HIGH RES SCENARIOS : FROM ADEQUACY TO STABILITY CHALLENGES AND NEW SOLUTIONS

Insights from OSMOSE and EU-SYSFLEX projects

Joint webinar by the
OSMOSE and EU-SysFlex projects
15th June 2021

AGENDA

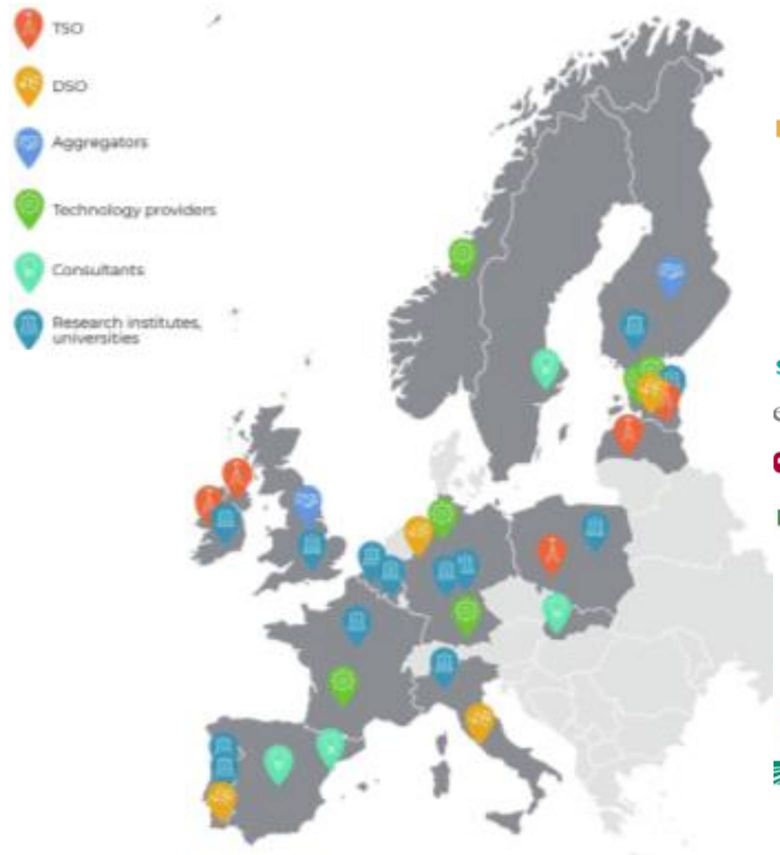
- **Introduction of the webinar and both projects**: Marie-Ann Evans (EDF), Nathalie Grisey (RTE)
- **Topic 1: Long-term scenarios and adequacy challenges**
  - OSMOSE: Optimal mix of flexibilities: Jens Weibezahn (TUB)
  - EU-SysFlex: Scenarios: Caroline Bono (EDF)
- **Topic 2: Frequency and stability challenges**
  - EU-SysFlex: Analysis of scarcities: Sheila Nolan (EirGrid)
  - OSMOSE: Grid forming to ensure stability: Carmen Cardozo (RTE)
- **Topic 3: Demonstrations of new flexibility providers**
  - EU-SysFlex: Demonstrating virtual power plants: Miguel Marques (EDP)
  - OSMOSE: Provision of frequency and voltage regulation by wind farms: Alessio Siviero (Terna)
- **Q&A session** moderated by John Lowry (EirGrid)

INTRODUCTION TO THE

EU-SysFlex PROJECT

Marie-Ann Evans (EDF), EU-SYSFLEX technical manager

The EU-SysFlex Project



TSO

EIRGRID SONI elering PSE AST

DSO

edp distribuição innogy e-distribuzione elektrilevi

Technology providers, consultants

SIEMENS ENERCON EURACTIV AKKA enoco PÖYRY CYBERNETICA zabala ESADE guardtime

Generation, retail and aggregator

upside HELEN

Research institutes, universities

Imperial College London INESCTEC VTT Fraunhofer KU LEUVEN UCD RSE UNIVERSITY OF TARTU vito EnergyVille NEW NATIONAL CENTRE FOR NUCLEAR RESEARCH EDF

EU-SysFlex in figures

TIMELINE
NOV 2017 - OCT 2021
FEB 2022

TOTAL BUDGET
€26.5 million

HORIZON 2020 CONTRIBUTION
€20.5 million

CONSORTIUM
34 organisations

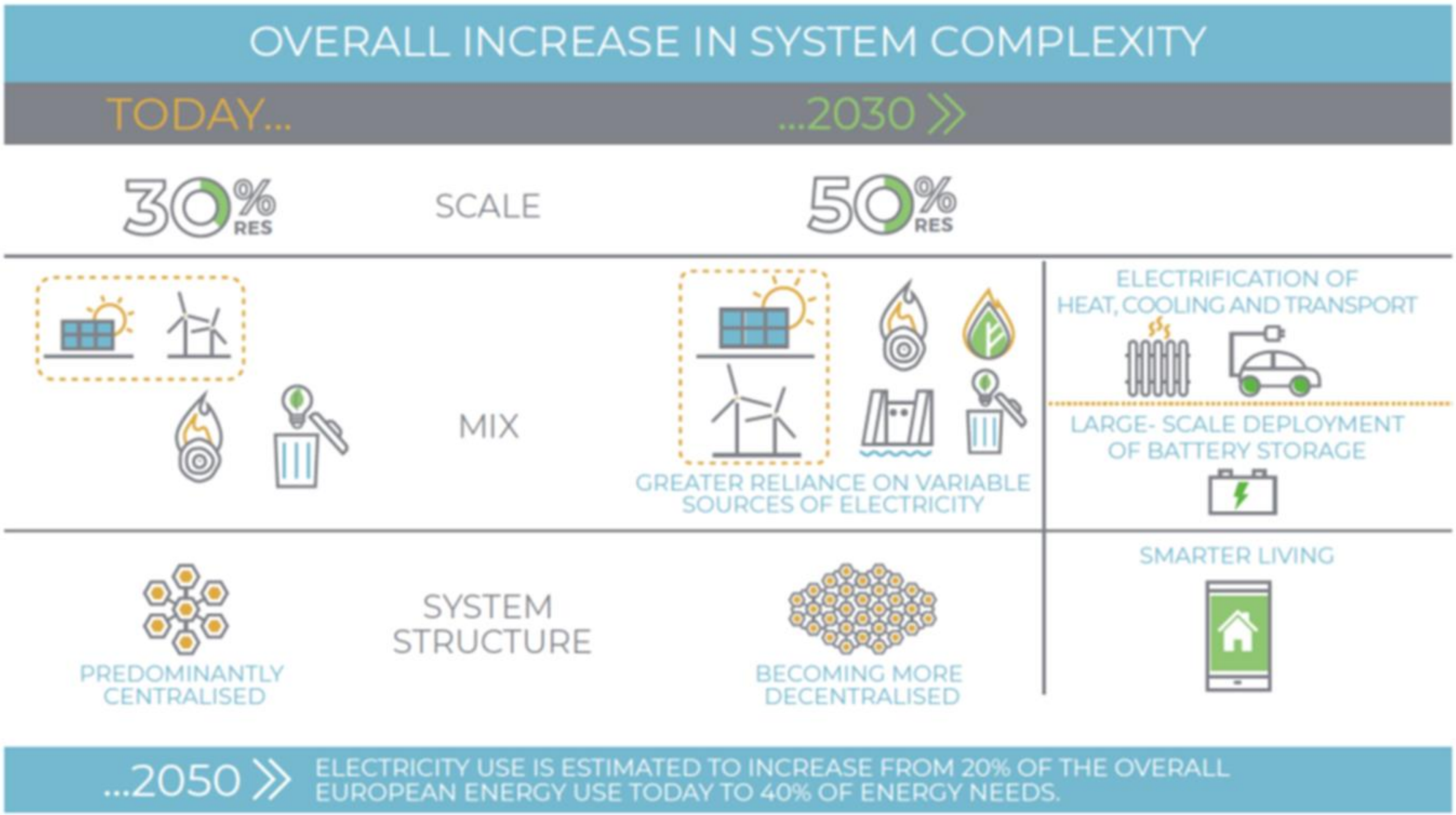
WORK PACKAGES
12

DEMONSTRATIONS
7

DELIVERABLES
100

OSMOSE EU-SysFlex

The EU-SysFlex Project demonstrates reliable and efficient flexibility solutions to integrate 50% RES in the European Power System



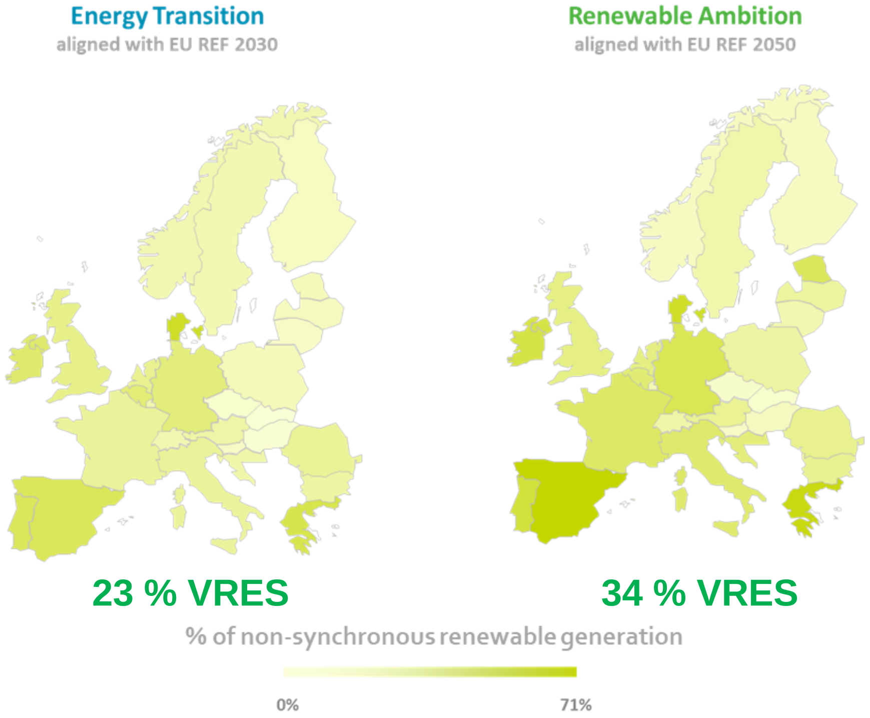
A future power system increasingly reliant on variable and non synchronous sources of electricity

Energy Transition

52% RES-E for Europe in 2030

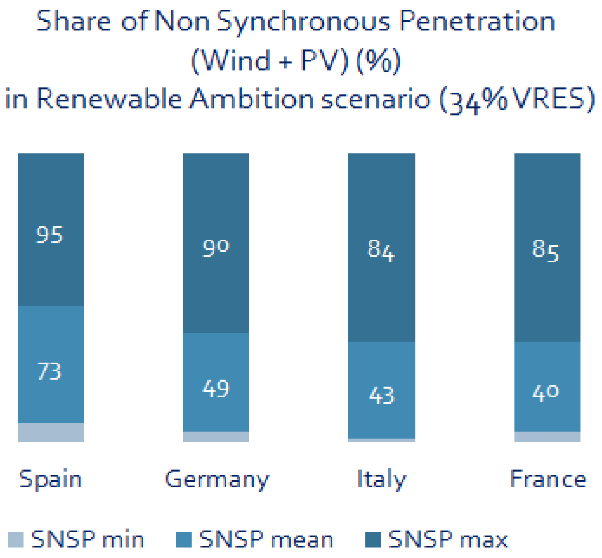
Renewable Ambition

66% RES-E for Europe in 2030



23 % VRES

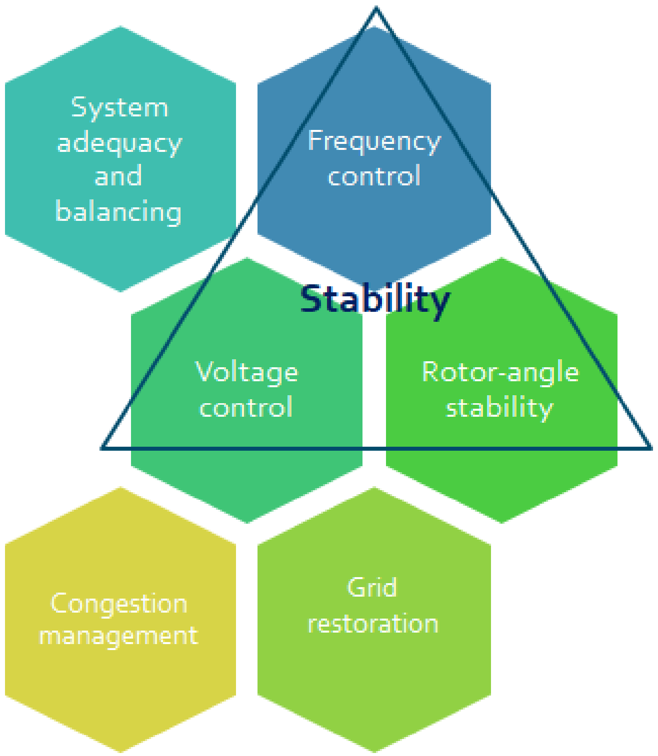
34 % VRES



- *Scenarios include electrification of demand (EV, HP, …) and energy efficiency.*
- *Storage includes pumped hydro and batteries but no Power-to-Gas at 2030.*
- *Sensitivities were studied : high solar, distributed RES, ...*

High RES-E scenarios translate in increasing **levels of VRES**,
and challengingly **high Shares of Non Synchronous Penetration in the systems**.

Key outcomes on technical challenges at high VRES



- Balancing and stability issues at high SNSP are experienced in the less interconnected areas and are appearing in Continental Europe at 34% VRES (Renewable Ambition), especially in case of system split.
- Congestions in all grids increase, as well as cross-borders unscheduled flows, and need inter-SO coordination: TSO-TSO and TSO-DSO
- Rethinking system operation and restoration process including vRES

THANK YOU!

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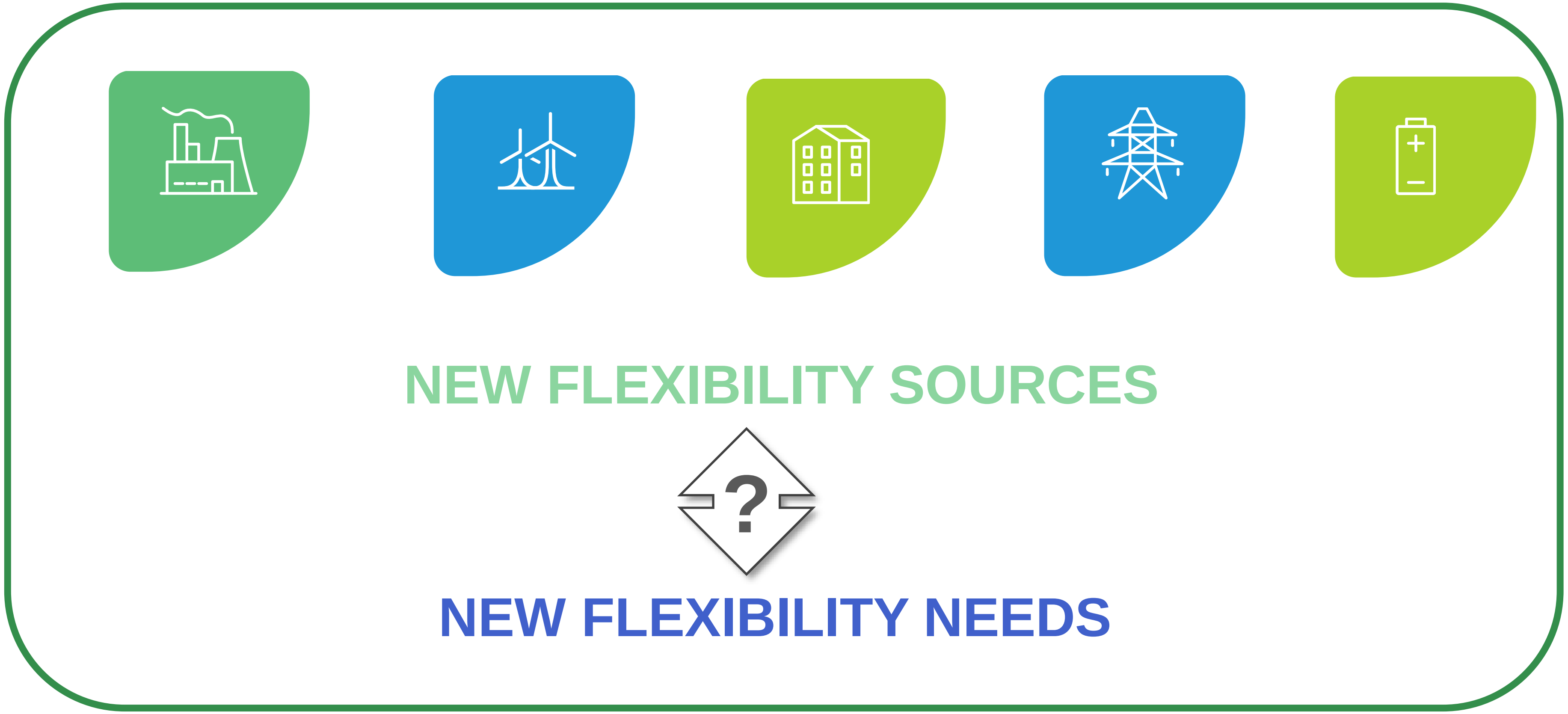
This project has received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 773505.

INTRODUCTION TO
OSMOSE PROJECT

Nathalie Grisey (RTE), OSMOSE coordinator

OSMOSE : A project about flexibility

Flexibility is understood as a power system's ability to cope with variability and uncertainty in demand, generation and grid, over different timescales.



OSMOSE : Consortium

- ✓ H2020 EU funded
- ✓ 27M€ budget
- ✓ 33 partners
- ✓ WP Leaders: **RTE**, REE, TERNA, ELES, CEA, TUB
- ✓ Jan 2018 – Apr 2022

OSMOSE : Objectives and WPs

Simulations of long-term scenarios

- ✓Identify future needs and sources of flexibility
- ✓Develop new tools and methods for flexibility assessment

WP1	Optimal mix of flexibilities
WP2	Market designs and regulations

WP7	Scaling-up and replication

4 Demonstrators

- ✓Foster the participation of new flexibility providers
- ✓Demonstrate new flexibility services and multi-services capabilities

WP3	Grid forming by multi-services hybrid storage
WP4	Multi-services by different storage and FACTS devices
WP5	Multi-services by coordinated grid devices, large demand-response and RES
WP6	Near real-time cross-border energy market

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WP5 Multi-services by coordinated grid devices, large demand-response and RES

WP6 Near real-time cross-border energy market

Presentations of today !

OSMOSE: Optimal fix of flexibilities

Jens Weibezahn (TUB)

Research Questions

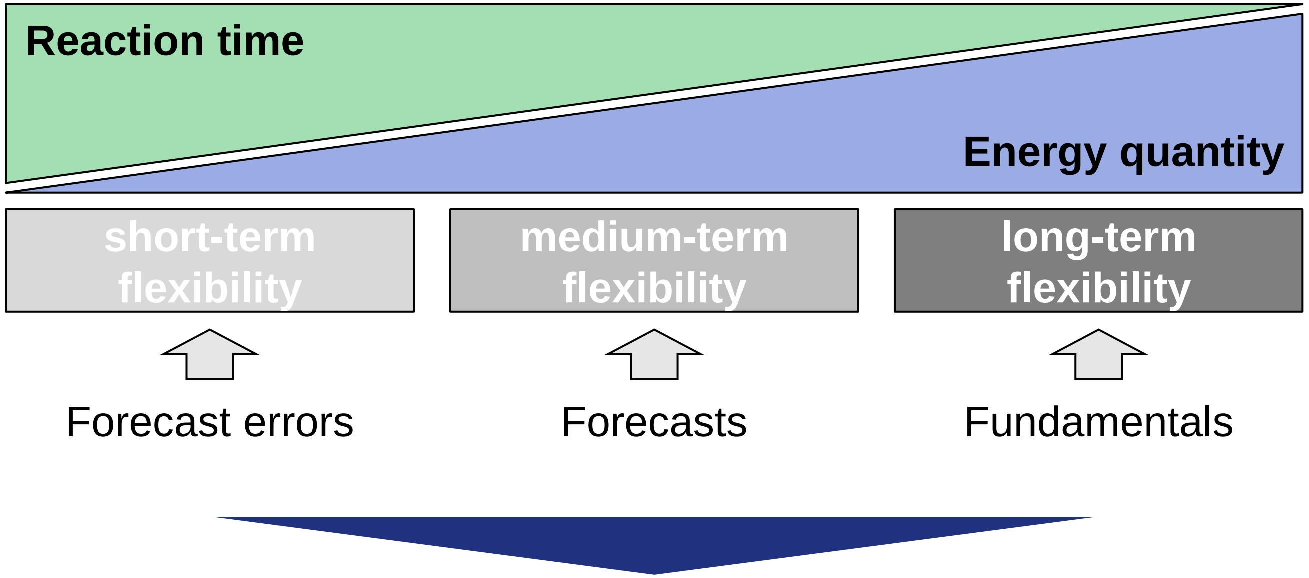
- How does the entire energy system develop in the long-term and what is the impact on the power sector?
- What kind of flexibility demands arise in the future system and how are they met?

Methodology

- Linking an energy system model for the “big picture” with a more detailed power sector model
- For scenarios: less focus on technical details of grid operation (e.g. inertia, reactive power) and more on future structure of supply and demand

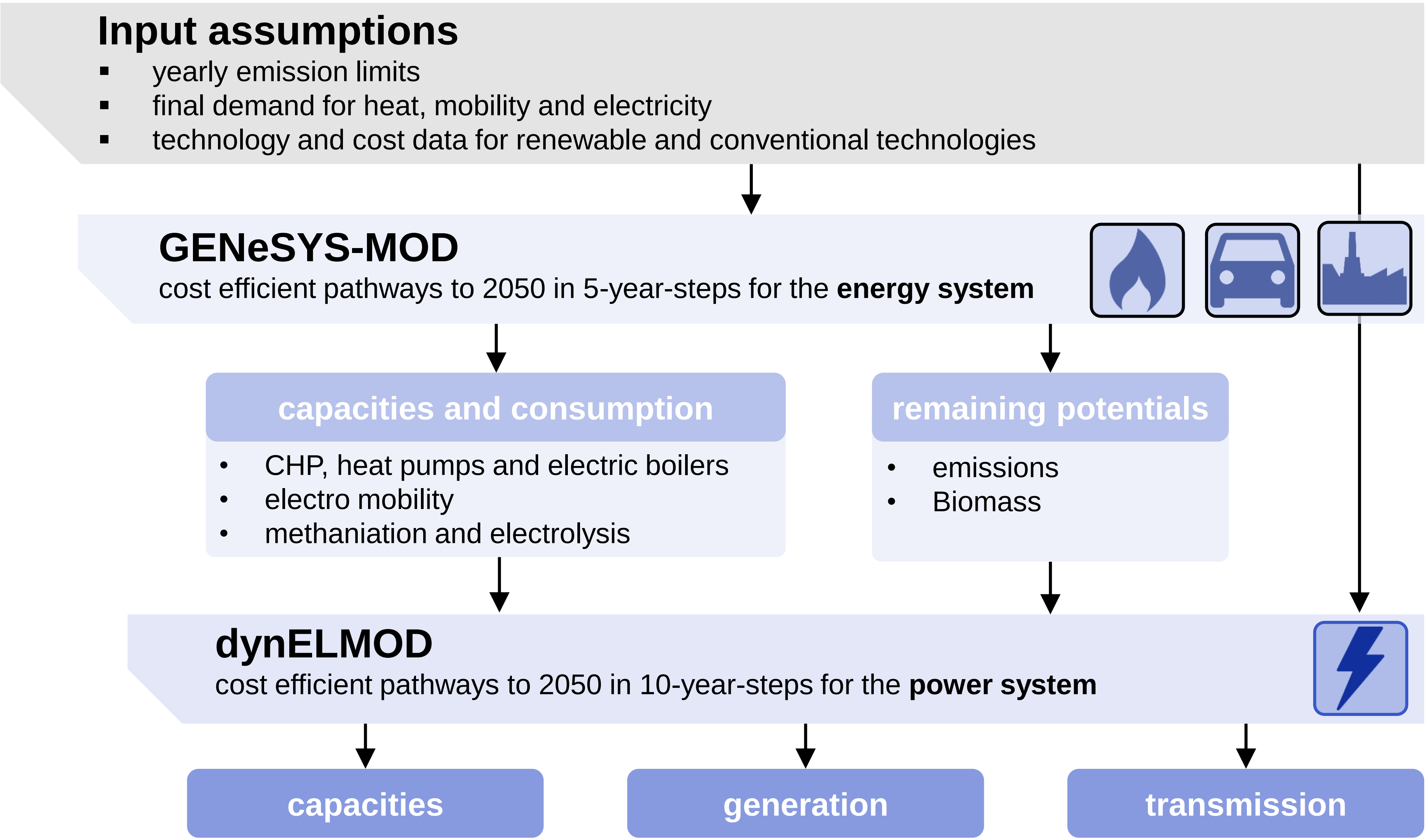
OSMOSE WP 1: Optimal Mix of Flexibilities

Definition
A power system's ability to cope with variability and uncertainty in demand and generation



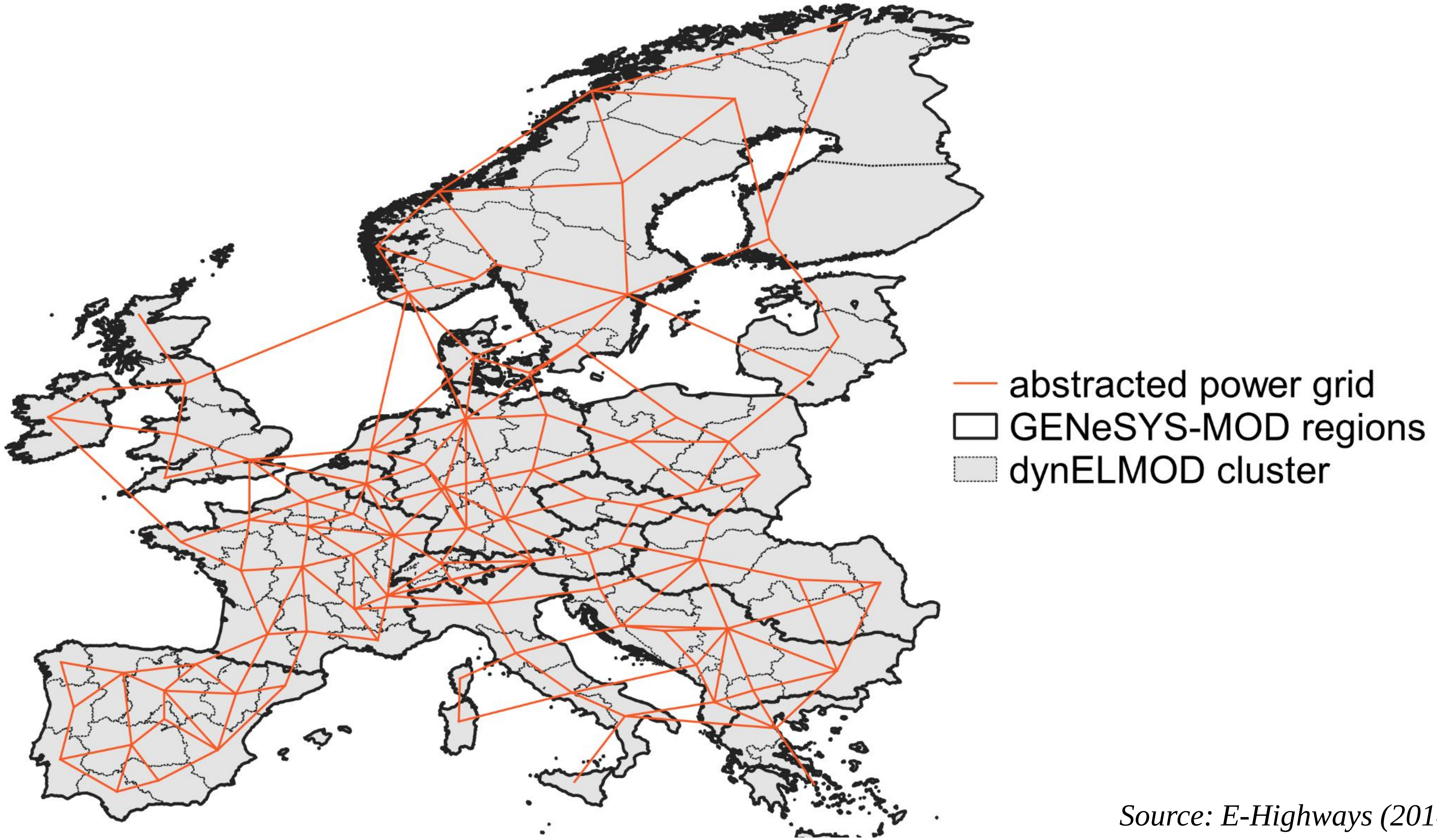
- **Increasing the shares of variable renewables will also increase the need for flexibility**
- **Electrification of the heat and mobility sector provides new sources for flexibility**

Applied Model Coupling



OSMOSE EU-SysFlex

Spatial Resolution of Applied Models



Source: E-Highways (2014)

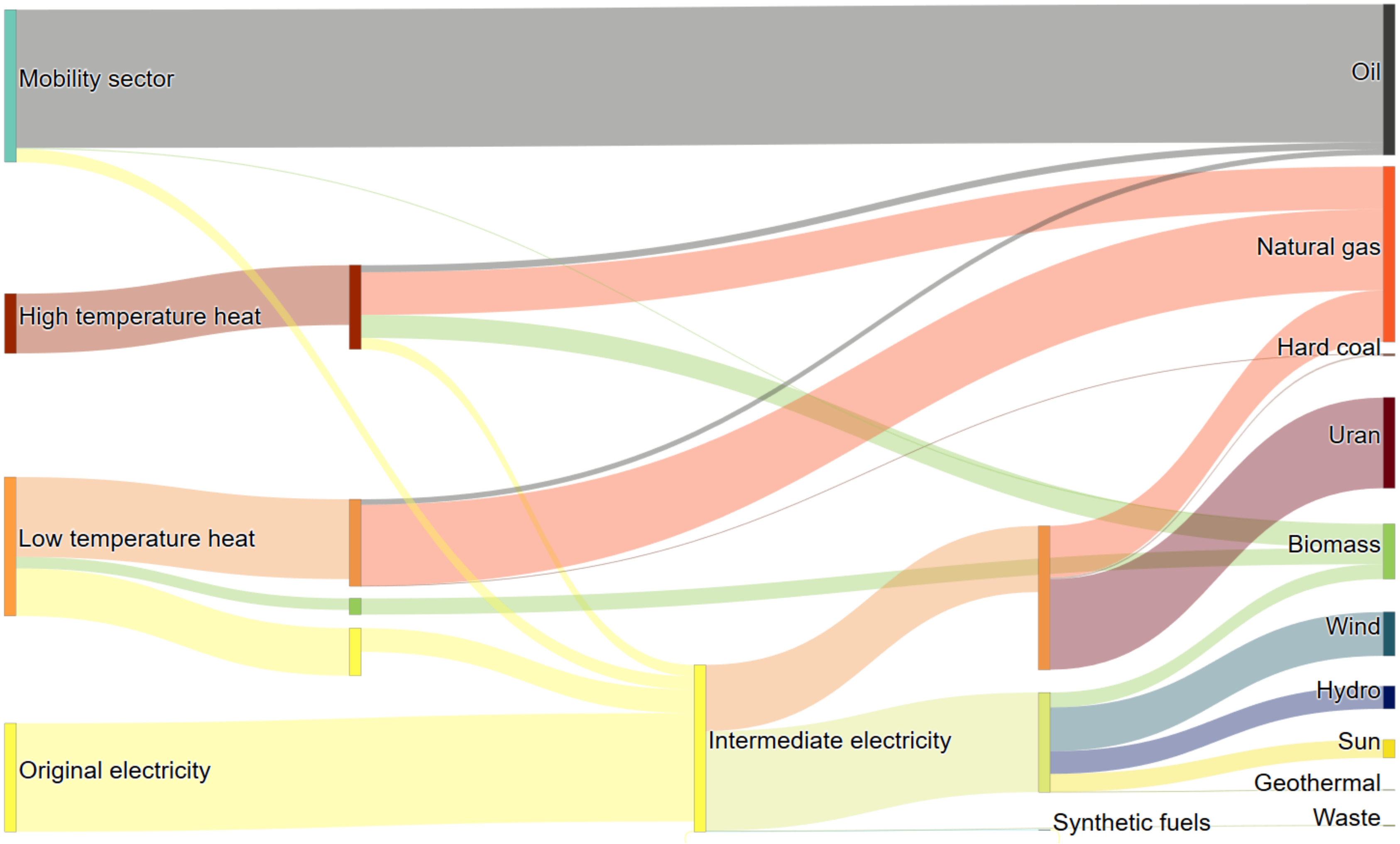
Scenario Assumptions

	Neglected climate action	Current goals	Accelerated transformation

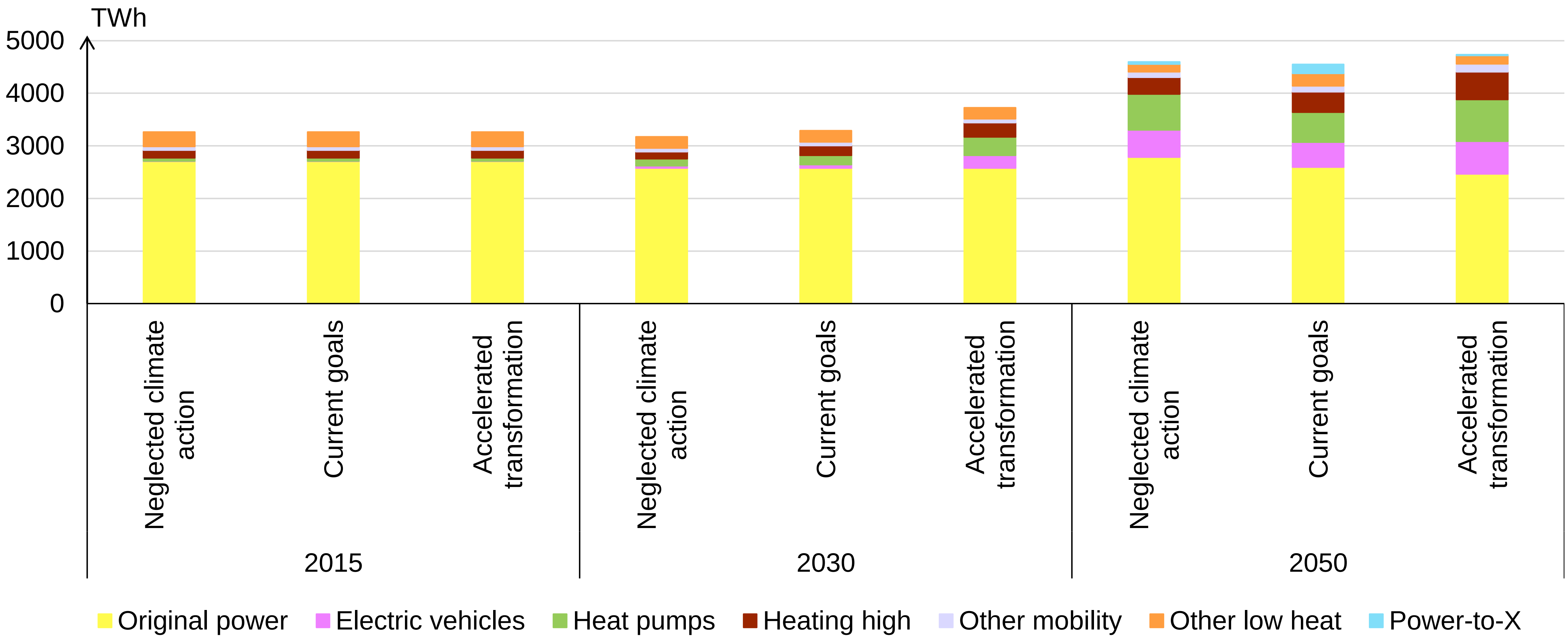
Emission levels
▪ 2030 and 2050
	• Both the 2030 and 2050 target are missed by 5% and 10%
	  • **35%** until 2030
	  • **70%** until 2050
		• Goals currently set on a European level are achieved
		  • **40%** until 2030
		  • **80%** reduction by 2050
			• More ambitious goals are set and achieved
			  • **55%** in 2030
			  • **98%** for 2050

Final energy demand (excluding transport sector)	• Slight overall increase	• Constant final demand for electricity and high temperature heat • demand for **low temperature heat** decreases by **20%**	• Moderate efficiency gains in electricity and high temperature heat • demand for **low temperature heat** decreases by **25%**
Technologies	• Coal phase-out until **2045**	• Coal phase-out until **2040**	• Coal phase-out until **2035**

Energy Flow in 2030, Accelerated Transformation



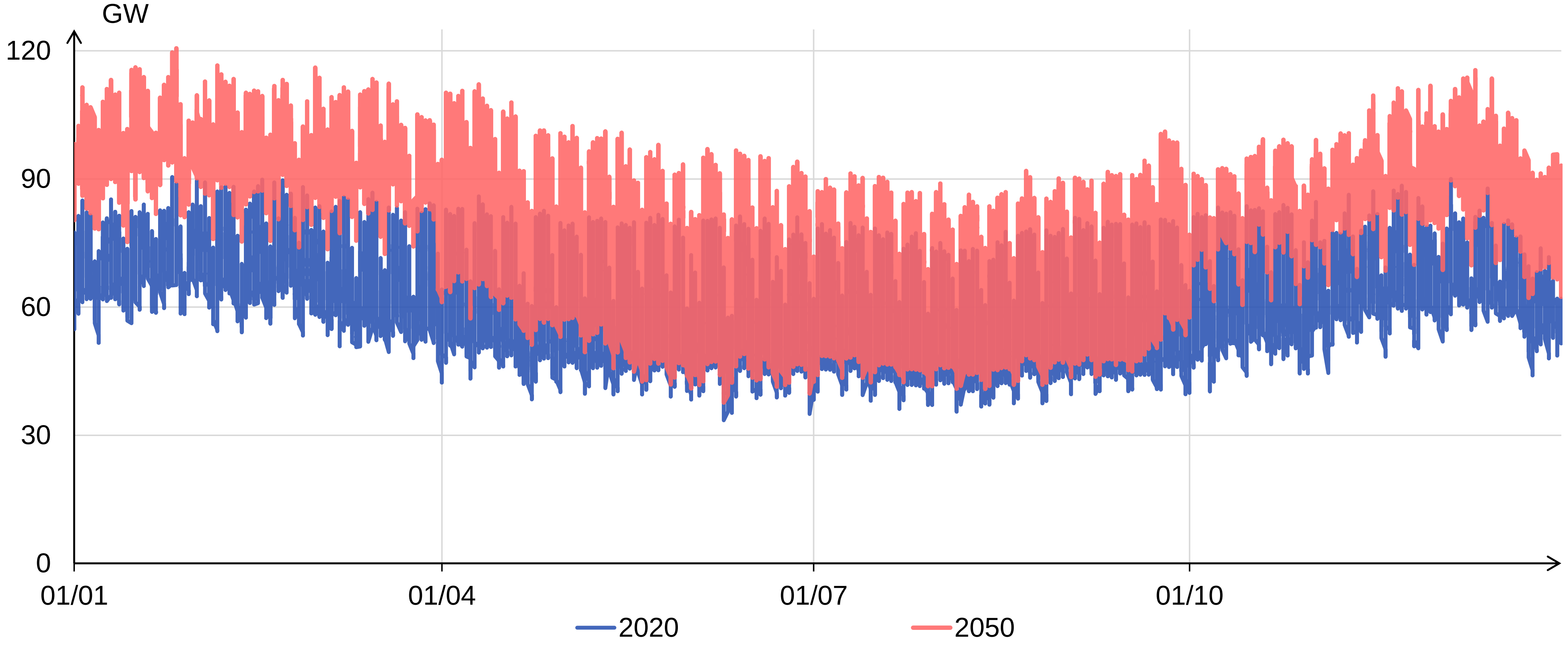
Final Electricity Demand



→ rising levels of electrification and gains in efficiency offset each other

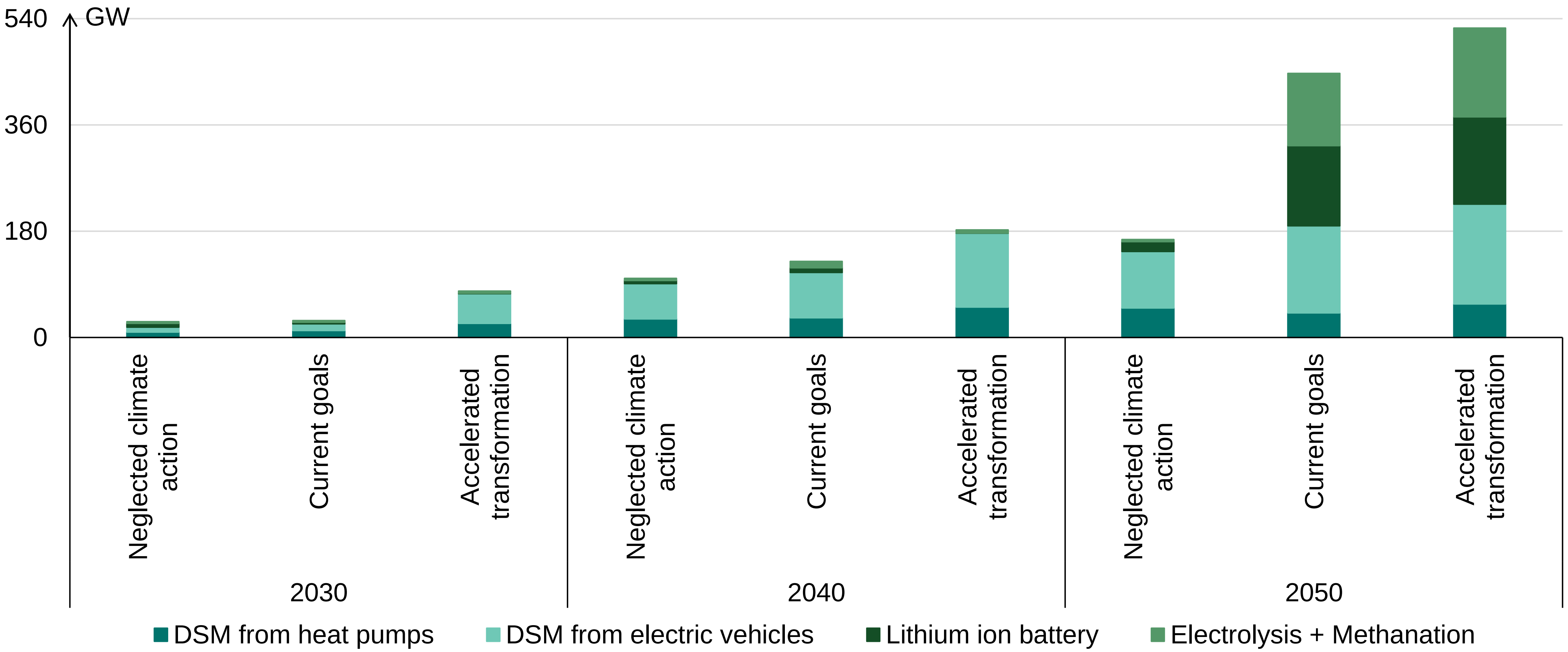
OSMOSE EU-SysFlex

Demand Profiles for Germany, Accelerated Transformation



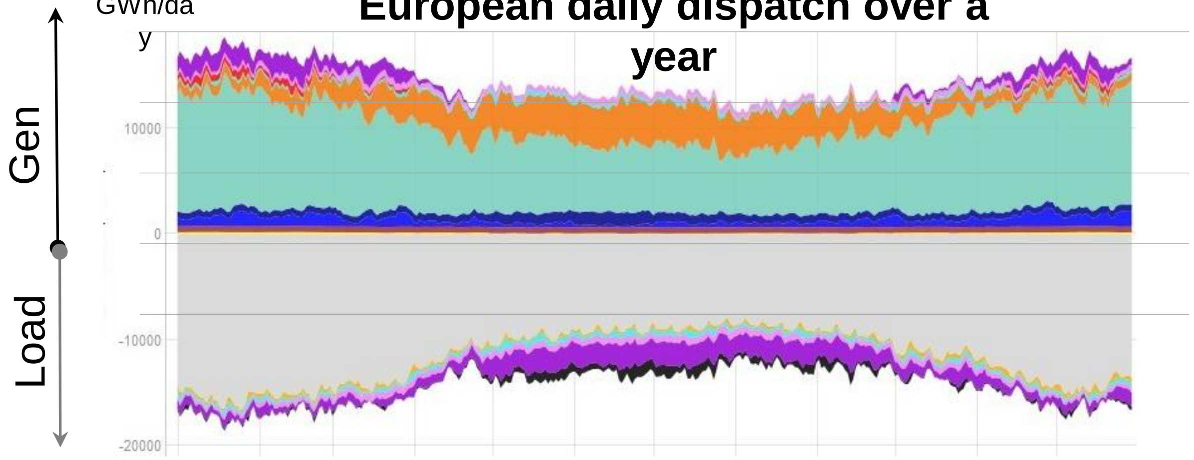
→ electrification greatly increases the volatility of load

Installed Flexibility Technologies



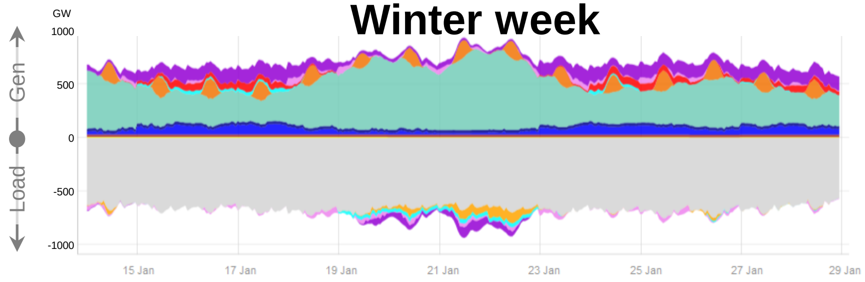
Monte-Carlo Hourly Dispatch, Current Goals 2050

European daily dispatch over a year

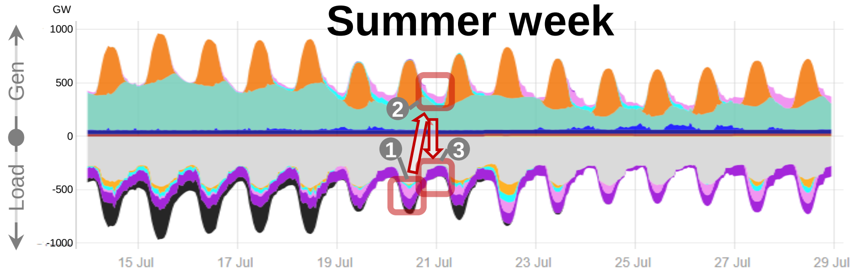


- Mix mainly based on **wind generation**
- Some **spillage** remaining in summer, and a little bit in winter as well.
- All sources of flexibility are utilized
- Significant **Gas-To-Power** in winter,
- **Power-to-Gas** especially in summer,

Winter week



Summer week



- Flexibility levers **interplay in summer**
  - Batteries and PSP used (daily cycle 1+2) to allow Power-to-gas to run outside sunny hours (seasonal storage 3)
  - Increased **Power-to-gas clean gas** generation without additional capacity

SPIL. ENRG | EXCHANGES | P2G IN + P2X | BAT IN | PUMP | GAS | TURB | SOLAR | WIND | RESERVOIR
DSM | EV | LOAD | P2G OUT | BAT OUT | ROR | MISC. RENEW | NUCLEAR

OSMOSE EU-SysFlex

Key Messages

- Electrification greatly affects temporal structure and overall level of electricity demand
- Electrification and sector integration requires short-term flexibility, but sector integration can also provide flexibility
- Chemical storage and long-term flexibility are important for deep decarbonization

Ongoing Work and Next Steps

- Improvement and refinement of scenario methodology: **AnyMOD.jl**
  - hourly temporal resolution
  - full interaction of sectors account for flexibility from transport and heating sector
  - gas and emerging hydrogen grids
- “Human-steered” coupling:
  - New time series creation for weather dependent data (more TS, more accurate geographical correlations)
  - Flexibility modelling enhancement within ANTARES
  - Generation and analysis of relevant variants
  - EVs penetration and sector-coupling assumptions
- Continuation of work on the automated GENESYS/ANTARES coupling
- Sizing and siting of flexibility options:
  - From the European perspective down to detailed simulations up-to the distribution level (60kV) for a **Portuguese** example
- **CSW** power system reliability analysis with interconnection and reserve (exchange) assessment, water management, and weekly market bid prices for hydro generation units
- Flexibility options modelled and implemented for an example of the **Italian** system:
  - Inertial response and fast frequency response from PV, wind plants and storage systems
  - Flexible power plants (OCGT)
  - Demand Side Management
  - Voltage regulation provided by RES

EU-SYSFLEX : Scenarios

Caroline Bono

Why build scenarios for EU-SysFlex ?

Some of the **key issues** addressed in EU-SysFlex

- What are the **technical scarcities** of the future European System?
- What is the **value** of **future System Services** provision to operate at high RES-E?
- What **technical** and **market solutions** are needed to **address technical scarcities** and **improve** the **resilience** of the **future European System**?

➡ **Need for scenarios shared across the project to explore technical and market solutions needed to address technical scarcities and improve the resilience of the future European System**

Scenarios were built to investigate questions addressed by EU-SysFlex and are used across the project

- Multiple scenarios considered to be basis of EU-SysFlex scenarios
- **Selection** criteria were defined
  - Consistent with the **goals** of the **EU-SysFlex project** (**> 50% RES-E**)
  - **Publicly available** data with individual EU28 country breakdowns
  - Incorporate the **targets, policies and directives of the European Union**
  - **Recently** developed scenarios
  - Two **consistent scenario years**

2 Core scenarios

Common basis throughout the project

→ Several consistent geographical perimeters
- Europe
- Ireland and Northern Ireland
- Central Europe
- Scandinavia

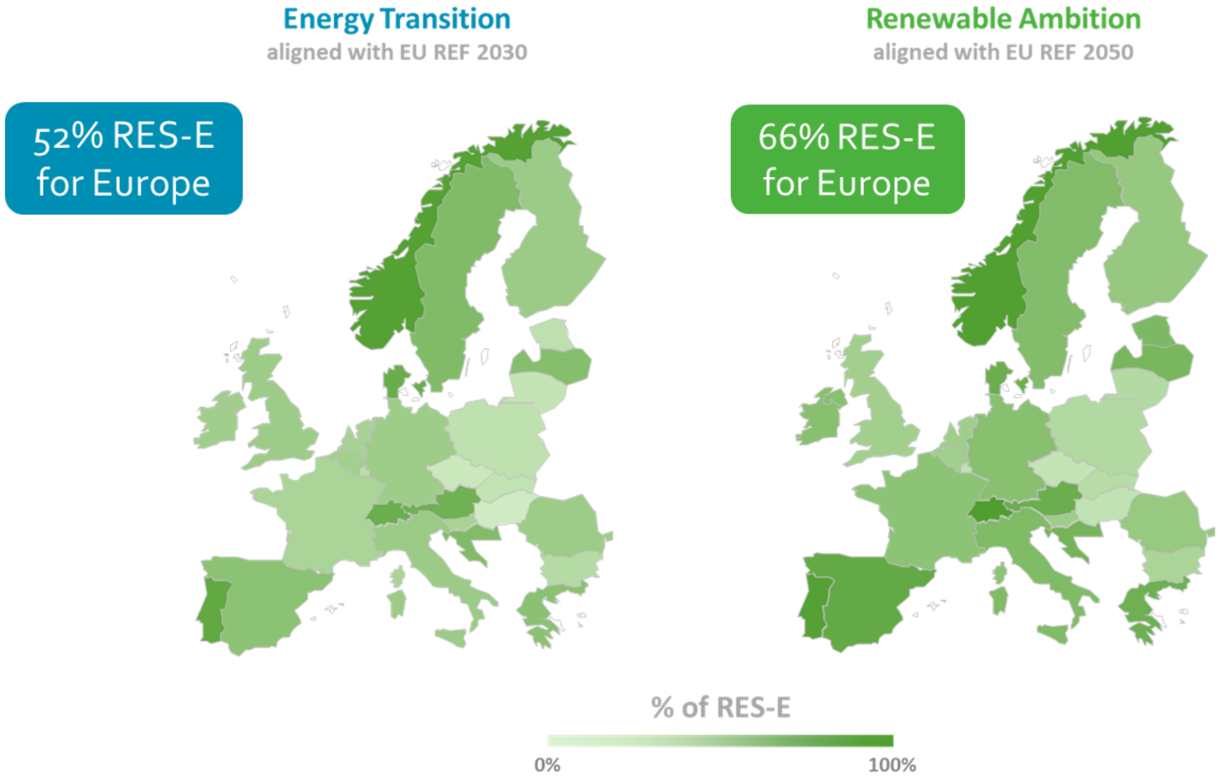
Network sensitivities

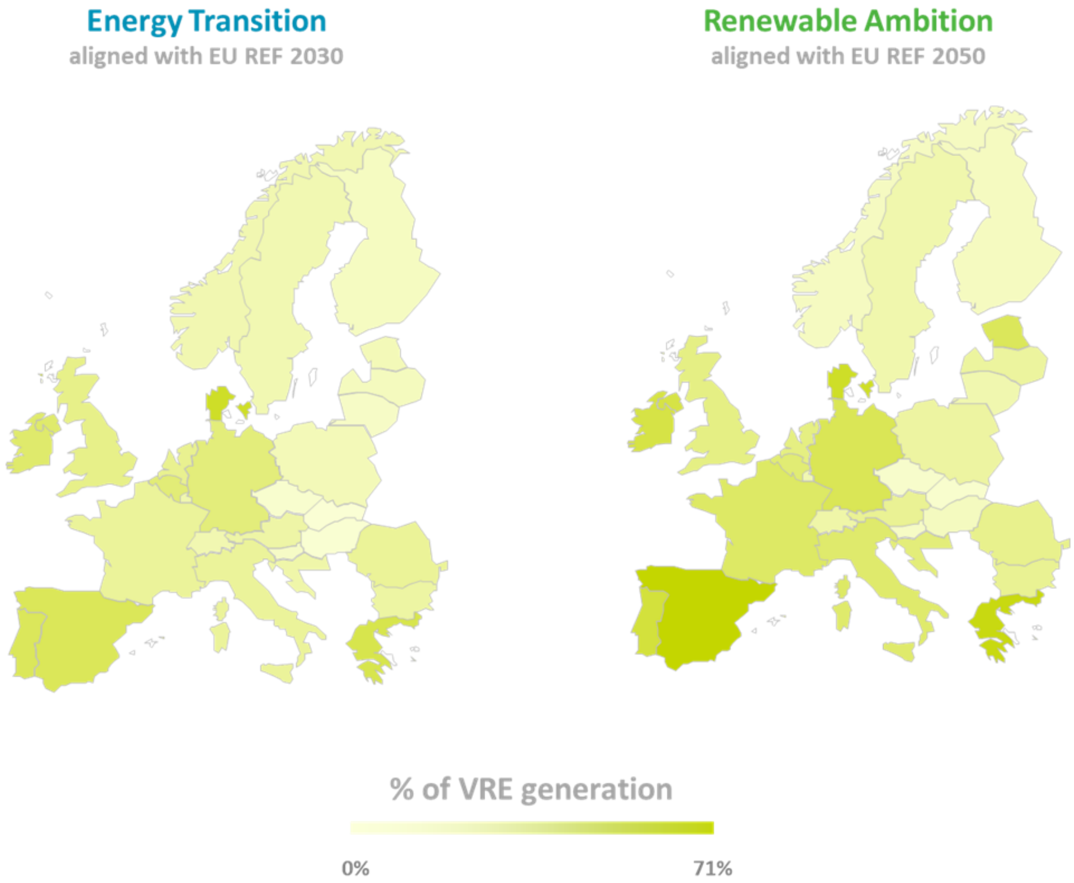
Exploring different configurations and solutions

Higher RES
Distributed RES

Flexibility solutions
Interconnections

Scenarios with ambitious levels of RES-E yielding to systems with high percentages of non-synchronous generation





OSMOSE EU-SysFlex

Context of EU-SysFlex scenarios

- EU Reference scenarios set out a **trajectory** based on the **European policy framework**
  - 2020 **renewable energy targets** are met
  - **Successful implementation** of **EU ETS**
  - **CO2 reduction targets** for the projected years are met
  - **Directives** are met (i.e. Energy Efficiency Directive (EED), Energy Performance of Buildings Directive (EPBD), …)

- **Final electricity demand increases** :
  - Population growth
  - **Shift towards electricity**
    - Heating and cooling
    - Electrification of transport (EVs as well as rail)
    - Digital products in residential and tertiary sectors

Creating a state-of-the-art dataset

EU Reference 2016

ENTSO-E TYNDP 2018

Yearly production in TWh

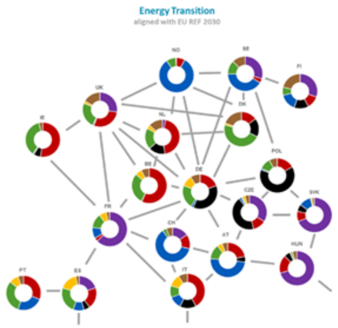
Norway

Installed capacity by fuel in MW

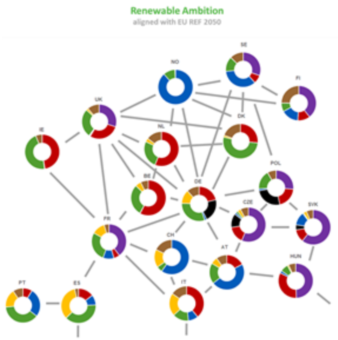
Switzerland

Yearly demand

Interconnections



Dataset with ~6000 files



20 countries

55 climatic years

Hourly data

Production constraints on plants

Key innovation & key messages

- **Reference scenarios** for **Europe** incorporating **targets, policies** and **directives** of the **European Union**
- **Scenarios** and **sensitivities** for **4 geographical areas**
  - Europe
  - Ireland&Northern Ireland
  - Central Europe
  - Scandinavia
- Scenarios are used **throughout the EU-SysFlex project** to explore
  - **Challenges** to the **future European power system**
  - **Technical** and **market solutions needed** to **address technical scarcities** and **improve** the **resilience** of the **future European System**

TECHNICAL SCARICITIES IDENTIFIED AT HIGH LEVELS OF RENEWABLES

Sheila Nolan
EirGrid
EU-SysFlex

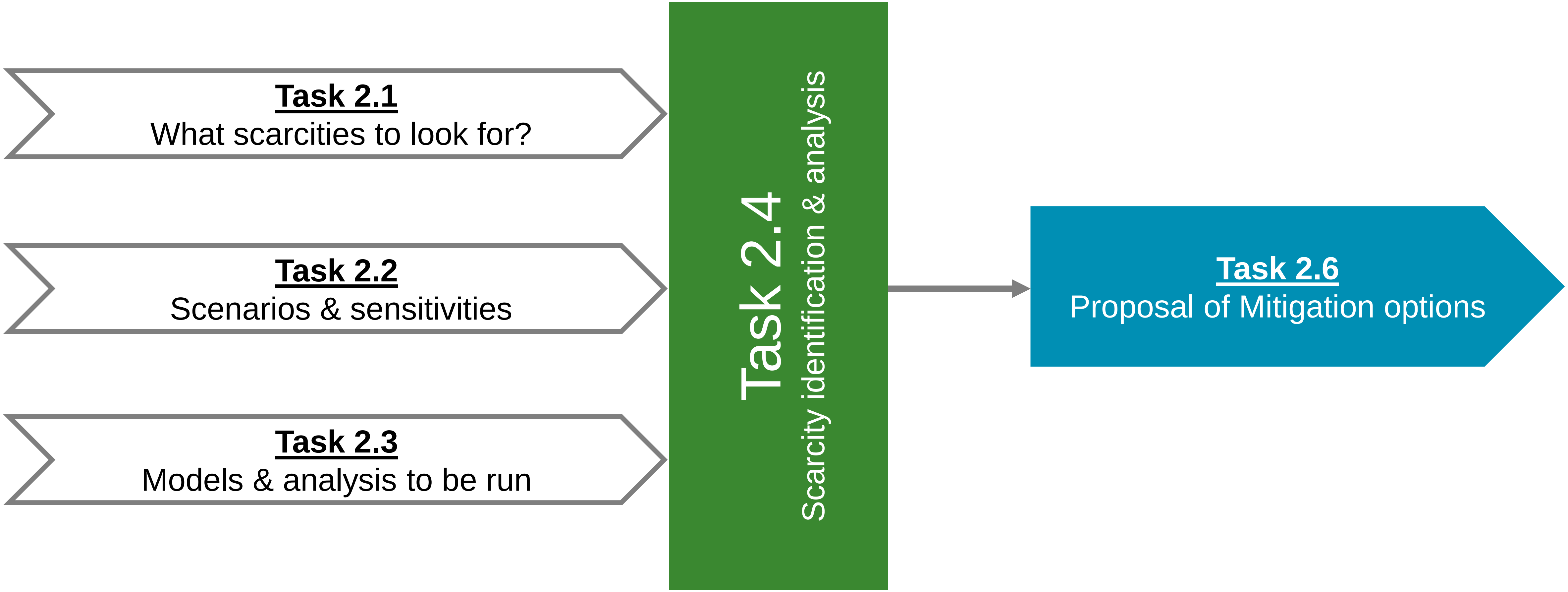
EU-SysFlex – WP2

WP2 EIRGRID

New approaches
for System Operation
with high RES

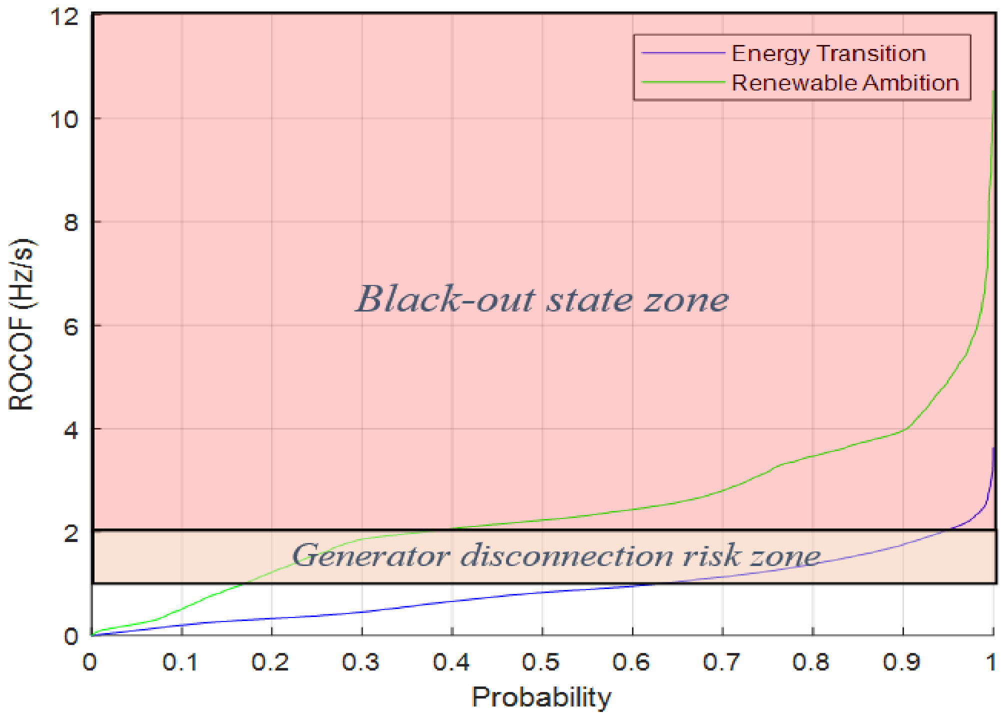
- Work Package 2 seeks to answer some key questions for EU-SysFlex:
    1. **What are the technical scarcities of the future power system?**
    2. **What solutions could be used to address the technical scarcities?**

Determining technical scarcities from detailed simulations

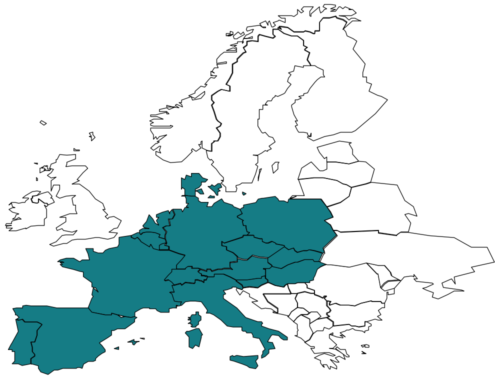


Several technical scarcities identified in a future system heavily reliant on non-synchronous sources of electricity

- Scarcities identified in the simulations:
  - **Lack of frequency control -** Inertia scarcity identified in the Continental system, where RoCoFs> 2Hz/s were identified. System split events are becoming more threatening due to increasing RoCoF values.

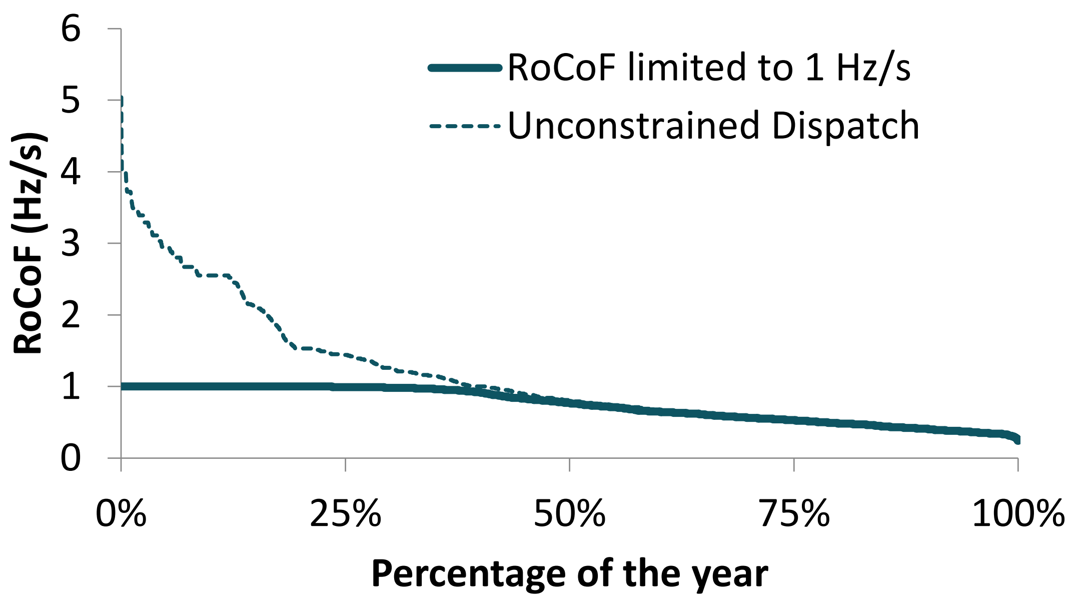


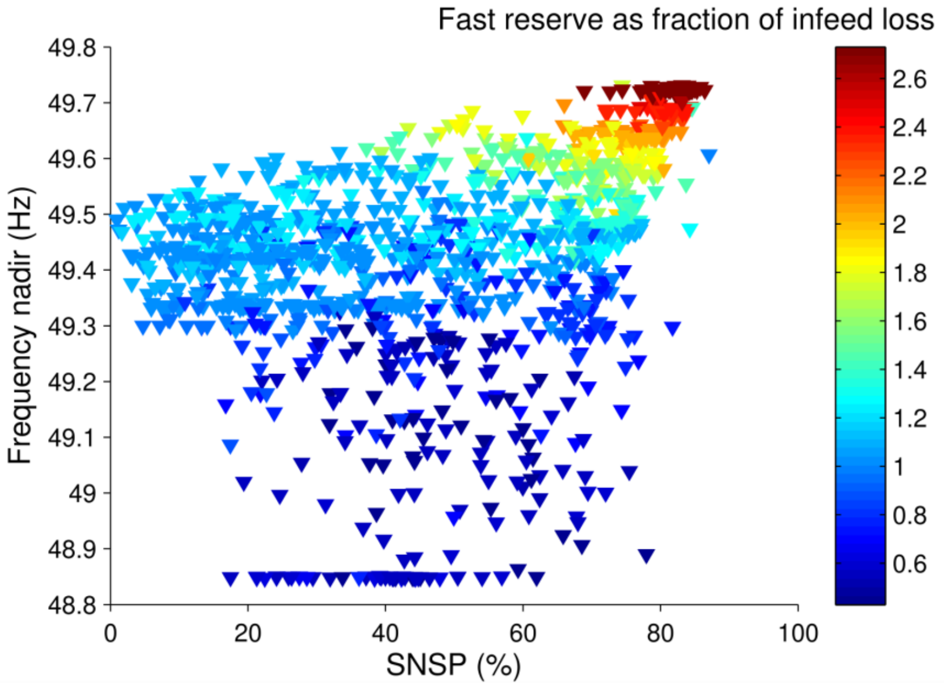
Many nadir values < 49 Hz → load shedding
Several nadir values < 47.5 Hz → risk of blackout

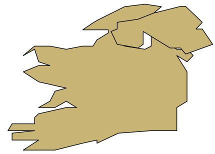


Several technical scarcities identified in a future system heavily reliant on non-synchronous sources of electricity

- Scarcities identified in the simulations:
  - **Lack of frequency control -** Inertia scarcity identified in IE and NI. A mitigating measure put in place to establish credible operating conditions in 2030. In IE and NI, in the cases where fast acting reserve volume is insufficient, the frequency stability is threatened.



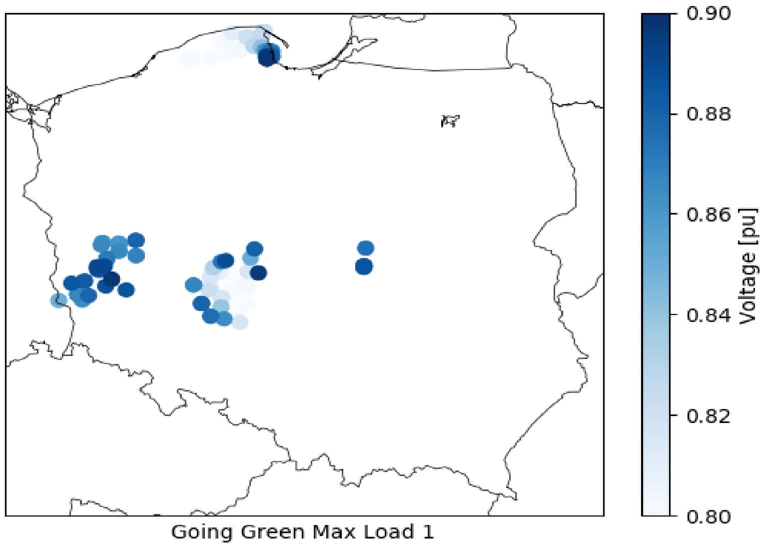


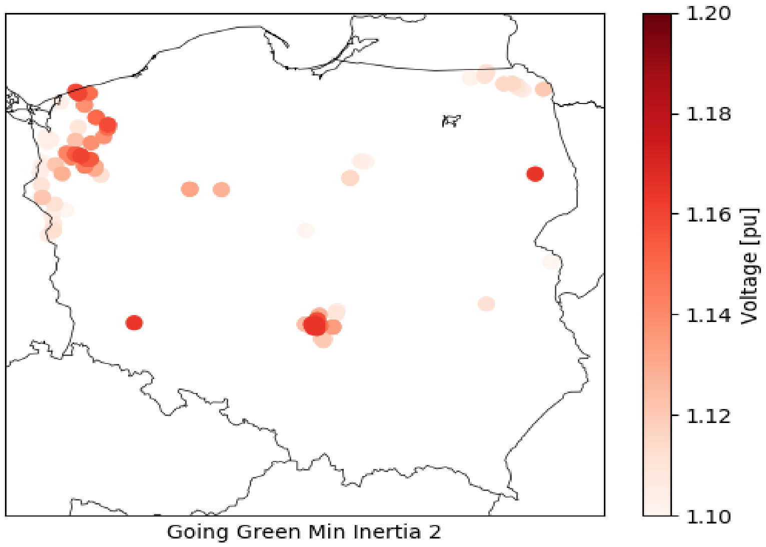


OSMOSE EU-SysFlex

Several technical scarcities identified in a future system heavily reliant on non-synchronous sources of electricity

- Scarcities identified in the simulations:
  - **Lack of voltage control** –Under voltage and over voltage issues identified on a sub-network of the continental system as well as problems with meeting the criterion of voltage stability margin





Significant Technical Scarcities

Not analysed	No Scarcity	Evolving Characteristic	Concern	Scarcity

Increasing level of non-synchronous generation →

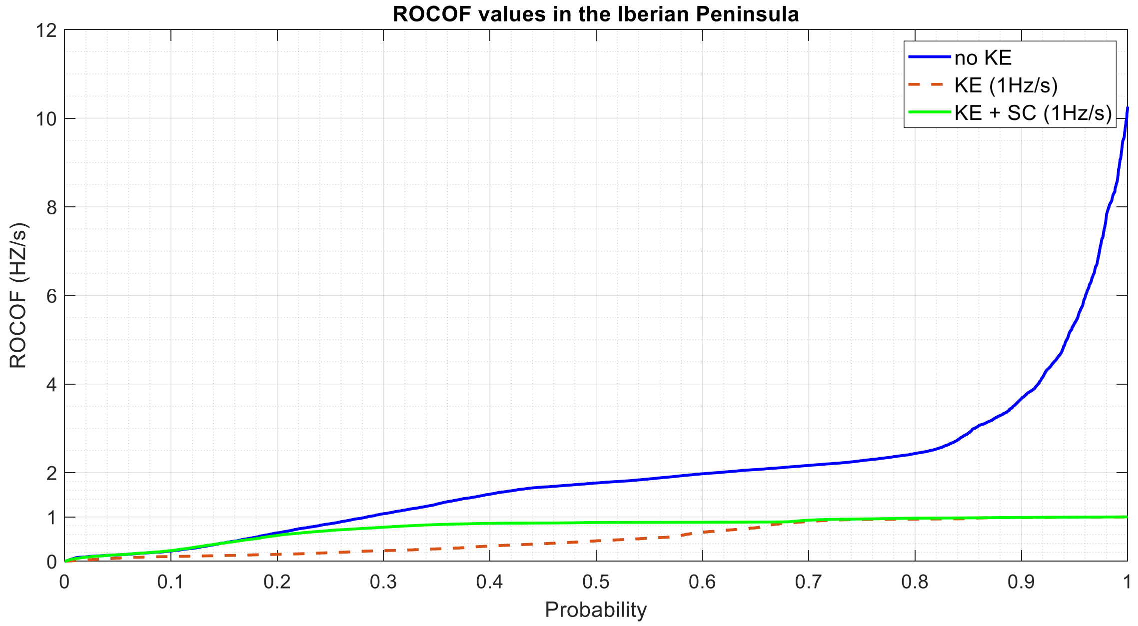
	Nordic System	Continental Europe	Ireland & Northern Ireland
RoCoF (dimensioning incident)	Evolving characteristic	Localised concern	Inertia scarcity
RoCoF (system split)		Global concern	N/A
Frequency containment (dimensioning incident)	Evolving characteristic	Evolving characteristic	Evolving characteristic
Frequency containment (system split)		Global concern	N/A
Steady State Voltage Regulation		SS reactive power scarcity	SS reactive power scarcity
Fault Level		No scarcity found at low vRES levels	Dynamic reactive injection scarcity
Dynamic Voltage Regulation		No scarcity found at low vRES levels	Dynamic reactive injection scarcity
Critical Clearing Times		Evolving characteristic	Evolving characteristic
Rotor Angle Margin			Localised concern
Oscillation Damping		Damping scarcity	Damping scarcity
System Congestion		Global concern	Transmission capacity scarcity
System Restoration			Evolving characteristic

Summary of Proposed Solutions

- Proposal of solutions and demonstration of some of the system services capability

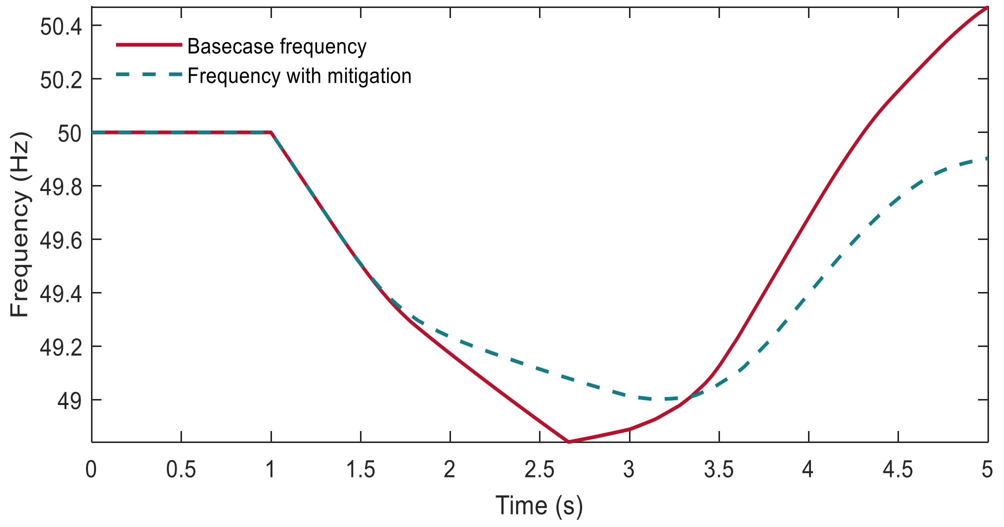
Scarcity	Proposed Solutions
RoCoF	EDF: Impact of adding inertia-related constraints into UC model. Must-run conventional units, **synchronous condensers**. EirGrid: Synchronous Inertial Response from range of **technologies available during high wind periods**
Frequency Containment	EirGrid: Reserve services from **technologies available during high wind periods**
Steady State Voltage Regulation	PSEi Reactive support from **wind generation** EirGrid: Reactive support from **non-conventional technologies**
Dynamic Voltage Stability	EirGrid: Dynamic Reactive support from **non-conventional technologies**
Rotor Angle Stability	PSEi : Tuning of **PSS** EirGrid: Dynamic reactive support from a range of technologies
System Congestion	EirGrid: Congestion management from **DSM and operational mitigations**
System Adequacy	EDF: Storage from **batteries and EVs**

Summary of Proposed Mitigations



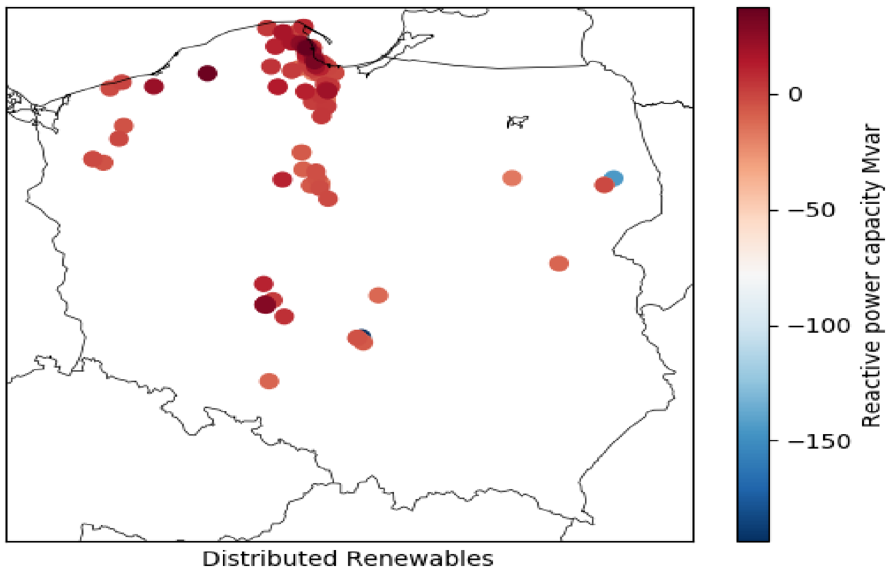
Addition of an inertial constraint in scheduling considerations for Continental Europe, plus installation of synchronous condensers.

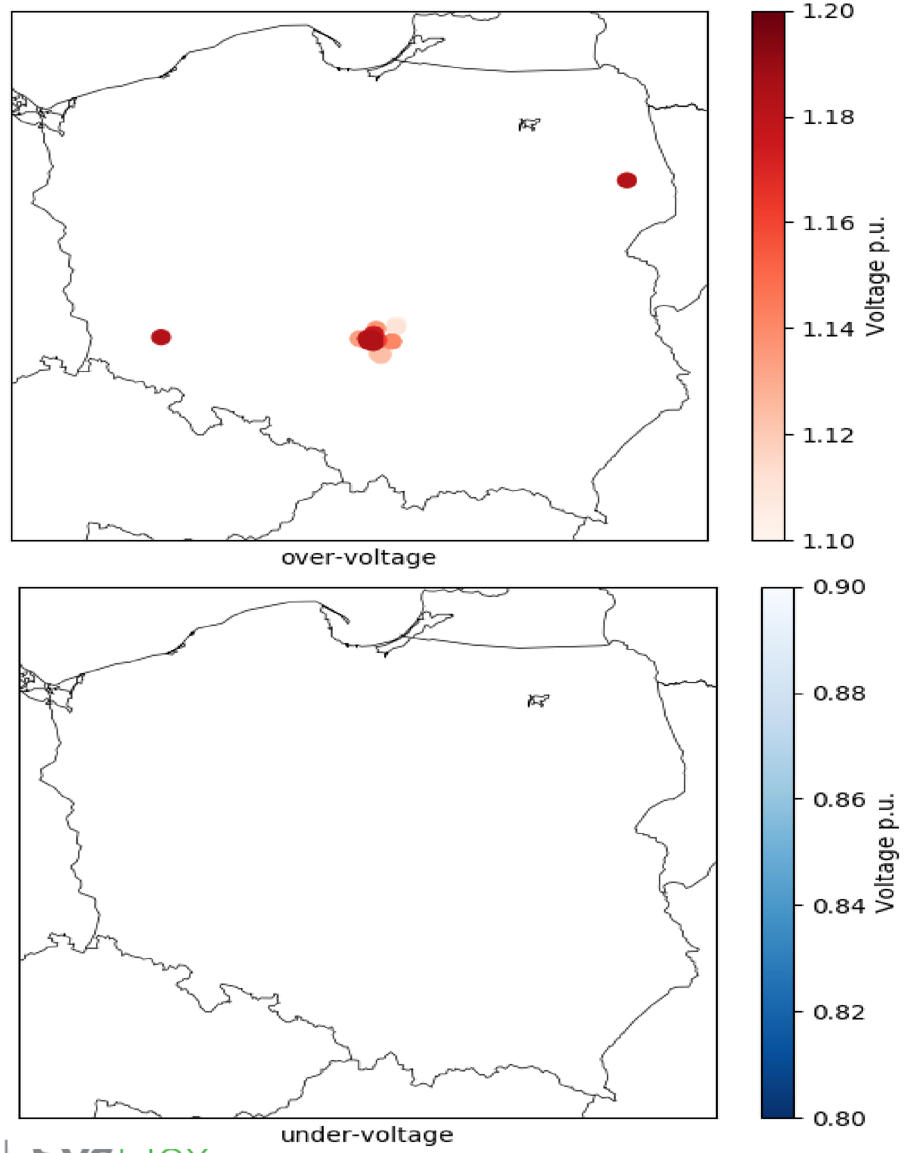
Use of batteries in the Ireland and Northern Ireland power system to provide fast frequency response



OSMOSE EU-SysFlex

Summary of Proposed Mitigations





Reactive Power Reserves from Non-Synchronous Energy Resources

Conclusions from EU-SysFlex WP2

- **Significant scarcities identified in the simulations:**
  - A range of mitigations are required across all scarcity categories
  - Key innovation is the range of studies carried out
- **The capability of range of different technologies to provide system services to mitigate the scarcities and challenges has been demonstrated, through simulation.**
- **Challenges are not only technical; they are also financial**
  - Downward trajectory of energy market prices
  - Energy revenues falling, leading to financial gaps
- **System services could be one of a range of mechanisms to support mitigation of the technical and financial challenges**

OSMOSE : Grid forming to ensure stability

Carmen Cardozo – RTE R&D – OSMOSE WP3

Recall on Grid forming

MIGRATE H2020 project ended in 2019.

1. Theoretical view of grid-forming (GFM) function as basically a stiff fundamental voltage source:

- Autonomous creation of the voltage waveform, islanding and synchronization with other sources.
- Contribute to "inertia" and short circuit "power" (rather RoCoF limitation, system strength and fault current).
- Absorb harmonic and unbalance current while limiting interaction and contributing to oscillation damping.

2. GFM Control laws: droop, dVOC, matching control

3. Large-scale simulation: stable 100% PE system

4. Laboratory scale experimentation (~kVA)

5. Recommendation for grid-codes.

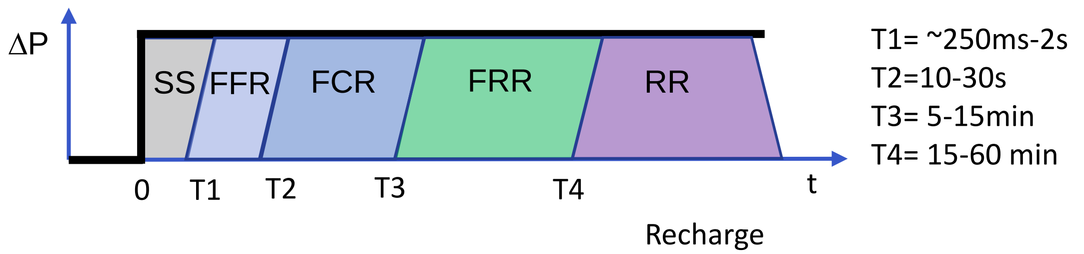
OSMOSE

WP3 objective: increase TRL with MVA demo

1. Prove the portability of Grid Forming Control on different hardware platforms (commercial convertor).

2. Test the robustness and effectiveness of grid forming control in two grid-connected environments.

3. Define synchronization services (SS) and KPI for a technological agnostic GFM capability specification.



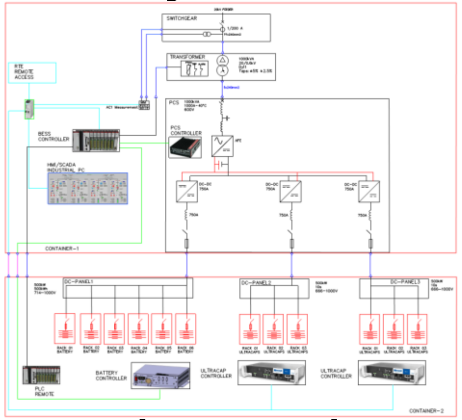
4. Provide insight in multi-services compatibility and DC power & energy constraints.

2 demonstrator of grid forming control and services with BESS OSMOSE WP3

Focus on showing technical feasibility and robustness

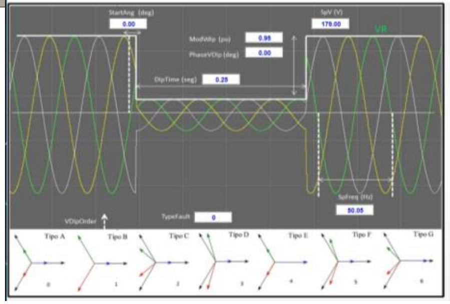
Rte Ingeteam

EMT control design HESS (UC+Battery)



PHIL test

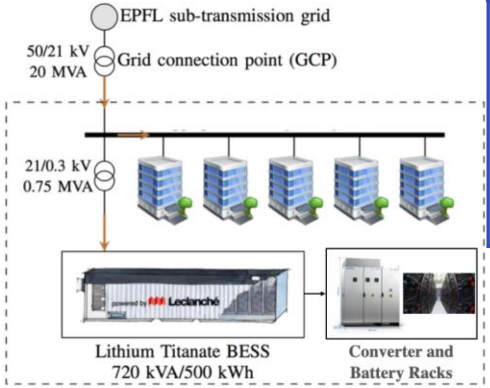
1 MVA VSC



Focus on quantify effectiveness and ensuring multiservice compatibility

EPFL

RTS & multiservice optimisation



On site performance assessment

More details tomorrow in IT challenges Webinar

Key innovation & key messages

Technical feasibility of grid forming and the provision of synchronization services with off-the-self VSC in BESS

OSMOSE
OPTIMAL SYSTEM-MIX OF FLEXIBILITY SOLUTIONS FOR EUROPEAN ELECTRICITY

Multi-service control algorithm for converters

Deliverable number: D3.1

OSMOSE
OPTIMAL SYSTEM-MIX OF FLEXIBILITY SOLUTIONS FOR EUROPEAN ELECTRICITY

Overall Specifications of the Demonstrations

D3.2

Published

Analysis of the synchronisation capabilities of BESS power converters

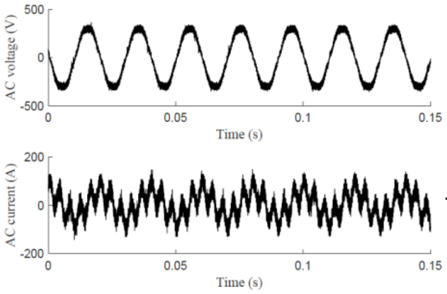
D3.3

Quantification of multi-service synergy and impact on sizing

D3.4

December 2021

Robustness to fault, unbalanced and harmonic distortion



OSMOSE WP3: Factory Acceptance Test of the grid forming demonstrator

Carmen Cardozo, Guillaume Denis and Thibault Prevost
RTE R&D
La Defense, France

Markel Zubiaga, Alain Sanchez-Ruiz and Juan Jose Valera
Ingeteam
Bilbao, Spain

Yannick Vernay
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Lyon, France
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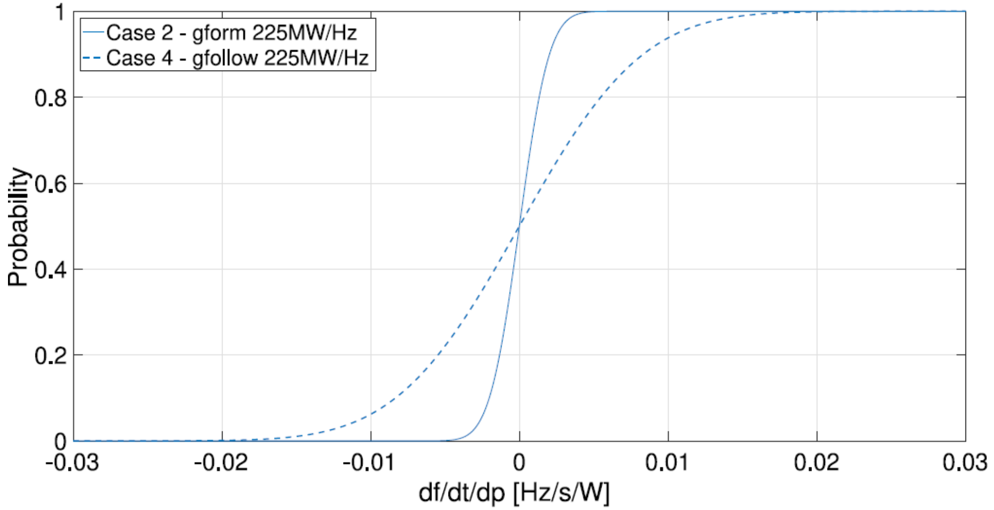
Available online

Grid forming effectiveness and multiservice

Performance Assessment of Grid-forming vs Grid-following Converter-interfaced BESS on Frequency Regulation in Low-inertia Power Grids

Yihui Zuo, Zhao Yuan, Fabrizio Sossan, Antonio Zecchino, Rachid Cherkaoui, Mario Paolone



IEEE TRANS. ON SMART GRID. 1

Real-time Control of Battery Energy Storage Systems to Provide Ancillary Services Considering Voltage-Dependent Capability of DC-AC Converters

Zhao Yuan, *Member, IEEE*, Antonio Zecchino, *Member, IEEE*, Rachid Cherkaoui, *Senior Member, IEEE*, Mario Paolone *Senior Member, IEEE*

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Next steps

Keep braking barriers that prevent any technology having grid forming capability to provide synchronization services.

Too tight requirements could exclude some technical solutions or entail over cost (ex. equipment oversizing)

Too loose might lead to lack of incentive or high prescriptions due to “low quality” but standard product.

- Technical open questions:
  - GFM capability and testing of specific technologies, other than VSC ESS, such as VRE, HVDC and FACTS.
  - Minimal energy buffer and current capability for providing synchronization services. Impact on design & sizing.
  - Limit instability risk of & between different industrial solutions, i.e. (re)synchronization & interactions.
  - System wide and local need for synchronization services. Optimal deployment and scarcity risk limitation.

- Regulatory on going work:
  - Grid forming in grid codes & standards: connection requirements ➡ compliance verification procedure.
  - Definition of synchronization services ➡ suitable certification, procurement & monitoring mechanisms.

EU-SYSFLEX: Demonstrating Virtual Power Plants

The 3 test cases of project EU-SysFlex

Miguel Marques - EDP

What's ahead

- Presentation of the 3 Virtual Power Plant demonstrations in project EU-SysFlex:
  - Utility-scale VPP demo in Portugal: Large Hydro & Wind
  - Multi-Resource VPP demo in France: Wind, Storage & PV
  - Distributed Energy Resources VPP in Finland: Storage, EV, PV
- Their objectives, status, results and next steps

Key messages

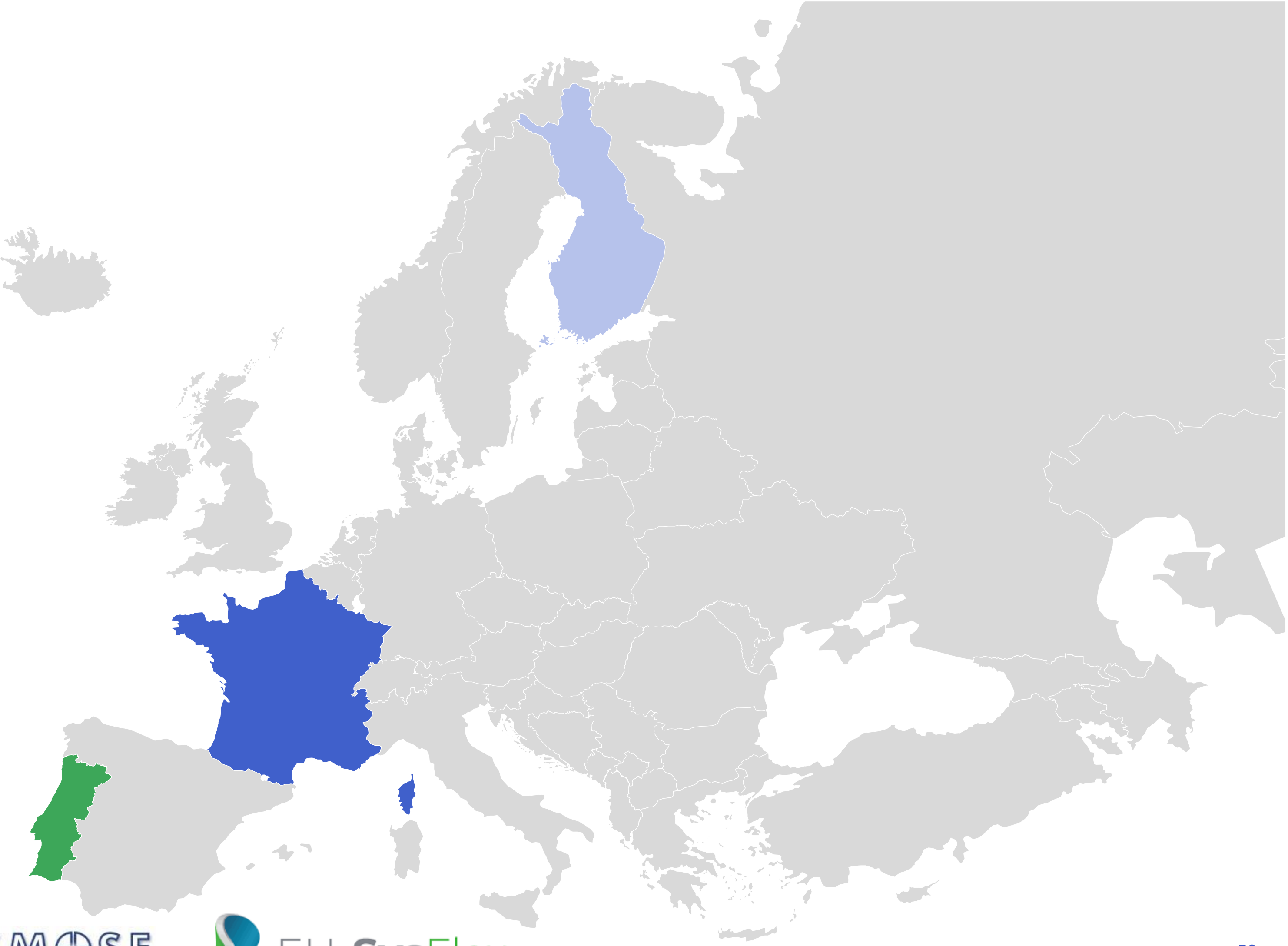
- Virtual Power Plants enable the aggregation and joint control & operation of different assets
- Within EU-SysFlex the 3 VPP/aggregation demos (Portugal, France, Finland) share some common features but are also highly complimentary: in the objectives, services provided, assets used, voltage levels, etc
- After ~3 years of conceptualization, development and early tests, all 3 demos are now well advanced in their demonstration stages, with some tests already fully
- The demos are now assessing and reporting on the results. Synergies and wider implications of these results are already underway – namely within the project’s flexibility roadmap
- VPP/aggregation concepts are bound to have a key role in the future energy system as technology matures and non-technical barriers fade

EU-SysFlex features 3 Virtual Power Plant / Aggregation demos

Distributed Energy Resources VPP
Finland

Renewables & Storage VPP
France

Utility-Scale Hydro & Wind VPP
Portugal



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The 3 demos are complimentary and feature a vast myriad of assets – at diverse scales and voltage levels

Portuguese VPP Demo

Assets

- Large variable speed storage **hydro plant**, Venda Nova III (750MW)
- 2 **wind farms**, Alto da Coutada and Falperra (total 165MW)

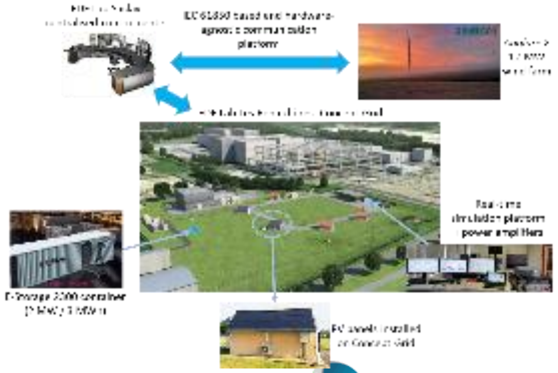
Objectives

- Test the operation of a VPP: the **joint bidding** and **operation** of Hydro+Wind
- Validate the VPP as a **RES-integration tool** via the aggregation with controllable units
- Prove the benefits of VPP as a **decision-support tool** and a **generation portfolio management tool** to optimize resource use

French VPP Demo

- **BESS** (2MW / 3MWh) and **residential PV panels -** EDF Concept Grid (Paris region)
- **Wind farm** located in Marne, 150 km from Paris (12MW)

- **Multi-services provision** (FCR, FFR, FRR, ramping, peak shaving, Q(U), etc.) + energy arbitrage
- VPP concept of **"multi-services provision by multi-resources"**



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Finish VPP Demo

- **3 types of BESS:** Industrial (1,2MW/ 0,56MWh), Office (120kW/136kWh), Residential (13 x 3kW/5kWh)
- **2 types of EV-Chargers:** Office 22 kW AC (8 units) + Public 50kW DC (1)
- **PV Plant** (850kWp)

- **Aggregation** of small distributed assets to TSO's ancillary services & for DSO's reactive power compensation needs
- Developing and piloting suitable interfaces to connect the distributed assets to the **aggregation platform**

All 3 demos have either finished the tests or about to wrap up the demonstration stage

First online test completed

- Online operation of the VPP successfully tested, essential conclusions yielded
- The online testing was preceded by offline tests to both the algorithmic part of the VPP (the VPP Core) and the VPP Controller, implementing the setpoints

Demonstration stage completed

- Industrial-scale BESS online and operating in TSO's reserve markets
- Office-scale BESS remote operation in peak-shaving mode and market integration to TSO's reserve market finalizing
- Result reporting ongoing

Testing of the whole VPP ongoing

- Hardware & ICT implementation in 2018-19
- Local controllers (wind & storage) of services provision developed, validation tests completed in 2020
- First operational version of EMS (Energy Management System) of the VPP commissioned and tested in 2020

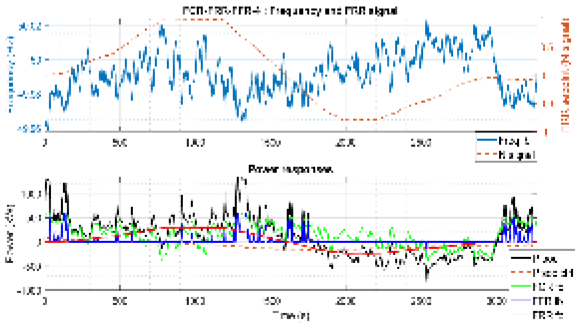
Even with some tests to be completed, the demos have already produced important results

Portuguese VPP Demo

- The VPP is computing accurate and reliable **dispatch schedules and bid suggestions** for the Hydro + Wind VPP
- Online, real-world **deviation handling**, with the hydro plant adjusting to the fluctuations of the wind farms' production
- The VPP tool is now fully capable of controlling the units as a VPP

French VPP Demo

- Development of a set of advanced tools (forecasting, optimization, control, communication, supervision, etc.) to ensure the full-chain operation of the VPP
- Day-ahead optimal scheduling and intraday adjusting of VPP programs & services provision based on forecasts of renewable generation and markets' prices
- Real-time demonstration of multi-services provision in real grid -----> conditions



Finish VPP Demo

- Set of **forecasting/optimization tools to estimate the available flexibility of the LV/MV assets** for TSO ancillary services has been developed
- Accomplished the **technical proof of concept of distributed flexibility resources**: BESS, PV and EV charging points and **controlling these assets** according to market actions
- Operating BESS in a **real-life TSO market**
- Technical proof of concept for a new market mechanism to **manage reactive power** in the TSO/DSO connection point

VPP/aggregation concepts are bound to have a key role in the future energy system as technology matures and non-technical barriers fade

Next Steps in demos…

- Report and assess the results yielded, measure and explore the KPIs
- Test with the hydro in pump mode – provided adequate market conditions exist
- Clearly define and quantify the benefits of the concepts vs BaU

- Finalize the full-chain VPP operation demonstration and the long-term simulations (taking place as we speak)
- Demonstration of reactive power services (expected in H2 2021)
- Assessment of KPIs and report on the results

…and beyond EU-SysFlex

- **Replicating and scaling-up** the concepts will reinforce the soundness of these aggregation concepts:
  - Using larger-sized BESS
  - With a larger number of distributed BESS
  - With a wider number of units under the VPP's management
  - …
- More accurate and advanced **control/forecast algorithms** can make for a more efficient and integrated concept (e.g. faster response in the EV-charging control)
- **Regulatory barriers** may wane once system-wide welfare are proven…but changes take time!

Thanks for your attention

EU-SysFlex

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The OSMOSE project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773406

The EU-SysFlex project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 773505

Voltage and frequency regulation from RES in OSMOSE

Alessio Siviero

Flexibility services by renewable energy sources: how?

Nowadays flexibility needs such as Voltage Regulation and Grid Inertia are provided only by conventional plants.
Are RES plants capable of providing such services?

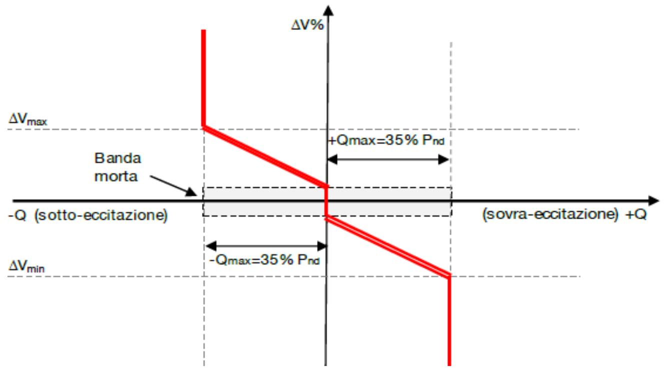
Automatic Voltage Regulation (AVC)

As reported in the latest Italian Grid Code update (A17), new wind plants will have to be technically ready to provide AVC

Centralized Regulation

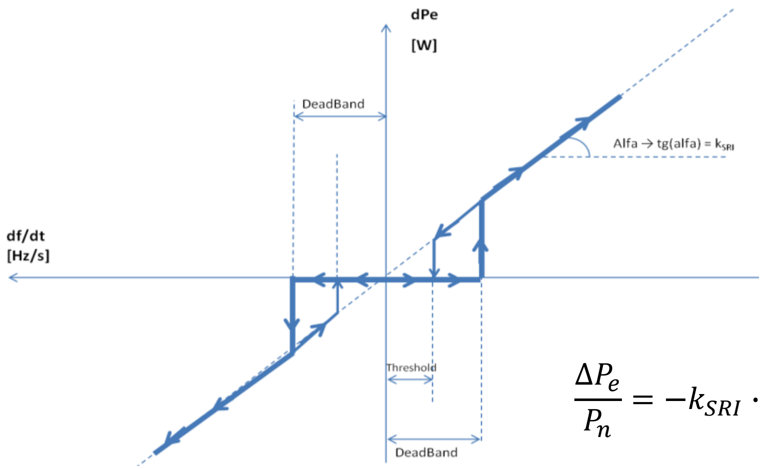
→ Terna communicates the target Q value and the plant provides reactive power up to its capability limit.
→ …

Local Regulation



→ Reference V value is communicated by Terna; Q provision by the plant follows a Q=f(ΔV) curve.
→ …

Synthetic inertia



$$\frac{\Delta P_e}{P_n} = -k_{SRI} \cdot \left(\frac{\Delta f}{\Delta t}\right)$$

Service characteristics required:

→ Power supply proportionally dependent on ROCOF.
→ Filtering of the measured frequency derivative
→ Maximum delay values for filtering and power output computational times
→ …

Osmose (Task 5 – RES) features two RES plants for innovative flexibility services testing

Two different RES power plants have been involved in the experimentation to understand RES flexibility provision capability:

Assets

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Vaglio

- Total nominal power: **15 MW+20 MW**
- Turbine Siemens Siemens-Gamesa G114 **– 2.5 MWx6**

OSMOSE

enel

Pietragalla

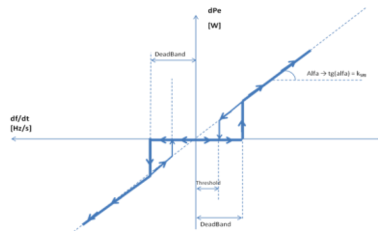
- **18 MW** wind power plant
- **2MW/2MWh, Li-ion (NMC) BESS**
- RES+BESS integrated system

Objectives

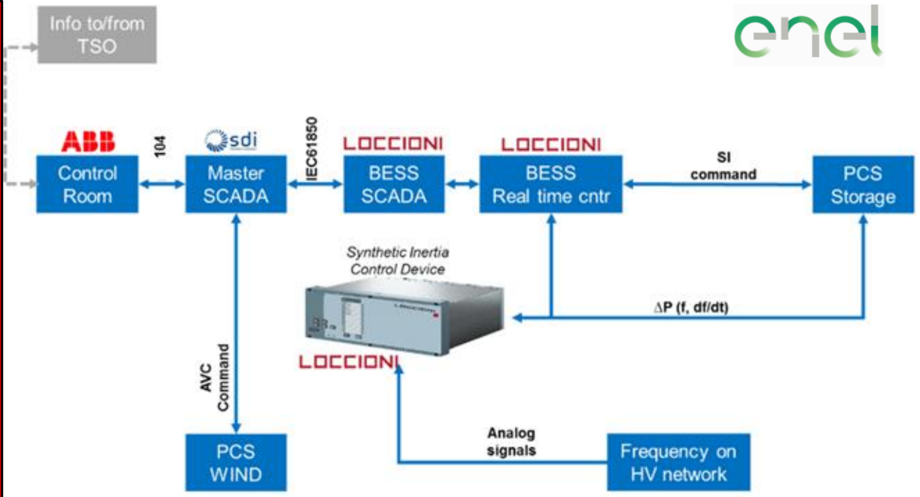
- **Technical characterization of synthetic inertia provision by a wind turbine**
- **Technical characterization of AVC provision by wind turbines and testing of the performance of the whole technology chain**

- **Technical characterization of synthetic inertia provision by the BESS system**
- **Technical characterization of AVC provision by BESS and wind turbines and testing of the performance of the whole technology chain**

Synthetic inertia implementation was challenging and required some major R&D activities



Pietragalla



Concept Starting from **real time HV measures**, a specific device («Synthetic Inertia Control Device», SICD) calculates **ROCOF** and subsequently the **P** set-point to be sent **directly** to the **BESS inverter**.

Challenges The main challenge regarded the **«measurement» module** of the SICD: Rocof needs to be calculated and properly filtered – we don't want «false» or «hectic» activations!

Innovation The main innovation lies in the **testing and combination of «existing» filtering** and data analysis techniques on an application working with very **high sampling frequency measurements**.

Where are we now. Implementation is complete and **tests are about to start**.

Concept The WTGs control system and power electronics of a single WTG have been reconfigured to use **WTG available mechanical inertia** to reduce **or inject an instantaneous ΔP** in response to a fictitious event and test the **technology and control chain performance**

Challenges & innovation The activity regards the **development and implementation of new control logics in the converter** firmware and PLC software upgrade – these logics were **never tested before** by Siemens Gamesa on this type of turbine. **R&D activities** are currently ongoing in Siemens Gamesa Laboratory with bench test activities on the different components of the turbine.

Where are we now. Bench test activities on going at the moment. Next is implementation on the wind turbine in Vaglio and experimentation

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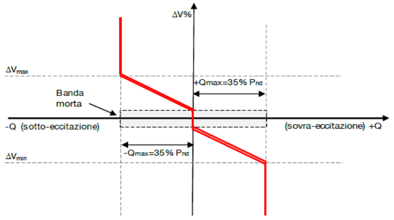
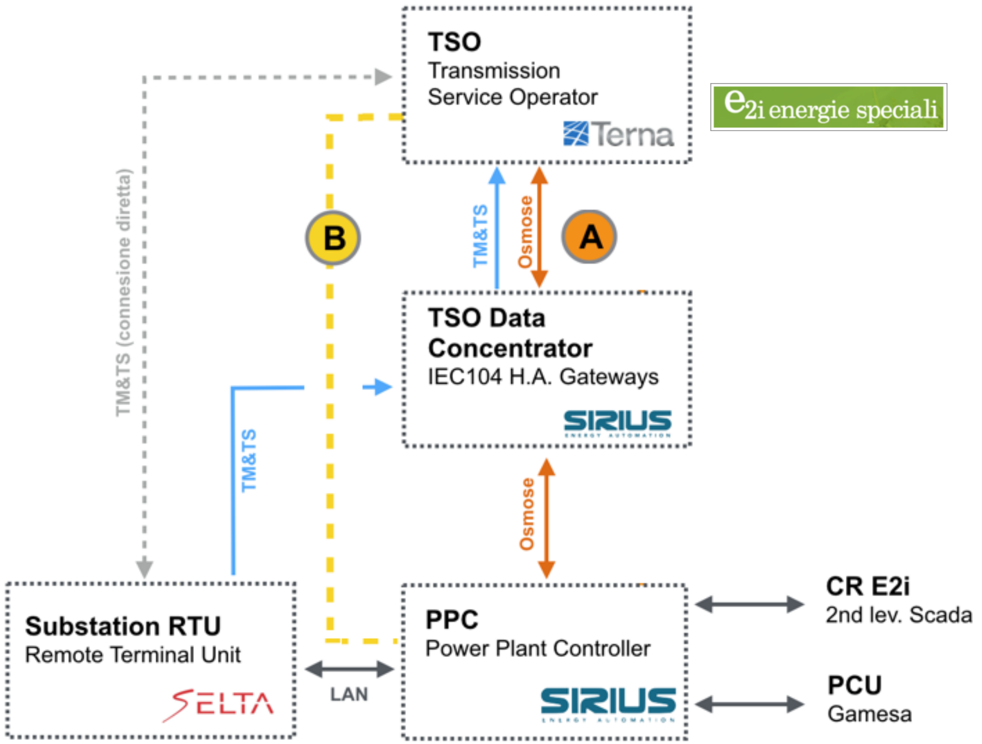
Vaglio

AVC implementation followed a similar path for both plants; its complexity increased with the plant’s complexity.





Concept Both plants underwent **hardware and software updates in their plant controller** so to implement the control and regulation algorithms necessary for AVC provision.

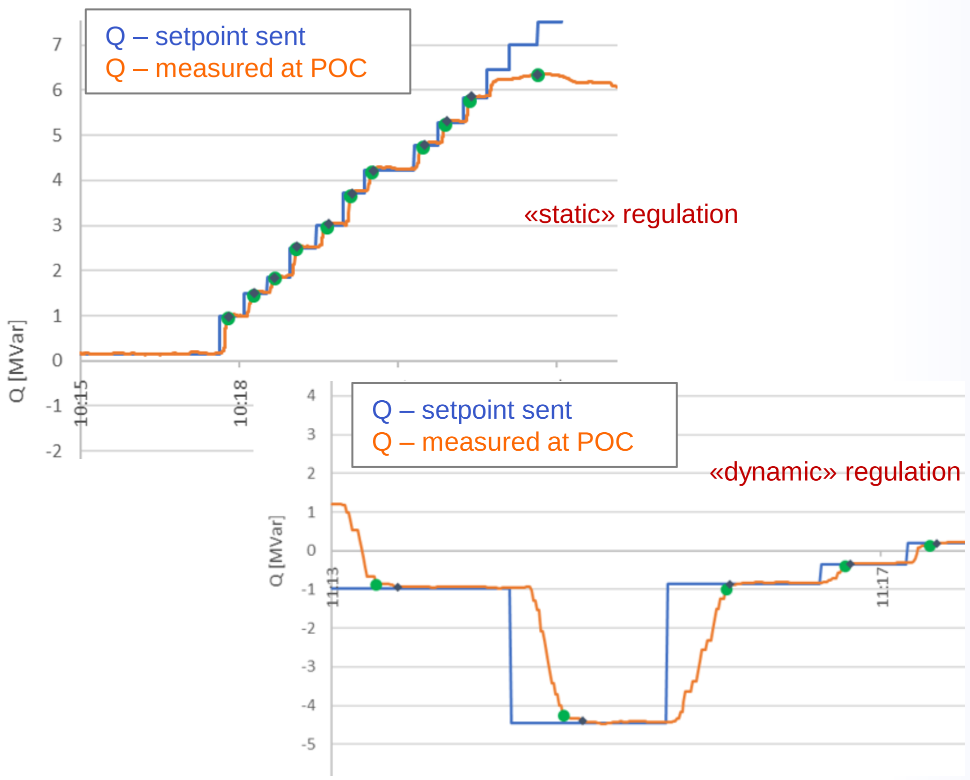
Challenges & innovation For both plants, a considerable amount of work has regarded the definition and implementation of the **most appropriate list of set-points, signals, measurements and commands** that would guarantee the service provision most efficiently. **Such plants are not usually “controllable” by the TSO for AVC provision**.

Pietragalla. The solution adopted in Pietragalla provides functionalities in order to guarantee for the **correct coordination between the wind power plant and storage system** during AVC service provision.

Vaglio The Vaglio solution should, eventually, allow a **comparison** between the AVC service provided thanks to **«direct» communication** with the TSO (solution «B» in the picture) and **«indirect» communication** with the TSO (solution «A» in the picture), especially in terms of rapidity of provision.

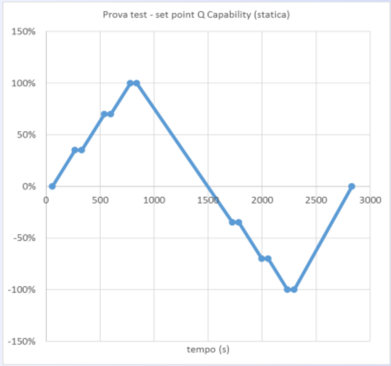
Where are we now:
Pietragalla: Connection tests with Terna are almost done and tests ready to start
Vaglio: Experimentation has already begun.

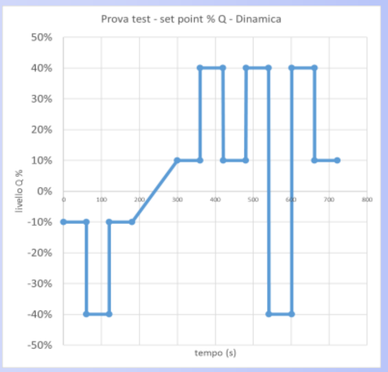
First AVC tests suggest that the plants can provide AVC; further tests will provide more insight.



Local tests. **Tests conducted in Vaglio with Q set-points** (*centralized* regulation) directly sent from the **local control system**

Test typology. Purpose is to test the **static and dynamic response** of the plant to a Q set-point. For this reason, the plant is asked to follow ramp and step set-points and its behavior is monitored in the process.





Preliminary results. **The plants seems capable of reaching the required set-points** but further analysis need to be made to understand better features related to capability saturation issues, set-point execution time and dynamic response curves.

Key messages

- The transformations undergoing in the Electricity System, strictly linked to the energy transition, require the identification of new resources for the provision of active and reactive power flexibility.
- Within OSMOSE (task 5 – RES) two power plants will serve as testing grounds for innovative means of provision of voltage regulation and synthetic inertia, investigating complimentary features.
- The design and implementation phase of the activity suggest that while AVC solution implementation requires the upgrade of existing systems, some more effort might be needed on synthetic inertia on a R&D level in the future (e.g., understanding of the load effects on turbine).
- After 3 years and more of design and implementation, the experimentation has begun. Preliminary results concerning AVC tests in Vaglio show promising results (but further analysis is needed).

Next steps

- AVC experimentation:
  - Local tests to be finalized in Vaglio with V set-point tests. Next, remote tests with direct input from the TSO will be performed
  - In Pietragalla, connection tests are to be finalized soon and local tests to performed consequently. Next, remote tests with direct input from the TSO will be performed.
- Synthetic inertia experimentation:
  - The system implemented in Pietragalla is ready to use. For some days per month, it will be activated and provide an immediate synthetic inertia response when a rocof event is registered.
  - The Vaglio solution will be implemented in the next weeks after the bench tests are completed.

Thanks for your attention

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EU-SysFlex

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CONCLUSIONS

Q&A SESSION

Thanks for your attention

OSMOSE

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