estimators from each TSO every 5 or 15 minutes) and automatic creation of merged real-time regional model and lists of Critical Branches/Critical Outages (CB/COs).
- FEB pre-processing and merge (FEBPP) is responsible for performing the quality check of FEB. Following this, valid FEBs are merged into a single file that is the input of OPT. It is also included the FEB Activation Module (FEB-AM), which activates selected bids and monitors their activation.
- Optimisation Platform (OPT), which selects which FEB will be activated.

7.2 Questionnaire

1. Please select what type of partner you are.
   ☐ TSO ☐ Flexibility Provider

2. Please briefly describe the services you offer as TSO/Flexibility provider.

   Please provide your contribution here

3. In providing your activity, which are the main goals you try to achieve for satisfying your customers and the results you yearn for?

   Please provide the answer trying to stress the aspects related to the flexibility integration and the flexibility support services.

4. Could you list any risks and/or issues have you identified, during your activity, that would you like to overcome?

   Ex. Lost the energy residuals is an issue that, as Flexibility provider, I would like to overcome.

5. Which are the main benefits that you expect to achieve using the EMP and FEMP? Does the use of the platforms provide economic advantages? If yes, please point out the related costs.

   Ex. As Flexibility providers, I expect to improve the current management of energy residuals using the platforms.

6. Which are the features of the platforms, or eventually of their modules, that you consider the most useful and/or innovative for your activity?

   Ex. The FEB-CM which can differ from one FEB provider to another.

7. On the other hand, which features of the platforms would you consider the drawbacks of the technology? Would you detect some risks/issues that could occur using the platforms?

   Please provide your contribution here.

8. Would the platforms generate benefits and advantages for your customers? If yes, which and how. Social benefits, functional, and financial gains can be considered in this context.

   Please provide your contribution here.

9. In order to understand the economic impact of the proposed flexibility integration and support services, please point out the main costs that, in your opinion, are tied to the use of the technology, for example those costs that could be decreased by the use of the platform.

   Ex. of costs: Operation and maintenance (O&M) costs, Personnel costs, Research and development (R&D) costs, Capex and Opex, Marketing and Promotion costs, Infrastructural costs, equipment costs, Consulting costs, etc.

7.3 Questionnaire filled in by ENEL

1. Please select what type of partner you are.
   ☐ TSO ☒ Flexibility Provider

2. Please briefly describe the services you offer as TSO/Flexibility provider.

   Enel participates in the flexibility service with a single generation hydroelectric unit. We make available on the unit in production the residual amount of energy not reserved by the TSO

3. In providing your activity, which are the main goals you try to achieve for satisfying your customers and the results you yearn for?

   We try to achieve two objectives: to make it possible to participate in as many units as possible and to maximize the asset by exploiting all available capacity.

4. Could you list any risks and/or issues have you identified, during your activity, that would you like to overcome?

   We have had to overcome obstacles relating to the harmonization of the service between Italian operators and have to identify the individual quarter-hours that can participate in the service (units in production, availability of secondary regulation, quantities not reserved by Terna)

5. Which are the main benefits that you expect to achieve using the EMP and FEMP? Does the use of the platforms provide economic advantages? If yes, please point out the related costs.

   The system allows you to quickly identify the quarter of an hour mentioned in the previous point. It therefore makes it possible to offer in a convenient and rapid way on the market and therefore to exploit the quantities of residual energy.

6. Which are the features of the platforms, or eventually of their modules, that you consider the most useful and/or innovative for your activity?

   The main development I can imagine is to allow a service (Web service or API) that allows automatic interfacing with flat dispatch systems. Another development point could be the interface with the Ws Terna to download the useful data automatically.

7. On the other hand, which features of the platforms would you consider the drawbacks of the technology? Would you detect some risks/issues that could occur using the platforms?

   We did not find any particular weaknesses. Perhaps the only point concerns the access policies which in case of exercise should be adequately.

8. Would the platforms generate benefits and advantages for your customers? If yes, which and how. Social benefits, functional, and financial gains can be considered in this context.

   The benefits are above all economic because they allow you to participate in a new market and increase the profitability of the assets.

9. In order to understand the economic impact of the proposed flexibility integration and support services, please point out the main costs that, in your opinion, are tied to the use of the technology, for example those costs that could be decreased by the use of the platform.

The service studied and implemented with hydroelectric production plants necessarily needs to have the plant in service otherwise it would not be able to provide it. In this specific case, the associated costs are those related to the management of the system itself and to the need to program the unit in service. This same approach can be used regardless of the technology used for the service. Costs could be reduced by using faster and more flexible resources such as the BESS (Battery Energy Storage System) which guarantee much faster entry into service times.

10. Sub-Task 6.7.1 of Grant reports: "…In close cooperation with WP1 and 2, and the different demonstrations, a technoeconomic framework able to quantify the impacts of extrapolated flexibility support and integration services, will be developed. This framework will leverage on a variety of different **service delivery models,** within which different revenue sharing modalities among the interested stakeholders will be considered." Do you know which kind of service delivery models it is referred to? This work should be done in relation to the outcome of Sub-Task 2.5.2 (**D2.5** due at M44 – RSE Responsibility. This deliverable is **pending, and a preliminary draft will be available only on January 2022**).

7.4 Questionnaire filled in by HDE

1. Please select what type of partner you are.
   ☐ TSO ☒ Flexibility Provider

2. Please briefly describe the services you offer as TSO/Flexibility provider.

   HDE operates and manages hydropower plants. The Company offers its ability to flexibly generate electricity to both the Energy and Dispatching Market.

3. In providing your activity, which are the main goals you try to achieve for satisfying your customers and the results you yearn for?

   We expect to increase our economic profits because of the price of energy traded on such close-to-delivery markets is expected to be higher than the current markets. This should be even more true considering the further penetration of RES which are expected to increase the value of the flexibility of the plants able to guarantee it. However, quantifying such profits is not easy because it has to do with the liquidity of this new market.

4. Could you list any risks and/or issues have you identified, during your activity, that would you like to overcome?

   Near-to-real-time markets may help in optimizing the energy not used in the previous market sessions as well as in limiting the possible unbalances caused by changes in the "boundary conditions", i.e., in the case of hydropower plants an unexpected weather evolution.

5. Which are the main benefits that you expect to achieve using the EMP and FEMP? Does the use of the platforms provide economic advantages? If yes, please point out the related costs.

   A better optimization of the energy not used in the previous market sessions or whose availability could not be forecasted earlier.

6. Which are the features of the platforms, or eventually of their modules, that you consider the most useful and/or innovative for your activity?

   The two most useful features are:

   - the possibility to fully exploit the flexibility offered by dispatchable power plants
   - the possibility to better integrate non-dispatchable renewable energy sources in the Energy Market. In fact, the FEB-CM “INDRES” allows to nowcast the power produced by such plants, which can be valorised through a market such as FlexEnergy Market.

7. On the other hand, which features of the platforms would you consider the drawbacks of the technology? Would you detect some risks/issues that could occur using the platforms?

   The greater risk is related to possible little liquidity on such a market platform.

8. Would the platforms generate benefits and advantages for your customers? If yes, which and how. Social benefits, functional, and financial gains can be considered in this context.

   It depends on the volume exchanged on the platform. In principle, increased profits are expected. If the quantity of energy optimized is significant, social (i.e. a lower cost of energy for the system) and functional (i.e. higher share of non-dispatchable RES can be integrated in the energy system) benefits are expected thanks to the increased availability of flexibility resources allowed by FlexEnergy Market.

9. In order to understand the economic impact of the proposed flexibility integration and support services, please point out the main costs that, in your opinion, are tied to the use of the technology, for example those costs that could be decreased by the use of the platform.

   Once the technology to exploit such close-to-delivery service is deployed, we do not expect further costs related to its use (beside standard O&M costs). We don’t expect any cost to decrease by using FEMP, but to increase our revenues (as explained above).

10. Sub-Task 6.7.1 of Grant reports: “…In close cooperation with WP1 and 2, and the different demonstrations, a technoeconomic framework able to quantify the impacts of extrapolated flexibility support and integration services, will be developed. This framework will leverage on a variety of different **service delivery models,** within which different revenue sharing modalities among the interested stakeholders will be

considered." Do you know which kind of service delivery models it is referred to? This work should be done in relation to the outcome of Sub-Task 2.5.2 (**D2.5** due at M44 – RSE Responsibility. This deliverable is **pending, and a preliminary draft will be available only on January 2022**).

7.5 Questionnaire filled in by HSE

1. Please select what type of partner you are.
   ☐ TSO ☒ Flexibility Provider

2. Please briefly describe the services you offer as TSO/Flexibility provider.

   Currently we provide ancillary services to the TSO. As a "flexibility owner" we also use the flexibility on the wholesale markets. In OSMOSE WP6 we're investigating the potential of a near-to-real time wholesale flexibility market where we provide buy and/or sell FlexEnergy bids (FEBs).

3. In providing your activity, which are the main goals you try to achieve for satisfying your customers and the results you yearn for?

   As a company that is present on a competitive market the result is usually measured in financial effects for the company. On the other side, the main goal for the customer or, in particular case of OSMOSE WP6, is to provide and deliver FEBs.

4. Could you list any risks and/or issues have you identified, during your activity, that would you like to overcome?

   For OSMOSE WP6 the flexibility is provided from the hydropower plants (HPP) which are Run-on-river. This means that the flexibility in subject to the available hydrology. If the hydrology is too high or too low, there's little space for flexibility.

5. Which are the main benefits that you expect to achieve using the EMP and FEMP? Does the use of the platforms provide economic advantages? If yes, please point out the related costs.

   Main benefit is having a tool which indicates how much energy (flexibility) is still left in the portfolio for near-to-real time market activities. This information is also useful for covering the outages inside the portfolio.

6. Which are the features of the platforms, or eventually of their modules, that you consider the most useful and/or innovative for your activity?

   FEB-CM since it contains a unit-based representation of the portfolio.

7. On the other hand, which features of the platforms would you consider the drawbacks of the technology? Would you detect some risks/issues that could occur using the platforms?

   FEB-CM works ok for near-to-real time actions however, for safety reasons more market time units should be considered for the calculation which makes the tool slow.

8. Would the platforms generate benefits and advantages for your customers? If yes, which and how. Social benefits, functional, and financial gains can be considered in this context.

   Supposing every bid has a fair price, an exchange of the FlexEnergy should result in financial gains. If these bids come from balancing inside the portfolio or balancing the difference between "forecasts" and "nowcasts" there are other benefits too.

9. In order to understand the economic impact of the proposed flexibility integration and support services, please point out the main costs that, in your opinion, are tied to the use of the technology, for example those costs that could be decreased by the use of the platform.

   If case of further development and functional market, balancing costs could be decreased.

10. Sub-Task 6.7.1 of Grant reports: "…In close cooperation with WP1 and 2, and the different demonstrations, a technoeconomic framework able to quantify the impacts of extrapolated flexibility support and integration services, will be developed. This framework will leverage on a variety of different **service delivery models,** within which different revenue sharing modalities among the interested stakeholders will be considered." Do you know which kind of service delivery models it is referred to? This work should be done in relation to the outcome of Sub-Task 2.5.2 (**D2.5** due at M44 – RSE Responsibility. This deliverable is **pending, and a preliminary draft will be available only on January 2022**).

    Our best guess is that by "service delivery model" is understood as "a way how to deliver or make the flexibility work".

7.6 Questionnaire filled in by ELES

1. Please select what type of partner you are.
   ☒ TSO ☐ Flexibility Provider

2. Please briefly describe the services you offer as TSO/Flexibility provider.

   Safe and reliable operation of Slovenia's electric power transmission system.

3. In providing your activity, which are the main goals you try to achieve for satisfying your customers and the results you yearn for?

   To provide electricity uninterrupted 24/7 to the end users/consumers. To enable secure operation of the electric system in the future due to high penetration of the RES in the ENTSO E interconnection.

4. Could you list any risks and/or issues have you identified, during your activity, that would you like to overcome?

Due the higher and higher share of the RES in the ENTSO E interconnection the frequency of the system is becoming more and more unstable due the stochastic events that cannot be foreseen. With the mechanism developed within OSMOSE WP 6 we would like to gain the insights, how can be influenced on the targeted cross border exchanges of the RES hydro activations in the spite of congestion management and power flow redirection, etc.

5. Which are the main benefits that you expect to achieve using the EMP and FEMP? Does the use of the platforms provide economic advantages? If yes, please point out the related costs.

   Try to define new intraday products of the better utilization of the RES units. Targeted congestion management for power flow redirection. Set the foundation for the nodal pricing.

6. Which are the features of the platforms, or eventually of their modules, that you consider the most useful and/or innovative for your activity?

   All of the SW modules of the FEM platform. Especially EN4M tool which must be used in upcoming projects due the observability of the grid and forming common grid model.

7. On the other hand, which features of the platforms would you consider the drawbacks of the technology? Would you detect some risks/issues that could occur using the platforms?

   sFTP protocols. They should be substituted with Ecco SP platform which is accepted by ENTSO E.

8. Would the platforms generate benefits and advantages for your customers? If yes, which and how. Social benefits, functional, and financial gains can be considered in this context.

   Developing of the platforms like FEM are crucial for the green transition in the light of RES integration in the grid and ancillary services for TSO’s that will arise from them.

9. In order to understand the economic impact of the proposed flexibility integration and support services, please point out the main costs that, in your opinion, are tied to the use of the technology, for example those costs that could be decreased by the use of the platform.

   When the technologies and products (SW and HW) will rich TRL 9, they will significantly reduce the investments costs in the reinforcement of the TSO’S globally.

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