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Project flyer & brochure (N3)

D11.20

EU-SysFlex

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ABBREVIATIONS AND ACRONYMS

EC-GA	Grant Agreement
EU-SYSFLEX	Pan-European System with an efficient coordinated use of flexibilities for the integration of a large share of Renewable Energy Sources (RES)
PC	Project Coordinator
PMB	Project Management Board
WP	Work Package

EXECUTIVE SUMMARY

The following report addresses the requirement for deliverable 11.19 “Project flyer & brochure” associated with task 11.2 “Visual identity and communication/dissemination infrastructure”. The report summarizes the content, design and workflow done during the preparation of the project flyer, brochure, and roadmap summary.

This document outlines the second project flyer, brochure, and roadmap summary as a part of the deliverable ‘Project flyer & brochure’. It has been created for multiple stakeholders and is based on all previous communication materials (such as flyer, project overview presentation, website, infographics, posters from General Assembly, video etc.), submitted deliverables, Grant Agreement, and contribution from project partners. The intent of the flyer and the brochure is to provide more detailed information on project (its aims, solutions, partners involved, work packages etc.) and invite stakeholders to follow the project on the website and social media channels.

Publishing the brochure and the flyer at the same time would mean that both communication materials would provide the same information. Therefore, to maximize the impact of the project with the new information and results, we consider that the best way to do so is to separate both materials. This way we can ensure that the flyer and the brochure will contain different information and will cover a longer period of the project.

As it was agreed within the PMB, the final report was to be issued at the end of the project to summarise the main outputs and outcomes of the project, and potential exploitation of the project results. This final report was decided to be replaced by the roadmap summary as a document efficiently summarizing all the important outcomes of the project.

The deliverable is prepared by the WP11 Leader and approved by the Project Management Board.

1. PROJECT FLYER #2

1.1 CONTENT

The second flyer of the project consists of eleven pages, what makes it rather smaller brochure than the flyer. However, partners opted for such a longer document since it was decided to rather spend the resources on the comprehensive materials and have one less flyer than agreed in the DoA. Moreover, due to the outbreak of COVID-19, the material was developed to be used mainly online. Project officer was informed about this change.

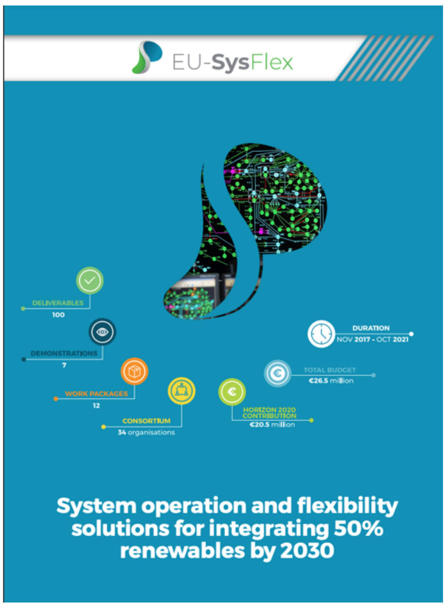
The flyer consists of the main project information such as: duration of the project, budget, overview of the consortium and contact information. The content of the flyer is focused on the project news and updates regarding innovations in product and market design, news from demonstrations and trial and introduces what the next steps shall be.

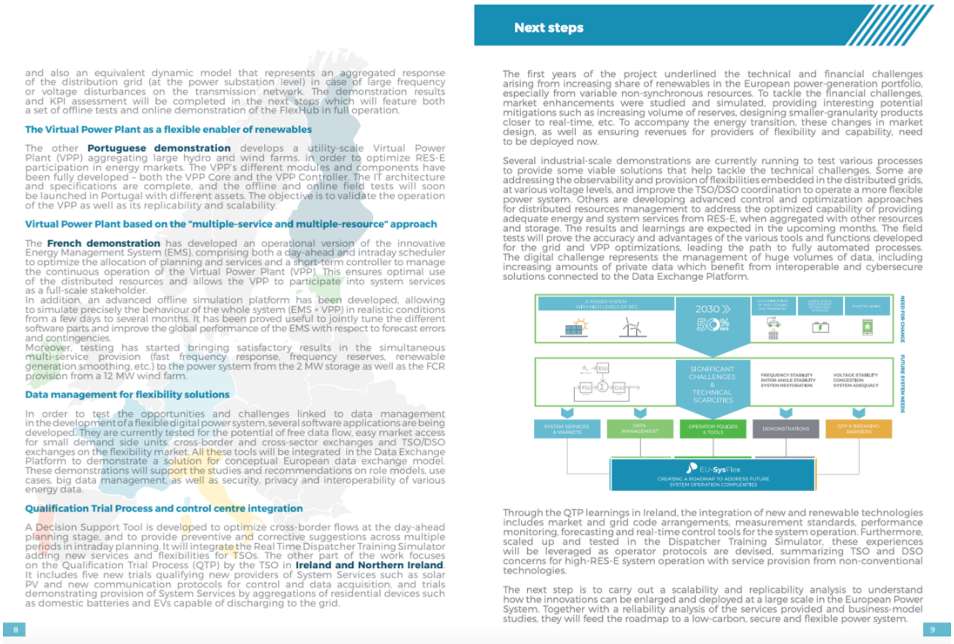
In more detail:

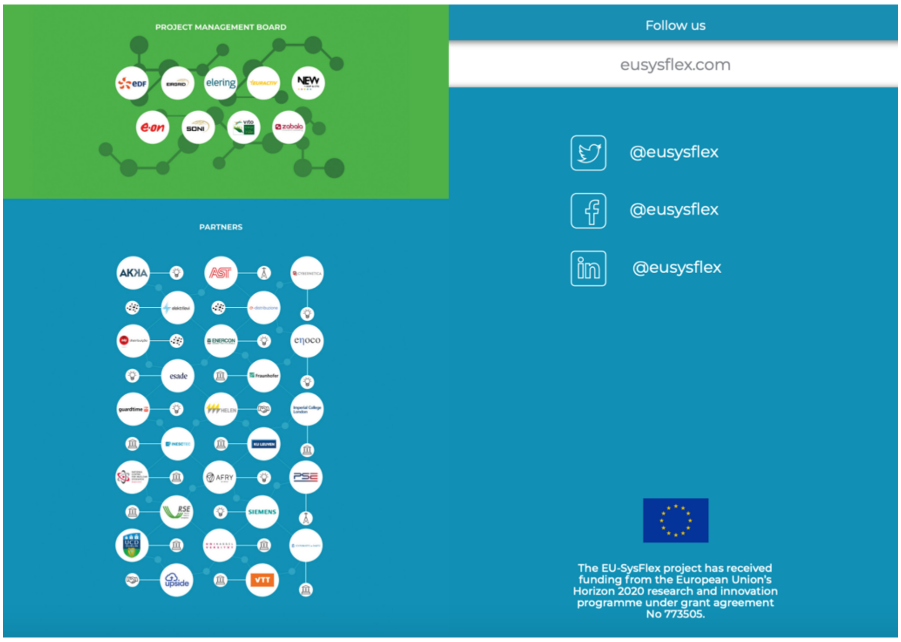
- First part of the flyer describes highlighted results of the WP2: New approaches for System Operation with high of RES-E
- Second part covers the outputs of the WP3: Market Design and Regulatory Options for innovative services
- Third part focuses on the news in the project demonstrations and trial
- Fourth part is focused on the next steps in the development of the main project output: The European Power System Flexibility Roadmap (WP10)
- These chapters are supplemented by the key project info and list of the partners involved.

1.2 DESIGN

The design of the project flyer was created by external graphic designer, who also is the graphic designer behind the project logo and visual identity. The design of the flyer is therefore based on the visual identity of the EU-SysFlex and in line with its design manual. Selected screenshots of the flyer are displayed below. Full flyer is attached in PDF format at the end of this document.







1.3 WORKFLOW

At the beginning of the 2020, WP11 leader prepared a plan for the next version of the project flyer and brochure. PMB members discussed this plan and agreed on the approach.

When discussing development of our second project flyer we agreed that the best approach might be to focus on developing rather a document that would be used online. The need for printed fliers has been limited by the outbreak of COVID-19: due to the anti-pandemic measures we were not able to organize or be part of any physical workshops in 2020. The project outputs and results that we have, needed to be shared with stakeholders (for example on webinars) by the online project flyer, with an adapted format, different from our previous one.

Upon an agreement within the PMB, WP11 leader prepared a proposal for the new project flyer together with the project coordinator. This proposal was presented to the PMB and afterwards, partners started their work on the texts and infographics for the new flyer. All the content was prepared in the close cooperation with the partners responsible for the WPs covered in the brochure. After several updates of the flyer, the final version was approved by the PMB. The flyer was published on the project website and social media in April 2021. WP11 leader developed a short article describing a news dissemination material and shared the flyer with the consortium. The flyer was promoted during webinars and presentations of the project partners. The flyer is available for download on the project website (in front page and the section 'Documents').

2. PROJECT BROCHURE #2

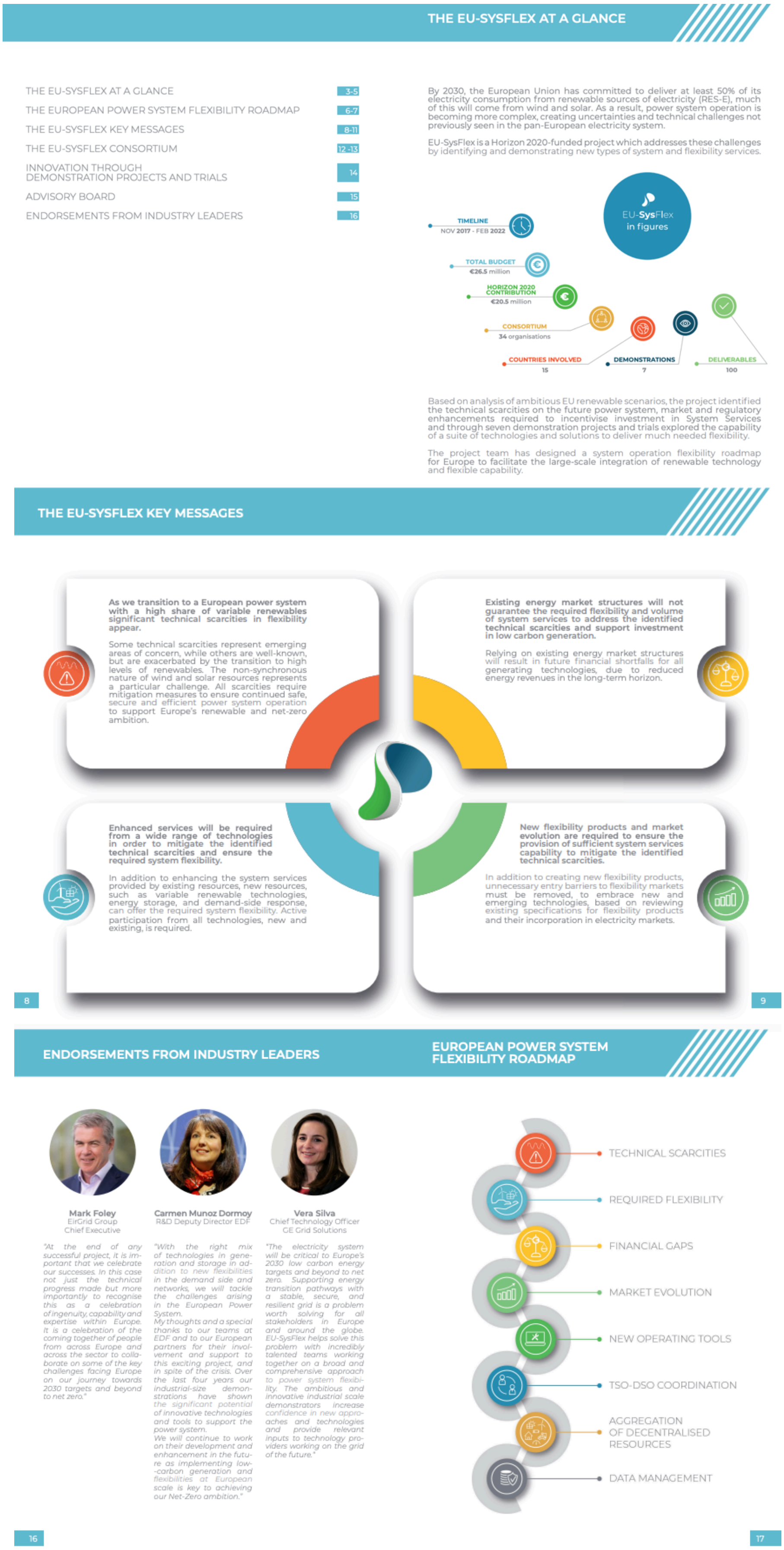
2.1 CONTENT

The second project brochure consists of 18 pages. As for the project flyers, the same approach was used for development of the brochures. Partners agreed that the first brochure provided sufficient information on the project, its aims and expected outputs. Therefore, it was agreed that the resources will be better spend when the new version of the brochure will be developed only for the last period of the project when the main outputs would be ready for publication. Due to this decision, additional resources could be spent on the development of the project overview presentation and infographics for the project website. Project officer was informed about this development.

The flyer consists of the main project information such as: duration of the project, budget, overview of the consortium, advisory board, Bridge initiative, demonstrations, and contact information. Focus of this flyer is the European Power System Flexibility Roadmap and its eight key messages. These contents are supplemented with the texts and infographics informing about the aims of the EU-SysFlex project, infographics of the roadmap and quotes on the project by the industry leaders.

2.2 DESIGN

The design of the project brochure was created by external graphic designer, who also is the graphic designer behind the project logo and visual identity. The design of the brochure is therefore based on the visual identity of the EU-SysFlex and in line with its design manual. Selected screenshots of the brochure are displayed below. Full flyer is attached in PDF format at the end of this document.



THE EU-SYSFLEX AT A GLANCE

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By 2030, the European Union has committed to deliver at least 50% of its electricity consumption from renewable sources of electricity (RES-E), much of this will come from wind and solar. As a result, power system operation is becoming more complex, creating uncertainties and technical challenges not previously seen in the pan-European electricity system.

EU-SysFlex is a Horizon 2020-funded project which addresses these challenges by identifying and demonstrating new types of system and flexibility services.

EU-SysFlex in figures

TIMELINE: NOV 2017 - FEB 2022
TOTAL BUDGET: €26.5 million
HORIZON 2020 CONTRIBUTION: €20.5 million
CONSORTIUM: 34 organisations
COUNTRIES INVOLVED: 15
DEMONSTRATIONS: 7
DELIVERABLES: 100

Based on analysis of ambitious EU renewable scenarios, the project identified the technical scarcities on the future power system, market and regulatory enhancements required to incentivise investment in System Services and through seven demonstration projects and trials explored the capability of a suite of technologies and solutions to deliver much needed flexibility.

The project team has designed a system operation flexibility roadmap for Europe to facilitate the large-scale integration of renewable technology and flexible capability.

THE EU-SYSFLEX KEY MESSAGES

As we transition to a European power system with a high share of variable renewables significant technical scarcities in flexibility appear.

Some technical scarcities represent emerging areas of concern, while others are well-known, but are exacerbated by the transition to high levels of renewables. The non-synchronous nature of wind and solar resources represents a particular challenge. All scarcities require mitigation measures to ensure continued safe, secure and efficient power system operation to support Europe's renewable and net-zero ambition.

Existing energy market structures will not guarantee the required flexibility and volume of system services to address the identified technical scarcities and support investment in low carbon generation.

Relying on existing energy market structures will result in future financial shortfalls for all generating technologies, due to reduced energy revenues in the long-term horizon.

Enhanced services will be required from a wide range of technologies in order to mitigate the identified technical scarcities and ensure the required system flexibility.

In addition to enhancing the system services provided by existing resources, new resources, such as variable renewable technologies, energy storage, and demand-side response, can offer the required system flexibility. Active participation from all technologies, new and existing, is required.

New flexibility products and market evolution are required to ensure the provision of sufficient system services capability to mitigate the identified technical scarcities.

In addition to creating new flexibility products, unnecessary entry barriers to flexibility markets must be removed, to embrace new and emerging technologies, based on reviewing existing specifications for flexibility products and their incorporation in electricity markets.

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ENDORSEMENTS FROM INDUSTRY LEADERS

Mark Foley
EirGrid Group
Chief Executive

"At the end of any successful project, it is important that we celebrate our successes. In this case not just the technical progress made but more importantly to recognise this as a celebration of ingenuity, capability and expertise within Europe. It is a celebration of the coming together of people from across Europe and across the sector to collaborate on some of the key challenges facing Europe on our journey towards 2030 targets and beyond to net zero."

Carmen Munoz Dormoy
R&D Deputy Director EDF

*"With the right mix of technologies in generation and storage in addition to new flexibilities in the demand side and networks, we will tackle the challenges arising in the European Power System.
My thoughts and a special thanks to our teams at EDF and to our European partners for their involvement and support to this exciting project, and in spite of the crisis. Over the last four years our industrial-size demonstrations have shown the significant potential of innovative technologies and tools to support the power system.
We will continue to work on their development and enhancement in the future as implementing low-carbon generation and flexibilities at European scale is key to achieving our Net-Zero ambition."*

Vera Silva
Chief Technology Officer
GE Grid Solutions

"The electricity system will be critical to Europe's 2030 low carbon energy targets and beyond to net zero. Supporting energy transition pathways with a stable, secure, and resilient grid is a problem worth solving for all stakeholders in Europe and around the globe. EU-SysFlex helps solve this problem with incredibly talented teams working together on a broad and comprehensive approach to power system flexibility. The ambitious and innovative industrial scale demonstrators increase confidence in new approaches and technologies and provide relevant inputs to technology providers working on the grid of the future."

EUROPEAN POWER SYSTEM FLEXIBILITY ROADMAP

- TECHNICAL SCARCITIES
- REQUIRED FLEXIBILITY
- FINANCIAL GAPS
- MARKET EVOLUTION
- NEW OPERATING TOOLS
- TSO-DSO COORDINATION
- AGGREGATION OF DECENTRALISED RESOURCES
- DATA MANAGEMENT

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2.3 WORKFLOW

Several months prior to the finalization of the project, WP11 leader begun discussions with the project leaders (Project Coordinator and Technical Manager). This small team developed a timeline and proposal for the development of the final brochure. This proposal was presented to the PMB and the work begun. Leader of the roadmap (UCD) joined the small team and they worked together on the content of the brochure. After the consent on the content was established, WP11 leader contacted the graphic designer and started working on the design of the brochure. After several updates of the brochure, the material was pre-approved by the small team and presented to the PMB for their revision. All the comments of the PMB were closely considered and most of them were incorporated into the final version of the brochure.

The brochure will be published on the project website and social media channels, consortium will receive the final version via email as well. Material will be promoted via project channels, newsletter and partners will be asked to disseminate the final brochure as well. The brochure will be available for download on the project website (in front page and the section 'Documents').

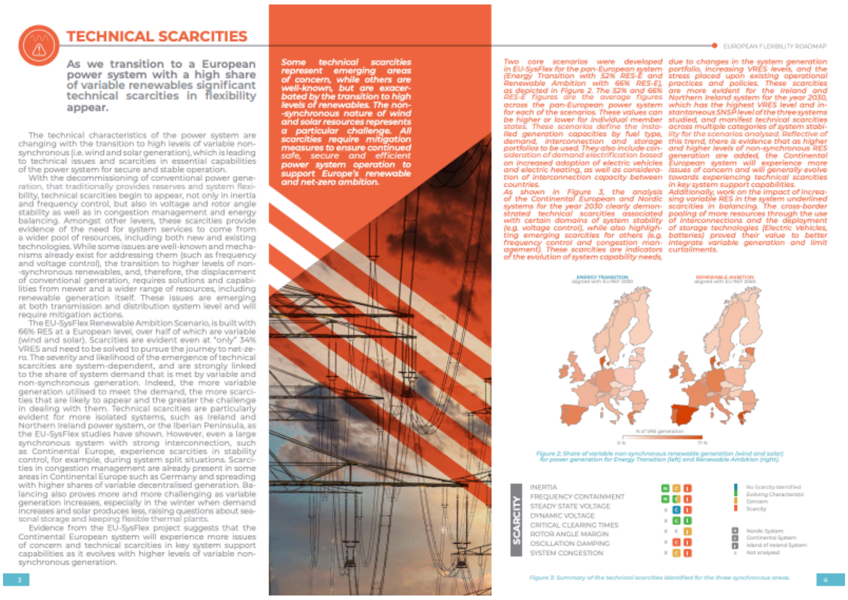
3. THE EUROPEAN POWER SYSTEM FLEXIBILTY ROADMAP: SUMMARY

3.1 CONTENT

The content of the roadmap summary was developed by the WP10, roadmap leader and all the partners involved. Once mostly finalised version was ready, WP11 leader contacted the graphic designer and worked closely with the roadmap leader, project coordinator and the technical manager on the graphic completition of the document.

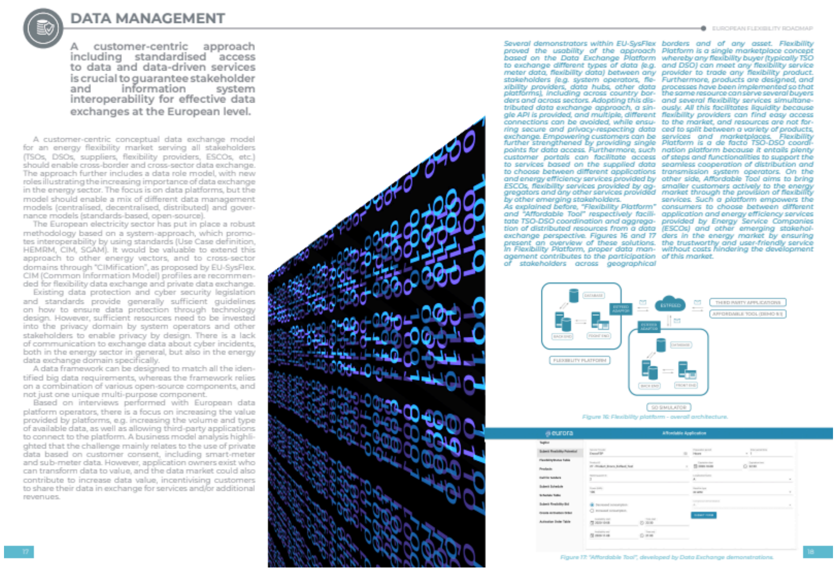
3.2 DESIGN

The design of the roadmap summary was created by external graphic designer, based on the proposal of the partners. The design of the summary is based on the visual identity of the EU-SysFlex and in line with its design manual. Selected screenshots of the summary are displayed below. Full summary will be available on the project website.



TECHNICAL SCARCITIES

As we transition to a European power system with a high share of variable renewables significant technical scarcities in flexibility appear.



DATA MANAGEMENT

A customer-centric approach including standardised access to data and data-driven services is crucial to guarantee stakeholder and information system interoperability for effective data exchanges at the European level.

3.3 WORKFLOW

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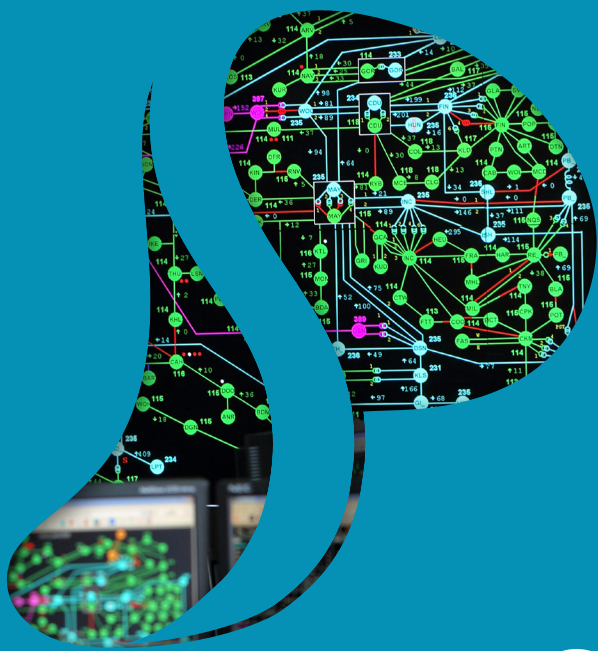
EU-SysFlex



DELIVERABLES
100

DEMONSTRATIONS
7

WORK PACKAGES
12

CONSORTIUM
34 organisations

HORIZON 2020 CONTRIBUTION
€20.5 million

TOTAL BUDGET
€26.5 million

DURATION
NOV **2017** - OCT **2021**

System operation and flexibility solutions for integrating 50% renewables by 2030

Development of new approaches for system operation with a high share of renewables

EU-SysFlex has developed several scenarios where renewables meet at least 50% of the total annual demand in the pan-European Power System. There are two Core scenarios which have 50% and 65% RES-E as the referral to the EU goals. Network Sensitivities were also developed, either to reflect even more ambitious policies (e.g. for the Ireland and Northern Ireland power system) or to analyse the impact of some technology choices on any given power system, e.g. higher solar penetration for the Nordic system, or higher levels of distribution-connected renewables for the Eastern European area.
Various stimuli were applied while combining unit commitment models with network and dynamic models. As a result, thousands of simulations were conducted in order to identify technical scarcities emerging in the European System with the transition to high variable RES-E penetration levels. The scarcity analysis led to the conclusions below:

- With decreasing shares of synchronous machines in the power system, **inertia is falling** across Europe, as well as in the Nordic and the Ireland and Northern Ireland power systems. This is leading to **higher rates of change of frequency (RoCoF) and challenges with containing frequency and maintaining frequency stability** particularly in less interconnected areas, such as island systems and weakly connected peninsulas, but also in the Pan-European system where a system split occurs.

- In the systems for which steady state voltage regulation was studied, higher renewable penetrations exposed **a scarcity in voltage control**. The Ireland and Northern Ireland system exhibits a **clear deterioration of fault levels and a dynamic voltage regulation scarcity**. While the model and cases analysed for continental Europe did not demonstrate any conclusive evidence of a dynamic voltage scarcity, it is likely that further analysis with a higher level of renewables at a subnetwork level on the continental system would reveal associated scarcities.

- The studies show no global scarcity in stability margin in either system, when assessed through critical clearing times for faults that are cleared by primary protection operation. However, **local issues with rotor angle stability can appear for specific unit commitment combinations, as well as for certain contingencies**.

- **Decentralised renewable penetration increases power injections across all networks and impacts circuit loading.** Congestion management is needed in the transmission and distribution systems, as well as for cross-border flows.

- System restoration is not identified as critical, as long as the availability and reactivity of sufficient black start units are managed actively. **Non-synchronous resources or storage can be used in restoration plans** provided that their variability is anticipated.

Summary of the results from the technical scarcity identification studies

	Continental Europe	Ireland & Northern Ireland
Rate of Change of Frequency	Localised Concern	Inertia Scarcity
Frequency Containment	Evolving Characteristic	Evolving Characteristic
Steady Stage Voltage Regulation	Steady Stage Reactive Power Scarcity	Steady Stage Reactive Power Scarcity
Fault Level	No Scarcity Found	Dynamic Reactive Injection Scarcity
Dynamic Voltage Regulation	No Scarcity Found	Dynamic Reactive Injection Scarcity
Critical Clearing Times	Evolving Characteristic	Evolving Characteristic
Rotor Angle Margin	Not Analysed	Localised Concern
Oscillation Damping	Damping Scarcity	Damping Scarcity
System Congestion	Global Concern	Transmission Capacity Scarcity
System Restoration	Not Analysed	Evolving Characteristic

No Scarcity | Evolving Characteristic | Concern | Scarcity

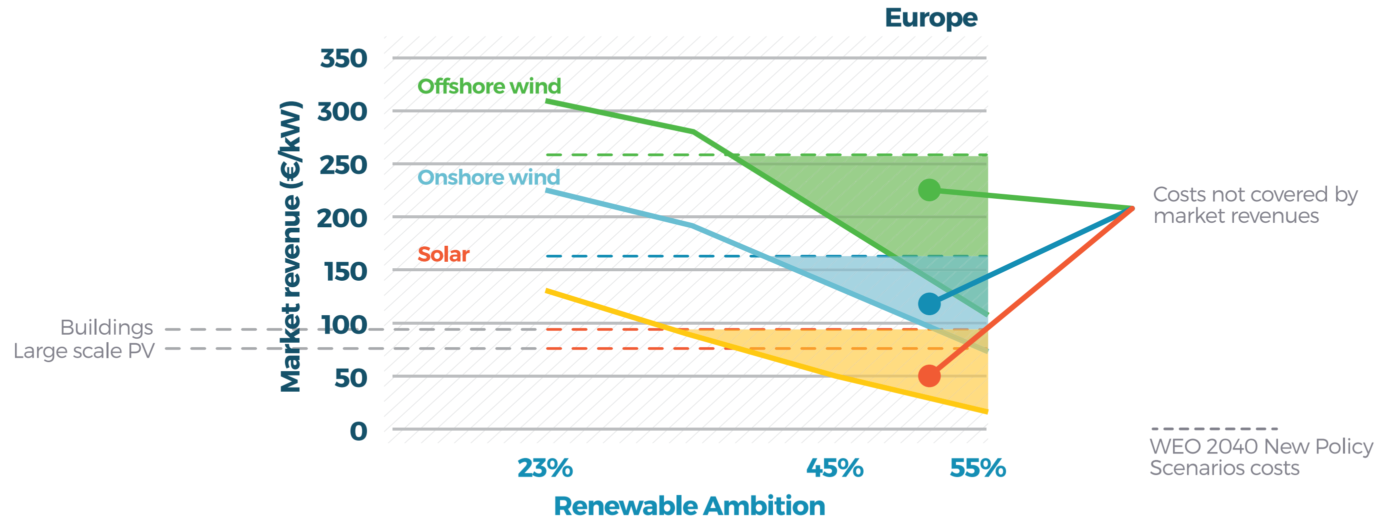
The analysis of the European power systems with high levels of RES-E, and more specifically variable non-synchronous RES-E such as wind and PV, clearly demonstrates a range of technical scarcities. These scarcities are more evident for the higher variable RES-E level targets in the Ireland and Northern Ireland system. These scarcities are indicative of the evolution of the power system and the need to adapt operational practices and policies and ensure there is sufficient capability in the portfolio of resources.
The challenges facing the evolving power system are not only technical; they are also financial. Economic analysis was performed in parallel to the technical simulations and a number of key challenges for the European Power Systems were identified:

- With increasing levels of renewables, it was shown that the capacity factors for peaking plants such as open cycle gas turbines (OCGTs) are also increasing. This indicates that **system operation is fundamentally changing with higher levels of RES-E where high net load ramps are possible and more flexible, fast responding units are a necessity**. While it is being seen that there is an increasing need for fast, flexible plants, it has been shown that if OCGTs are relied upon for providing the required flexibility at high penetrations of variable renewables, that the potential carbon emission reduction benefits from the renewables may be impacted and could taper off at high levels of renewables.

- There is a **downward trajectory of energy market prices** and an increase in time spent with zero marginal prices in future scenarios **leading to falling revenues**.

- There is an increase in the number of technologies not making a profit as a result at very high levels of variable renewables – and not just renewables, but also conventional technology. Clear evidence that an additional revenue stream and/or additional subsidies are required – **system services could be part of this revenue stream** (the value of which needs to be studied more widely but was found to be sufficient to fill the financial gaps for the Ireland and Northern Ireland power system). Additional externalities and positive benefits associated with transition to a power system with high levels of variable renewables exist that are not yet captured in the value of system services.

Annual Market Revenues Fall with Increasing Variable Renewable Share



Innovations in product and market design

A detailed overview of different system services and products (including detailed specifications) for the countries in scope has been realized. A questionnaire has been issued covering innovations in product and market design for future system services. For each system service, the innovation potential with respect to future products providing this service was defined. Examples of existing products were provided as possible blueprint for a generic product or in case no product exists, proposals for new system services were designed. In particular for congestion management, it was observed that no specific products were yet available. Multiple products for congestion management are proposed offering different procurement times to answer the need for congestion management in different time frames.

Business Use Cases for the demonstrations of the project have been elaborated using the roles and product definitions identified above. In addition, a detailed comparison of the different use cases was elaborated to lay a foundation for the research on market design options in the next step. One of the main observations and differences between the demos were the different roles assigned to the distribution system operator (DSO) in the context of procurement and activation of flexibility.

The process to acquire flexibilities for system needs under different selected market and optimisation options was investigated. The results present an analysis of advantages and disadvantages of regulated or market-based procurement for different scarcities. Various approaches for the organization of the flexibility bid selection are examined spanning the range from centralized and decentralized optimization to a distributed market organisation. Additionally, the impact of grid constraints, driven by an increase in renewable energy sources connected to the distribution grid is considered in the flexibility procurement process; then the process itself to solve grid constraints is evaluated for different services. Moreover, the possibility to have joint procurement of different services, in particular the frequency control products (mFRR) and congestion management is discussed as an example accompanied by evaluation of the current market data:

- **Market-based vs regulated organization**

  If market-based is the preferred solution, a regulated organization could still be preferred in some cases, i.e. a regulated approach could be considered in case of insufficient liquidity or transparency, difficulties in pricing of the service, risks related to secure and reliable delivery of the service or the risk of gaming. The relative merits and suitability of regulated and market-based solutions strongly depend on the technical characteristics of the service to be provided.

- **Optimisation methodologies and grid constraint management**

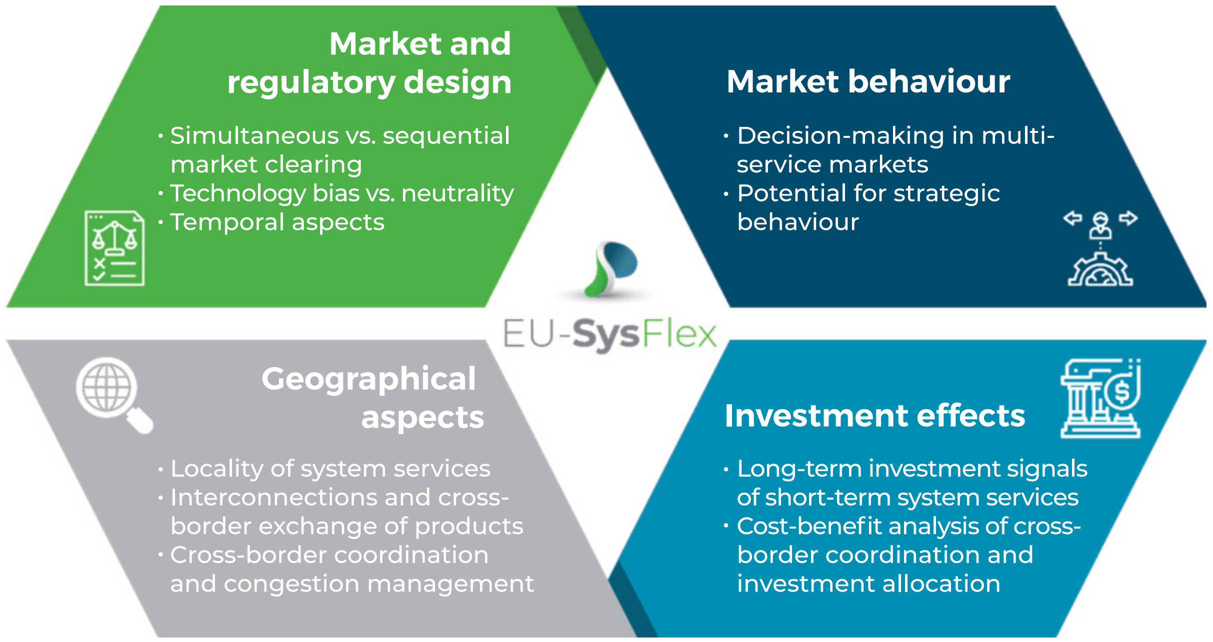
  A new role, the Optimisation Operator – has been introduced in order to separate the process and perform the selection of flexibility bids and analyse the allocation of this task to different stakeholders. Such optimization (also called market clearing) can be carried out in a centralized or decentralized manner and is separated from market organisation. The results show that both centralised and decentralized optimizations can be applied for selecting flexibilities for a large set of products. Different options, regarding the amount and type of grid data shared between the System Operator and the Optimisation Operator have been assessed.

- **Joint procurement of manual frequency restoration reserves (mFRR) and congestion management product**

  Joint procurement of congestion management and mFRR energy products appeared to be the most relevant to be studied due to the similar characteristics of the underlying needs. Possible cases of synergy were identified, and different options were assessed.

Advanced power system and market modelling studies have been deployed, considering both long-term and short-term impacts of these designs on the pan-European power system. The figure below provides an overview of the relevant topics examined within EU-SysFlex.

Overview of research questions related to market design

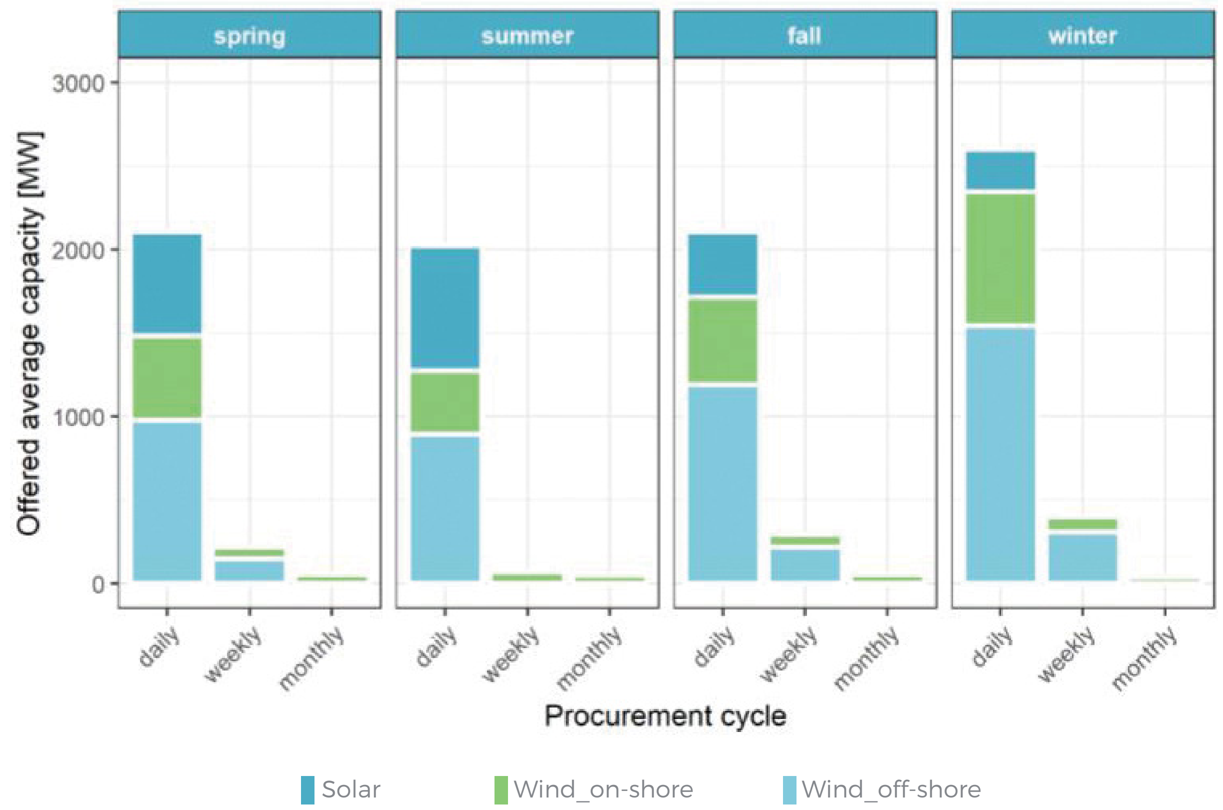


A range of advanced models was used, ranging from flexible Unit Commitment models (stochastic/deterministic, adaptive in terms of considered technologies, interconnections, geographical and temporal scope, etc.) over game theoretic approaches (equilibrium models, bi-level optimization, etc.), agent-based simulations to investment models.

The crucial points of attention are the trade-off between optimality and complexity of the market and control mechanisms, and the role of DSOs in enabling the use of distributed resources. A more complex market clearing algorithm, combining e.g. energy and reserve needs, has to be weighed against the operational and economic benefits. Important elements in the granularity of system service products are the following: the sizing frequency and resolution, the procurement frequency and contract duration.

A weighting between the development of more complex products and market designs against the potential welfare benefits is required. The extent to which market designs allow to fully translate the technical potential into market value is a crucial performance indicator for the market design options. The figure below illustrates the impact of the procurement cycle on the offered capacity of RES-E to provide frequency control. A shorter procurement cycle might increase operational complexity, but this is less important compared to the welfare gains due to higher RES-E participation.

Impact of procurement cycle on the offered capacity of RES-E for frequency control



More complex cross-border market coordination results in an increase in social welfare, however, this may lead to a reduction of security margins (through joint reserve sizing). The mechanisms and benefits of a coordinated network management and investment in network assets including phase-shifting transformers might be broader than the directly affected control zones. Hence, methodologies to share costs and benefit beyond the directly affected control zones offer new possibilities. The impact of system service markets on long-term investments is becoming increasingly crucial. Investment decisions change strongly in the presence/absence of requirements for different system services. The magnitude of the investment signals driven by system services markets will require more attention.

News from demonstrations and trial

Enabling provision of system flexibility from the distribution grid

Three EU-SysFlex demonstrators in Germany, Italy and Finland are analysing and testing opportunities arising from decentralised flexibility resources to serve TSOs' and DSOs' needs. The three demonstrators complement each other in reaching the joint objectives of improving the TSO-DSO coordination, providing ancillary services to TSOs from distribution system flexibilities and investigating how these flexibilities could meet the needs of both TSOs and DSOs.

The **German Demonstrator** is enabling the provision of flexibilities from the meshed high voltage distribution grid. The demonstrator has set up a new coordination process between TSO and DSO to manage increasing congestions in the transmission and distribution grids that arise due to the growing decentralized renewable resources and changing flows. Furthermore, the demonstrator has developed a new automated tool for voltage control and reactive power management. Field tests are currently starting in order to:

- prove the more **efficient voltage control and congestion management,**
- validate the new **processes including data exchange,**
- test the **function of tools** under **online grid operating circumstances,**
- validate the **accuracy of forecasting,**
- analyse the advantages of **combined optimization of active and reactive power**
- and demonstrate the feasibility of a **fully-automated process** for grid optimization.

The **Italian Demonstrator** focusses on providing flexibilities from the medium voltage level has completed its development of automated tools for Network State Analysis, Network Optimization and Reactive Power Management. Among the developed solutions, we should highlight the upgrade of forecasting for RES-E generation as well as load and grid optimization. Offline simulations, including the use of RES-E, Storage, On Load Tap Changer (OLTC) and Static Compensator (STATCOM) in congestion management, balancing and voltage support all demonstrated the effectiveness of the new coordinated process for the provision of ancillary services to the TSO. Overcoming the challenge of specifying the STATCOM with its innovative functions at the distribution level, the set-up for the field tests is being completed to validate the tools and simulations' results. This will pave the way to RES-E integration thanks to an advanced Smart Grid infrastructure and improved Distribution Network Observability and to introduce a new concept of resilient network.

In the **Finnish Demonstrator,** the concept of aggregation of flexibilities at the low voltage level is validated in several pilots. One is dedicated to the coupling of e-car charging stations and smaller-scale batteries while the other provides a system software to aggregate small-scale batteries. Field tests of a large-scale battery energy storage system show satisfactory results on frequency control (FCR-N) and reactive power compensation that will be further improved. Preliminary tests of management of electric heating loads with a high number of loads showed that the communication channel is too slow for the services targeted. However, the flexible potential of the loads will be evaluated in the next steps. For all pilots, defining the economic profitability in the flexibility market and acceptance by customers will be key to industrialization.

Distribution grid as a key flexibility provider

The Flexibility Hub (FlexHub) in **Portugal** is a platform for DSO-TSO coordination that aims to exploit the potential flexibility of assets (RES-E, storage, etc.) connected to the distribution grid. The FlexHub includes a reactive power market simulator that clears local reactive power flexibility to balance the DSO and TSO reactive power needs, a DSO software tool for the Traffic Light Qualification of bids for secure provision of active power to the TSO (in an enhanced restoration reserve market), and also an equivalent dynamic model that represents an aggregated response of the distribution grid (at the power substation level) in case of large frequency or voltage disturbances on the transmission network. The demonstration results and KPI assessment will be completed in the next steps which will feature both a set of offline tests and online demonstration of the FlexHub in full operation.

The Virtual Power Plant as a flexible enabler of renewables

The other **Portuguese demonstration** develops a utility-scale Virtual Power Plant (VPP) aggregating large hydro and wind farms, in order to optimize RES-E participation in energy markets. The VPP's different modules and components have been fully developed – both the VPP Core and the VPP Controller. The IT architecture and specifications are complete, and the offline and online field tests will soon be launched in Portugal with different assets. The objective is to validate the operation of the VPP as well as its replicability and scalability.

Virtual Power Plant based on the "multiple-service and multiple-resource" approach

The **French demonstration** has developed an operational version of the innovative Energy Management System (EMS), comprising both a day-ahead and intraday scheduler to optimize the allocation of planning and services and a short-term controller to manage the continuous operation of the Virtual Power Plant (VPP). This ensures optimal use of the distributed resources and allows the VPP to participate into system services as a full-scale stakeholder.
In addition, an advanced offline simulation platform has been developed, allowing to simulate precisely the behaviour of the whole system (EMS + VPP) in realistic conditions from a few days to several months. It has been proved useful to jointly tune the different software parts and improve the global performance of the EMS with respect to forecast errors and contingencies.
Moreover, testing has started bringing satisfactory results in the simultaneous multi-service provision (fast frequency response, frequency reserves, renewable generation smoothing, etc.) to the power system from the 2 MW storage as well as the FCR provision from a 12 MW wind farm.

Data management for flexibility solutions

In order to test the opportunities and challenges linked to data management in the development of a flexible digital power system, several software applications are being developed. They are currently tested for the potential of free data flow, easy market access for small demand side units, cross-border and cross-sector exchanges and TSO/DSO exchanges on the flexibility market. All these tools will be integrated in the Data Exchange Platform to demonstrate a solution for conceptual European data exchange model. These demonstrations will support the studies and recommendations on role models, use cases, big data management, as well as security, privacy and interoperability of various energy data.

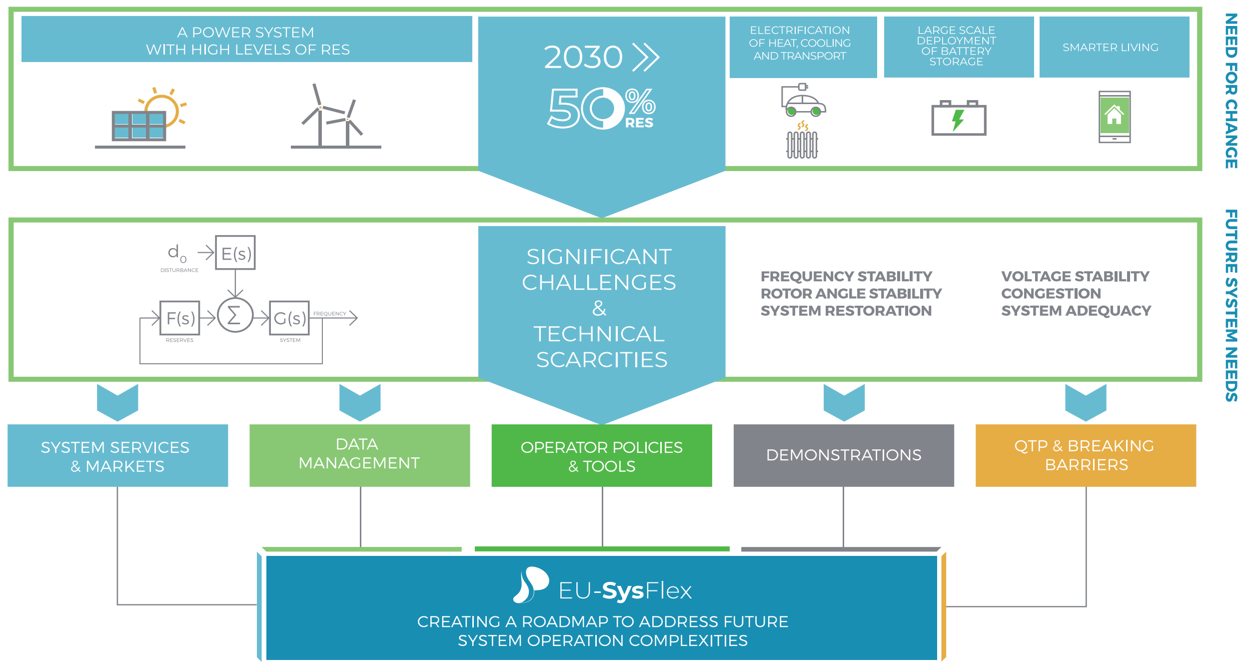
Qualification Trial Process and control centre integration

A Decision Support Tool is developed to optimize cross-border flows at the day-ahead planning stage, and to provide preventive and corrective suggestions across multiple periods in intraday planning. It will integrate the Real Time Dispatcher Training Simulator adding new services and flexibilities for TSOs. The other part of the work focuses on the Qualification Trial Process (QTP) by the TSO in **Ireland and Northern Ireland**. It includes five new trials qualifying new providers of System Services such as solar PV and new communication protocols for control and data acquisition, and trials demonstrating provision of System Services by aggregations of residential devices such as domestic batteries and EVs capable of discharging to the grid.

Next steps

The first years of the project underlined the technical and financial challenges arising from increasing share of renewables in the European power-generation portfolio, especially from variable non-synchronous resources. To tackle the financial challenges, market enhancements were studied and simulated, providing interesting potential mitigations such as increasing volume of reserves, designing smaller-granularity products closer to real-time, etc. To accompany the energy transition, these changes in market design, as well as ensuring revenues for providers of flexibility and capability, need to be deployed now.

Several industrial-scale demonstrations are currently running to test various processes to provide some viable solutions that help tackle the technical challenges. Some are addressing the observability and provision of flexibilities embedded in the distributed grids, at various voltage levels, and improve the TSO/DSO coordination to operate a more flexible power system. Others are developing advanced control and optimization approaches for distributed resources management to address the optimized capability of providing adequate energy and system services from RES-E, when aggregated with other resources and storage. The results and learnings are expected in the upcoming months. The field tests will prove the accuracy and advantages of the various tools and functions developed for the grid and VPP optimizations, leading the path to fully automated processes. The digital challenge represents the management of huge volumes of data, including increasing amounts of private data which benefit from interoperable and cybersecure solutions connected to the Data Exchange Platform.



Through the QTP learnings in Ireland, the integration of new and renewable technologies includes market and grid code arrangements, measurement standards, performance monitoring, forecasting and real-time control tools for the system operation. Furthermore, scaled up and tested in the Dispatcher Training Simulator, these experiences will be leveraged as operator protocols are devised, summarizing TSO and DSO concerns for high-RES-E system operation with service provision from non-conventional technologies.

The next step is to carry out a scalability and replicability analysis to understand how the innovations can be enlarged and deployed at a large scale in the European Power System. Together with a reliability analysis of the services provided and business-model studies, they will feed the roadmap to a low-carbon, secure and flexible power system.

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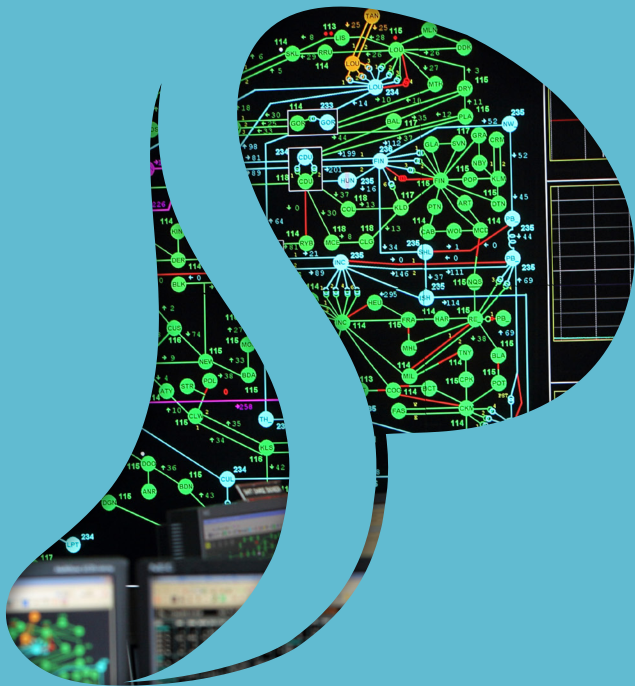

System operation and flexibility solutions for integrating 50% renewables by 2030

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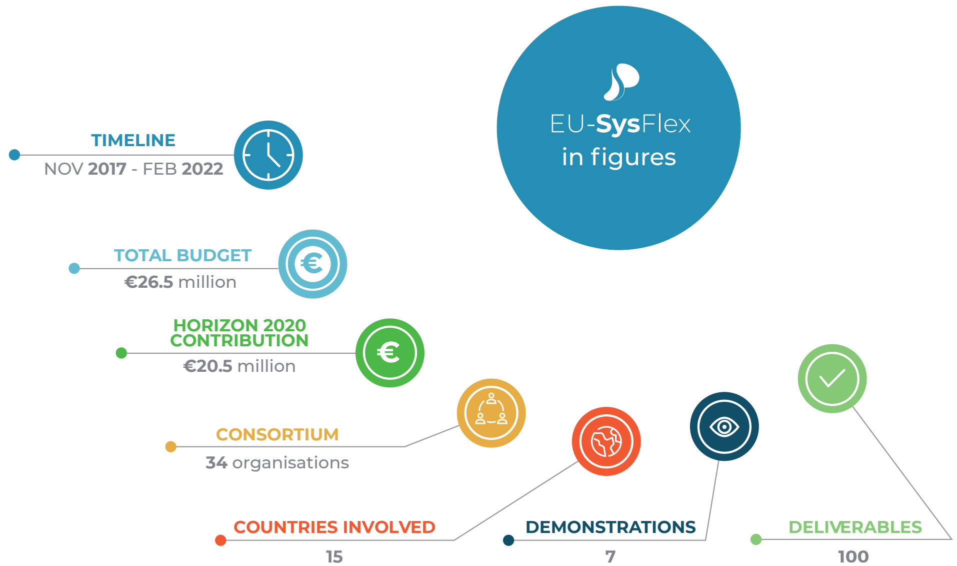
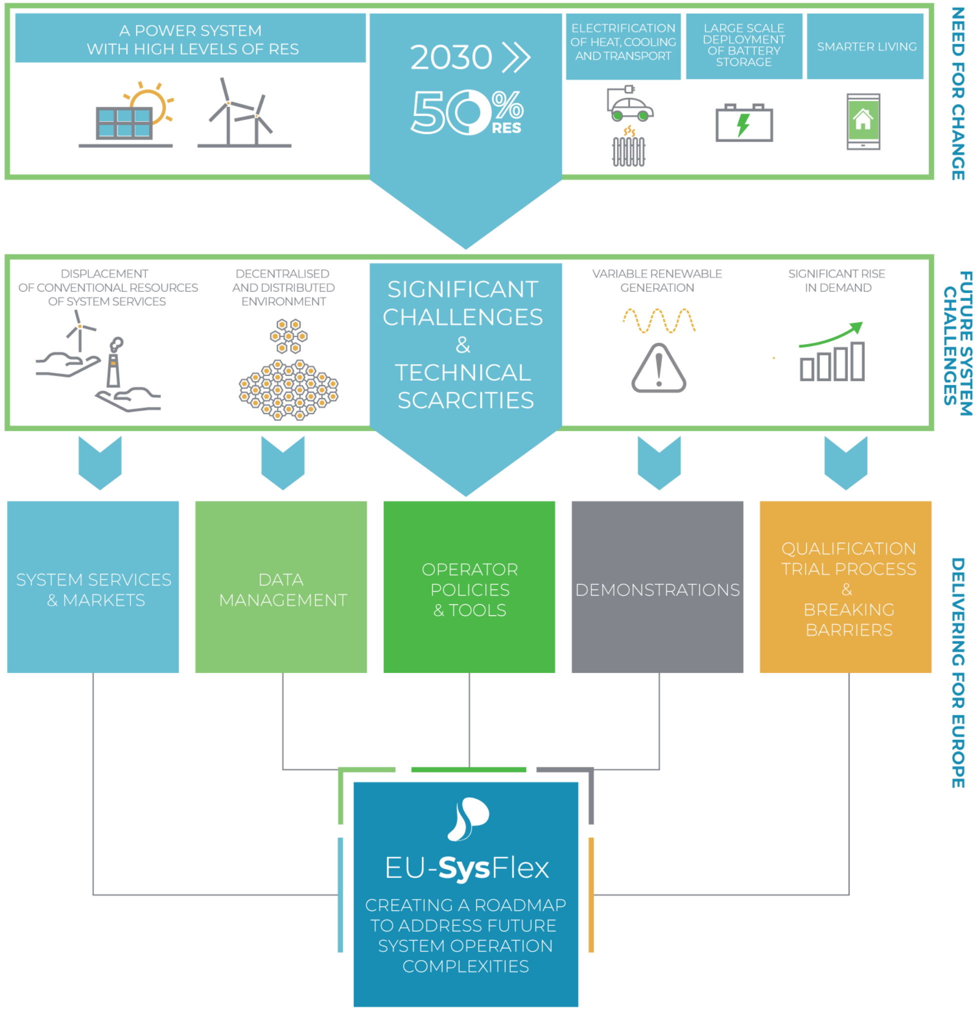
By 2030, the European Union has committed to deliver at least 50% of its electricity consumption from renewable sources of electricity (RES-E), much of this will come from wind and solar. As a result, power system operation is becoming more complex, creating uncertainties and technical challenges not previously seen in the pan-European electricity system.

EU-SysFlex is a Horizon 2020-funded project which addresses these challenges by identifying and demonstrating new types of system and flexibility services.



Based on analysis of ambitious EU renewable scenarios, the project identified the technical scarcities on the future power system, market and regulatory enhancements required to incentivise investment in System Services and through seven demonstration projects and trials explored the capability of a suite of technologies and solutions to deliver much needed flexibility.

The project team has designed a system operation flexibility roadmap for Europe to facilitate the large-scale integration of renewable technology and flexible capability.



Meeting Europe's renewable ambition will require a transformation of the energy system. In the not too distant future our electricity grid will consist of a high share of wind and solar.

Wind and solar are what we call variable technology, in that their output varies with respect to weather conditions, they also perform differently from an electrical perspective to traditional conventional power stations. As the percentage of wind and solar increase with respect to traditional sources of electricity generation we begin to see an impact on how the electricity grid performs.

This together with other changing dynamics on the power system such as the electrification of heat and transport, a shift towards a more decentralised and distributed environment as well as greater consumer participation in the energy space all culminate in further power system operation complexities and technical scarcities.

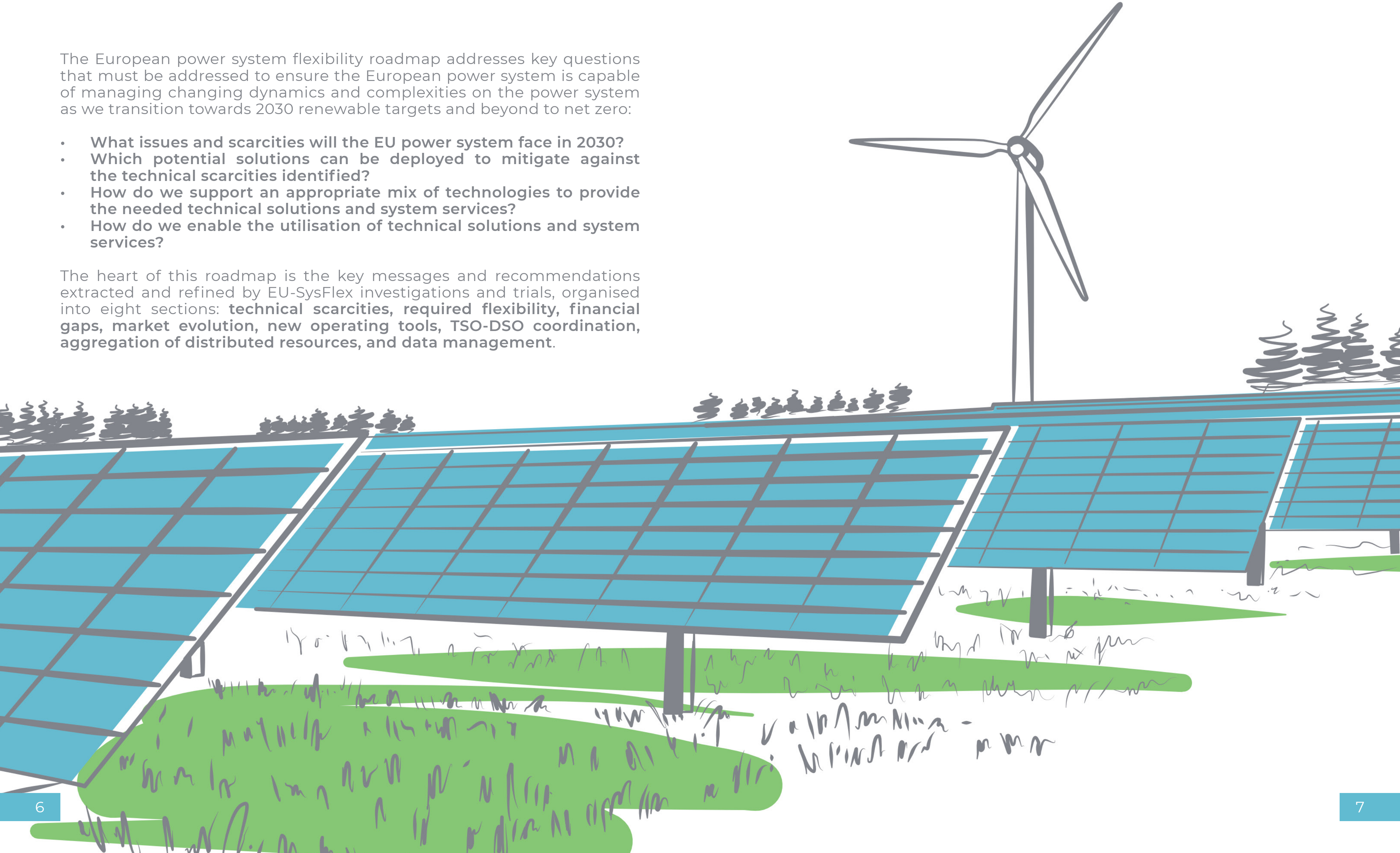
EU-SysFlex has analysed much of these challenges over a four-year period culminating in the publication of the European power system flexibility roadmap. Its aim is to help guide stakeholders in addressing changing system operation dynamics and complexities. The roadmap provides a framework to ensure Europe delivers a more flexible, dynamic and reliable power system while delivering on our renewable ambition.

The European power system flexibility roadmap incorporates the findings and results of the EU-SysFlex project. It is built on the scalability and replicability analysis (SRA) of solutions from the analysis and investigations on technical scarcities, system services, market design, system operator procedures, and data management, as well as the results from seven demonstration projects and qualification trials.

The European power system flexibility roadmap addresses key questions that must be addressed to ensure the European power system is capable of managing changing dynamics and complexities on the power system as we transition towards 2030 renewable targets and beyond to net zero:

- **What issues and scarcities will the EU power system face in 2030?**
- **Which potential solutions can be deployed to mitigate against the technical scarcities identified?**
- **How do we support an appropriate mix of technologies to provide the needed technical solutions and system services?**
- **How do we enable the utilisation of technical solutions and system services?**

The heart of this roadmap is the key messages and recommendations extracted and refined by EU-SysFlex investigations and trials, organised into eight sections: **technical scarcities, required flexibility, financial gaps, market evolution, new operating tools, TSO-DSO coordination, aggregation of distributed resources, and data management**.



As we transition to a European power system with a high share of variable renewables significant technical scarcities in flexibility appear.

Some technical scarcities represent emerging areas of concern, while others are well-known, but are exacerbated by the transition to high levels of renewables. The non-synchronous nature of wind and solar resources represents a particular challenge. All scarcities require mitigation measures to ensure continued safe, secure and efficient power system operation to support Europe's renewable and net-zero ambition.

Existing energy market structures will not guarantee the required flexibility and volume of system services to address the identified technical scarcities and support investment in low carbon generation.

Relying on existing energy market structures will result in future financial shortfalls for all generating technologies, due to reduced energy revenues in the long-term horizon.

Enhanced services will be required from a wide range of technologies in order to mitigate the identified technical scarcities and ensure the required system flexibility.

In addition to enhancing the system services provided by existing resources, new resources, such as variable renewable technologies, energy storage, and demand-side response, can offer the required system flexibility. Active participation from all technologies, new and existing, is required.

New flexibility products and market evolution are required to ensure the provision of sufficient system services capability to mitigate the identified technical scarcities.

In addition to creating new flexibility products, unnecessary entry barriers to flexibility markets must be removed, to embrace new and emerging technologies, based on reviewing existing specifications for flexibility products and their incorporation in electricity markets.

New operator decision support tools with enhanced forecasting, state estimation and optimisation capabilities are required for the future power system to activate new flexibilities.

Demonstrations were successful in showcasing the potential of a range of emerging technologies. However, rollout trials are required to fully understand their reliability and their ability to provide all of the flexibility required for an environment with high shares of wind and solar generation.

Aggregation of decentralised resources enables access to a wider range of flexibility options, including the participation of residential customers, and a range of distribution-connected assets.

Aggregating several decentralised resources, e.g. wind turbines, energy storage, electric vehicles, heat pumps, including as part of a virtual power plant (VPP), and using a combination of coordinated controls and optimisation, can greatly enhance the overall reliability, performance and profitability of the system services provided.

Efficient coordination between transmission system operators (TSOs) and distribution system operators (DSOs) is critical given the significant share of future resources connecting to the distribution network.

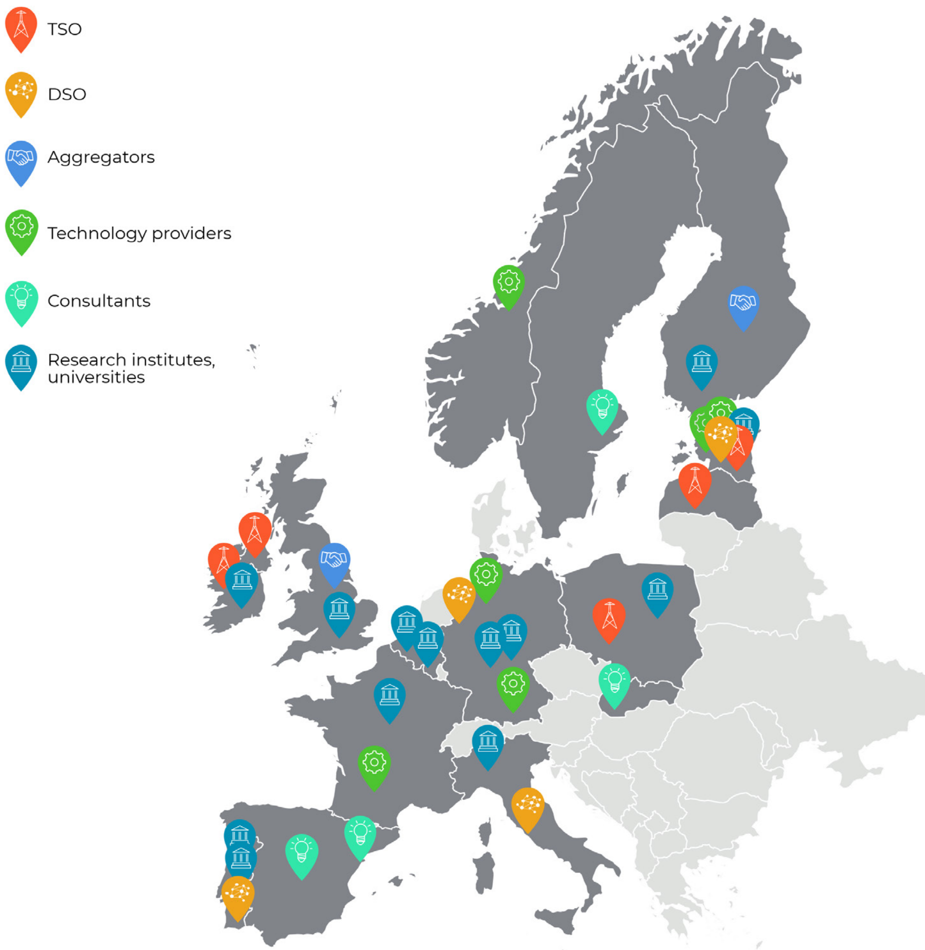
Extensive trials and demonstrations, supplemented by scalability and replicability analyses, provide validation that a dedicated coordination approach is required, so that all assets connected at any layer of the power system can be utilised to the mutual benefit of both TSO and DSO.

A customer-centric approach including standardised access to data and data-driven services is crucial to guarantee stakeholder and information system interoperability for effective data exchanges at the European level.

Interoperability is a key requirement for the future power system in which new and numerous players will handle and share large volumes of energy-related data. Data platforms based on standardisation can progressively achieve secure and privacy-respecting cross-border and cross-sector data exchanges.

THE EU-SYSFLEX CONSORTIUM

EU-SysFlex is a **unique consortium of 34 members** comprising transmission and distribution system operators, aggregators, technology providers, research and academic institutions as well as consultancies. They are located in **15 countries** across Europe.



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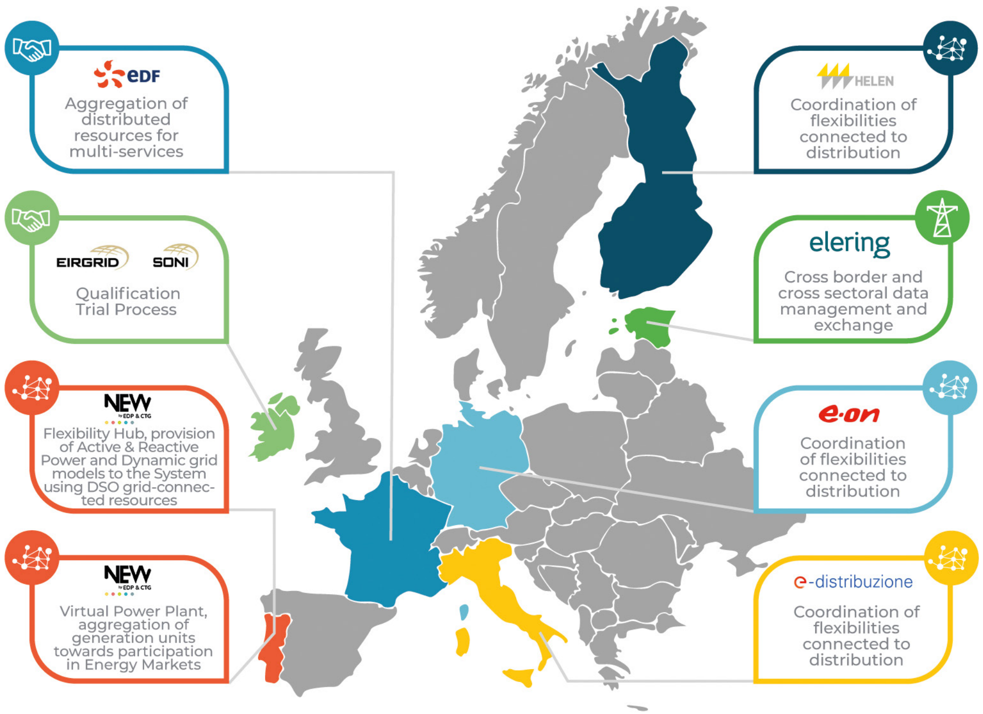
Increasing the flexibility of the pan-European system requires a comprehensive and all-encompassing vision that extends across a **broad portfolio of new approaches, solutions and technologies**. EU-SysFlex provides this by demonstrating different business use cases in seven field tests at all system levels and across Europe: **Portugal, Germany, Italy, Finland, France, Poland and Estonia** as well as a qualification trial process in **Ireland** and **Northern Ireland.**

The demonstrations and trials provide evidence of how the timely provision of required system services will be achieved using new approaches to coordinate the resources, actors and new technology mixes that will be present in the future European system. This involves testing **new concepts, tools and a wide range of flexibilities** including centralised pump storage plants, batteries, wind and photovoltaics (PV), heat loads, electric vehicles (EV). The interaction between the **system layers and actors, and the replicability of concepts and approaches** is also addressed.



Find more information on the demonstrations and trials here.

ADVISORY BOARD

The Advisory Board is a **consultative body** set up to help further develop the value of EU-SysFlex's findings and ensure a wide EU impact, facilitate their implementation by TSOs not directly participating in EU Sys-Flex, provide external and independent support, facilitate replicability and scalability, and to cooperate in disseminating and exploiting the results. Below is a list of the companies and organisations represented on the EU-SysFlex advisory board.

EU-SysFlex project is also part of the **BRIDGE** Initiative. BRIDGE is a European Commission initiative which unites Horizon 2020 Smart Grid and Energy Storage Projects to create a structured view of cross-cutting issues which are encountered in the demonstration projects and may constitute an obstacle to innovation.

Mark Foley
EirGrid Group
Chief Executive

"At the end of any successful project, it is important that we celebrate our successes. In this case not just the technical progress made but more importantly to recognise this as a celebration of ingenuity, capability and expertise within Europe. It is a celebration of the coming together of people from across Europe and across the sector to collaborate on some of the key challenges facing Europe on our journey towards 2030 targets and beyond to net zero."

Carmen Munoz Dormoy
R&D Deputy Director EDF

"With the right mix of technologies in generation and storage in addition to new flexibilities in the demand side and networks, we will tackle the challenges arising in the European Power System.
My thoughts and a special thanks to our teams at EDF and to our European partners for their involvement and support to this exciting project, and in spite of the crisis. Over the last four years our industrial-size demonstrations have shown the significant potential of innovative technologies and tools to support the power system.
We will continue to work on their development and enhancement in the future as implementing low-carbon generation and flexibilities at European scale is key to achieving our Net-Zero ambition."

Vera Silva
Chief Technology Officer
GE Grid Solutions

"The electricity system will be critical to Europe's 2030 low carbon energy targets and beyond to net zero. Supporting energy transition pathways with a stable, secure, and resilient grid is a problem worth solving for all stakeholders in Europe and around the globe. EU-SysFlex helps solve this problem with incredibly talented teams working together on a broad and comprehensive approach to power system flexibility. The ambitious and innovative industrial scale demonstrators increase confidence in new approaches and technologies and provide relevant inputs to technology providers working on the grid of the future."

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