Value and Demonstrations of Flexibility Provision by Distributed Resources

Insights from OSMOSE and EU-SYSFLEX projects

Joint webinar by the
OSMOSE and EU-SysFlex projects
17th June 2021

AGENDA

- **Introduction of the webinar and both projects**: Marie-Ann Evans (EDF), Nathalie Grisey (RTE)
- **Topic 1: Value of distributed flexibilities**
  - OSMOSE: Modelling distributed flexibilities in 2030 market simulations: Giuditta Pisano (ENSIEL-UniCA)
  - EU-SysFlex: Challenges for TSO-DSO coordination when using distributed flexibility for system purposes: Helena Gerard (EnergyVille, VITO)
- **Topic 2: Demonstrations**
  - EU-SysFlex: Portuguese DEMO Flex Hub: Susete Albuquerque (E-REDES)
  - OSMOSE: A tool to support the TSO & DSO in the optimal planning of the flexibilities: Rui Pestana (REN), Ricardo Pastor (NESTER)
  - EU-SysFlex Italian demo: Use of flexibilities connected to the MV grid for congestion management and voltage control: Simone Tegas (e-distribuzione S.p.A.)
  - EU-SysFlex German demo: Processes and systems for using flexibility from distribution grid to integrate a high share of RES in a resilient, stable and efficient operated energy supply system: Maik Staudt (Mitnetz Strom)
- **Q&A session** with guest Tommaso De Marco (Terna) and moderated by Helena Gerard (VITO)

Your questions on the upcoming presentations

- Please use the “Q&A” section and specify the targeted speaker
- There will be a brief Q&A session after each presentations (except project introductions) and a longer one at the end of the webinar
- In case some questions are not answered during the Q&A session due to lack of time, they will be answered per email by the speakers

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 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

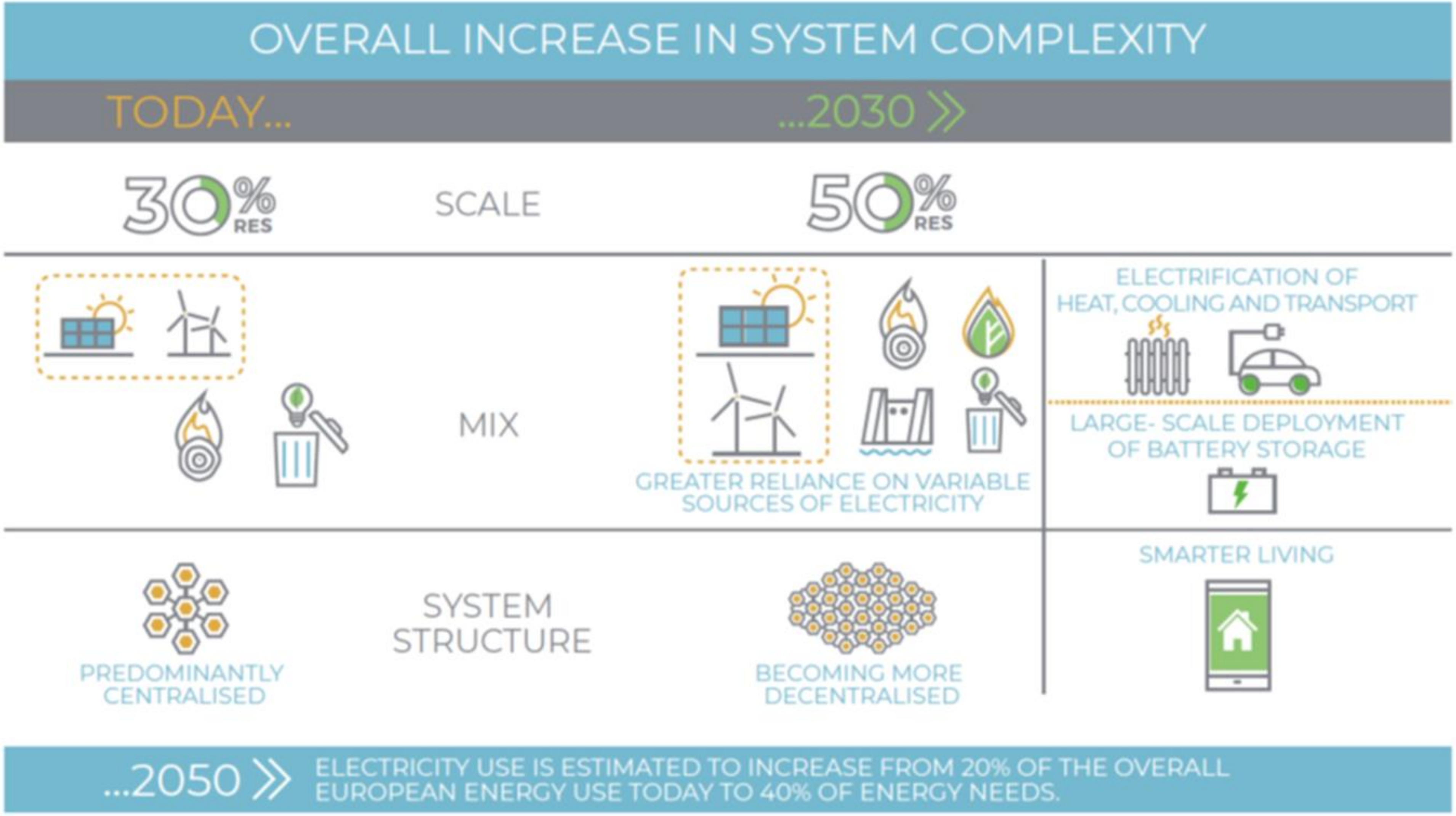
WORK PACKAGES
12

DEMONSTRATIONS
7

DELIVERABLES
100

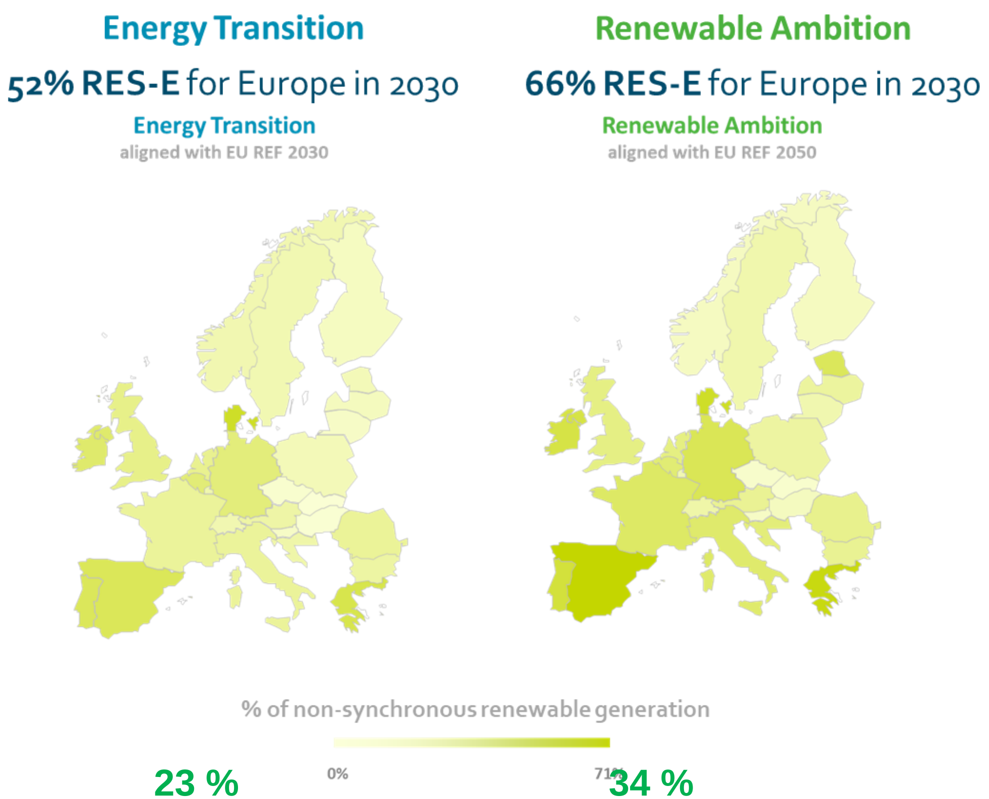
OSMOSE EU-SysFlex

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



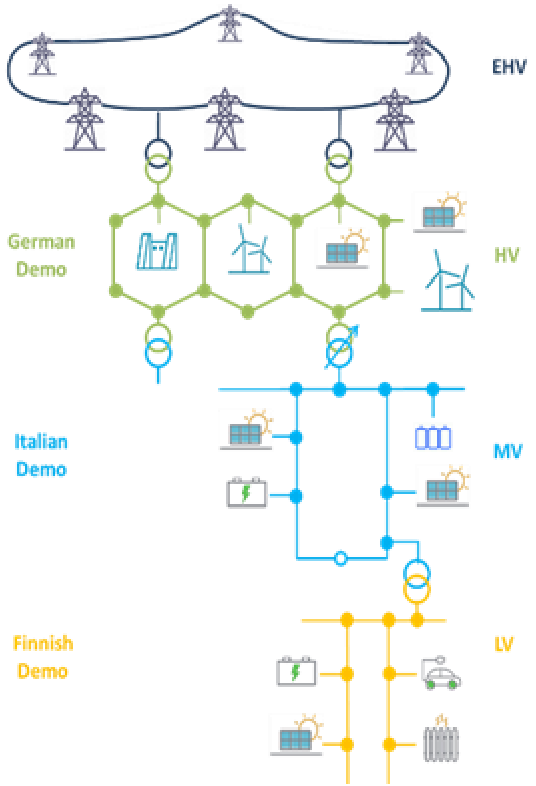
OSMOSE EU-SysFlex

A future power system increasingly reliant on variable and distributed sources of electricity and flexibility



23 % VRES

34 % VRES

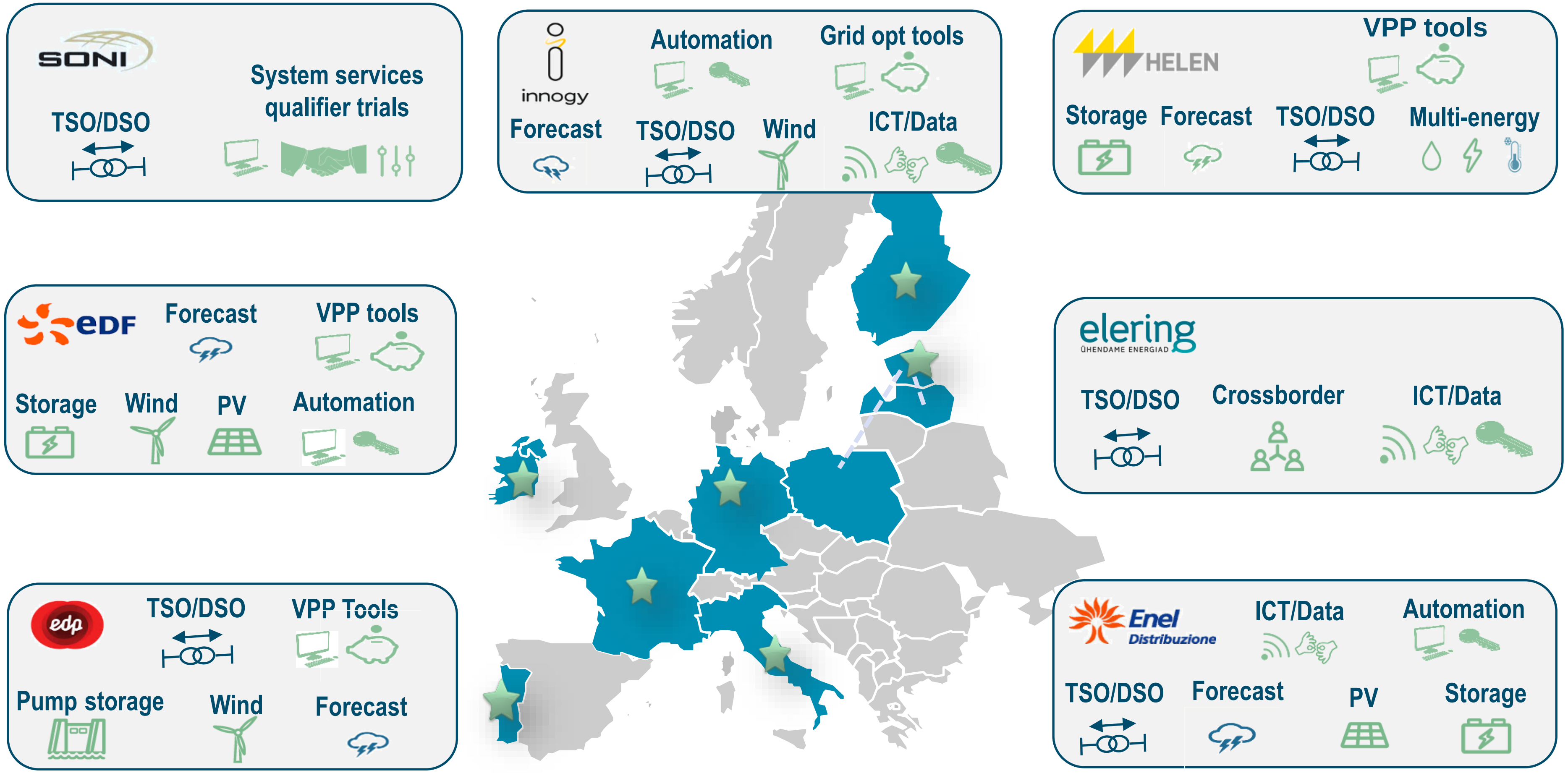


High RES-E scenarios translate in increasing **levels of distributed electricity and flexibility sources in all voltage levels**: VRES, grid assets, storage, EV, DSR, …

To operate reliably the future system and unlock the full flexibility potential, **coordination between System Operators is key**.

OSMOSE EU-SysFlex

Industrial scale demonstrations of system services provided by distributed sources



OSMOSE EU-SysFlex

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 the 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.

NEW FLEXIBILITY SOURCES

?

NEW FLEXIBILITY NEEDS

OSMOSE EU-SysFlex

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

OSMOSE : Objectives and WPs

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WP2 Market designs and regulations

WP7 Scaling-up and replication

Presentations of today !

4 Demonstrators

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- ✓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

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Topic 1: Value of distributed flexibilities

OSMOSE Modelling distributed flexibilities in 2030 market simulations

Giuditta Pisano (ENSIEL-UniCA)

ensiel
ENERGIA E SISTEMI ELETTRICI

EnSiel is no-profit research organization, formed by:

- Italian **Ministry for Education, University and Research - MIUR**
- Italian **Ministry for the Economic Development - MISE**
- #21 members + #5 (partners) **Public Universities**

with experts in Energy and Electric Power Systems.

MIUR

MISE

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Università di Messina

OSMOSE EU-SysFlex

Flexibility

Flexibility is:

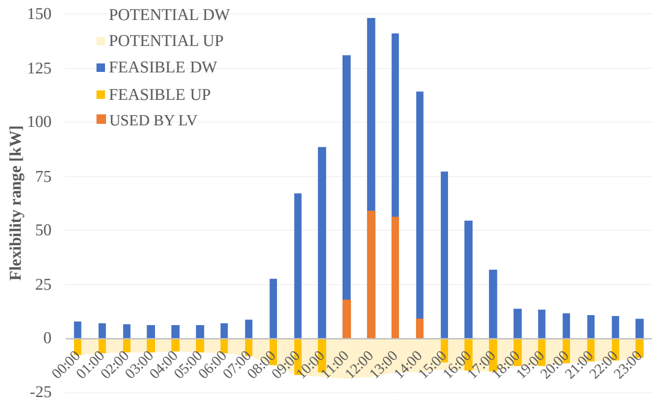
- From Distributed Energy Resources' (DERs) point of view: "***the ability to be easily modified"***
  - DERs can ***modulate, shift, vary*** in upward or downward their expected set point of active and reactive power (produced or demanded)
- From the power system' point of view*: "**the ability to manage changes"***

- It is mainly found at the **distribution system level**, but it is needed by **both TSO and DSOs** to cope with grid operation challenges

Hot points for the exploitation of DER flexibility

- Regulation
- Market
- DSO’s role
- TSO/DSO interaction
- Balance between local/global services
- EU 944/2019 application

- Local needs of DER flexibility (both at MV and LV levels)
- **Open options:**
  - DER flexibility exclusively exploited by (and reserved to) the TSO → **distribution grids need upgrade (investments)**
  - DER flexibility exclusively used by DSOs → **TSO continues to resort the usual flexibility providers** (e.g. hydro plants)
  - (Intermediate option) DER flexibility used by **both DSOs and TSO** → **lack of use cases**

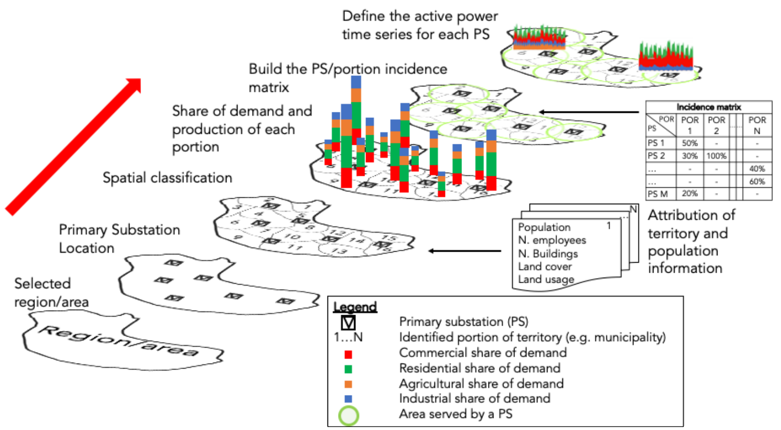


Modeling distribution grid flexibility

Within OSMOSE project

- ***Objective:*** evaluate the contribution of the distribution systems to power system security and adequacy by assessing the flexibility services, potentially offered to the existing or new markets, by the DERs connected to selected distribution networks (in Italy and in France).
- ***Achieved results:*** aggregated bids in terms of quantity/price pairs offered by each selected distribution network (DN)
- Two main tasks:
  1. **Representing distribution grid by building synthetic networks**
  2. **Assessment of the distribution network market potential**

Modeling distribution grid flexibility

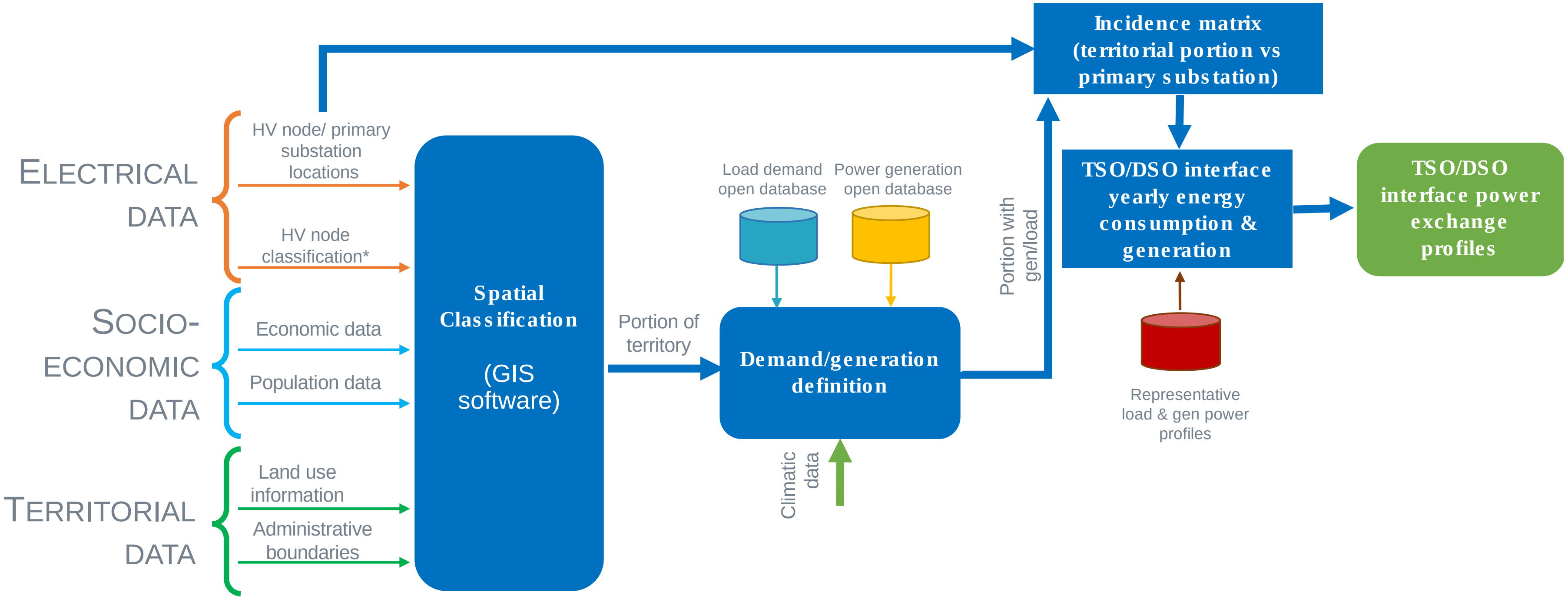


1. Synthetic distribution grids

a. **Estimation of load and generation profiles** by using only available open data and by resorting GIS applications and tools

- Limit the area of interest (a group of distribution networks that serve a territorial portion, e.g., the one of which the open data is available)

- Consider or estimate the expected profiles of demand and production at the PCC at the TSO/DSO interfaces

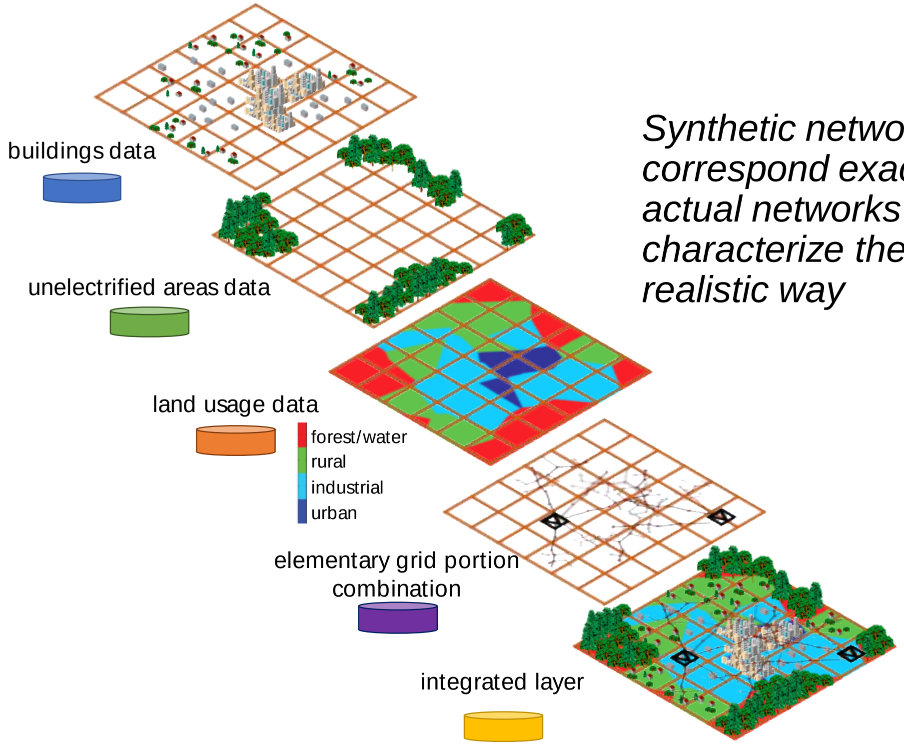


*user substation, distribution network, production substation

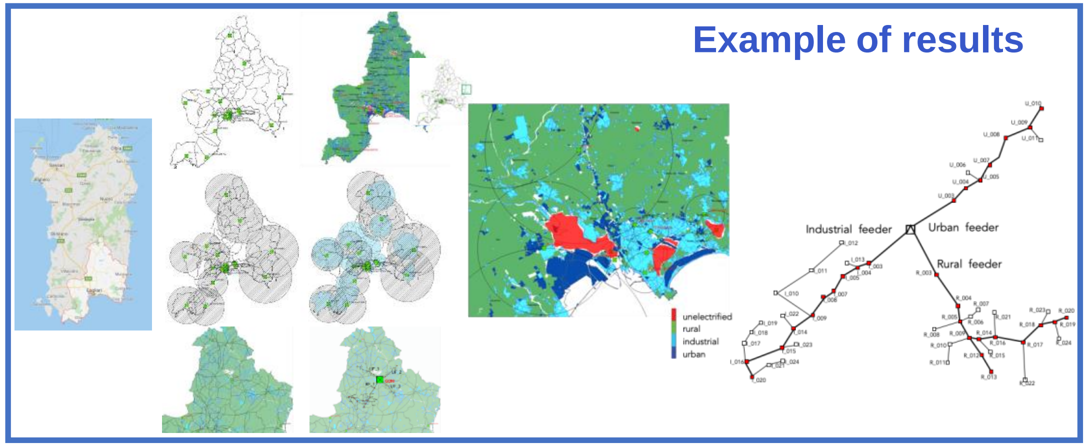
Modeling distribution grid flexibility

1. Synthetic distribution grids

b. Building **synthetic networks** by composing elementary portions of representative networks according to the territory segmentation derived by the land usage (GIS)



Synthetic networks do not correspond exactly to the actual networks but can characterize them in a realistic way



[1] G. Pisano, N. Chowdhury, M. Coppo, et Al. “Synthetic models of distribution networks based on open data and georeferenced information.” Energies 2019 (MDPI), 12(23), 4500.

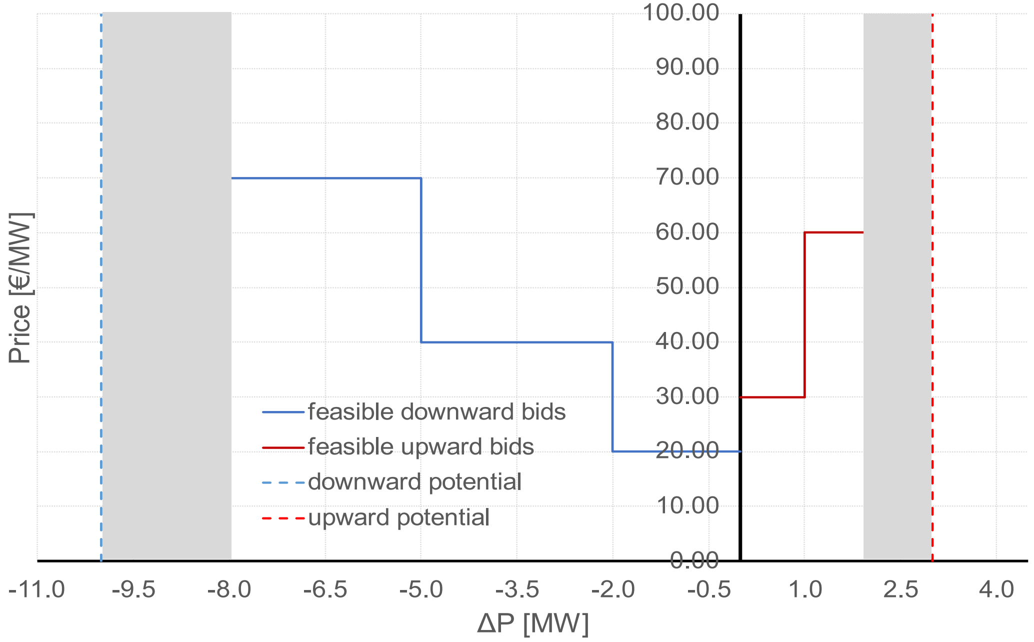
Modeling distribution grid flexibility

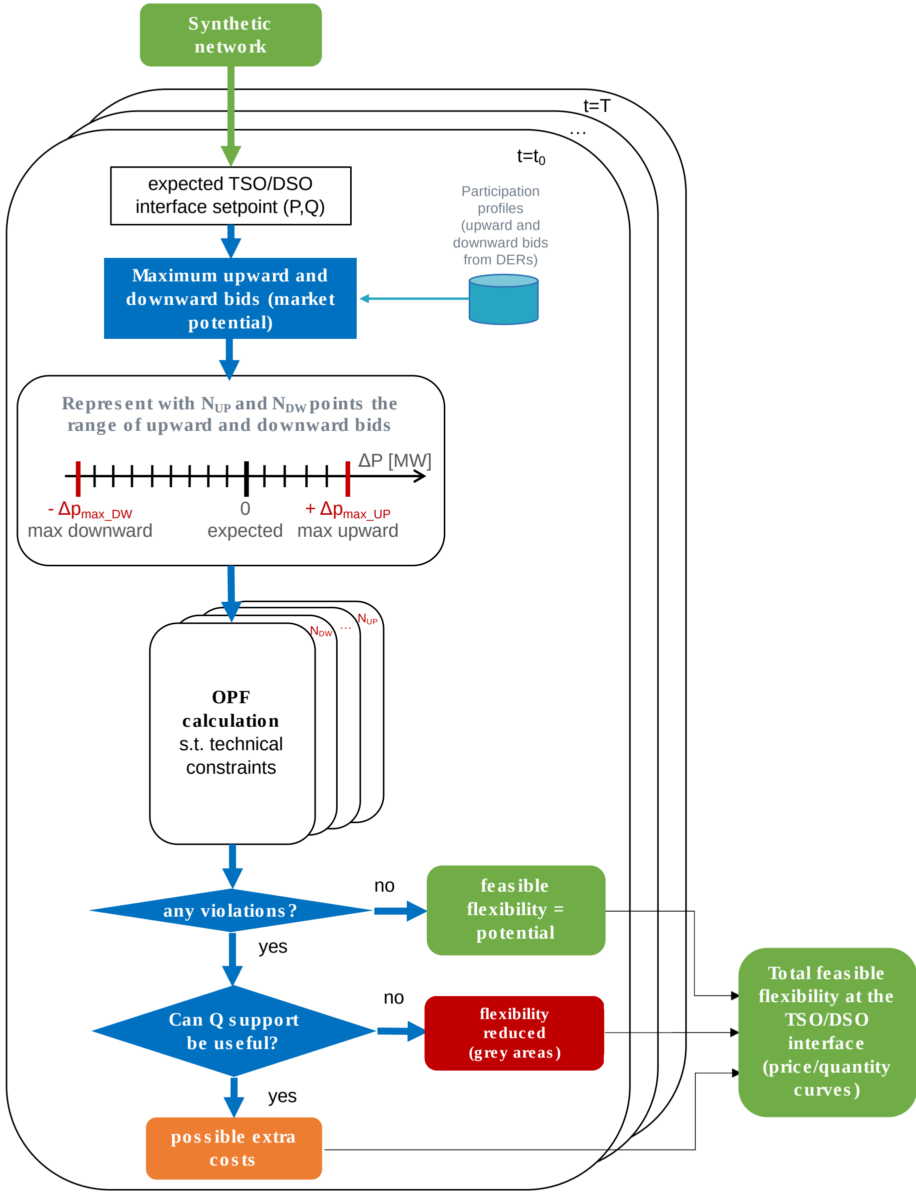
2. Assess the bids

- **Volume** and **price** pairs at the TSO/DSO interface (the underline distribution modelled an **equivalent power plant**) by running OPF calculations that consider the technical constraints of the distribution grids

Example of results

price/quantity bids (@12:00 of summer working day)

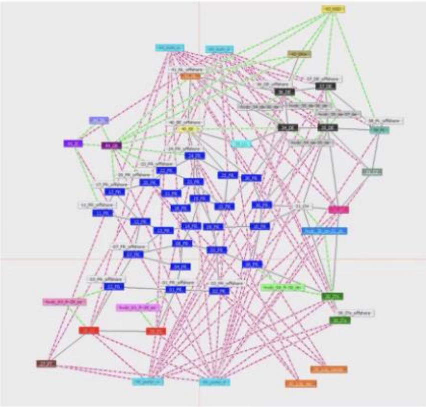




French use case

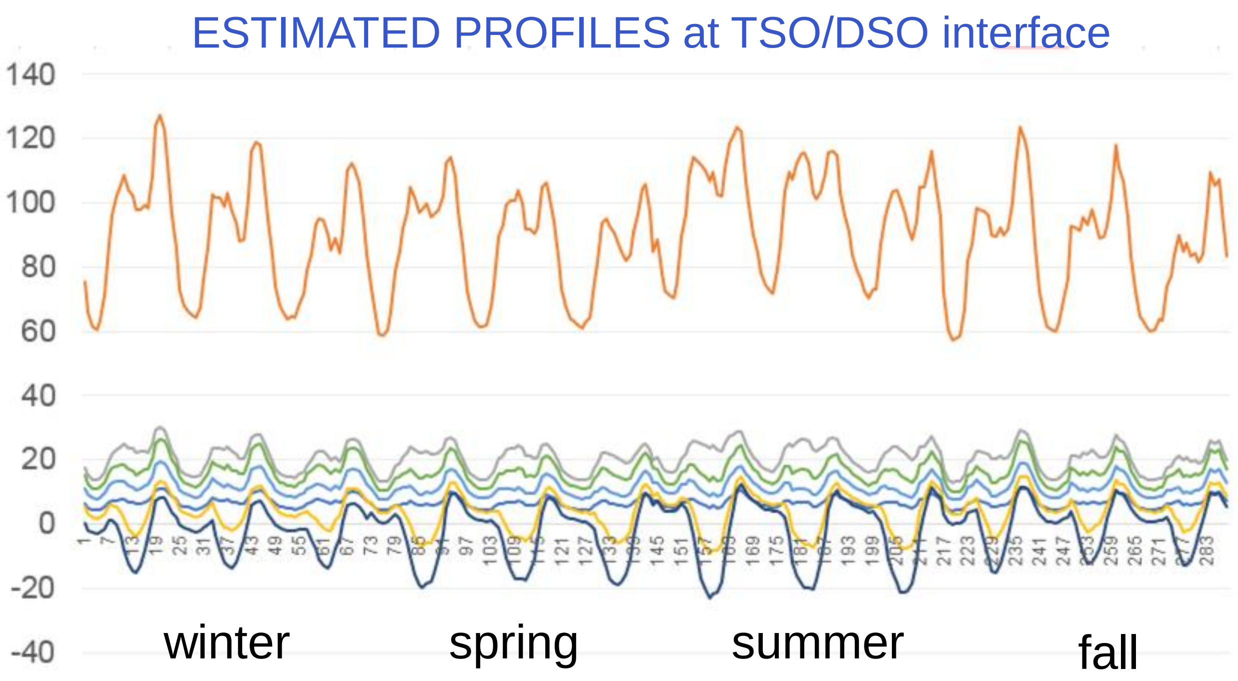
Use case

- OSMOSE study perimeter: central France simulated with the nodal market model within the same WP2 of OSMOSE
- Small region, but…
  - **#290** HV nodes (different voltage levels, several in the same location)
  - **#263** distribution networks (DNs)
  - **#7** regions (Auvergne, Bourgogne, Centre, Basse-Normandie, Île-de-France, Pays de la Loire, Rhône-Alpes)
  - **#14** departments (Allier, Cher, Essonne, Eure-et-Loir, Indre, Loir-et-Cher, Loire, Loiret, Nièvre, Orne, Puy-de-Dôme, Sarthe, Yonne, Yvelines)



Modeling distribution grid flexibility

- Power profile at the TSO/DSO interface - example
  - **twelve typical days** (working, Saturday and holiday for the four seasons respectively)
  - DG power installed in the selected DNs – 2030 forecasting:
    - 1,93 GW of PV
    - 4,4 GW of WIND
- Reverse flows



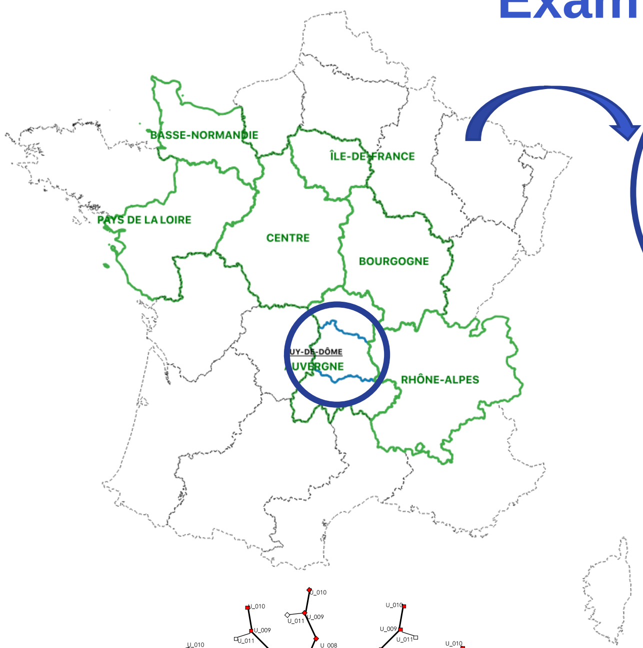
Estimated load – Estimated production = Estimated residual load

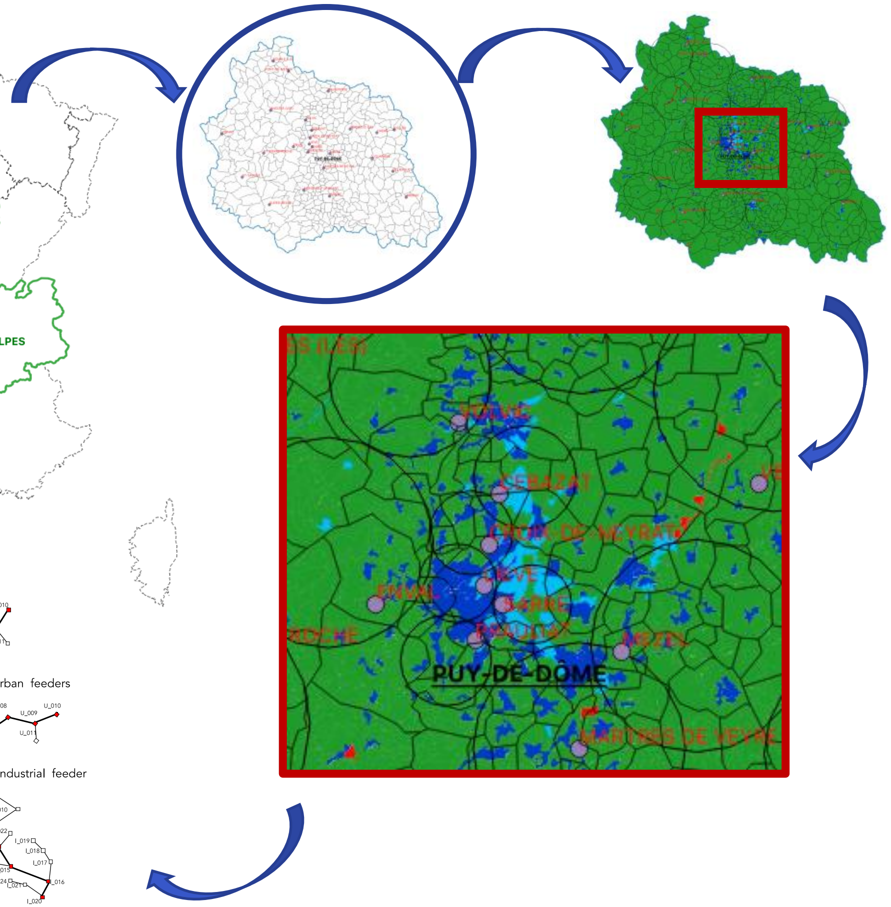
Modeling distribution grid flexibility

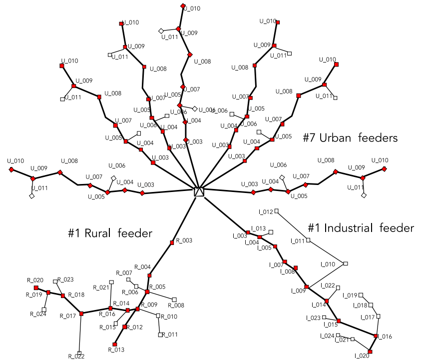
- Synthetic network model - example
  - The synthetic networks are built by composing four **elementary portions** of distribution networks representative of given ambits

- For each real DN:
  - Estimated demand [GWh/y]→derived by public data and GIS tools
  - Number of Rural, Industrial and Urban Feeders
  - Error in the model (covered by a non-flexible *jolly* feeder)

Example of results (French case)



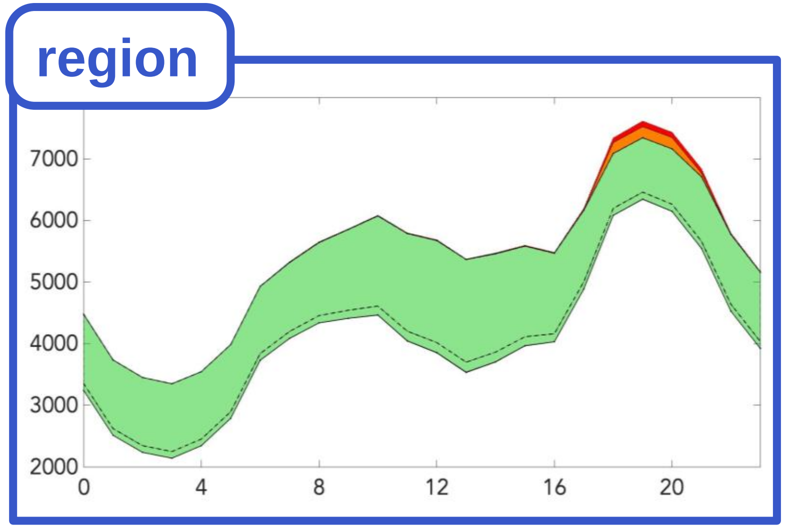


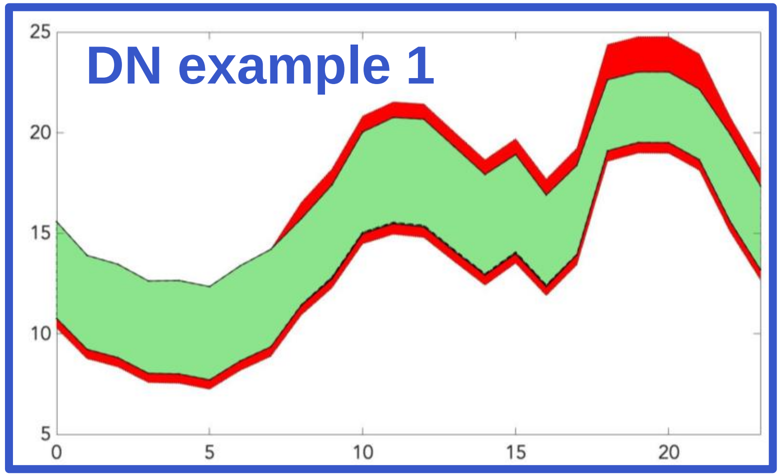


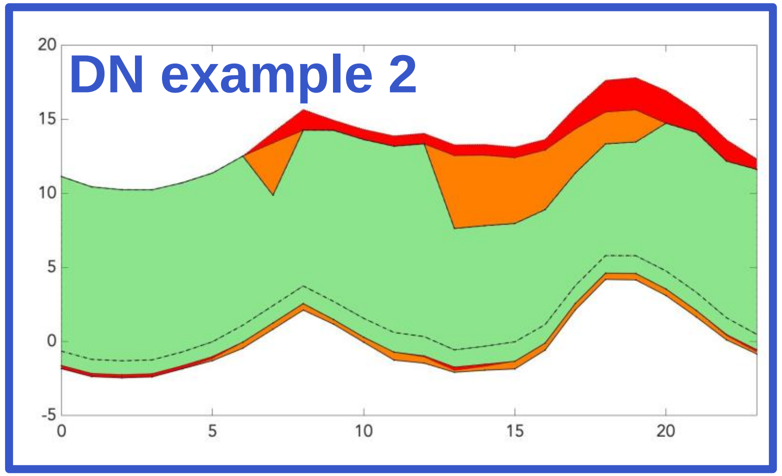
Results for Central France

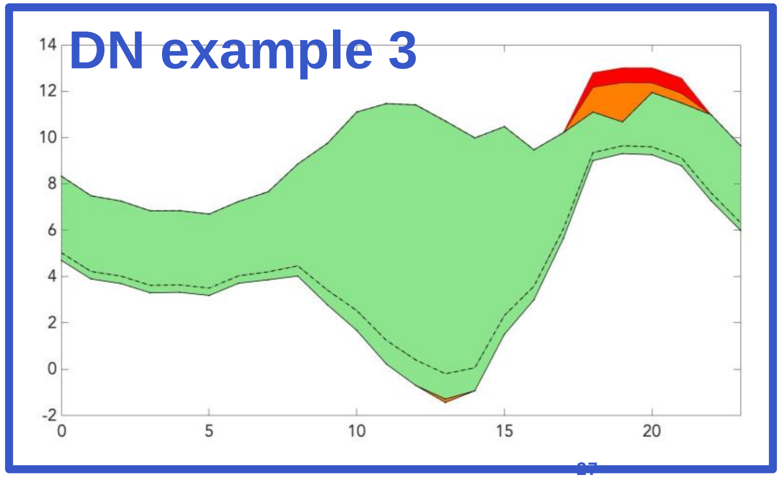
	UPWARD bids	DOWNWARD bids
Potentially offered Energy [GWh/year]	862.220	8626.752

- Two DG scenarios:
  1. ***fit & forget***→ small sizes, distributed **UP -1.5%; DW -0.9%**
  2. ***critical***→ big sizes, concentrated **UP -14.6%; DW -10.8%**









OSMOSE EU-SysFlex

Key messages/remarks

- The proposed methodology can be used by:
  - **TSO:** *to estimate the expected **level of flexibility** products offered by distribution networks and the relevant prices*
  - **DSOs:** *can understand in advance **the effects** of the exploitation of flexibility for operational and planning analysis*
  - **Players of the ancillary service market:** *can assess at what extent the flexibility products from distribution system could **compete with them***
  - **DERs aggregators:** *can **simulate reasonable operative conditions** to better define prices and quantities of products that could be offered by their portfolio of customers*
- **Flexibility** products may **compete with traditional options** for network expansion
- Grid limitations cannot be disregarded
- **TSO/DSO integration needed**

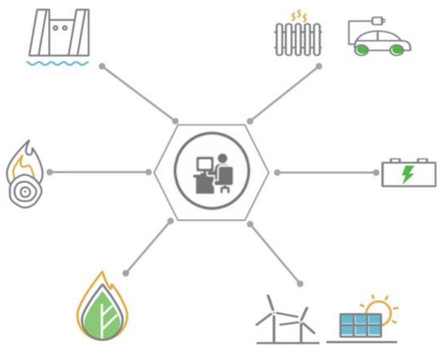
Challenges for TSO-DSO coordination when using distributed flexibility for system purposes

Helena Gerard (EnergyVille/VITO), Senior Researcher

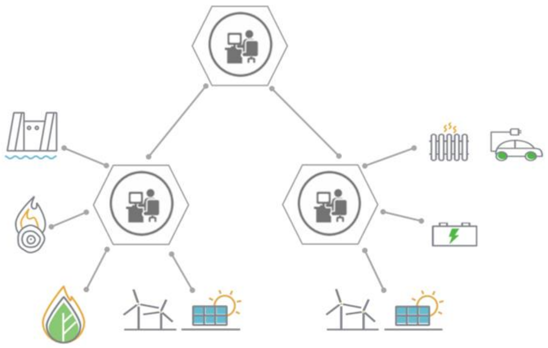
The Challenge of TSO-DSO coordination

TSO-DSO coordination will be organized in a different way dependent on the chosen design

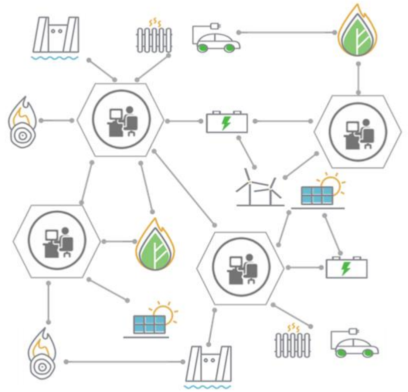
Market design options - from centralized to decentralized to distributed (P2P) markets



Centralized



Decentralized



Distributed

- **Challenge 1**: How to integrate grid constraints in different market design concepts?
- **Challenge 2**: How to organize a combined approach for product/market design for multiple system services?
- **Challenge 3**: How to facilitate participation of FSPs, independent of the chosen set-up for TSO-DSO coordination?

Challenge 1: How to integrate grid constraints in different market design concepts?

- Grid constraints as part of the prequalification process (before procurement)

  1. **Market prequalification:** compliance with the financial and IT requirements necessary to participate in a flexibility market (at the level of the Flexibility Service Provider)

  2. **Technical prequalification:** compliance with the technical requirements for the product procured (at the level of the Flexibility Unit)

  3. **System prequalification:** verification if the provision of flexibility from a specific location is not violating grid constraints (= STATIC)

- Grid constraints included in the procurement phase (clearing)

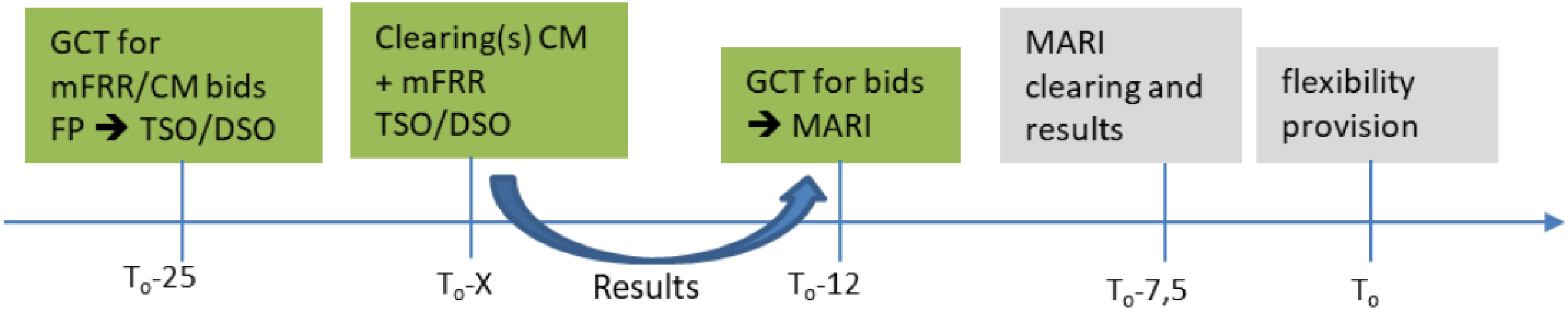
  - **Option 1**: Clearing where all **grid information is included in the market optimization/clearing** algorithm -> risk of complexity
  - **Option 2**: Clearing where **partial grid data** (statistical representative grid model) **is included in the market optimization/clearing** algorithm -> possible need for a ex post check
  - **Option 3**: Clearing happens without grid information -> outcome is sent to different system operators who define for each bid the relevant **bid limitations** -> information sent back market operator

The option selected will determine the role of the system operators in the process and the possible role of an independent third party

Challenge 2: How to organize a combined approach for multiple system services?

- **Question**: How to jointly organize the 'procurement process' of balancing and congestion management
- **Precondition**: Joint product is a prerequisite
- Joint product could allow FSPs to bid only once, joint optimization/procurement could decrease flexibility volume needed by TSOs and DSOs
- Multiple **definitions** of 'joint procurement':
- **Integrated process**: joint bidding and Joint optimisation

Number of products	Number of scarcities*	Number of buyers	Joint Procurement	Optimisation across scarcities	Example
1	1	1	No	No (separate optimisation of scarcities)	Separate procurement of mFRR and CM by TSOs; procurement of CM by DSOs
1	1	2	Yes	No (separate optimisation of scarcities)	Coordinated procurement of CM by TSOs and DSOs
1	2	1	Yes	Yes (joint or coordinated)	Procurement of mFRR type of product for CM and imbalances by TSOs; Procurement of CM product for CM and voltage control by DSOs
1	2	2	Yes	Yes (joint or coordinated)	Procurement of mFRR type of product for CM and imbalances by DSOs and TSOs
2	1	1	Yes	No (separate optimisation of scarcities)	Procurement of reactive power and active power for voltage control by TSOs or DSOs
2	2	1	Yes	Yes (joint or coordinated)	Procurement of reactive power and active power for CM and voltage control by TSOs or DSOs
2	2	2	Yes	Yes (joint or coordinated)	Procurement of reactive power and active power for CM and voltage control by DSOs and TSOs



Challenge 3: How to facilitate participation of FSPs, independent of the model for TSO-DSO coordination?

- The '**supermarket concept**'
  - ➢ Flexibility service providers provide the specifications of a pool of flexibility
  - ➢ System operators 'shop' on a daily basis to match the actual system needs with the provided offers
- Advantages:
  - ➢ The possible risks of violating 'technology neutrality' in the product design is avoided
  - ➢ Increases liquidity and reduces market fragmentation
- Attention points:
  - ➢ Increases the level of complexity and decision making for the system operators
  - ➢ Requires advanced analytical **tools for decision making** for system operators

Conclusions

TSO-DSO coordination is not a 1-dimensional problem, limited to the decision on the ‘model for TSO-DSO coordination

- TSO-DSO coordination impacts both network planning and network operation
- Both vertical and horizontal coordination are crucial
  - Vertical: TSO-DSO: manage conflicts local vs. national optimization priorities
  - Horizontal: TSO-TSO: reserve exchange/sharing, congestion management
- TSO-DSO coordination for system services deals with to both the design of products and the design of flexibility mechanisms
  - ✓ Multiple flexibility mechanisms exist – from tariffs – to connection agreements – to flexibility markets
- TSO-DSO coordination is necessary at the level of prequalification – procurement – activation – settlement
- TSO –DSO coordination deals with roles, responsibilities, information sharing, business processes

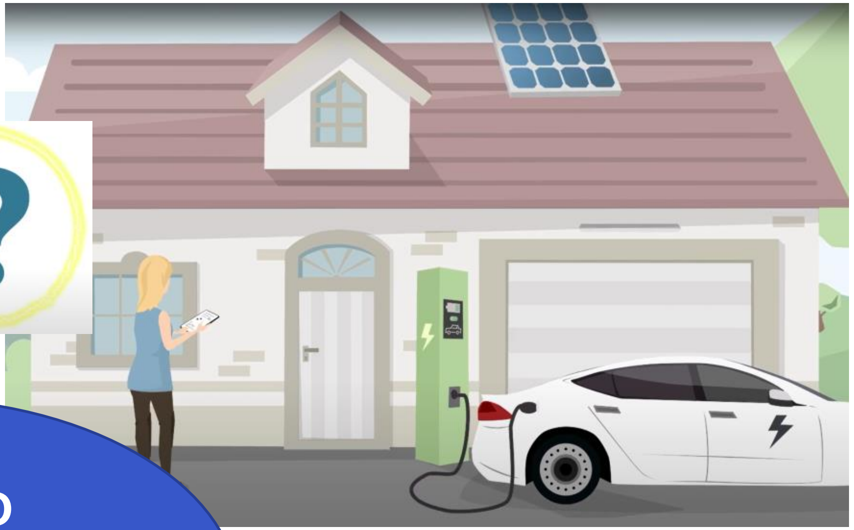
Innovations at many levels is required

Topic 2: Demonstrations

EU-SysFlex: Portuguese DEMO Flex Hub

Susete Albuquerque (E-REDES)

Flexibility: DSO and TSO collaboration



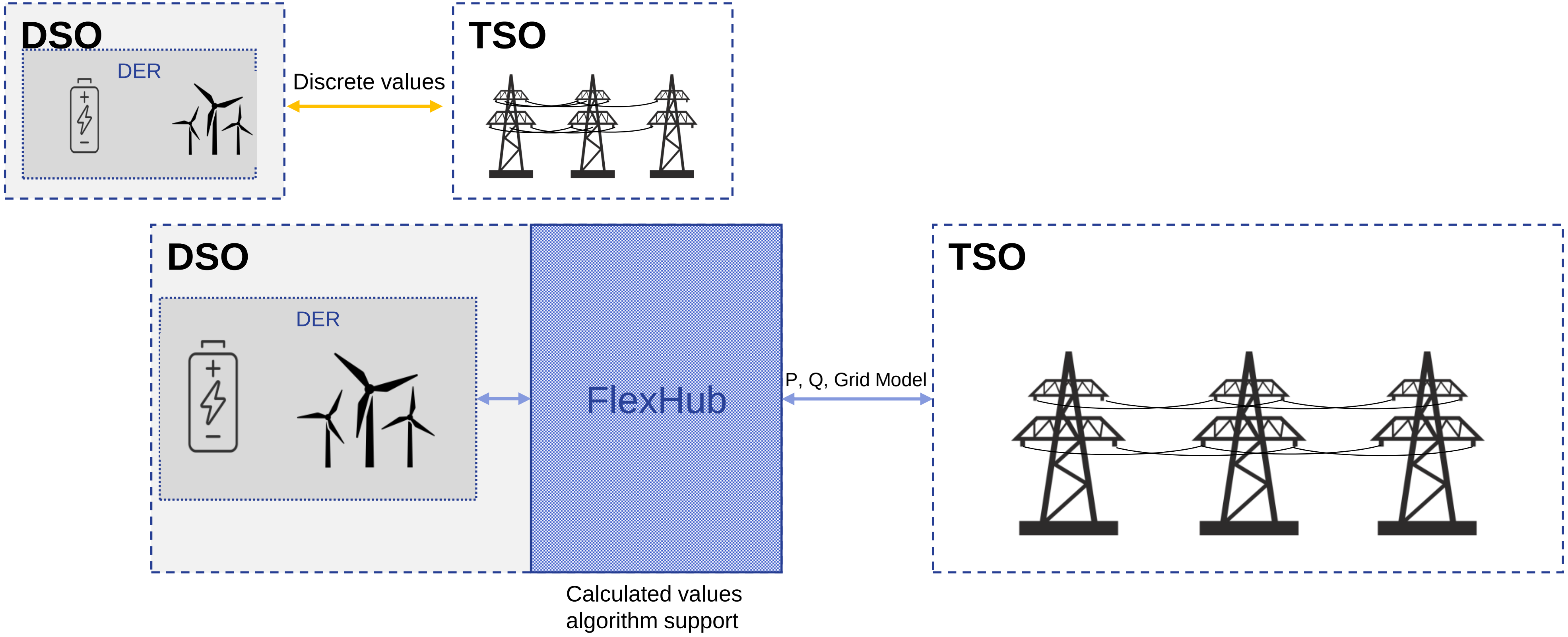
DSO & TSO
Network Planning
&
Collaboration

Flexible and
Responsive
Systems

Resilient
Cost Effective
Stable

OSMOSE EU-SysFlex

EU SysFlex Portuguese DEMO: Flex HUB changes



EU SysFlex Portuguese DEMO: Flex HUB

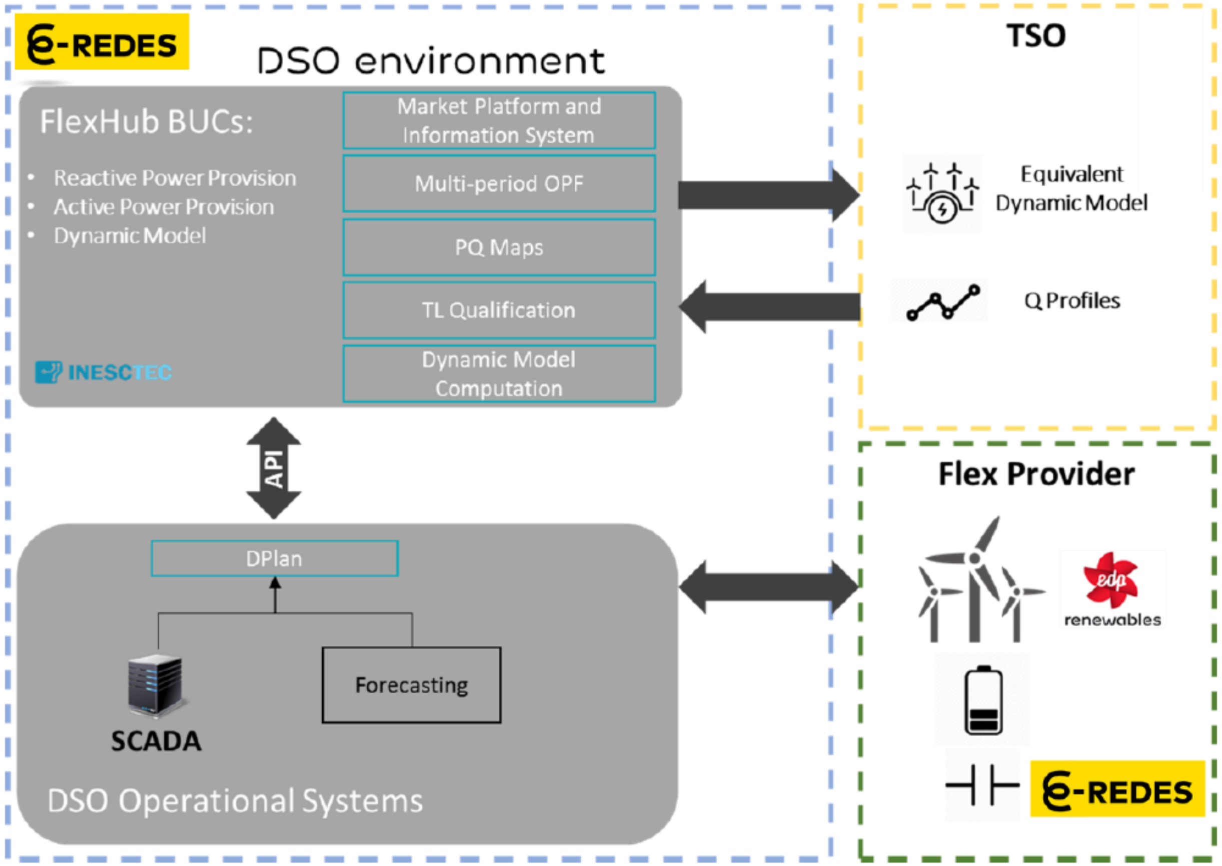


FIGURE 3: FLEXIBILITY HUB - DEMO HIGH LEVEL ARCHITECTURE

TSO needs:
active/reactive power DSO/TSO interconnection point

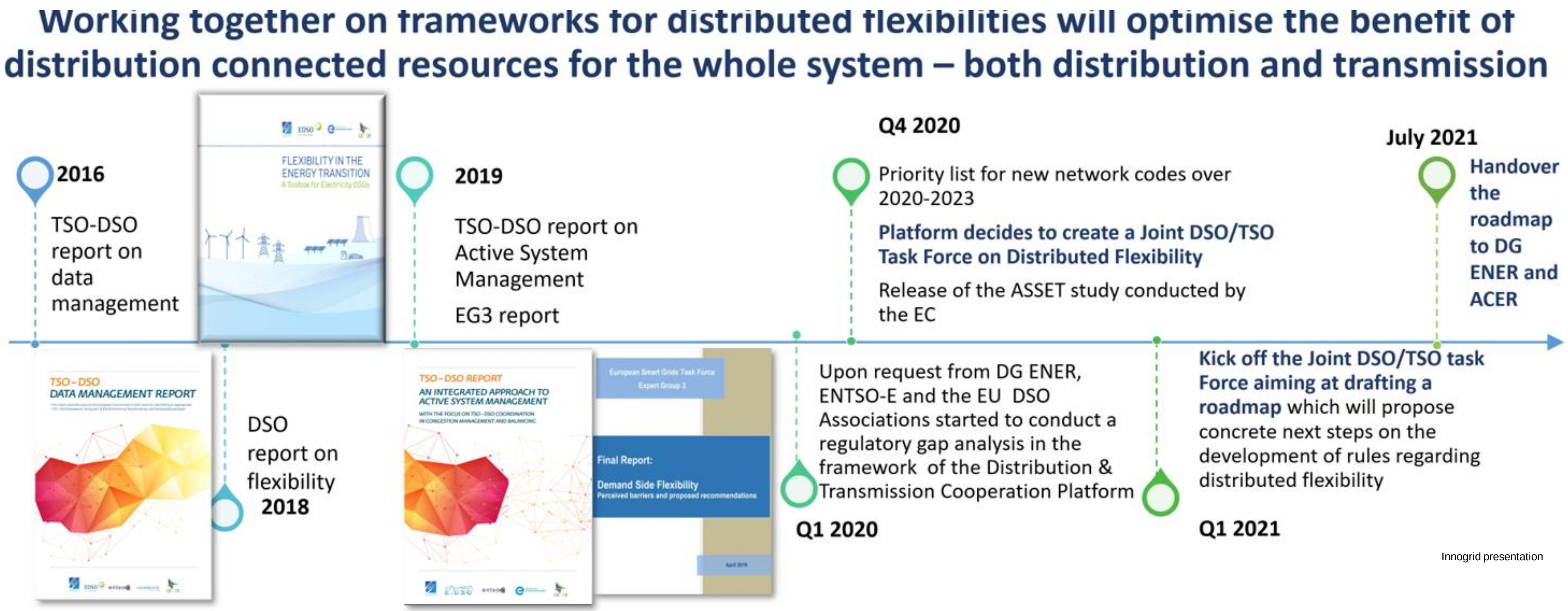
Dynamic model for the distribution network (check the stability of the Grid)

How can the DSO help?

DSO will cooperate with TSO to solve constraints and contribute to systemic resilience

Next steps

- **How to share more information between DSO and TSO**
- **Increase DSO and TSO cooperation and collaboration to unleash the potential of flexibility**
- **EU H2020 projects:** ONENET, Interconnect, EUniversal….



Innogrid presentation

OSMOSE EU-SysFlex

OSMOSE - Portuguese demo

A tool to support the TSO & DSO in the optimal planning of the flexibilities

Rui Pestana (REN)
Ricardo Pastor (R&D NESTER)

Question/issue addressed in presentation

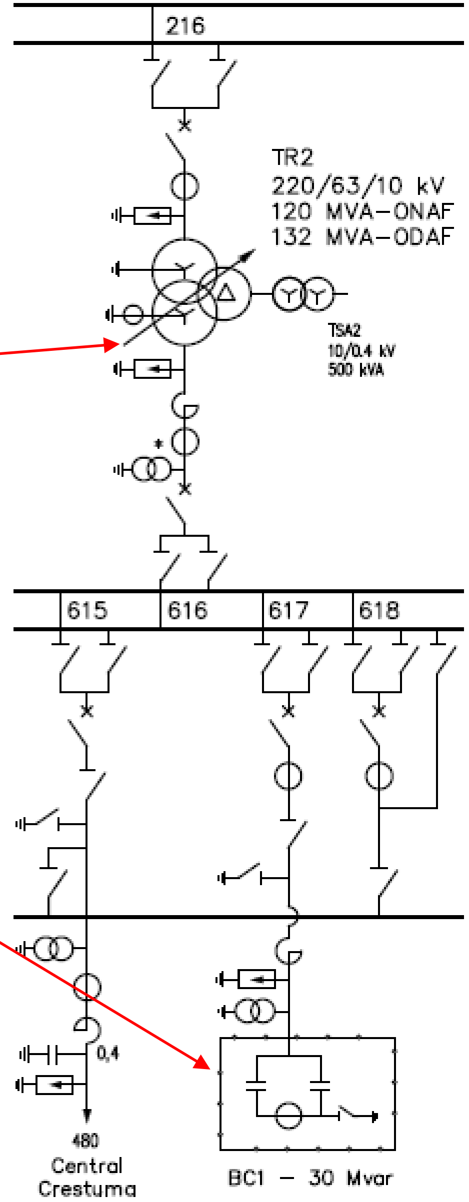
- Is there a need for joint optimization in the TSO & DSO interface?
- What is the Flexibility Scheduler?
- Voltage control and reactive power issues versus active power issues.

➢ Is there a need for joint optimization in the TSO & DSO interface?

- Yes:
  - Since it’s not done yet.
  - Sometimes the TSO needs to request the DSO to delay the switching (ON & OFF) of the shunt capacitors at medium voltage, to improve the voltage quality.
  - By optimizing the voltage profile we can jointly reduce active losses.
  - By implementing the close loop’s (meshed) we can reduce the power at risk (lack of N-1) of the radial DSO grid.
- However:
  - Merging both networks can be a big challenge.
  - In some part’s of the networks, there may be no flexibilities synergies between the TSO & DSO.
  - Meshed grid’s may increase the risk at N-1 in the distribution network (contingency at the TSO grid may induce an overload on the distribution network).

➢ What is the Flexibility Scheduler?

- It's a optimization tool to minimize the DSO grid losses
- Setting the best use of flexible assets:
  - Tap position of the VHV/HV power transformer from the TSO
  - High Voltage (60 kV) shunt capacitors from the TSO
  - Tap position of HV/MV power transformers from the DSO
  - Medium Voltage (15 kV) shunt capacitors from the DSO
  - Reactive power output of dispersed renewable generation at the DSO grid
- Taking in consideration the voltage nodal limits, generation and branch constrains,
- For the next 24 hours (multi-period),
- Aggregates the objective function and the restrictions with penalty factors that monetize all these components.

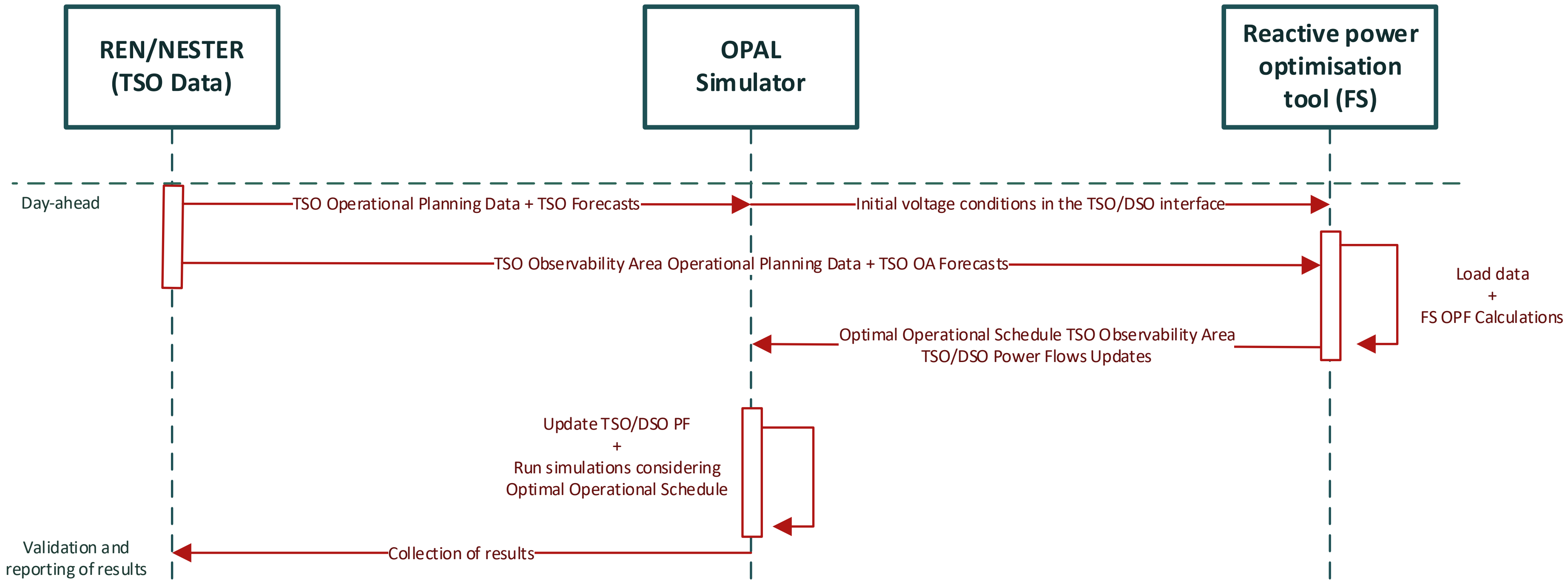


➢ Voltage control and reactive power issues versus active power issues

- Voltage control and reactive power:
  - Is a daily issue, with lower voltage during peak hours and higher voltage during off-peak hours
  - Has a direct impact in minimizing losses
  - And in the power quality

- Frequency control and active power:
  - Frequency is not a DSO concern (TSO business)
  - Congestion is more an active power (MW) issue, but in reality it's apparent power (MVA), so the reactive power can also help solving some issues.
  - Congestion may occur at peak or at short time.
  - Long term planning should identify and solve grid issues (built-and-forget).
  - Fast installation of solar PV may create problems, faster than they can be solved by the planning stage.

➢ Flexibility Scheduler Demonstration



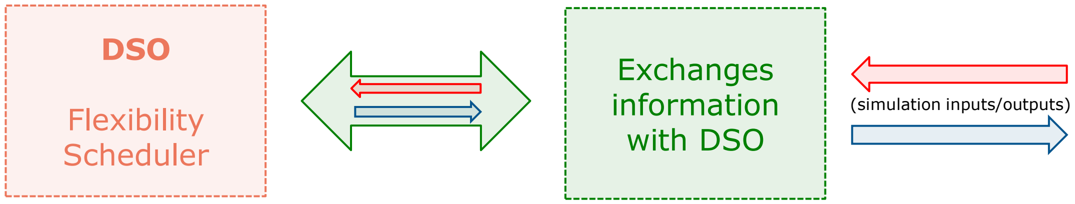
Flexibility Scheduler Demonstration

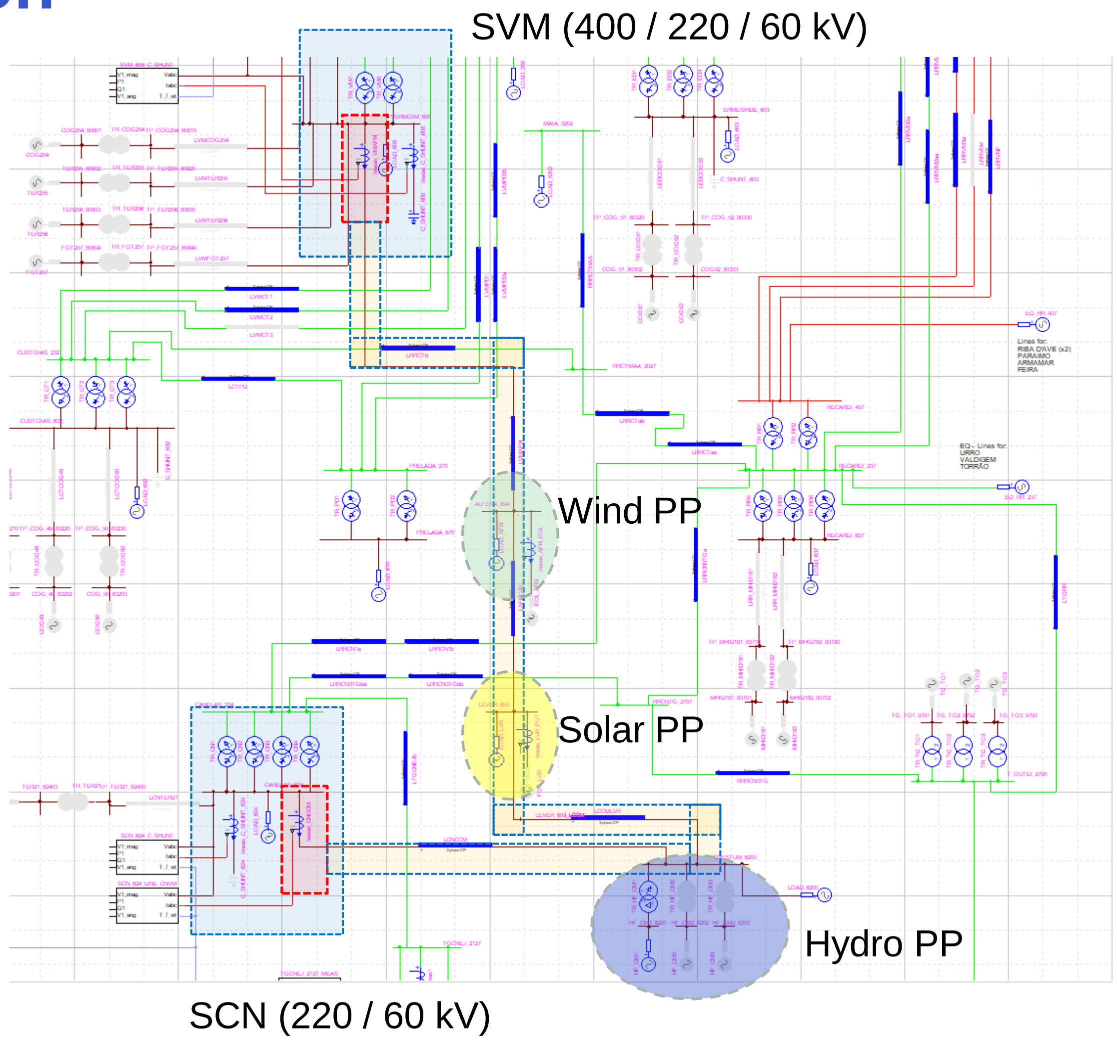
DSO observability on TSO network

TSO & DSO interface

Distribution mesh (detailed model only in FS)

Power Plants





Key innovation & key messages

- The Flexibility Scheduler (FS) enables a joint optimization on the TSO & DSO interface.
- The FS with the multi-period optimization, allows a secure operational planning for the next 24 hours.
- The FS allows the optimisation of the overall (TSO & DSO) grid losses.

Next steps

- Complete the real-time simulation of the Flexibility Scheduler with the TSO grid simulator (OPAL – Hypersim).
- Finish the deliverable D7.4 - Tests results of the flexibility scheduler.

EU-SysFlex - Italian demo

Use of flexibilities connected to the mv grid for congestion management and voltage control

Simone Tegas (E-Distribuzione S.p.A.)

Partnership and Demonstrator setup

e-distribuzione

enel

RSE
Ricerca
Sistema
Energetico

Area of "Forlì – Cesena"
Emilia Romagna Region

Environment of the Italian demonstrator

- 1 HV/MV (132/15 kV) substation
- 330 MV/LV (15/0.4 kV) substations*
- 39.8 MWp - Installed DER Capacity
- ≈ 46 GWh/y - Av. Energy Produced

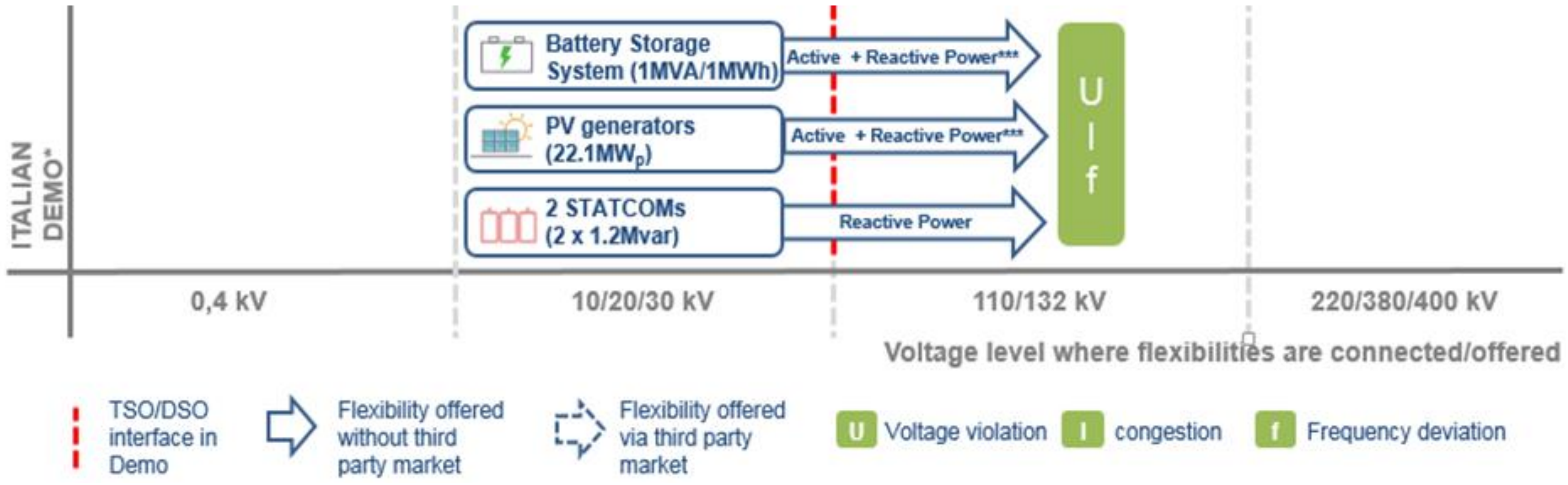
Scope of the Italian demonstrator

- Electric Storage System (1 MVA/1 MWh)
- 4 PV Generators ≈ 2.8 MW
- On-Load Tap Changer (OLTC) at HV/MV substation
- STATCOM (1 module per MV busbar) 2 x 1.2 Mvar

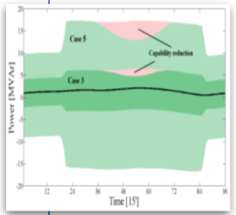
Value updated on 19/10/2020

Main objectives

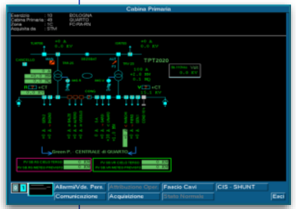
- Proof of concept of an efficient and automated coordination process between DSO and TSO
- More accurate RES feed-in and load forecasting
- Include RES, Storage and STATCOM and OLTC in the congestion management and voltage regulation of both TSO and DSO grids
- Test of use of the same resources also for balancing



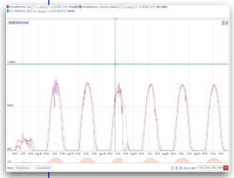
Achieved results



Improvement of the network optimization tool, core of the NCAS (Network Calculation Algorithm System) module of the Local SCADA, through the implementation of the reactive power capability calculation at the Primary Substation interface



Implementation of the regulation functionalities for voltage support, allowing the DSO to send signals to DSO assets and controllable RES based on the voltage or reactive power requirements from the TSO



Development of the Nowcast functionality, which integrates the forecast of the distributed resources energy production with the network management and optimization tools

Construction of the Secondary Substation for the connection of the STATCOM to the DSO grid according to the Italian electrotechnical standards

Key Messages

- New concept of DSO as Active System Operator
- Improved TSO/DSO Coordination needed in addition with increasing RES integration and Distribution Network Observability
- New assets (like STATCOMs) can be tested in order to perform services like Reactive Power compensation and Voltage Support
- A new concept of resilient grid is possible in scenarios in which DERs are also exploited to guarantee continuity of supply and quality of energy

EU-SysFlex - German demo

Processes and Systems for Using Flexibility from Distribution Grid to Integrate a High Share of RES in a Resilient, Stable and Efficient Operated Energy Supply System

Maik Staudt – Mitnetz Strom

The German Demonstrator in EU-SysFlex makes use of Flexibilities in the HV Distribution Grid of MITNETZ STROM to fulfil congestion management and voltage control.

Partners

MITNETZ STROM

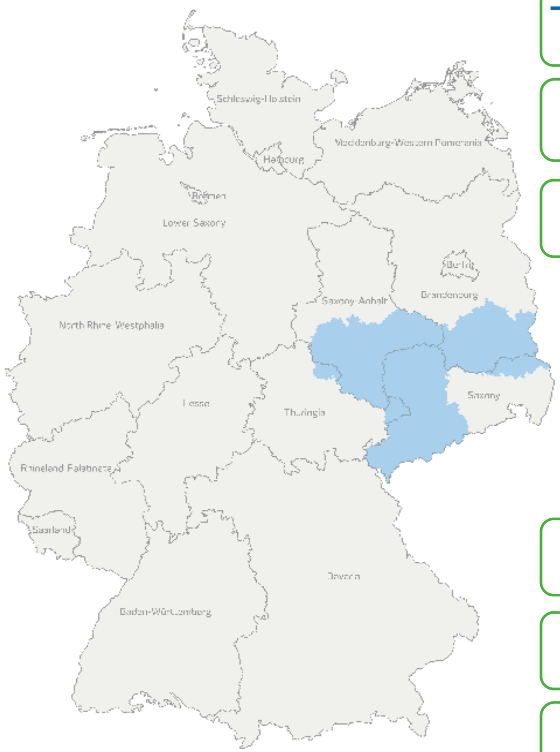
e·on

Fraunhofer IEE

UNIKASSEL VERSITÄT

INESCTEC

Environment and scope of the demonstrator



Environment of the German demonstrator

- MITNETZ STROM — >6,000 km HV grid
- TSO DSO — 16 TSO/DSO interfaces
- >9.3 GW installed RES

Scope of the German demonstrator

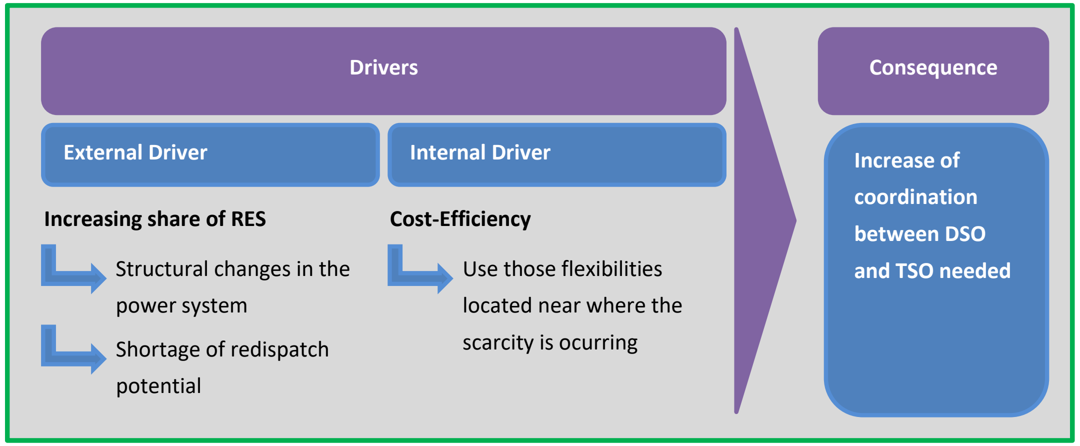
- 1.500 Assets in HV level used
- 5 GW of flexibility potential
- Reactive power flexibility of -350 to +280 Mvar

Internal and External Drivers Cause the Need for an Increase of Coordination between the DSO and the TSO in Germany.

External drivers

- **An increasing share of RES of more than 50% in 2030 (approx. 40% in 2017 in Germany) is expected**
  - The number of conventional power plants will decrease due to structural changes of the power system and so the redispatch potential of conventional plants in the transmission grid.
  - Thus, higher requirements in congestion management for both TSO and DSO arise.

Drivers for the German Demonstrator



Internal drivers

- **The amount of needed flexibilities can be reduced if they are close to where the congestion is occurring to meet cost-efficiency**

The German demonstrator objectives

- **Set-up of a new process and coordination for congestion management**
- **Development of a new automated tool for voltage control and reactive power management**

TSO Congestion Management with Flexibilities in DSO Domain needs a Coordination to prevent Faults and to ensure Liability in securing Flexibility Offers by DSO

Active power management today

- **Foreseen congestion are managed with redispatch measures**
  - only conventional power plants connected to the transmission network are considered
- **If the redispatch potential is not sufficient, feed-in curtailment is needed**
  - TSO issues a request to DSO for RES curtailment as an emergency measure, DSO is responsible to fulfil the measure

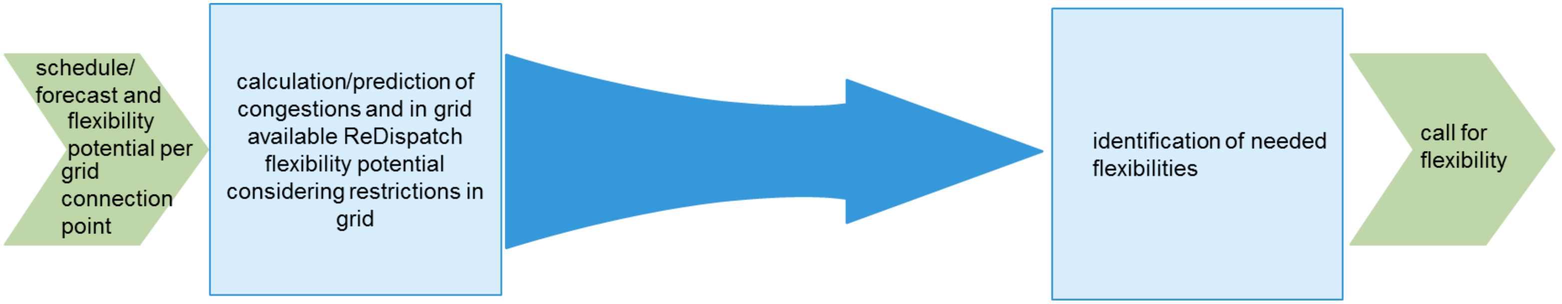
Limits of today's active power management

- The need and therefore costs of redispatch measures increase.
- The redispatch potential in the transmission grid is exhausted due to the minimum capacity of conventional power plants.
- Additionally, the risk of countermeasures due to insufficient TSO/DSO coordination increases.

Active power flexibilities within EU-SysFlex

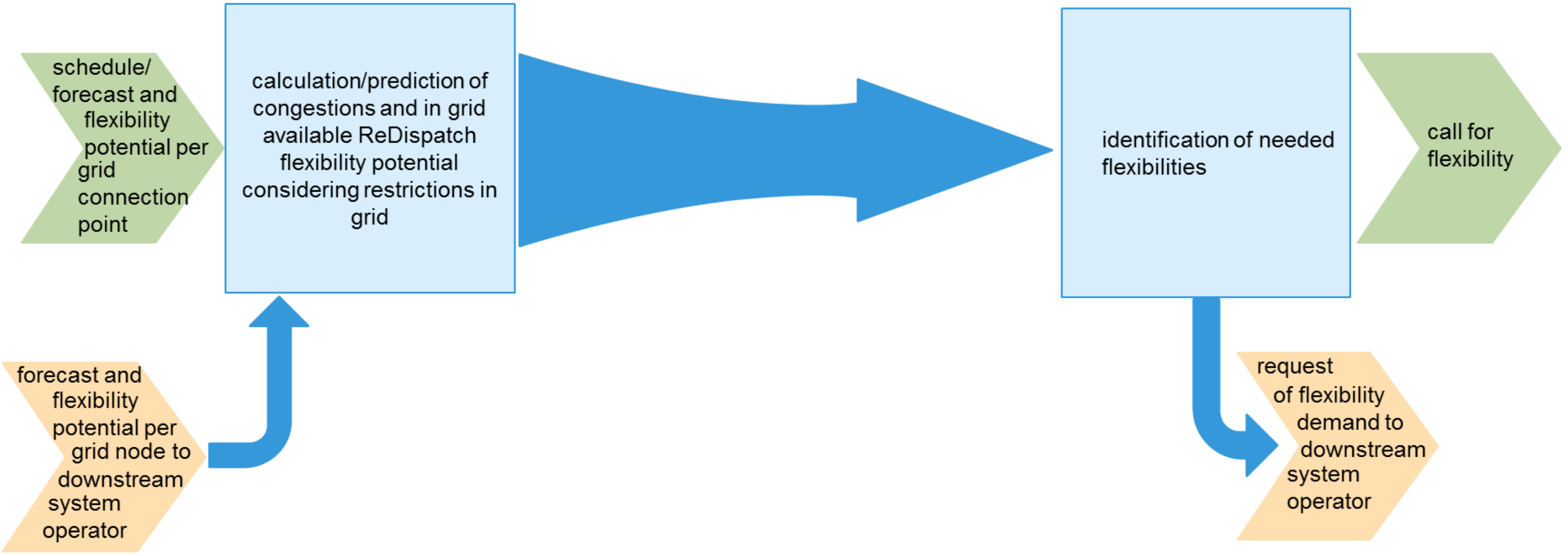
- **In the German demonstrator a cooperation process between TSO and DSO and an automated process of schedule-based congestion management is being set-up.**
  - First, congestions in the distribution network is managed by DSO.
  - Remaining flexibility potentials of active power are offered to TSO.
  - TSO requests the necessary flexibilities from DSO based on its transmission network calculations.
  - DSO breaks this down on individual plants and gives the instruction to DERs.
  - Due to forecast deviations, a continuous intra-day process for flexibilities is implemented analogue.

The increasing DSO Demand of Flexibilities in Congestion Management led to Designing a new Process



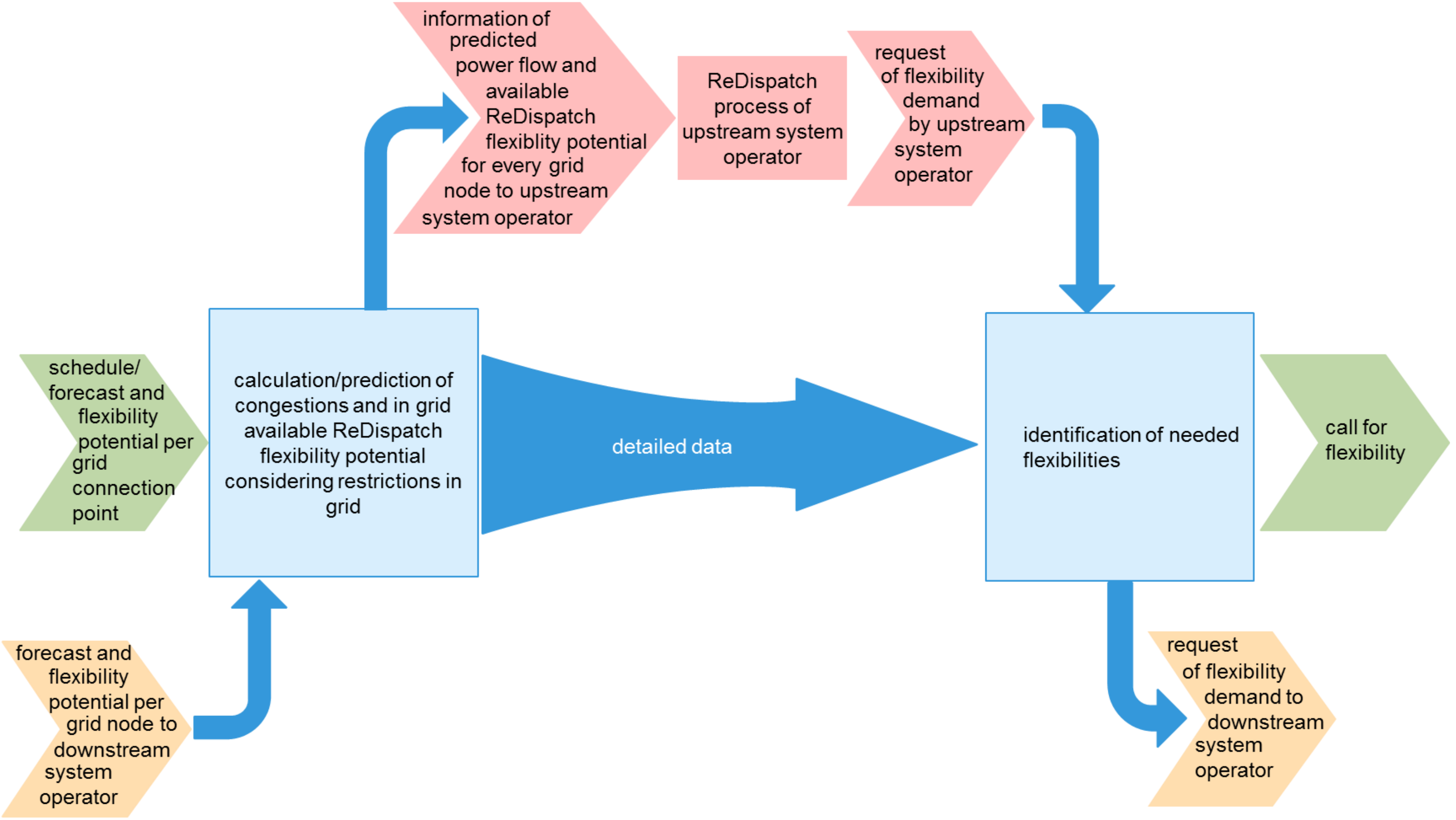
- input data is used to calculated power flow as forecast value
- this power flows enable the DSO to predict congestions and available flexibility potentials
- it allows to optimise the power flow to calculate the most efficient use of flexibilities
- needed flexibilities get instructed for delivery

The increasing DSO Demand of Flexibilities in Congestion Management led to Designing a new Process to Coordinate with Downstream System Operators



- to enhance input data, forecasts at downstream grid conjunction points is delivered by secondary DSO as output of its process
- if flexibilities designated as available in downstream grid are needed due to depleted potential in own grid, requests to the secondary DSO can be made

The Need for Increasing DSO/TSO-Coordination in Congestion Management led to Designing a new Process



- the same way the secondary DSO can give information, the TSO can be informed about forecasted power flow and available flexibility potential at grid conjunction point by the
- if the TSO needs flexibility, a request about using available flexibilities can be made to the direct connected DSO

Automated Reactive Power Management makes Flexibilities in the Distribution Grid available for a Dynamic Voltage Control for the first time.

Reactive power flexibility today

- **Two tools are being used at the TSO/DSO interface**
  - One option are inductors at the interface and EHV/HV.
  - Second option are on-load tap changers.
  - Both tools are controlled by the TSO, but used in coordination with the DSO.
  - Today's coordination process is done by phone.

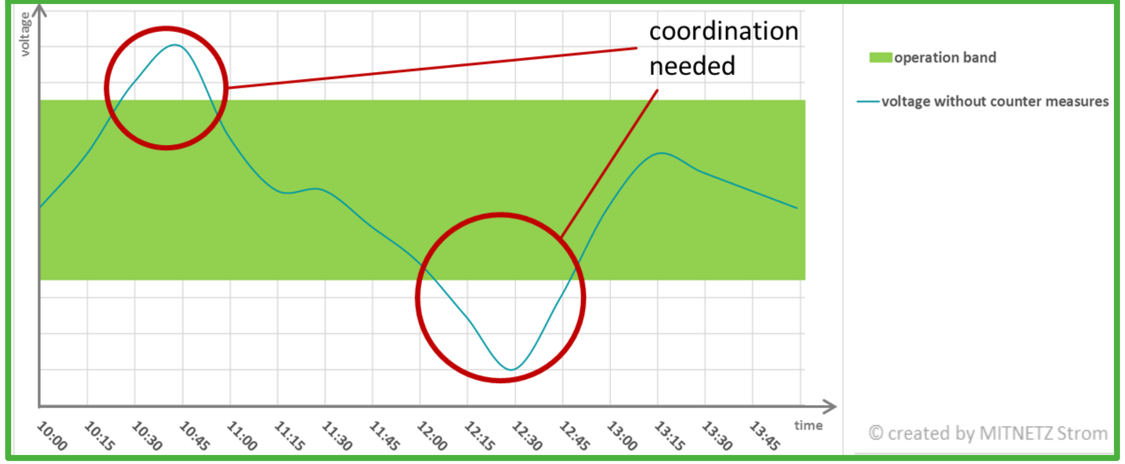
Reactive power flexibility within EU-SysFlex

- **setup of an automated tool for dynamic voltage control and reactive power management aligned with congestion management process**
  - DSO calculates the reactive power potentials which can be offered to TSO
  - in the event of voltage limits violations, TSO puts in a request for the offered potential

Limits of today's reactive power flexibility

- The usage of these two existing tools for voltage control depends on availability of a sufficient amount of reactive power flexibilities in EHV.
- Dependencies on conventional plants in the EHV level does not fit into a future power system with increasing share of RES in the distribution grid.
- The limited coordination between TSO and DSO regarding reactive power management leads to limited settings for voltage control.

Predicted voltage at TSO/DSO interface



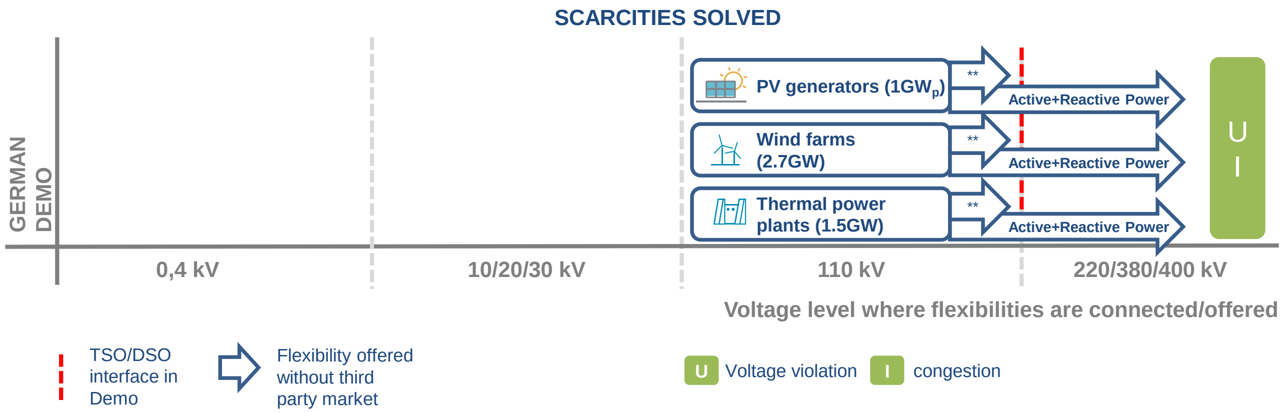
OSMOSE EU-SysFlex

As a Result of the German Demonstrator, Processes for Active and Reactive Power Management to use RES from the Distribution Grid are aligned.

The expected outcome of the German Demonstrator

- **Developed active and reactive power management process to include RES from the distribution network**
- **Proof of concept of coordinated TSO/DSO congestion management**
- **Feasibility of fully automated process of a combined grid optimization (P and Q)**
- **More accurate RES feed-in and load forecasting**

Offered flexibilities and addressed scarcities



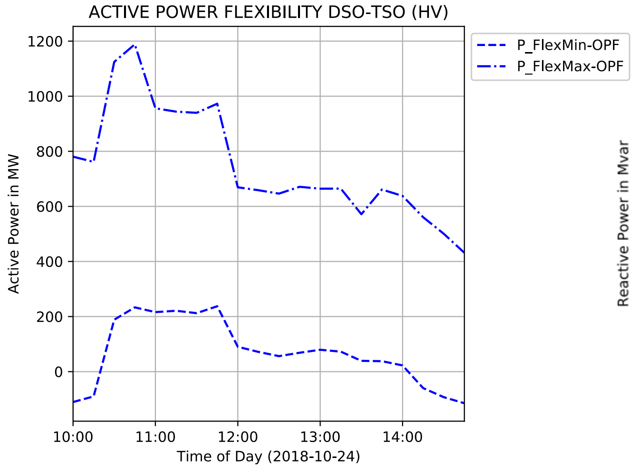
** The German Demonstrator enables the provision to the TSO and the usage of the flexibilities in its own grid

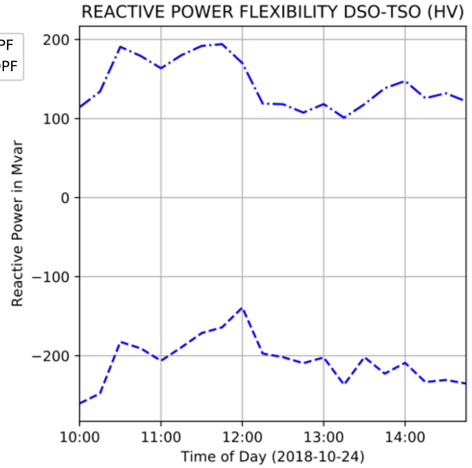
OSMOSE EU-SysFlex

First Results of Optimisation Approaches show broad Capabilities of Distribution Grid in Providing Flexibilities

Iterative Sequential Optimisation

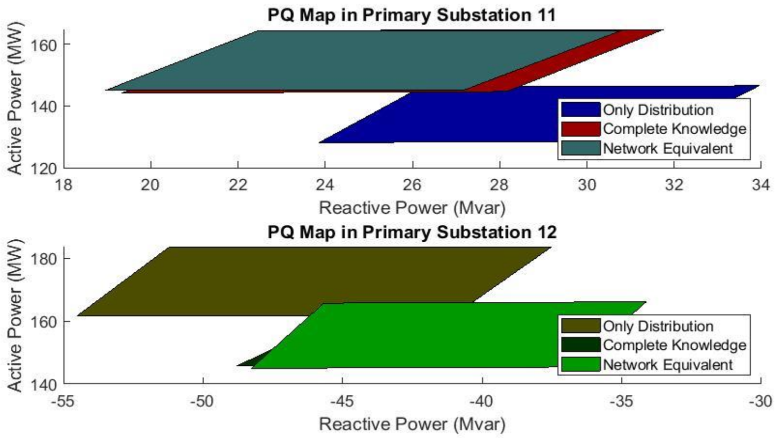
- the optimisation results into active and reactive power flexibility ranges taking into account (n-1) safety
- specific demands within these limits can be requested (e.g. active power set-point 300MW)
- the optimisation tool calculates set-points to control the flexible units within the inspected area
- optimisation goal always considers loss-minimisation





PQ-Map

- Decision-aid tool for both TSO and DSO, suggesting alternative active and reactive power operating points
- PQ-maps are not reliable when there is no information of how the transmission network operates
- The inclusion of the network equivalent allows to capture how the PQ limits are redistributed throughout the different TSO-DSO connections



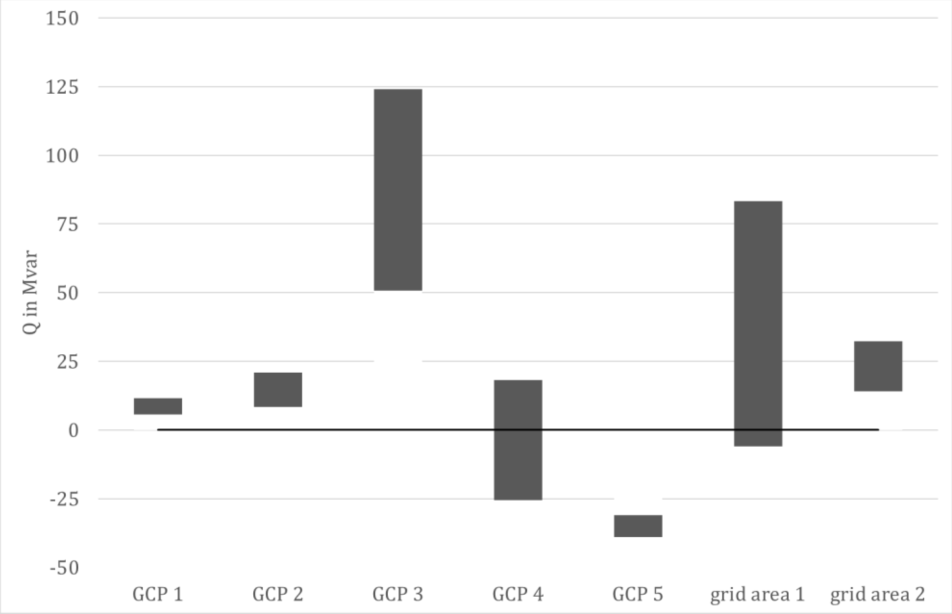
ETZ Strom

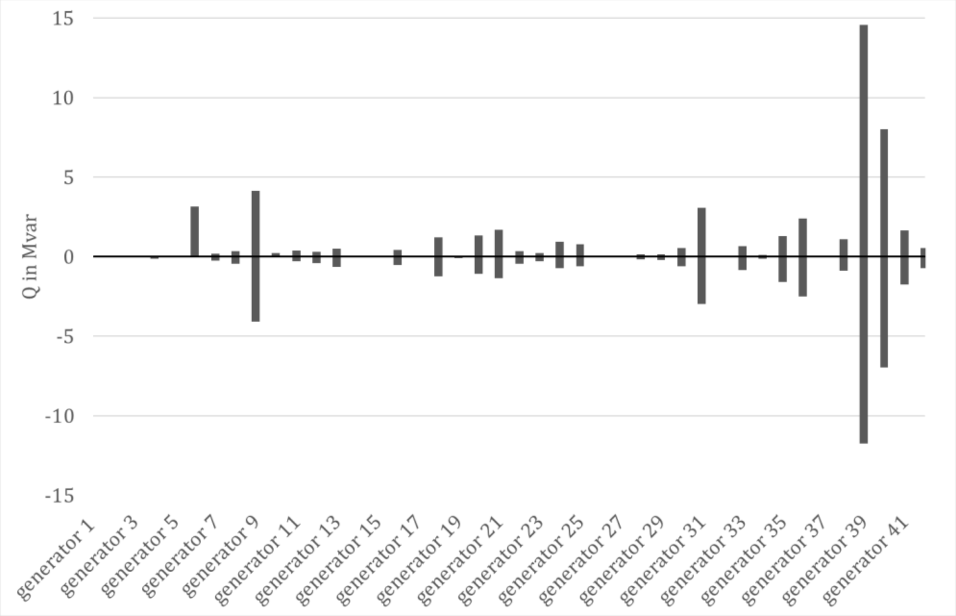
As a result of the German demonstrator, the 1st use case to serve the reactive power management process has gone live.

Grid Calculation and Optimisation to Predict Available Flexibilities

- **data exchange implemented**
- **load flow calculation implemented**
- **reactive power flow optimisation implemented**

Example of Flexibility Range at TSO-DSO-Interconnection





OSMOSE EU-SysFlex

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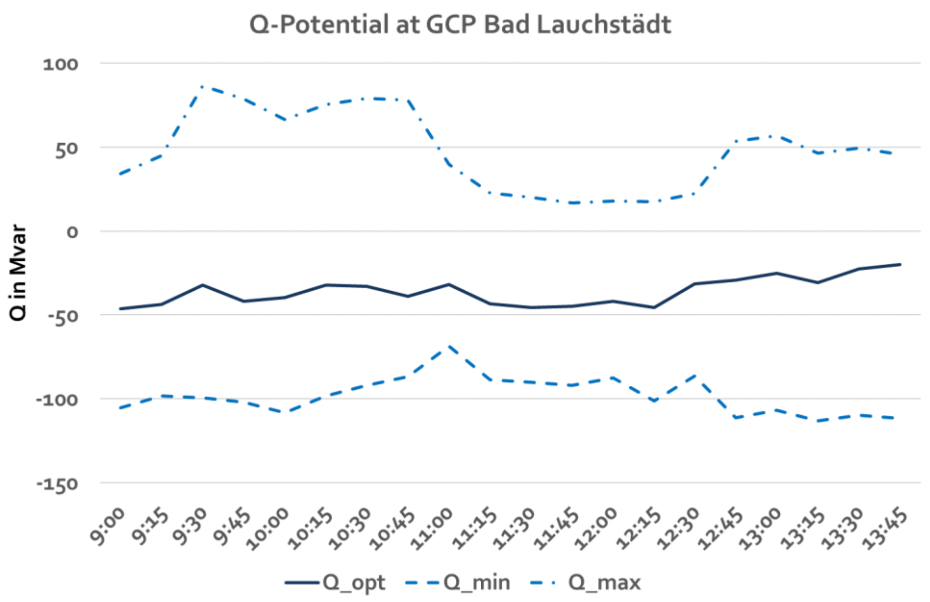

- 380kV to 110 kV interconnection
- high infeed of wind approx. 1 GW
- curtailment infeed of 500 MW (until end of shown timeline)
- while strong change of power flow, potential stronger limited than in stable condition
- optimisation works can stabilise reactive power flow while change of infeed occurs

CONCLUSIONS

Q&A SESSION

Thanks for your attention

OSMOSE

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