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#ETIPSNET

# ENLIT EUROPE – EU Project ZONE

## Flexibility for Resilience - How can flexibility support power grids resilience?

**11.00 – 12.30**
**30 November 2022**

**Moderated by Natalie Samovich**

# Agenda

| | |
|---|---|
| **11.15– 11.20** | **Opening the session by the Moderator** Natalie Samovich – ETIP SNET WG1 Chair |
| **11.20 – 11.30** | ***Digitalising the energy system - EU action plan – implication on Flexibility*** - Karsten Krause (Policy Officer DG ENEG Unit B5) |
| **11.30 – 11.40** | ***Presentation of the joint ETIP SNET and ISGAN - White Paper Flexibility for Resiliance*** - Natalie Samovich – ETIP SNET WG1 Chair |
| **11.40 – 11.50** | **BD4NRG project** -Massimo Bertoncini - Director of R&I projects on Smart Energy |
| **11.50 – 12.00** | **Edge-FLEX project -** Antonello Monti - Director of the Institute for Automation of Complex Power Systems , RWTH Aachen University - Germany |
| **12.10 – 12.30** | Panel discussion |
| **12.30** | End of the session |

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# Opening

**Natalie Samovich**

**ETIP SNET WG1 Chair**

# Digitalising the energy system - EU action plan – implication on Flexibility

**Karsten Krause**
**Policy Officer**
**DG ENEG Unit B5**

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# EU Action Plan for the Digitalisation of the Energy System

&

# Implications on Flexibility


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# Twin Energy and Digital Transition

European Green Deal

Europe fit for the Digital Age

a better-functioning, smart, integrated and interconnected energy system, where new business models can easily emerge in a fast-changing market.

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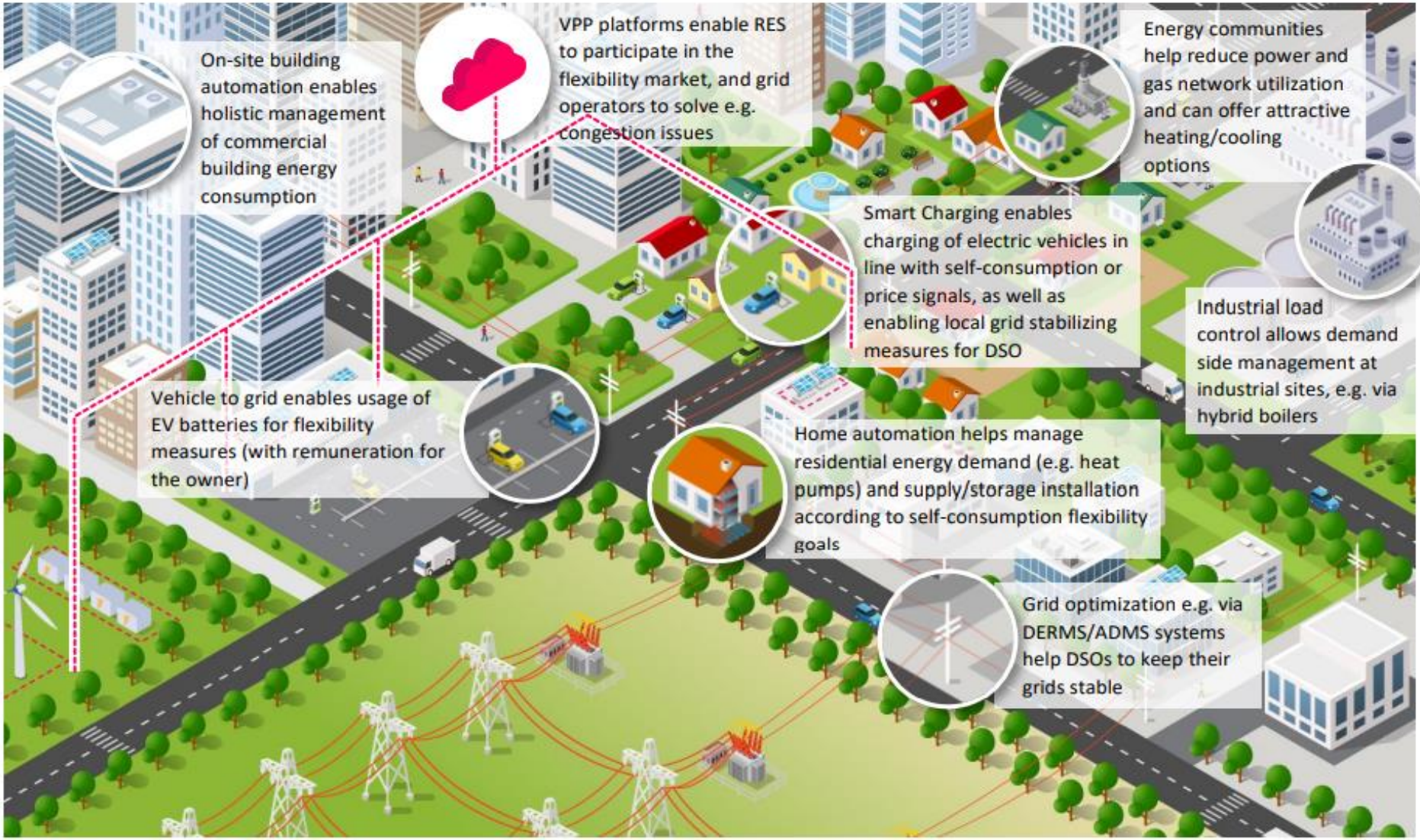
# The value of flexibility

- Most renewable energy sources are of a variable nature. The availability of sun, wind, or water varies from seconds to seasons. This variability creates a potential mismatch between generation and demand.
- Balancing the energy system depends on adding flexibility, on both supply and demand sides. This flexibility ideally connects locally and system-wide, through an array of solutions.
- Such flexibility will be particularly important for short-term fluctuations, whereas it is unlikely to be an efficient or sufficiently scalable solution for seasonal fluctuations that require long-term energy storage.
- This ‘smartness’, in turn, will avoid additional capital expenditures for enhancing the existing grid infrastructure.

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# Main areas of the Digitalisation Action Plan


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# A European framework for sharing data to support innovative energy services

- Priority **high-level use cases**: (a) flexibility services, (b) smart charging of electric vehicles, and (c) buildings
- Developing a **Common European Energy Data Space** (interoperable framework of common standards and practices)
- Building on the energy and digital regulatory framework, including the Implementing Acts under preparation
- Creating an EU **Smart Energy Expert Group** with a ‘Data for Energy’ working group

# Increasing investments in digital energy infrastructure


- Creating a **digital twin** of the electricity grid with ENTSO-E and EU DSO Entity
- Supporting National Regulatory Authorities and ACER in defining common **smart grid indicators and objectives**
- Urging Member States to accelerate the rollout of **smart meters** and revisit their costs-benefits analysis when necessary

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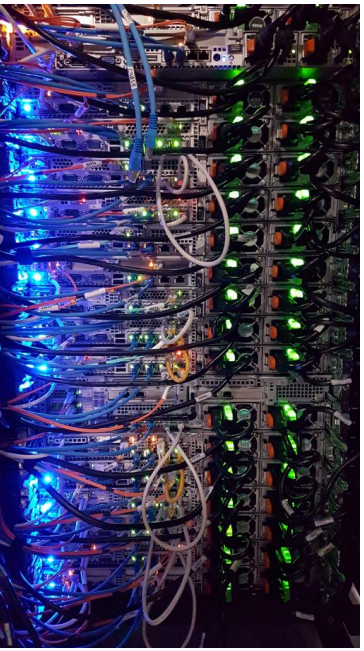
# Empowering citizens

- Fitness Check of EU **consumer law on digital fairness**
- **Strategies to engage consumers** in the design and use of digital tools
- A **common reference framework for an app** helping consumers reduce their energy use, especially during peak hours
- Tools, guidance and a first-of-a-kind platform that facilitate the use of digital solutions in **energy communities**
- Large-scale partnership on the digitalisation of the energy value chain as part of the **EU's Pact for Skills**

# Ensuring cybersecurity

- Complement **cross-sector legislation**, such as the NIS 2 Directive, the Cyber-resilience Act, and the proposed Council Recommendation on critical infrastructure
- With a **network code for cybersecurity aspects of cross-border electricity flows**
- And later a **delegated act on the cybersecurity of gas and hydrogen networks**

# Energy consumption of the ICT sector



- **Eco-design and labelling of products**
  *e.g. energy-label for computers*
- Measures targeting **communication networks**
  *e.g. EU code of conduct for their sustainability*
- Measures targeting **Data Centres**
  *e.g. environmental labelling scheme*
- Measures targeting **crypto-assets**
  *e.g. energy-efficiency label for blockchains*

# An EU-wide coordinated approach

- Increasing investments in digital solutions in **National Energy and Climate Plans, Digital Decade roadmaps, and Recovery and Resilience Plans**
- **EU funding** to accelerate the **development and deployment** of innovative digital energy solutions
- Structured **high-level dialogue** on digitalisation
- **Platform for cooperation** between digital and energy innovators
- Reinforcing **international collaboration**

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# Main areas of the Digitalisation Action Plan


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# Thank you

*Stay informed: DG ENER work on Digitalisation of the energy sector: https://energy.ec.europa.eu/topics/energy-system-integration/digitalisation-energy-sector_en*

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# Presentation of the joint ETIP SNET and ISGAN

# White Paper Flexibility for Resilience

**Natalie Samovich**

**ETIP SNET WG1 Chair**

# Flexibility benefits for resilience
# How can flexibility support power grid resilience?

A report summarising experiences from large number of initiatives in a collaborative effort between of ISGAN Annex 6 and ETIP SNET WG1

Editors: Irina Oleinikova, Emil Hillberg, & Antonio Iliceto

Contributing authors:

- Alexander Fuchs, Albana Ilo, Cansin Yaman Evrenosoglu, Christos Dikaiakos, Ewa Mataczynska, Gianluigi Migliavacca, Jirapa Kamsamrong, Nuno de Souza e Silva, Poria Divshali, Rajiv Porwal, Santiago Gallego, Turhan Demiray


Full paper available here:

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# Focus areas

Flexibility meets Resilience:

Definition of Flexibility & Resilience

How can flexibility support power grid resilience?

- Next level of flexibility
- System operation & Grid planning
- Risk management and energy transition

Conclusions & Key messages

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# Focus areas

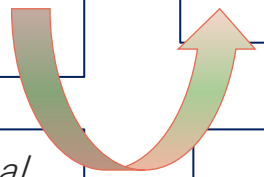
Focus on Power System Flexibility & Resilience originating from

- vRES integration, societal developments, electrification, & sectorial integration
- Flexibility needs for normal operation to ensure secure grid utilization
- Value: decrease overall costs & overcome challenges
- Resilience requirements for extreme situations to prevent severe events
- Threats: instability, cybersecurity, climate change, …

# How can flexibility support power grid resilience?

*Resilience areas: Anticipation, Preparation, Containment, Mitigation, Rapid recovery, & Adaptation*

Resilience solutions (*conventional containment and restoration*): diminish with decommissioning of primary energy reserves



*Novel Resilience solutions: increased possibilities with integration of DER & controllable assets – flexibility providers*

Resilience requirements: increase with grid utilization, climate change/ severe weather, data handling/cybersecurity

# Examples of flexibility supporting system resilience

Harsh measures !

***Today:***

- ***Load shedding***
- ***Interruptible customer***

Consumers decisions !

***Tomorrow:***

***Smart load shedding, offering modulated load reductions vs a proper compensation on an ad hoc market***

Delicate and centralised operation!

**Today :**

- **Black start capabilities only in large generation plants**
- **Top-down process, from HV network**

Resources available at almost no extra cost

**Tomorrow:**

**- Energy stored in EV, in H2 tanks, in Heat sinks can trigger bottom-up energization**
**- Micro-grids architecture reduces blackout footprint**

Expensive assets kept as reserve

**Today :**

- **N-1 criterion as minimum safety (sometimes N-2)**

No extra cost for extra reserve!

**Tomorrow:**

**- N condition acceptable with automatic reactions of some flexibility devices/processes**



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# Flexibility meets resilience

**Power system resilience reflects the impact of severe events**

- an overarching concept, from design & investments, to operation & maintenance
- planning time frame: build resilience into future networks
- operational time frame: mange security by optimizing inherent resilience of existing systems

**Flexibility concerns the power systems ability to manage changes**

- ability to improve resilience characteristics of the system of systems
- planning must embrace wide range of options to enable operational flexibility
- capabilities: to be considered using a holistic approach
- resources: add new dimensions to the electrical TSO-DSO interactions

# Flexibility support for power grid resilience

- **Flexibility and Resilience** originate from different situational needs, but are highly related with a common foundation in e.g.: vRES integration, societal developments, electrification, & sectorial integration
- **Digitalisation and Cyber security** are further providing the pressure on requirements and the means for solutions
- **Economic values** provided by large scale flexibility solutions motivates resilience-enhancing investments and security measures
- **Standardisation of solutions** is needed to increase the reliability & acceptance for large scale deployment of flexibility

# Flexibility support for power grid resilience

**Next Level of Flexibility**

Fully deployed and utilized for operation and planning of the power system, being integrated in procedures for long-term planning as well as in tools for stability support

- Development of solutions providing the next level of flexibility is a hot topic in the power system sector
- However, integrating flexibility solutions involve significant risks, volatility, and uncertainty
- Flexibility solutions intended to provide resilience support must be rigid and secure to provide the trust required for operation and planning

# Flexibility support for power grid resilience

## System operation & grid planning

Advanced solutions to prevent extraordinary events and increase secure utilization of the grid: System Integrity Protection Schemes

Improved System Technical Performance and Security of Supply Flexible capacities and controllable assets providing resilience support for

- Increased number of mitigating measures
- Improved performance (congestion, voltage, stability, loss-reduction, etc.)
- Simplified maintenance & operation processes

## Risk management and energy transition

Alternative Grid Development, providing an agile and sustainable development of the power grid

- Optimise investments vs. operation
- Investment deferral, more efficient planning
- Moving towards TOTEX regulation

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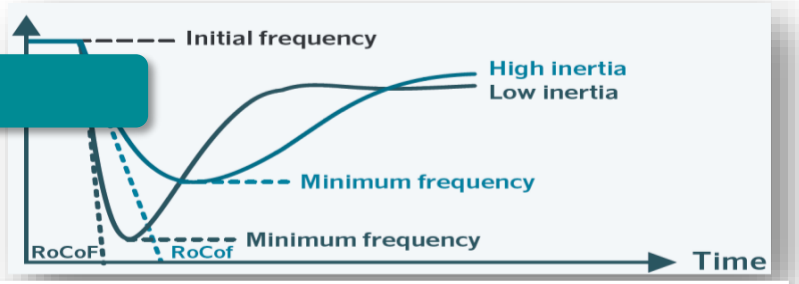
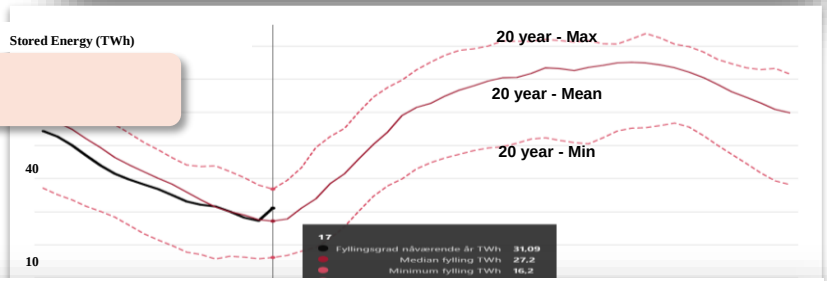
**Flexibility solutions provide support during normal operation, in decreasing of costs and overcoming of challenges, and could be categorised as:**

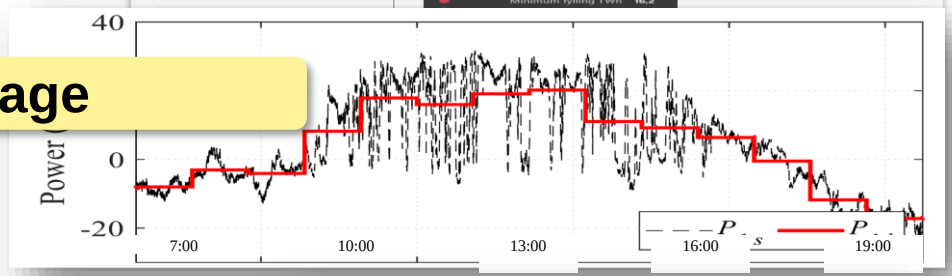
## Flexibility for Power



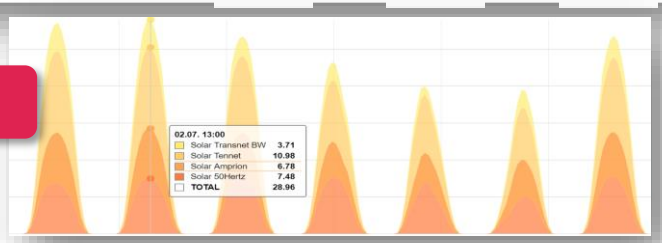

## Flexibility for Energy




## Flexibility for Voltage

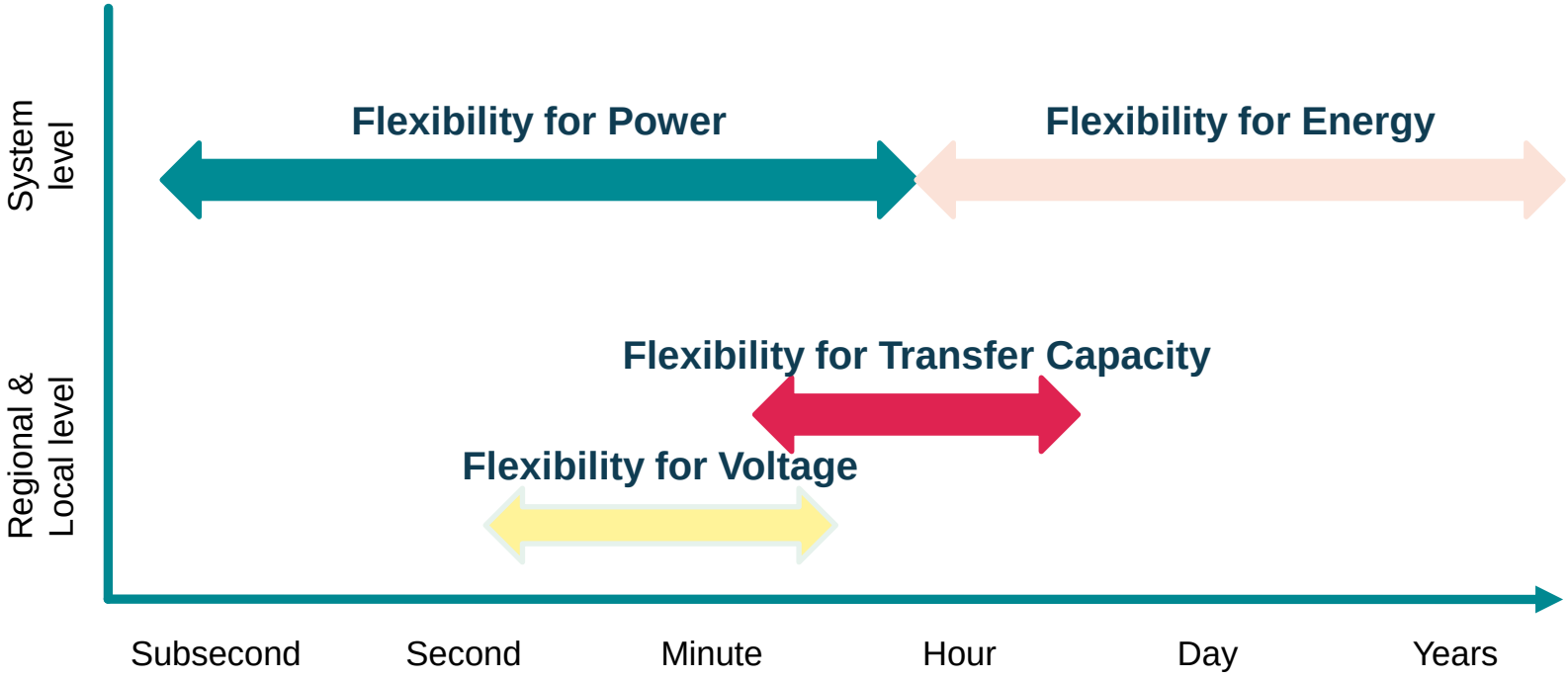



## Flexibility for Transfer Capacity



(ISGAN, 2020)

# Flexibility needs in spatial and temporal perspectives from sub-seconds to seasons and years on local and over-all system levels




(ISGAN, 2020)



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# Defining Resilience in the power system context

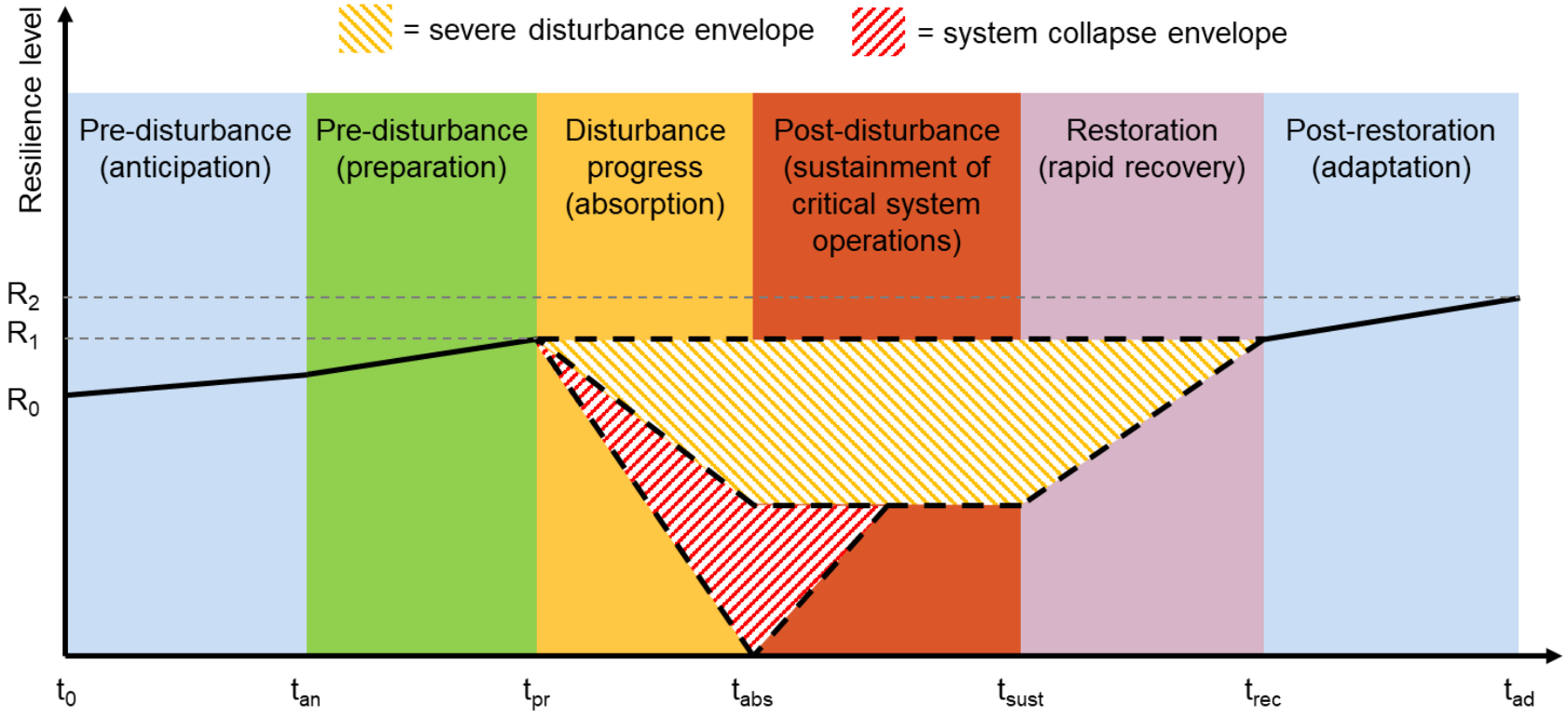
- **Resilience of the power system reflect the impact of severe events**

- Many definitions, incl.: "*the ability to limit the extent, severity, and duration of system degradation following an extreme event*" (CIGRE 2019)

    - Level of details, relations to resilience enhancing solutions, prevent agreement on a common definition.

- This broad definition - relating solely to the impact of severe events –simplify understanding and discussion on solutions providing increased resilience

# Resilience relies on a set of key measures deployed before, during, and after an event




(CIGRE, 2022)



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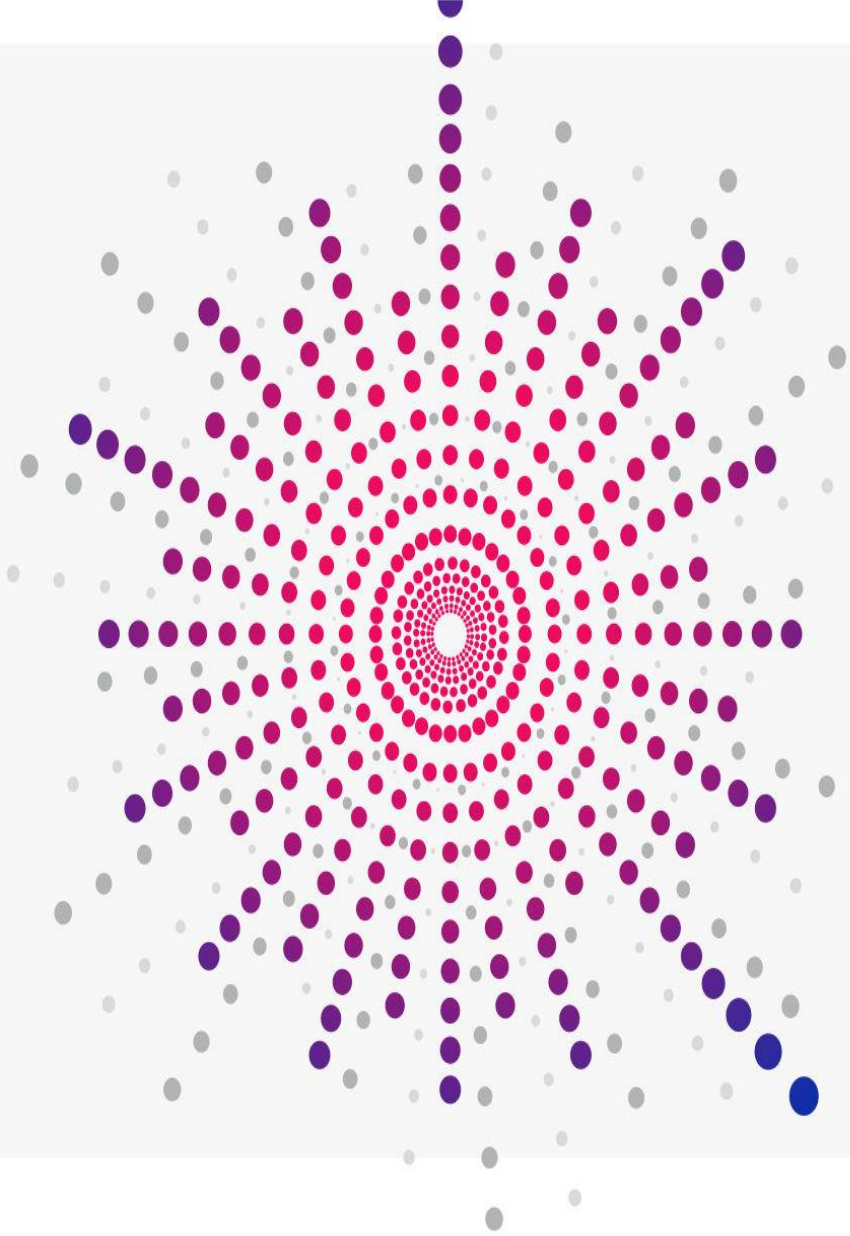
# Thank for your attention!

*Check the brand new ETIP SNET Website*

*Subscribe to the Newsletter*

# BD4NRG project

**Massimo Bertoncini**
**Director of R&I projects**
**on Smart Energy at Engineering**



BD4NRG
Big Data for Next Generation Energy

# Optimal Big Data-driven Flexibility Management for Grid Improved Resilience

Massimo Bertoncini
Director of R&D Program - Digital Energy
Project Coordinator
Engineering Ingegneria Informatica (ENG)

ENGINEERING

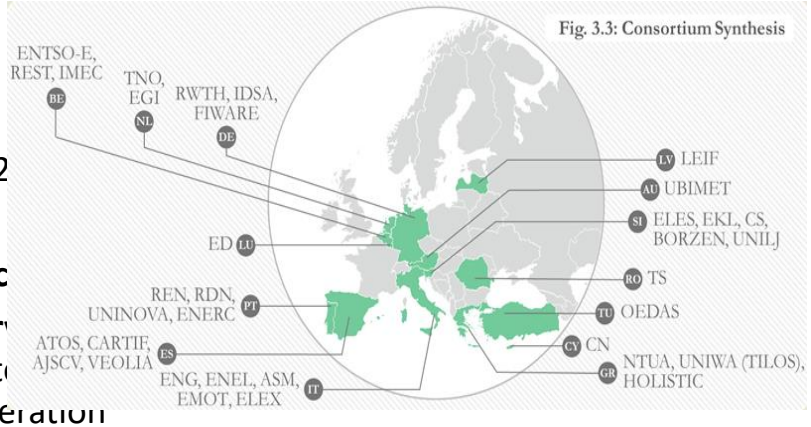
12/12/2022

# Project Identity Card

BD4NRG aims at evolving, upscaling and demonstrating an innovative **energy-tailored Big Data Analytics Toolbox (BD4NRG Toolbox), and the underlying big data management Framework** which will significantly contribute to **unlock novel cross-stakeholders business opportunities for electricity and other non-energy stakeholders** as result of ***multi-value chain energy-centered data-driven AI-based services***

**Project Identity card**

- Call -> H2020-DT-2019- / DT-ICT-11-2019 IA
- Starting Date: 1st January 2021 – Duration: 36 months – Now M2
- Total Costs: 11.883.025 Euro - EU contribution: 9.996.700 Euro
- **35 partners** from **11 Countries** covering the **whole energy value c**
- **12 Large Scale Pilots** where to validate **Big Data AI Analytics Ser**
  - ✓ Optimised management of non-grid owned (behind-the-met
  - ✓ Improved efficiency and reliability of electricity networks oper
  - ✓ Near real time energy-efficient end user comfort management
  - ✓ Optimal risk assessment for energy efficiency investments planning

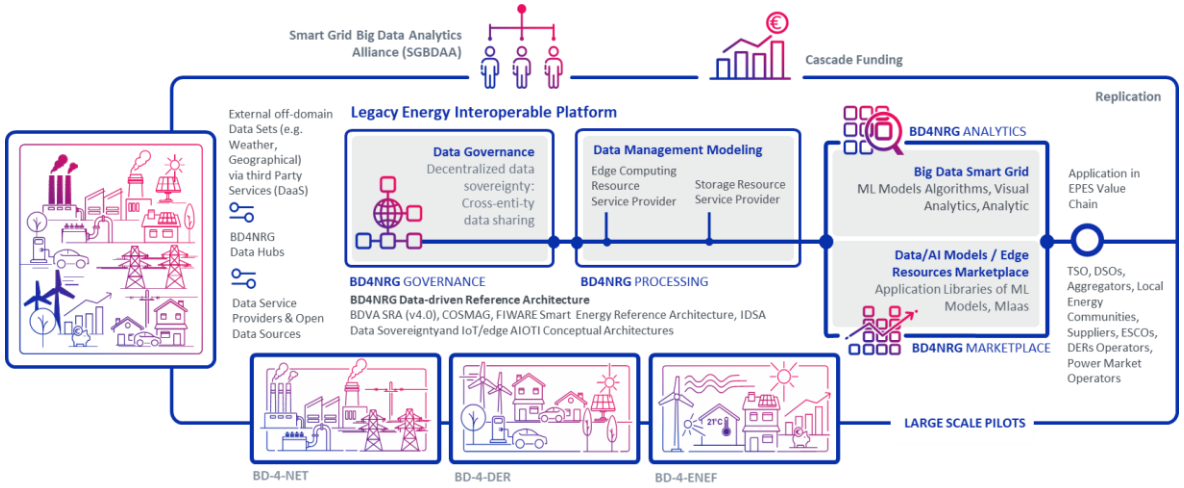


# BD4RG Addressing the New Energy Context

- Energy **data-driven** platforms, hubs, solutions and European-wide **Energy Data Spaces**
  - may become the fuel for increased **system-level cross-value chain energy and resource-efficiency**, and better yet greener quality of life
  - are expected to enable systematic **cross-stakeholders interoperability,** and hence facilitate new energy-centered cross-value chain data-driven services, which may:
    - *increase the **customers portfolio** of energy operators, through new energy fingerprinting-based services (es comfort, wellness. Mobility, personal safety)*
    - *opening up to **new non energy stakeholders** (e-mobility, care service providers, security providers, building/facility operators, real estates,…) to offer bundles of services, which include as well energy services (es. paying KWh as Kms…)*
- There are some **silver bullets**…
  - Insufficient cross-value chain interoperability
  - Lack of trust both at B2B and B2C level, preventing energy data sharing (data sovereignty is not fully integrated in the Energy platforms/hubs
  - Market failures/ business models immaturity of the energy data value chain (es. insufficient propagation of shared data value along energy value chain)

# BD4NRG Achievements To Date

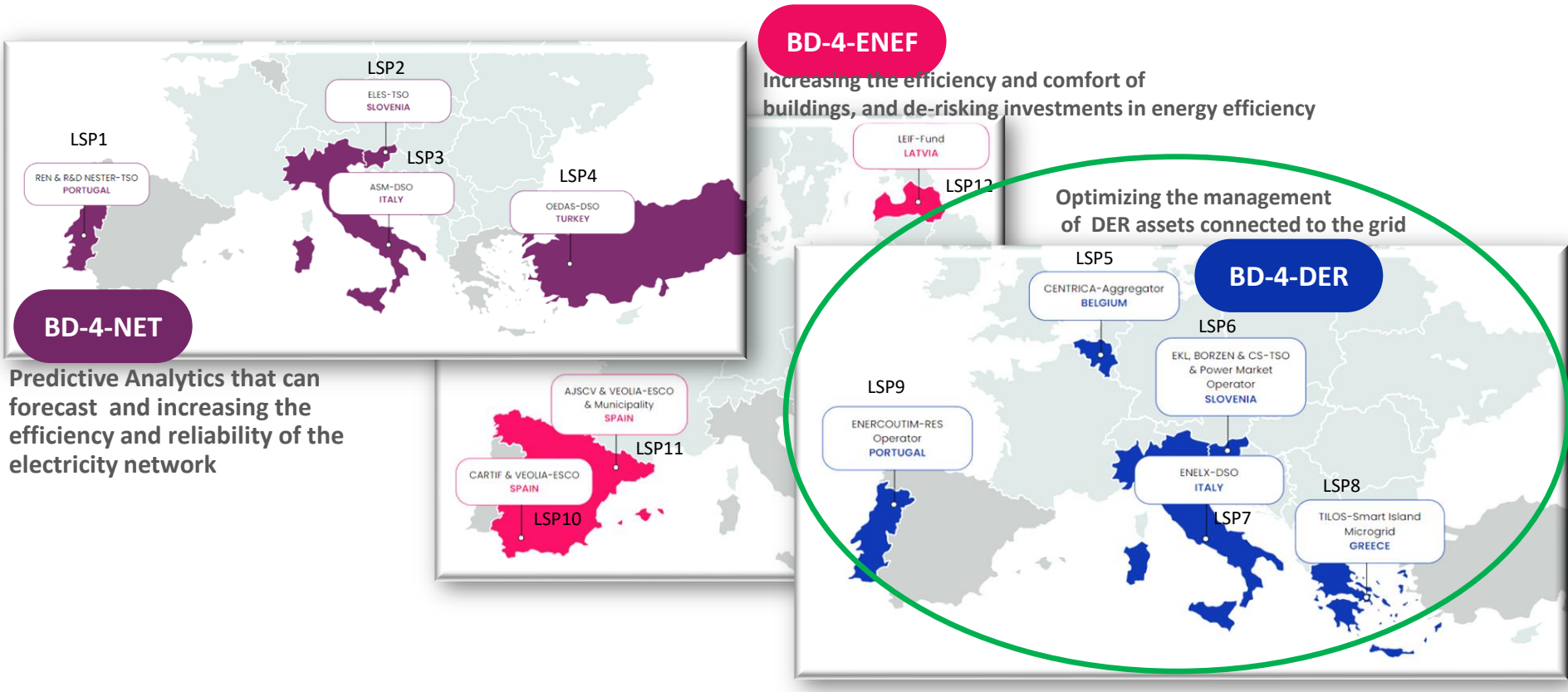
- Innovative energy-tailored **Big Data Analytics Toolbox** (**BD4NRG Toolbox**) which will significantly contribute to achieve a techno-economic optimal management of Electric Power and Energy Systems (EPES) value chain
- **BDA Analytics Services** for (i) optimised management of grid and non-grid owned assets; (ii) improved efficiency and reliability of electricity networks operation; (iii) optimal risk assessment for energy efficiency investments planning




…To enable a **consumer-centric data-driven electricity-centered energy system**

# Who can provide/consume data?

*12 Large-Scale Pilots (LSPs)*

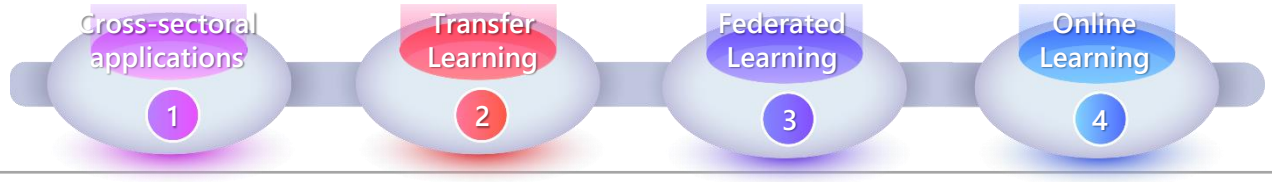



**Predictive Analytics that can forecast and increasing the efficiency and reliability of the electricity network**

# How are the data analysed?

*Pilot-oriented Analytics Services*

**Highlights**




| Analytics Services | Data Analytics Techniques & Algorithms | Category | Related LSP |
|---|---|---|---|
| Grid-secure dispatch of battery energy storages systems | Linear Regression (LR); Linear programming | Machine Learning, Optimization Algorithms | LSP5 |
| Energy state forecasting of water heaters using transfer learning | Physics-informed neural network; Multi-Layer Perceptron (MLP) | Machine Learning, Deep Learning, Transfer Learning | LSP5 |
| NWP-based Mid-term Photovoltaic production forecasting | XGBoost (XGB); LightGBM (LGBM); Multi-Layer Perceptron (MLP) | Machine Learning, Deep Learning | LSP8 |
| Large scale Load Forecasting at an island level | Decision Tree (DT); Extreme Gradient Boosted Trees (XGBoost); LightGBM (LGBM); Multi-Layer Perceptron (MLP) | Machine Learning, Deep Learning | LSP8 |
| Water Pumping Systems Load Shifting | Heuristic Algorithm | Optimization Algorithms | LSP8 |
| PV & CPV Production NWP-independent Short-Term Forecasting | Stacked LSTM; Bi-Directional LSTM; CNN-LSTM; Convolutional LSTM | Deep Learning | LSP9 |
| Thermal Comfort Analytics for Buildings | Linear Regression (LR); Random Forest (RF); Prophet Model | Machine Learning | LSP11 |

# Cross-stakeholder Flexibility Assets Forecasting and Aggregation – (1/2)

## Where: Belgium
## Pilot Leader – CENTRICA

### Use Case 1 Transfer learning for asset energy forecasting

machine learning

### Use Case 2 Grid-friendly asset dispatch

machine learning & optimization algorithms

## Main Outcomes

cross-context transfer learning data-driven services & algorithms for residential flexibility asset profiling in cold start conditions

Using service provider's local grid information in a cross-domain context of grid-friendly aggregation activations

## Major takeaways

More efficient learning leading to *higher consumer comfort* and *faster cost/revenue benefits* of controllers

Grid-friendly demand response activations can *mitigate congestion or voltage issues* compared to conventional activation

centrica
Business Solutions

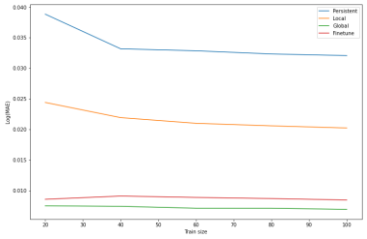
# Cross-stakeholder Transfer Learning for Flexibility Assets Forecasting and Aggregation – (2/2)

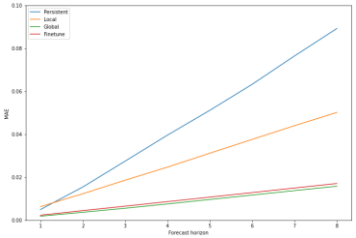
BD4 NRG
Big Data for Next Generation Energy

Pilot setup

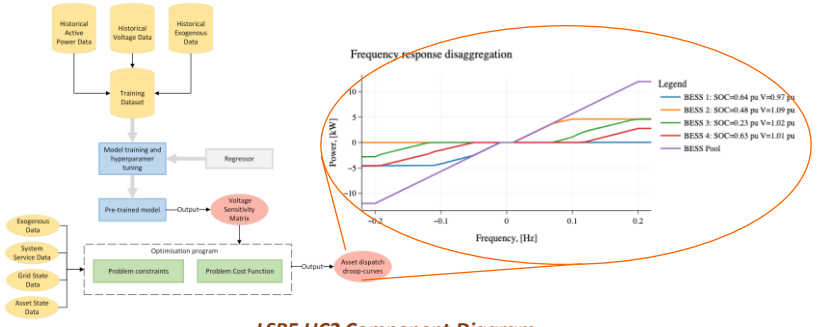

*Hot water heaters*

*Battery energy storage system*





*LSP5 UC1 Component Diagram & results. SOURCE: UGent/IMEC*




*LSP5 UC2 Component Diagram*

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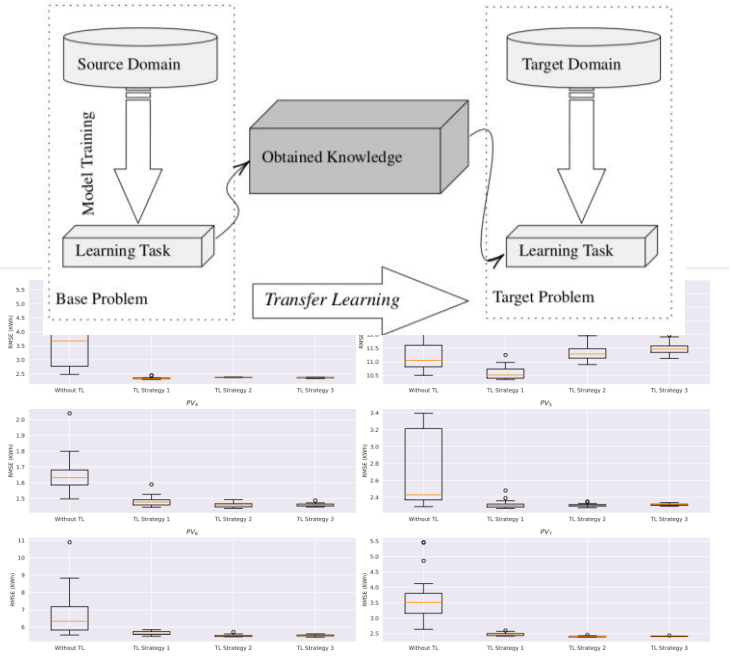
Business Solutions

## How are the data analysed?

*Transfer Learning*

- What happens when few data are available?
- **Application:** Cross-context transfer learning algorithms for residential flexibility asset profiling with a view to reduce the time necessary for model training

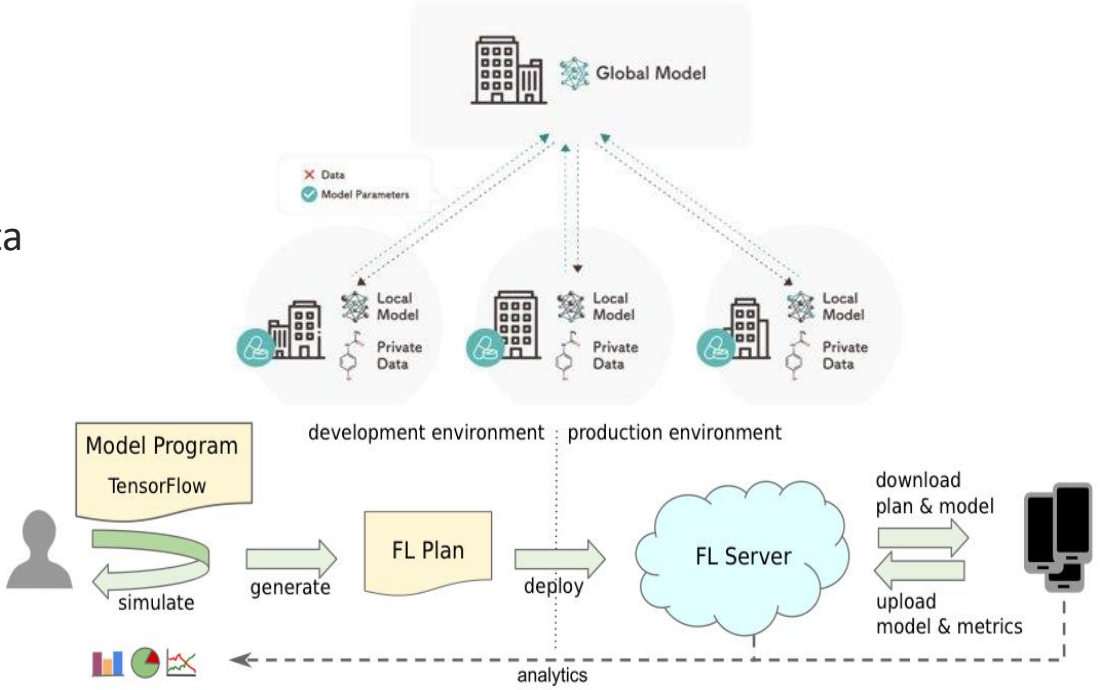



***Publication**: Transfer learning strategies for solar power forecasting under data scarcity. Scientific Reports (Nature), 12 (14643), 2022.*

## How are the data analysed?

*Federated Learning*

- Uses local information to build global knowledge
- Does not disclose sensitive data
- **Application:** Management of residential demand-response/flexibility assets management to retrieve loc grid information used for aggregation activations (LSP5)



# Predictive Demand and Generation Forecasting for Optimized Local Energy Community Management

## Where: Greece (Tilos Island) - Pilot Leader – UNIWA

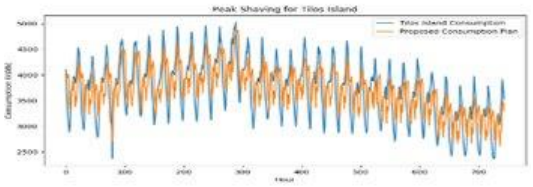
**Infrastructure & Data Used:**

- **Municipal loads**' demand
- **Residential**/**Commercial loads**' demand
- **Distributed PV** plants' power generation
- **Weather** data


*Grafana environment for data sharing*

**Main Achievements:**

- **Forecasting Models** for **PV generation** & **load demand**, combined with **optimization scheduling algorithms** for deferrable loads (e.g. water pumps)
- **Big data analytics community level service** for peak shaving and RES shares' utilization increase



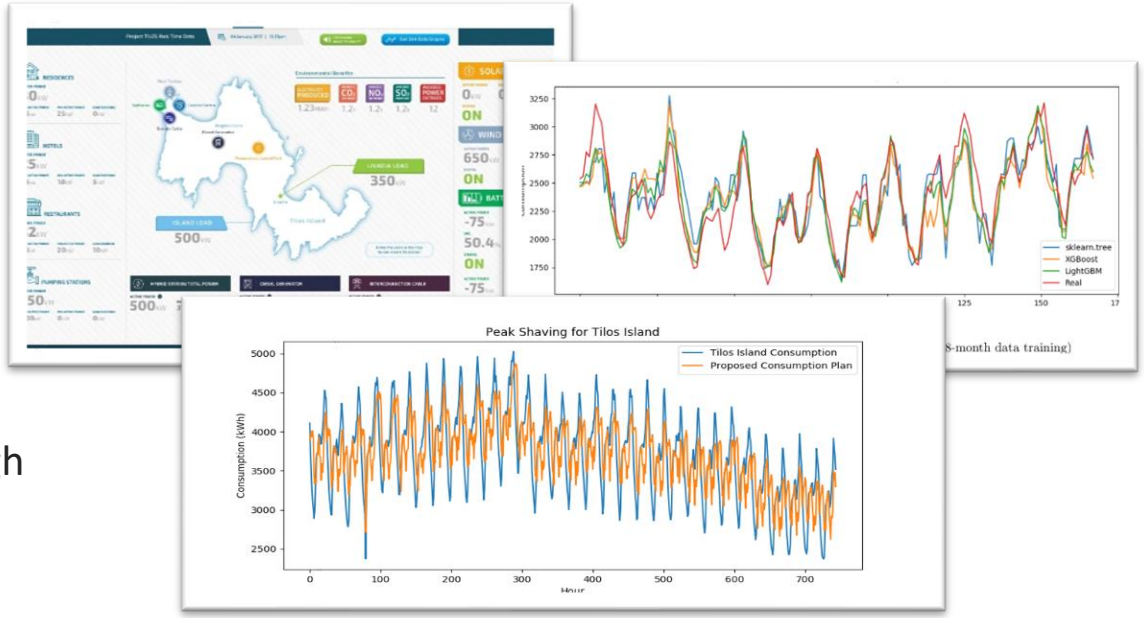

*Peak shaving techniques*

# How are the data analysed?

*Cross-sectoral application: Energy & Water*

## Optimized local energy community management

- Improved analytics-based forecasting for RES local generation and flexible/controllable loads
- **Application:** Peak shaving through smart scheduling of water pumping systems (LSP8 – Tilos island municipality)




***Publication**: ML-based energy management of water pumping systems for the application of peak shaving in small-scale islands, Sustainable Cities and Society 82, 103873.*

# Collaborative aggregated energy generation prediction

BD4NRG
Big Data for Next Generation Energy

## Where: Portugal - Pilot Leader – ENERCOUTIM – In progress

**Use Case 1: Optimizing and improving management and prediction of DER production**

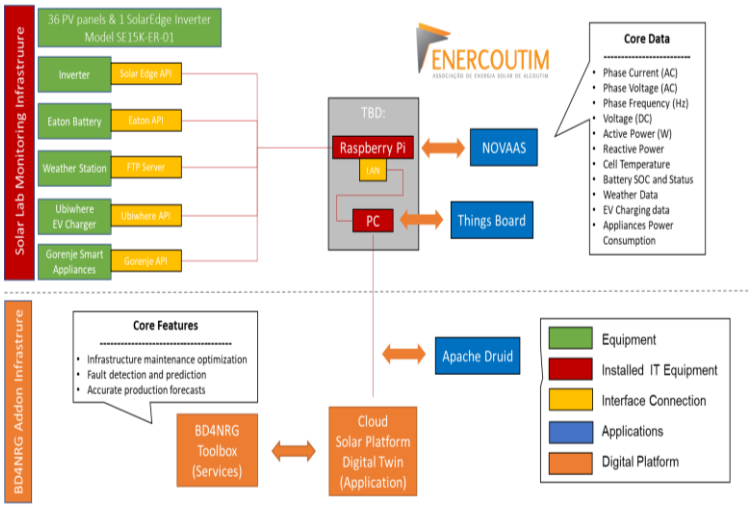
**Use Case 2: Energy sector digital twin**

**Infrastructure & Data Used:**

- **CPV** and **Solar Lab** data (DC/AC Current/Voltage, Phase Frequency, Active/Reactive Power, Cell Temperature, Elevation Angle, Tracker motor angles)
- **Faults** records
- **Operational** & **maintenance** data of PV plants

**Main Achievements:**

- **AAS Environment** for Solar Lab and Cluster created.
- AAS **meta data modelling**.
- **Prototype connection** of asset under WP3.
- **Initial** power generation **forecasts** for **renewable energy** plants on plant level.



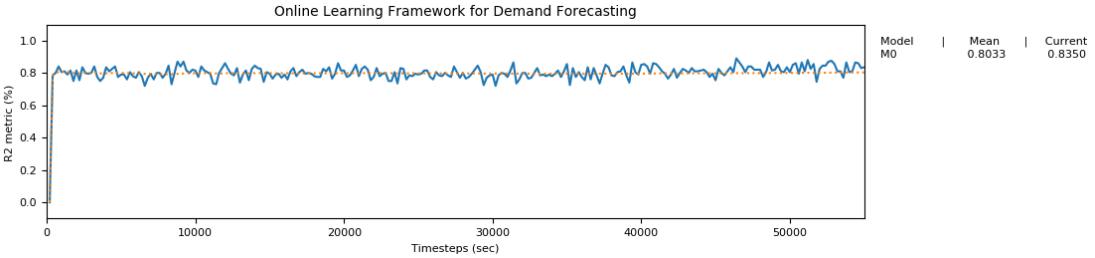

*Solar Lab PV Site Infrastructure*

ENERCOUTIM
ALCOUTIM SOLAR ENERGY ASSOCIATION

## How are the data analysed?

*Online Learning*

- Adapt better to changes in the data distribution (data variety).
- Faster model updates (data velocity).
- Smaller data storage capacity (data volume).
- **Application:** An online learning framework for load forecasting in energy microgrids (LSP9 - microgrid applications load forecasting)

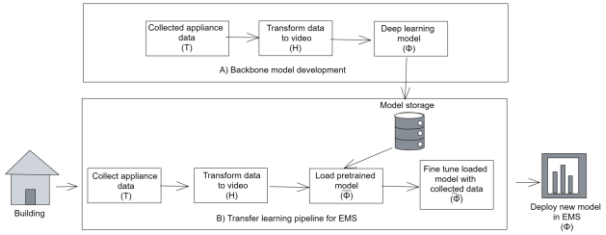


# Coordinating Grid-owned and Behind-the-meter Assets for Grid Operation vs Near Power Market Operation Settlement

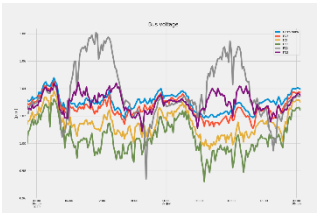
## Where: Slovenia - Pilot Leader – BORZEN – In progress

**Use Case 1:** **Identification of flexibility potential, based on near-real time data**

**Use Case 2:** **Independent aggregator flexibility activation, quantification and settlement**




*DR scenarios via EMS*



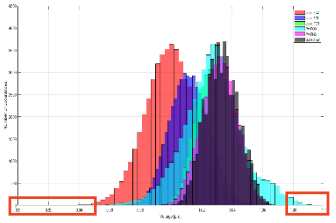
*Grid modelling*

### Infrastructure & Data Used:

- Power quality meters (voltage and current measurements and calculated electrical parameters)
- **Smart metering** data (voltage, current, power, energy) from **households**, consumers with **self-production** and **energy production** locations

### Main Achievements:

- **Grid modeling**, **power quality** prediction, corrective measures via **demand-response** TSO's assets' **fault analytics** service development
- Fine-grain **consumers profiling**, **clustering** and **flexibility assessment**
  - Machine learning for **regression**/**classification** models **labeling** energy **consumption production**
  - **Explicit** and **implicit demand-response** scenarios via EMS / smart metering infrastructure



*Flexibility potential*

# BD4NRG project

**Massimo Bertoncini**
**Director of R&I projects**
**on Smart Energy at Engineering**

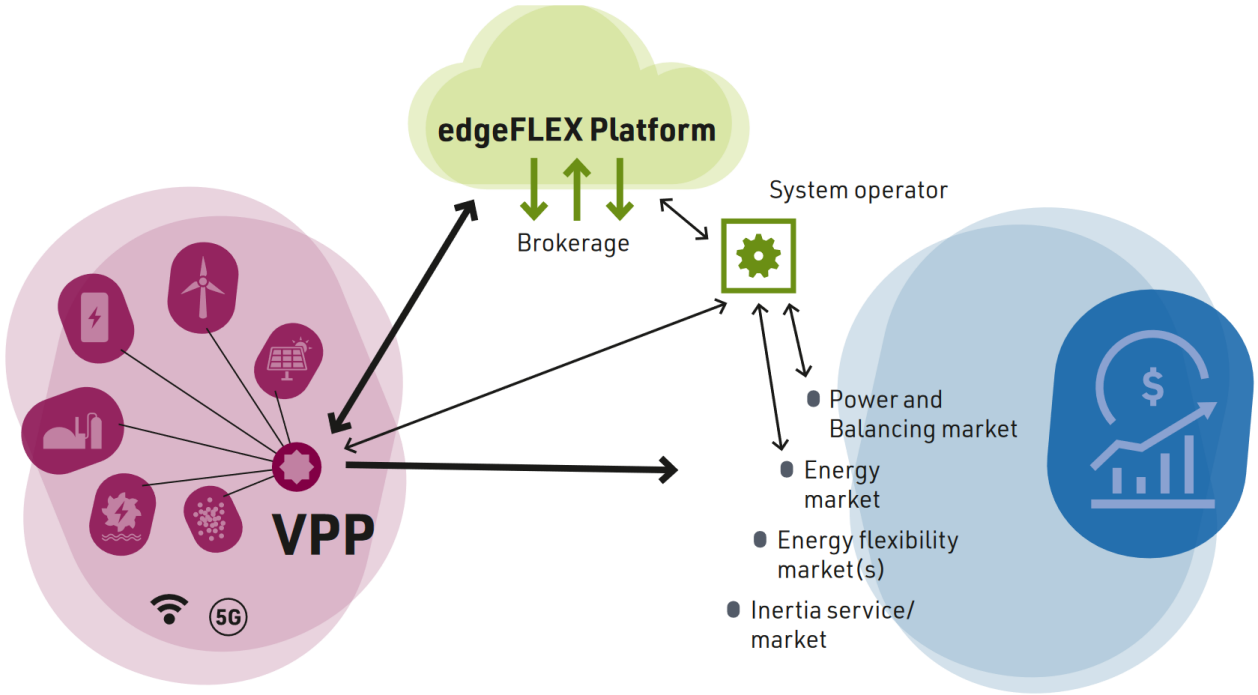
# Edge-FLEX project

**Antonello Monti**
**Director of the Institute for Automation of Complex Power Systems**

edgeFLEX

# Managing future grids with the new VPP Concept

# Next generation Virtual Power Plant

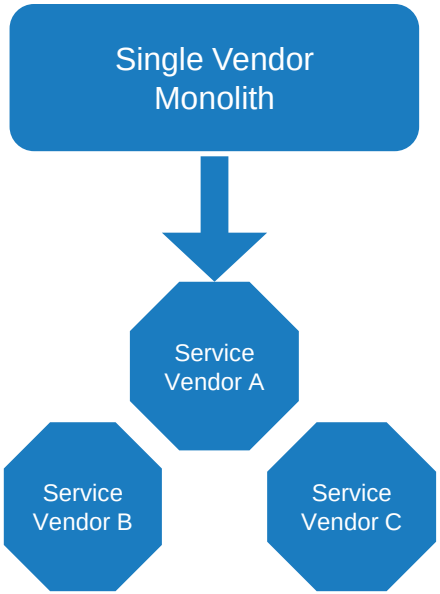



edgeFLEX aims at involving **Virtual Power Plants** and **Energy Communities** in the grid management, by enabling **Slow and Fast dynamics services** and fostering a new **local energy and flexibility market.**

# edgeFLEX foundations - SOGNO

- From a monolithic approach to the SOGNO Microservice solution
  - Flexible access to system automation based on cloud-native **microservices**
  - **Decentralized service procurement** from one or more providers without vendor lock-in
  - Multiple suppliers of **measurement devices and algorithms**
  - Hosted **on-premise** or in **public cloud**
  - Support of multiple **standard data models**

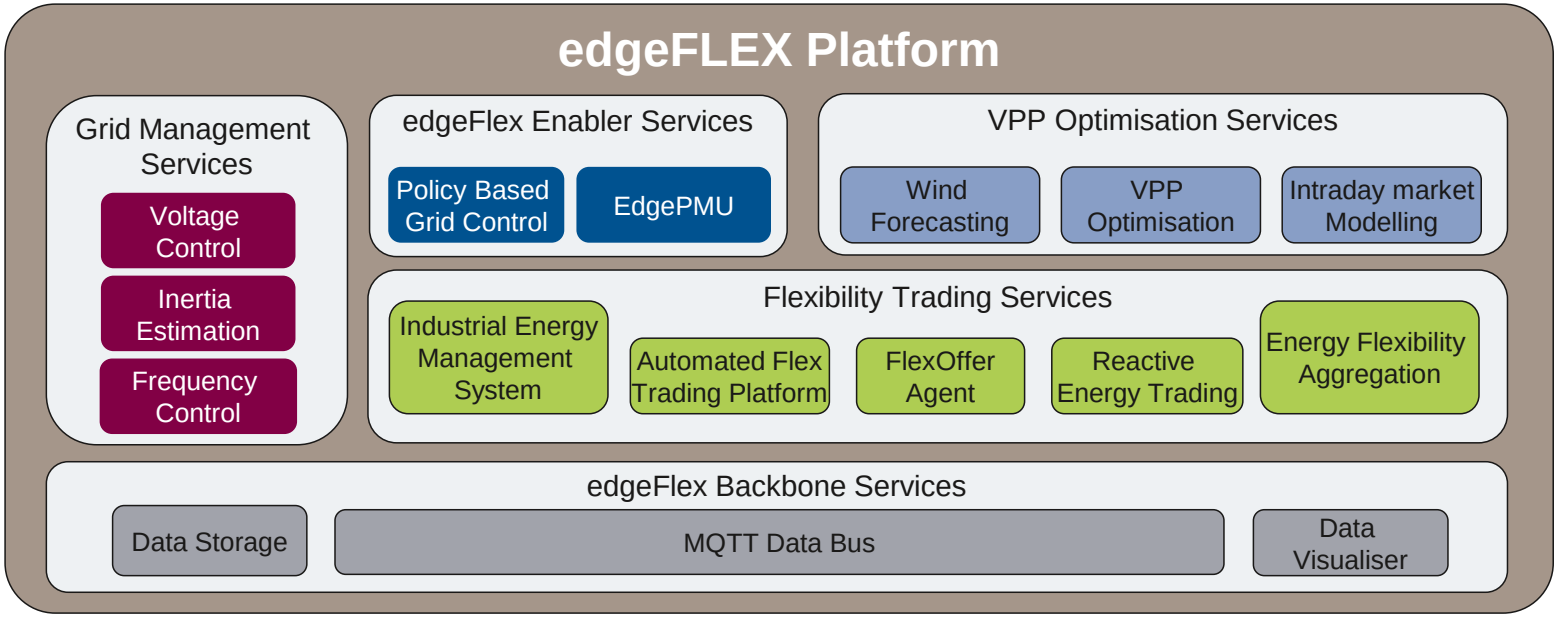




- Supported by Linux Foundation Energy
- Rich Catalogue of Services
- Open source code repository available on Github
- Wide spreading industrial adoption

**edgeFLEX project**
Prof. Antonello Monti (RWTH)

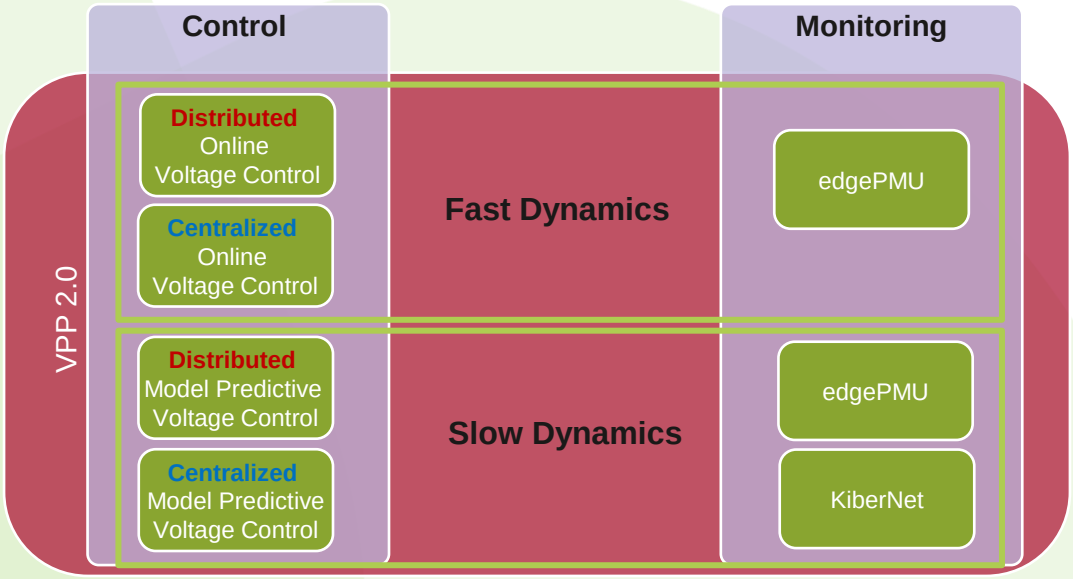
# edgeFLEX Components and Services



# Voltage Control Research Summary

- **Novel concept of Distributed Online and Model Predictive Voltage Control**
  - to obtain a **peer-to-peer** and **secure** volage control algorithm, with a **plug and play** capability
- **Integration of Centralized Online and Model Predictive Voltage Control in the platform**
  - For the implementation of **fast and slow actions** in the **field trial**
  - To **engage** customers by interfacing with **Flexibility Market** (Kibernet)

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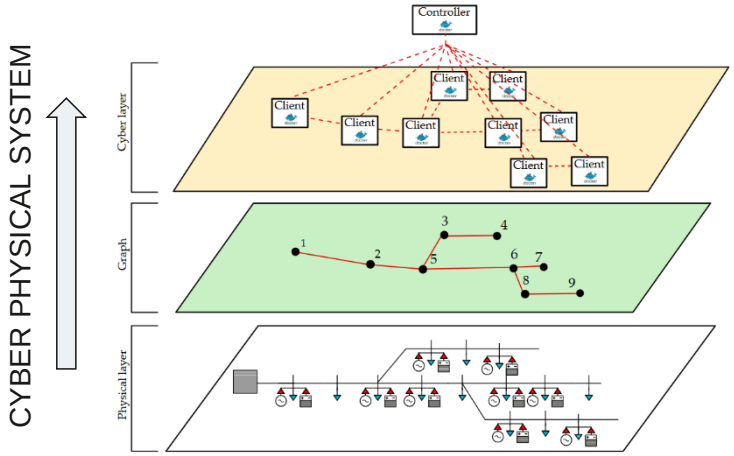
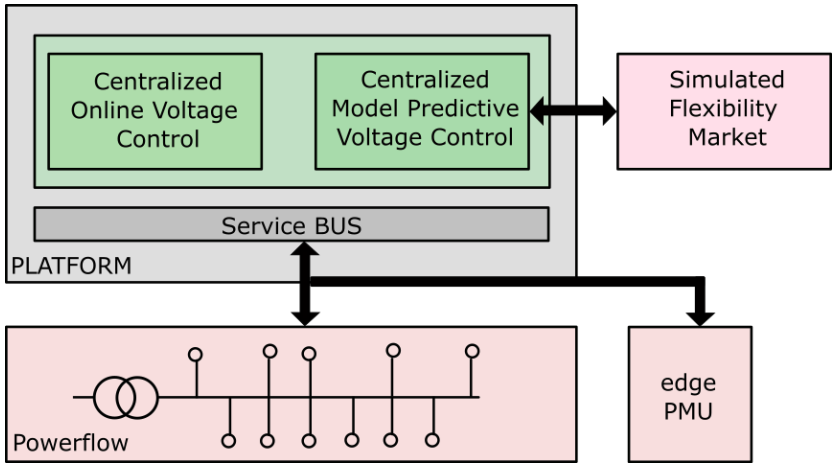
# Voltage Control

## Distributed Online Voltage Control with Software Containers




- Robustness against model error
- Scalable

## Centralized Controllers with Software Containers




- Can be instantiated as microservices in the edgeFLEX platform

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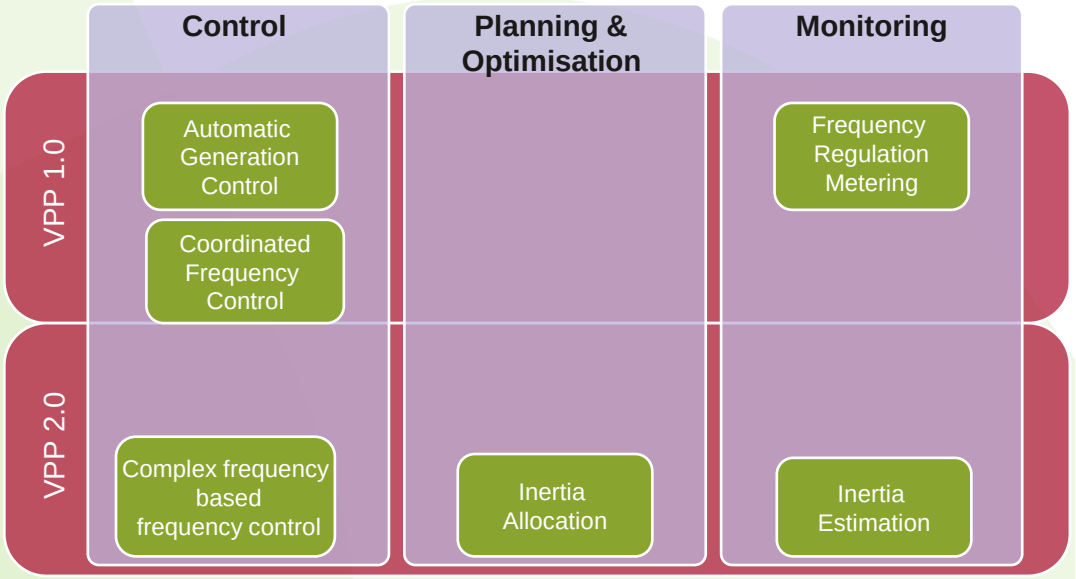
# Frequency Control Research Concepts

- Novel frequency control for current VPPs
  - **enhances** the overall **dynamic performance** of VPPs depending on existing regulations.
- Novel concepts for frequency control, inertia estimation and frequency support services allocation for Energy Communities in *future VPPs*
  - **advance the role of VPPs in providing ancillary services**
- New theoretical advancement: the development of the **concept of the "*complex frequency.*"**

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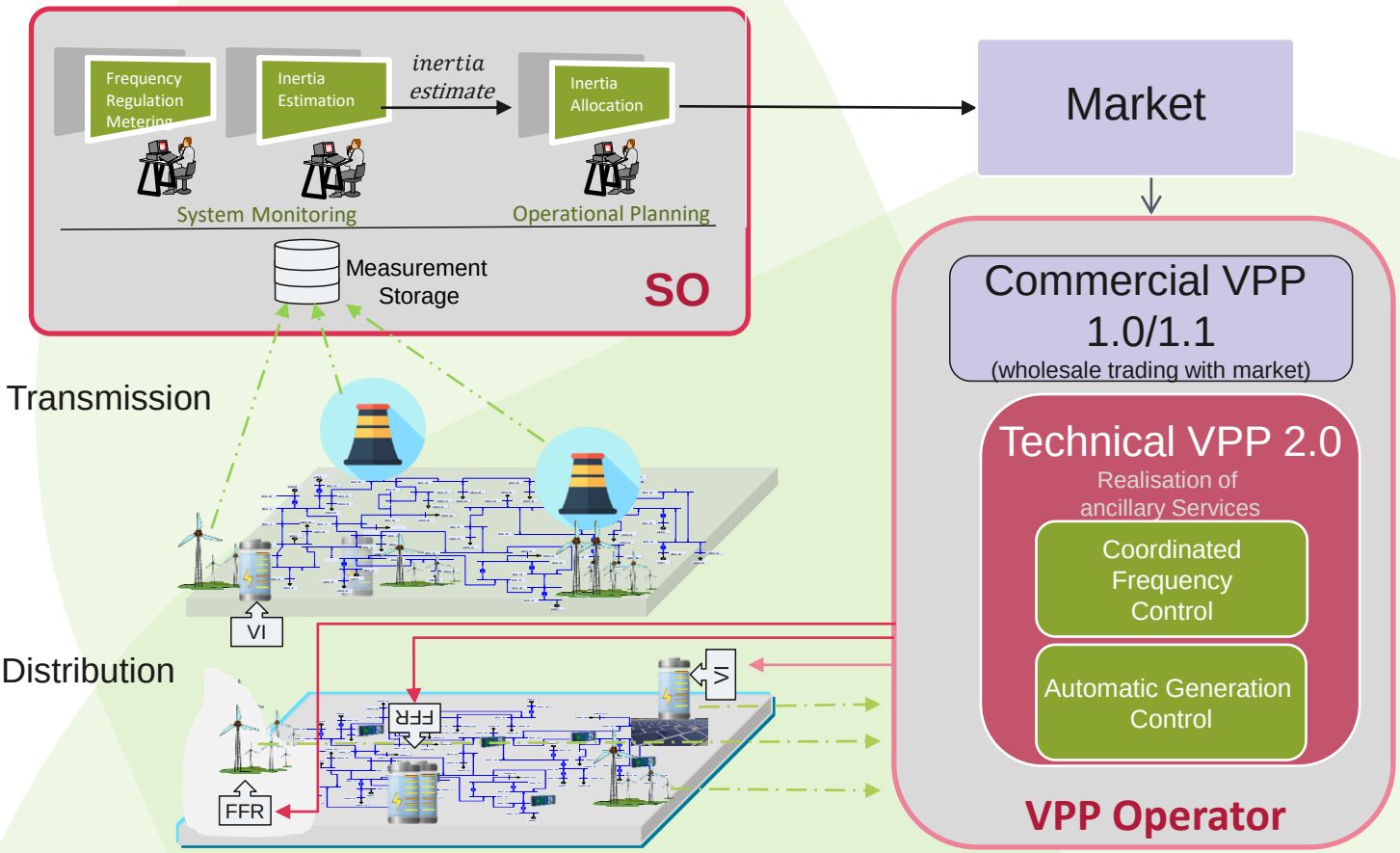
# edgeFLEX Vision



# edgeFLEX consortium


**edgeFLEX Consortium**

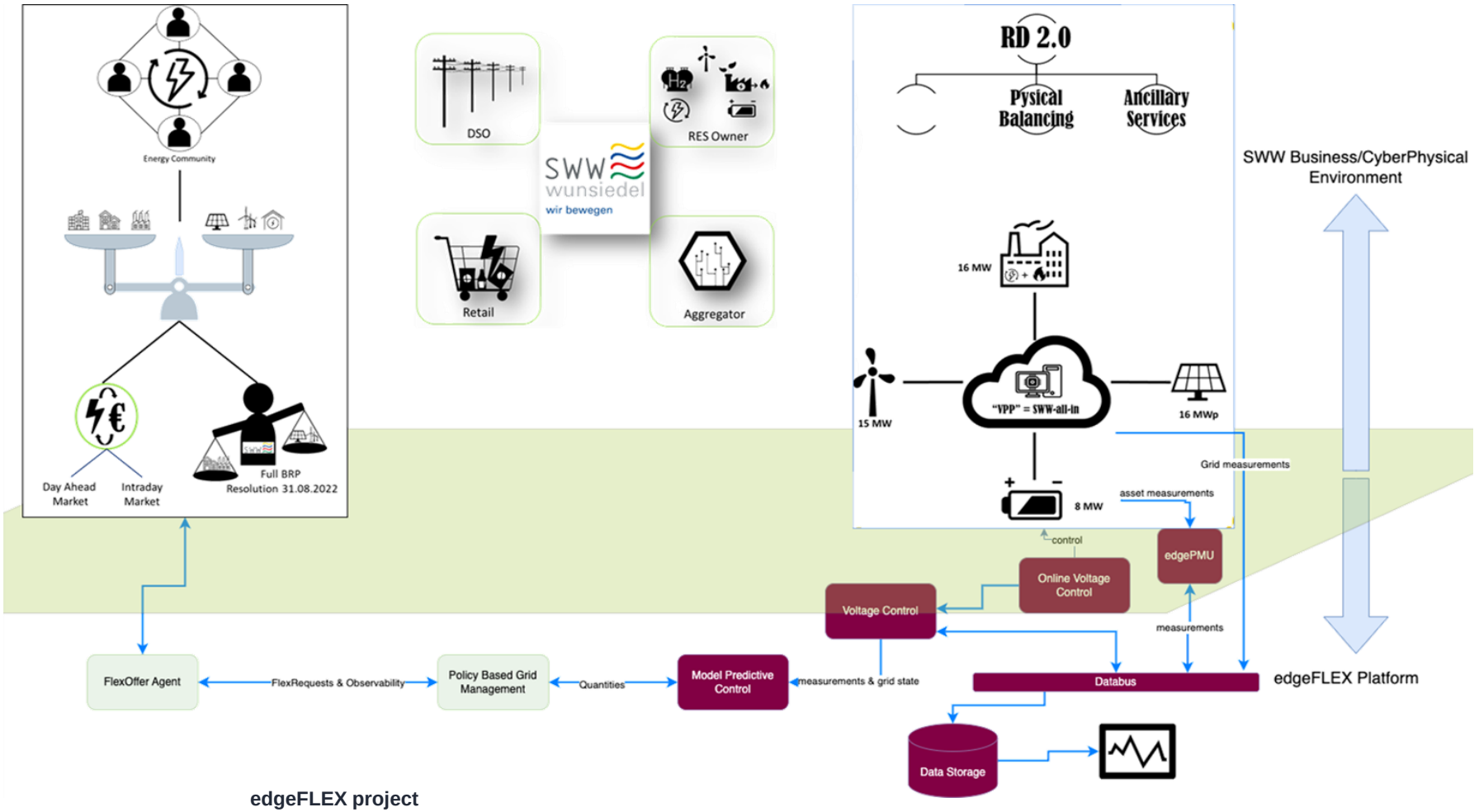
10 partners institutions
- 6 SMEs and LEs
- 4 Universities

6 countries involved

**Trials in Germany**
T1 all over Germany: Slow Dynamics
T2 in Wunsiedel: Slow + fast Dynamics
T4 in Aachen: Laboratory Test
**Trial in Italy**
T3 in Milan: Fast Dynamics

Utilities have already expressed their interest in joining the trial as first external testers at their own expenses

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edgeFLEX

**www.edgeflex-h2020.eu**

This project has received funding
from the European Union's Horizon 2020
research and innovation programme under
grant agreement No 883710.

European Commission

# Panel discussion

European Commission

#ETIPSNET

# TITLE of the speech