ARTIFICIAL INTELLIGENCE BASED SOLUTIONS FOR ELECTRICAL GRIDS

Clustering and Global Challenges

Parallel Session 2 - Smart Energy

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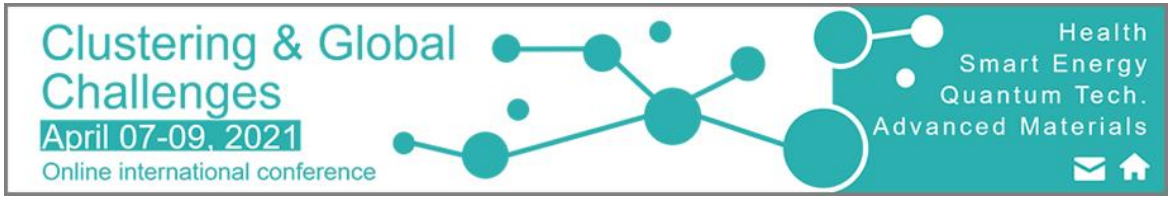

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CITCEA-UPC

Wind power

Solar energy

Power electronics dominated power systems

Transmission and distribution networks

Microgrids

Smart grids and Big data

Energy economics

Electrical mobility

Energy storage

Digital grids

Power-electronics

Automation and industrial communications

Digital control

Electrical machines

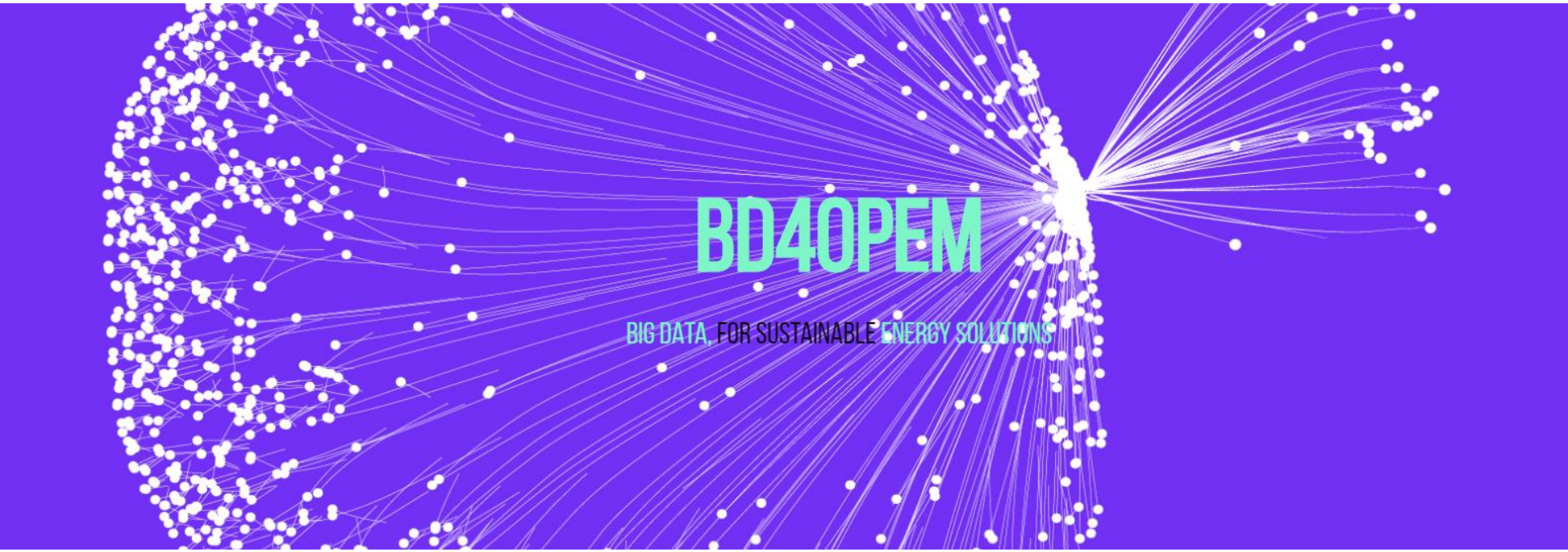
CITCEA

CITCEA-UPC

- Research center of the Technical University of Catalonia - UPC
- Founded in **2001**
- Part of the TECNIO network, by ACC1Ó (Catalan Government)
- Consolidated research center SGR, by AGAUR (Catalan Government)
- 60 people: 11 professors, **25 engineers**, 3 administrative staff, 10 PhD students, 20 Master and Bachelor students
- 110 customers, 250 projects
- **10 patents**
- More than 500 conference papers
- More than 300 journal papers
- **1 spin-off** company (teknoCEA)

BD4OPEM

BD4OPEM H2020
Big Data for OPen innovation Energy Marketplace



https://cordis.europa.eu/project/id/872525/es

https://bd4opem.eu/

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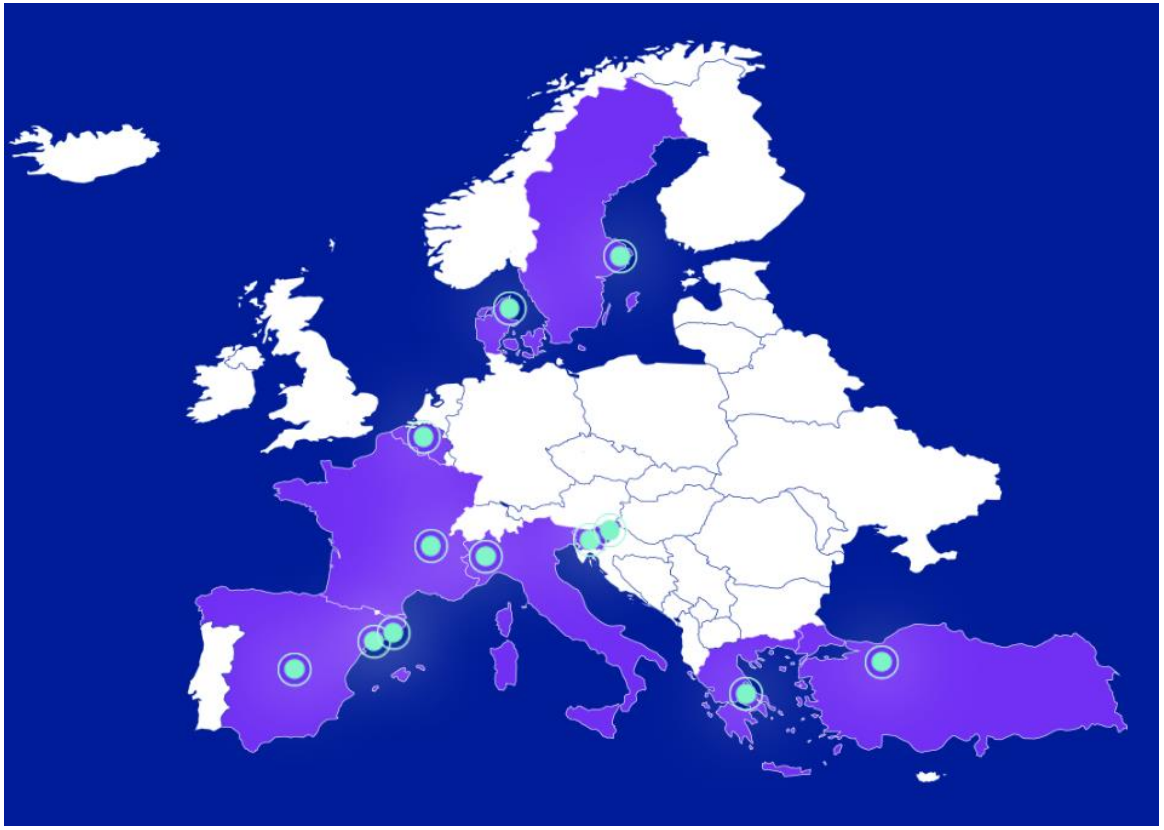
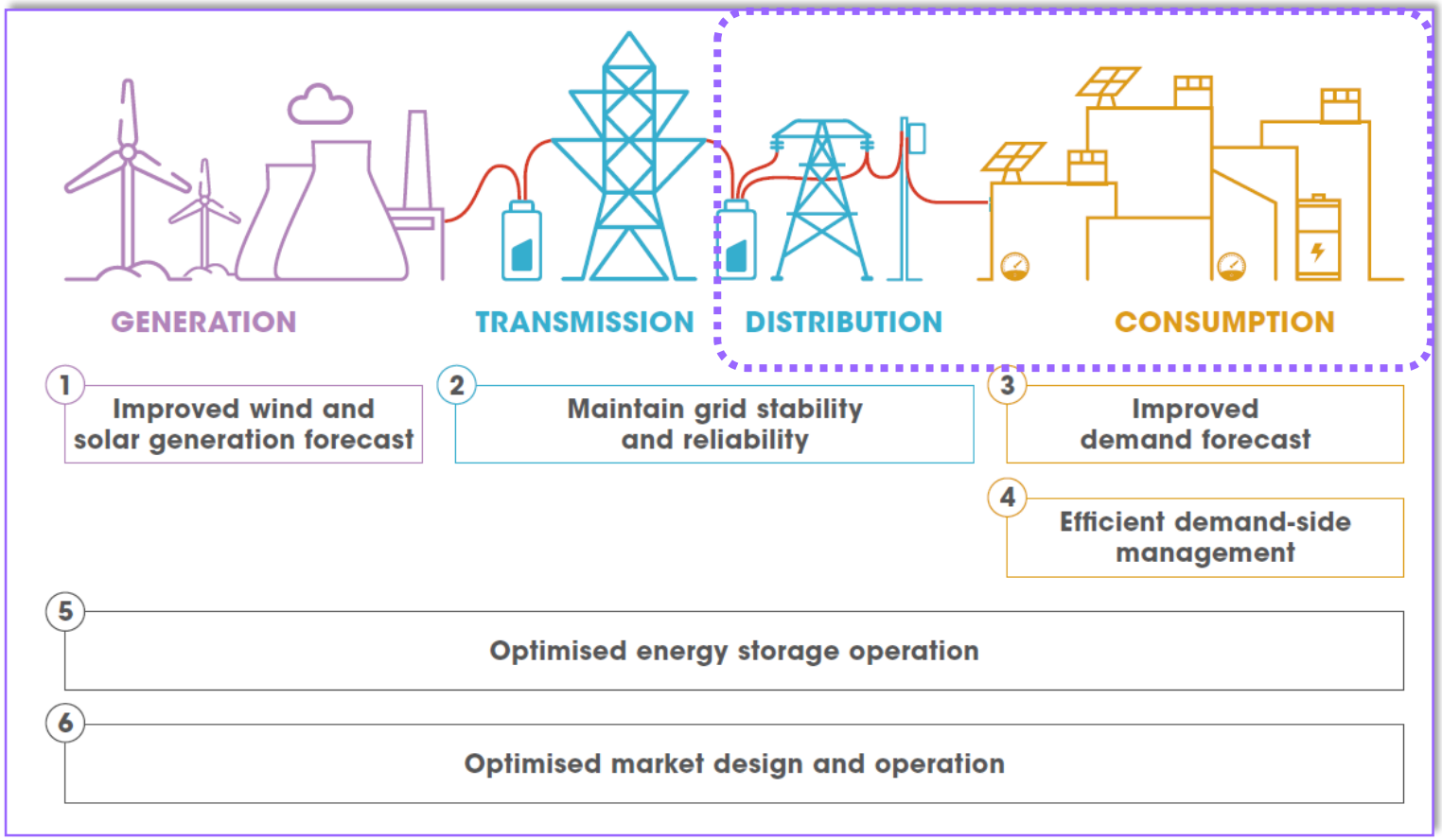
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 872525

The consortium

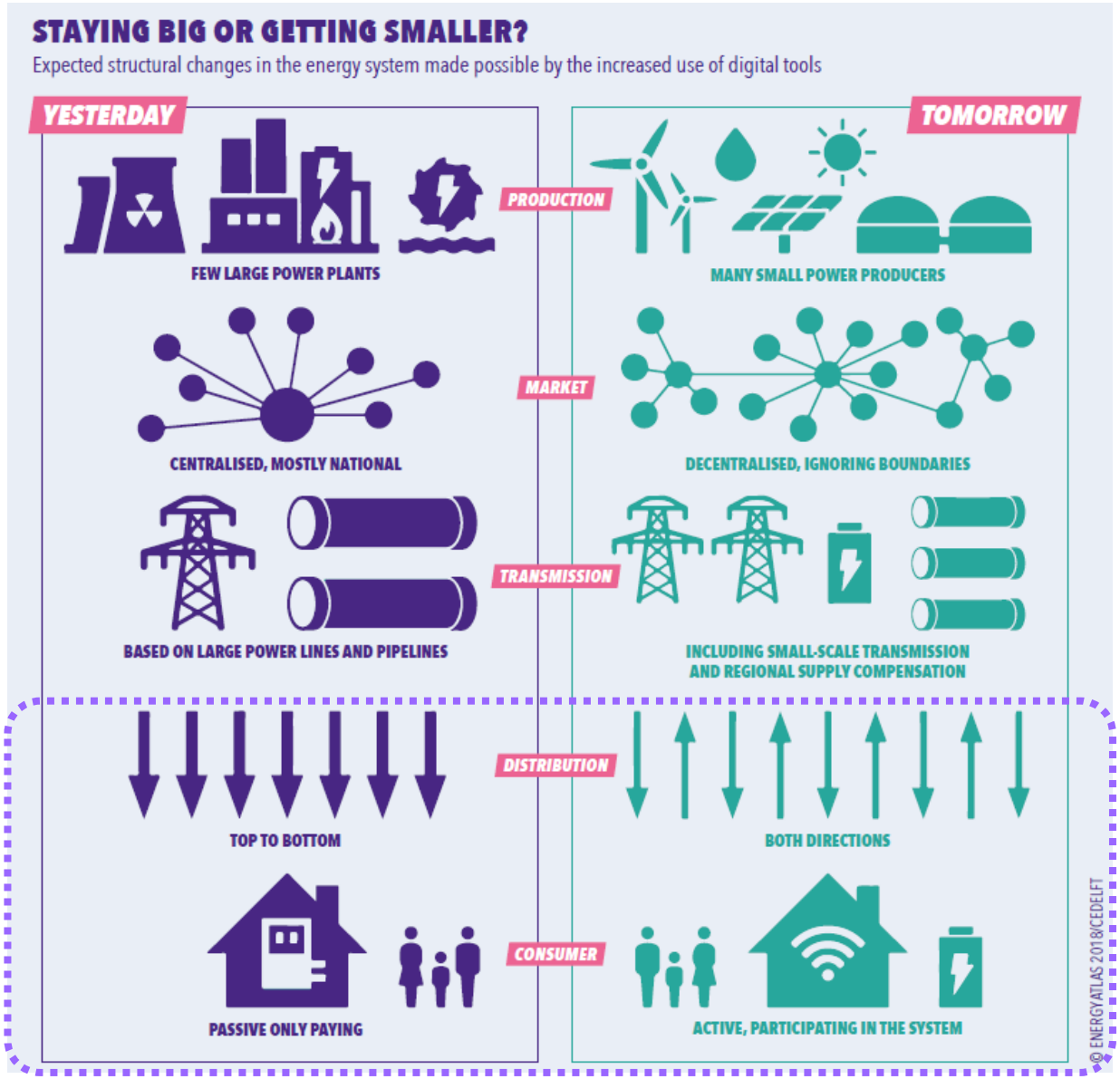


The consortium

Scope

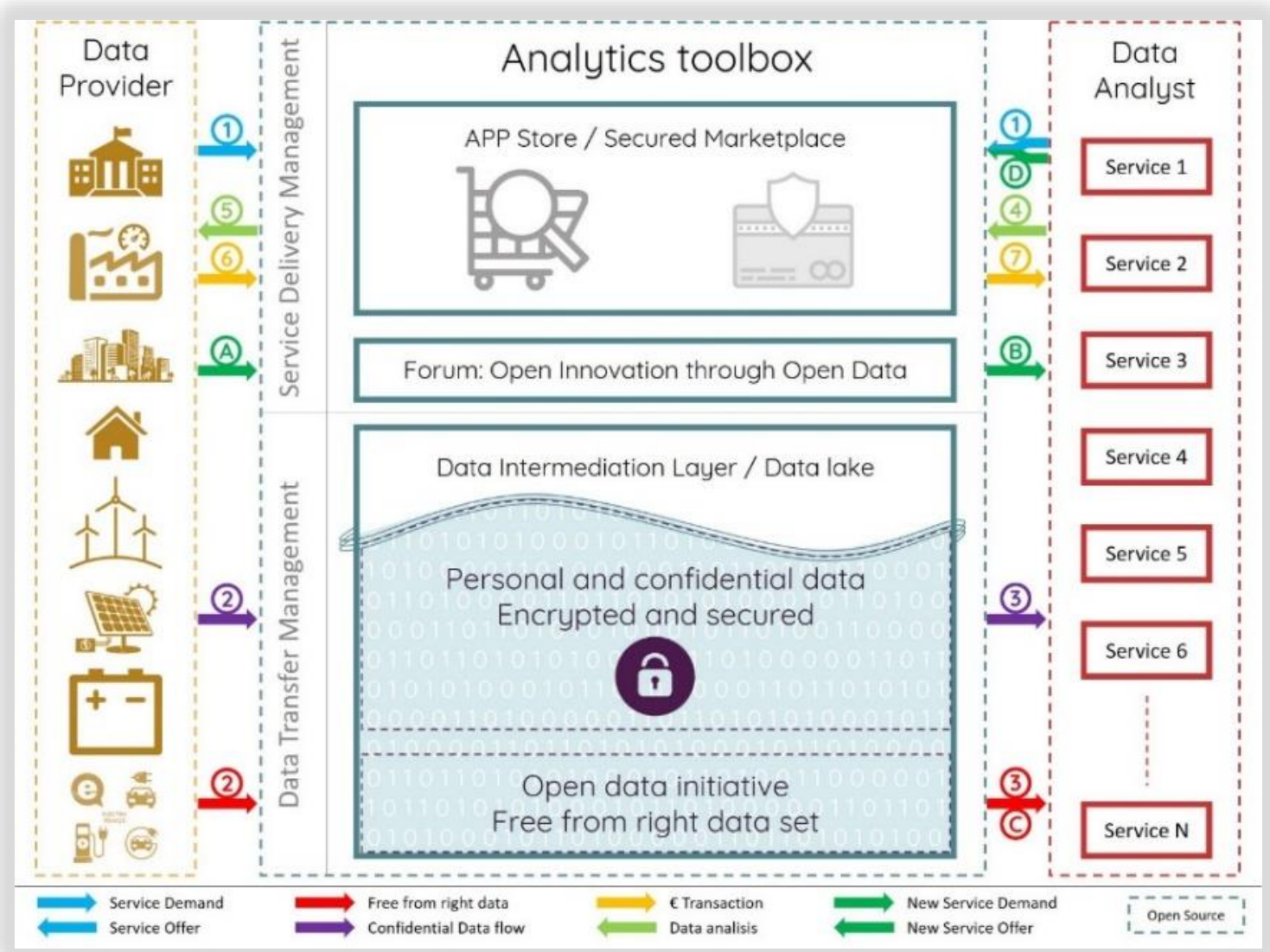


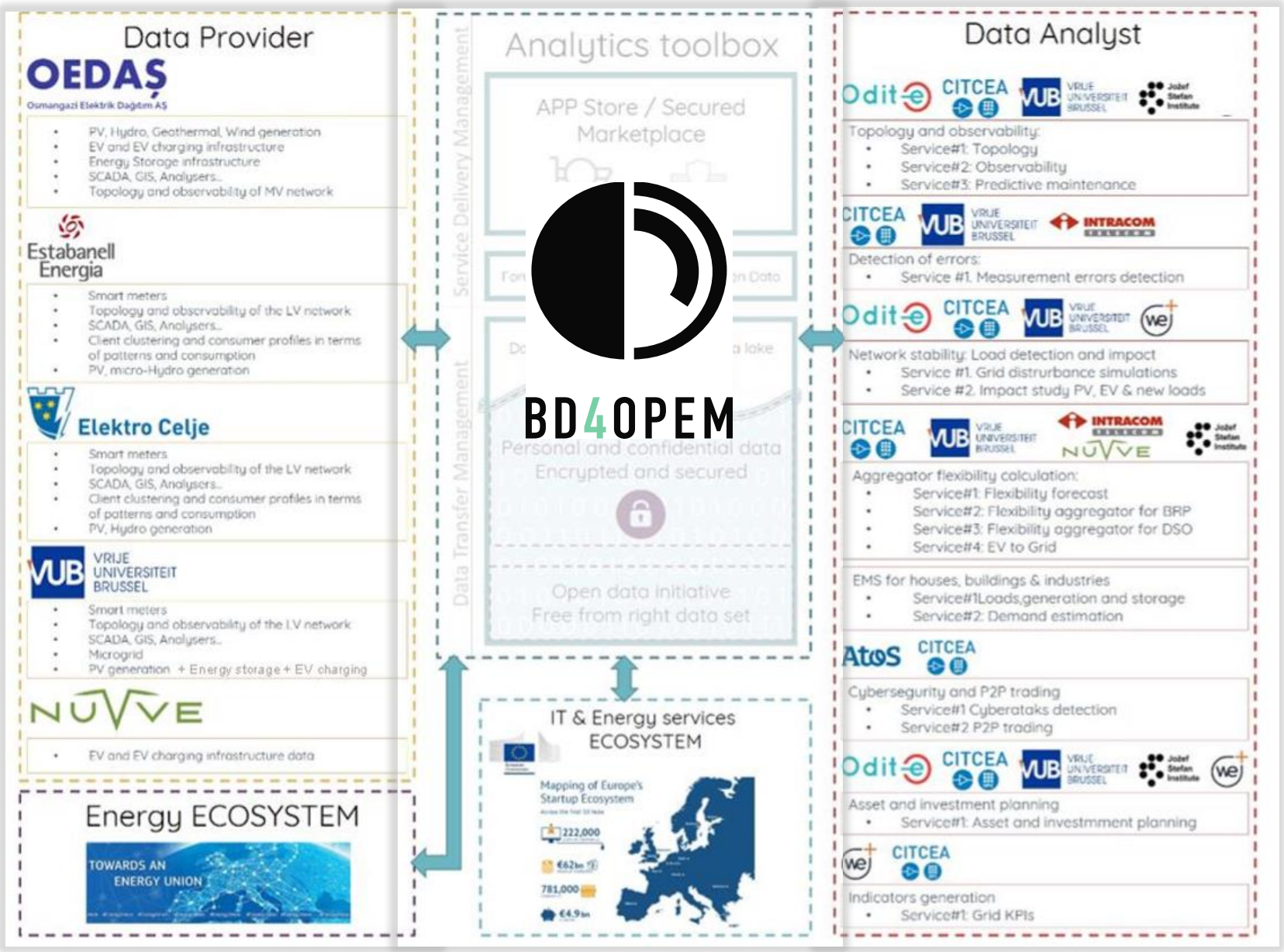
Source: IRENA. Artificial intelligence and big data innovation landscape brief, 2019



Fuente: Friends of the Earth Europe, Unleashing the power of Community Renewable Energy, 2018

Objectives


Data Provider
Service Delivery Management
Data Transfer Management
Analytics toolbox
APP Store / Secured Marketplace
Forum: Open Innovation through Open Data
Data Intermediation Layer / Data lake
Personal and confidential data
Encrypted and secured
Open data initiative
Free from right data set
Data Analyst
Service 1
Service 2
Service 3
Service 4
Service 5
Service 6
Service N
Service Demand
Service Offer
Free from right data
Confidential Data flow
€ Transaction
Data analisis
New Service Demand
New Service Offer
Open Source



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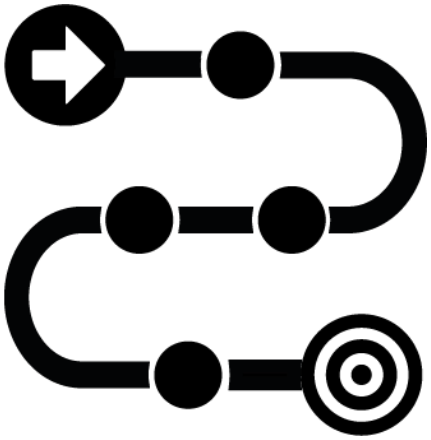
AI based services

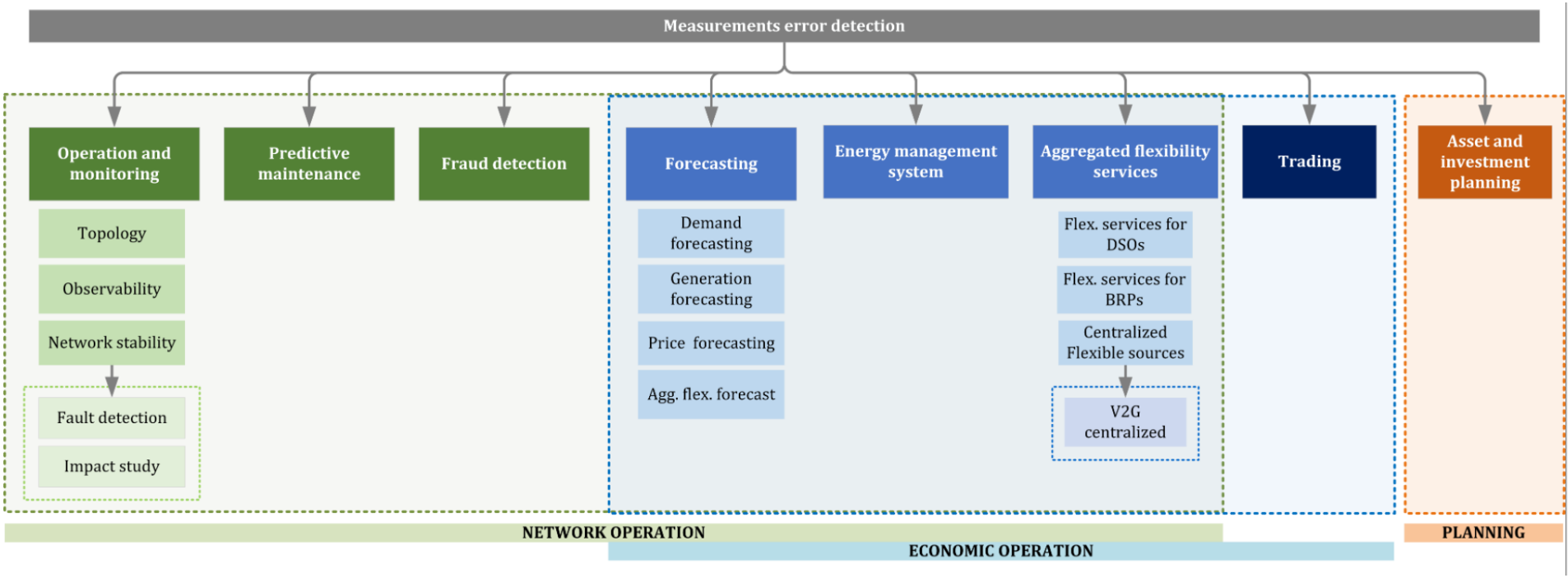
Monitoring



Operation and maintenance

Planning

AI based services

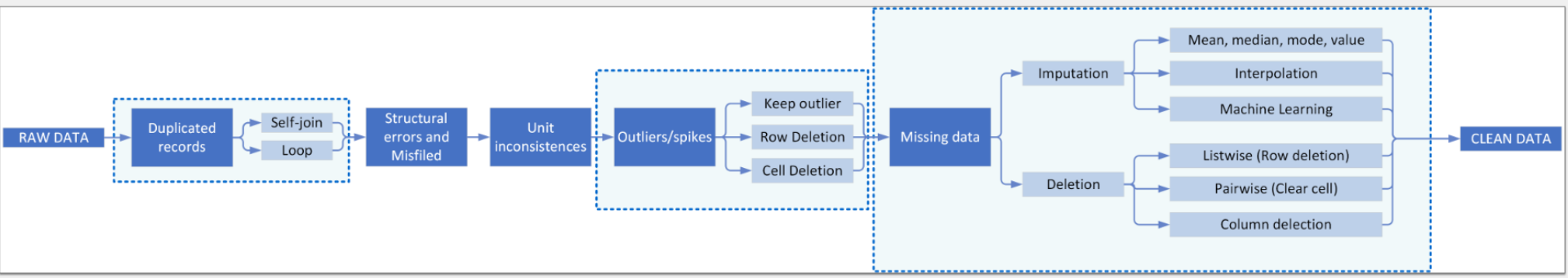


Error detection

Description: To perform data preprocessing and cleaning. Preprocessing of data coming from several data sources (PMUs, smart meters, temperature sensors…) Depending on the type of anomaly detected, a correction will be automatically performed.

Execution: Online

Techniques: Statistics, Data mining, Pattern recognition



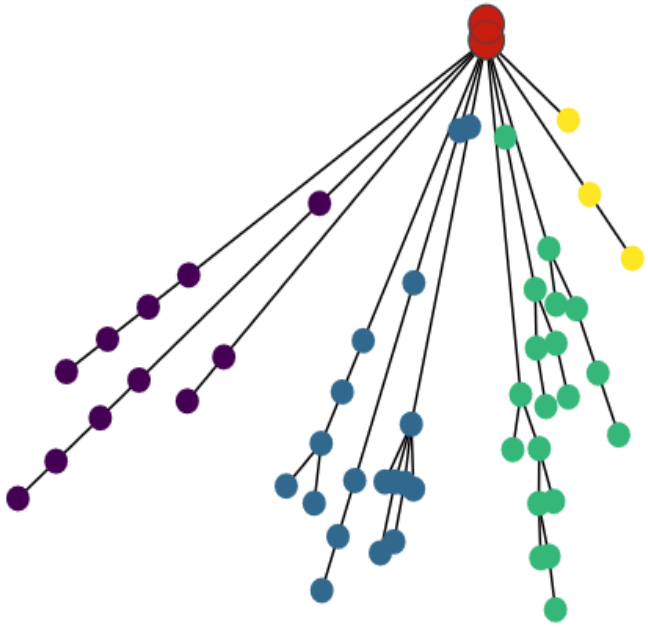
Topology

Description: Efficient and fast way to perform the retrieval of the topology of a network. Topology includes the meter – phase – feeder – transformer connection within the LV grid. This solution will allow DSOs to have a real vision of the low voltage network.

Execution: Offline

Techniques: Statistics, Machine learning

ESP TUR BEL DNK SVN



Source: Odit-e

Predictive maintenance

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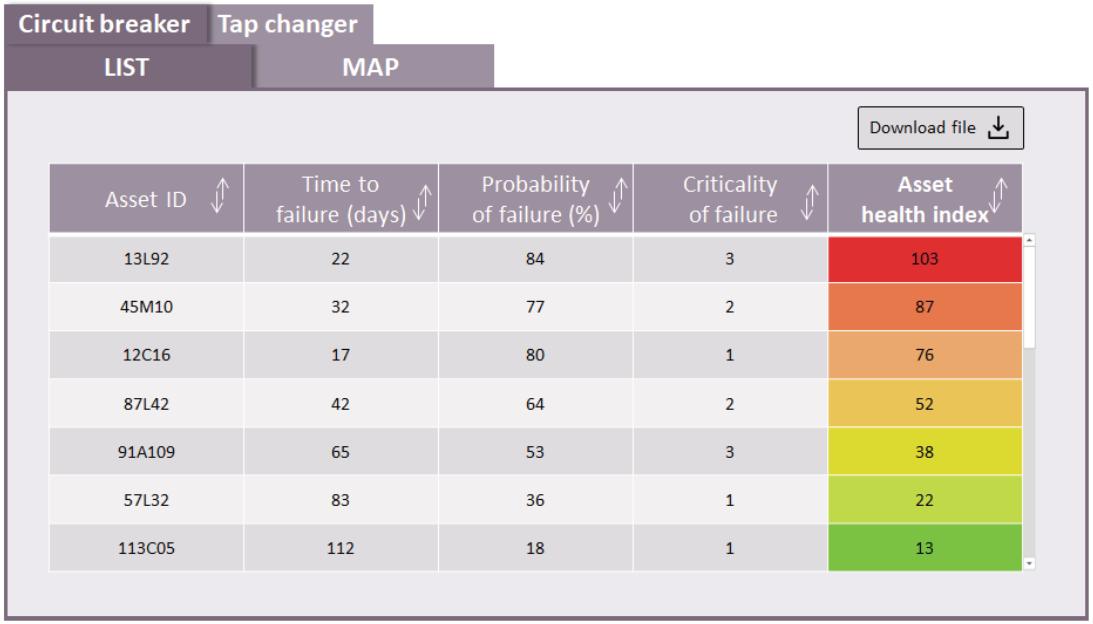
Description: An algorithm is trained with historical different components (e.g. transformers) failure data, including different grid and transformer variables. By monitoring these variables, the algorithm can predict the probability of a component failure in different time windows.

Execution: Offline

Techniques: Statistics, Machine Learning



Asset ID	Time to failure (days)	Probability of failure (%)	Criticality of failure	Asset health index
13L92	22	84	3	103
45M10	32	77	2	87
12C16	17	80	1	76
87L42	42	64	2	52
91A109	65	53	3	38
57L32	83	36	1	22
113C05	112	18	1	13

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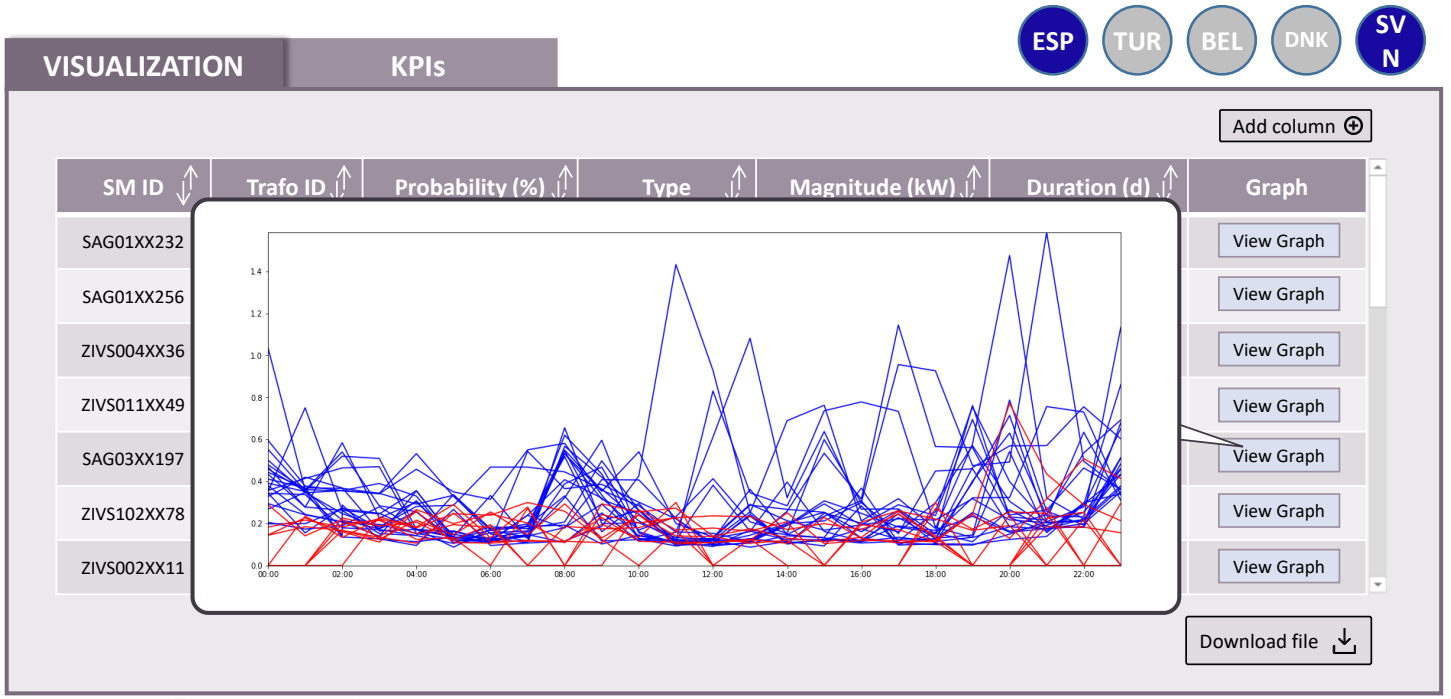
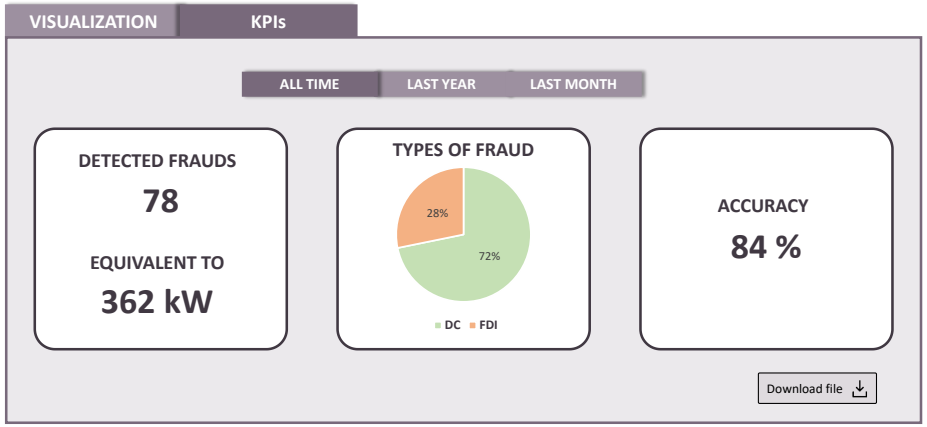
Fraud detection

Description: To perform a Non-Technical Losses study based on inconsistencies in energy balance and fraud patterns recognition.

Execution: TBD

Techniques: Statistics, Machine learning (Supervised: Classification and Unsupervised: Clustering)





Grid disturbance simulations

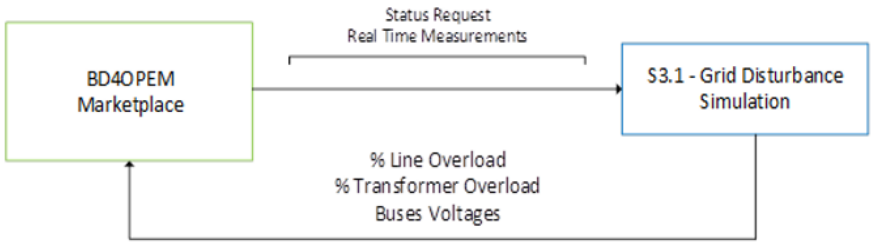
ESP TUR BEL DNK SVN

Description: To identify possible congestions scenarios and power quality issues in a MV/LV distribution grid. Probabilistic power flows will be computed using trained neural networks, leading to low computational requirements and allowing its on-line execution.

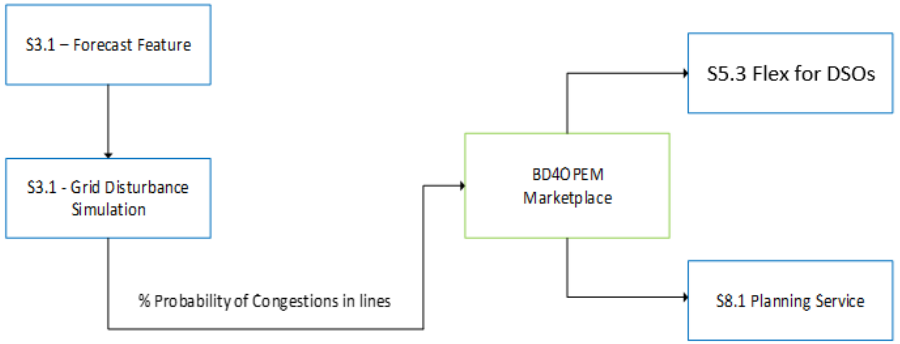
Execution:

- Online: determine, in the day ahead, the probabilities of congestions and the need to activate grid flexibility (S5.3).
- Offline: identify, based on long term forecast, probabilities of congestions produced by the growth of power demand, new generation facilities, etc. This will permit the DSOs to predict when and where perform new investments (infrastructure) will be required (S8.1).

Techniques: Statistics, Deep learning, Optimization



Service Forecast Execution Modality



Service Real Time Measurement Execution Modality

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Energy Management System

ESP TUR BEL DNK SV N

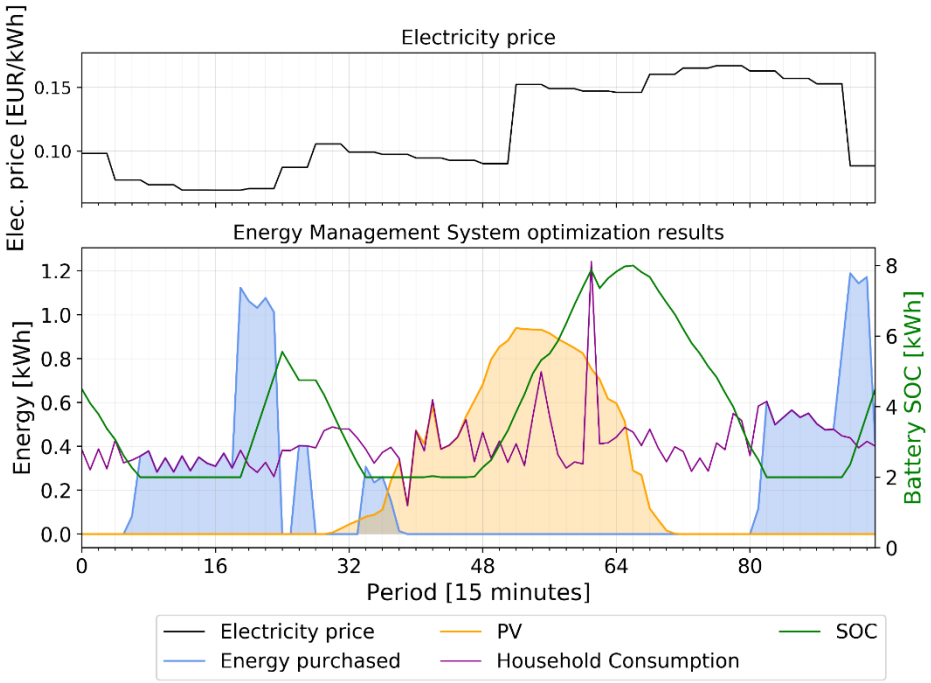
Description: EMS at household level or at community level allows managing the assets to:

- Meet a specific optimization criteria (minimize the energy bill, maximize the self-consumption, enjoy comfort, mobilize flexible assets)
- Provide a flexibility service to third parties through incentive-based programs

Load forecasting and PV generation forecasting will be also determined in this service.

Execution: Online

Techniques: Statistics, Optimization, Deep learning, Clustering



S. Barja-Martinez, F. Rucker, M. Aragüés-Peñalba, R. Villafáfila-Robles, I. Munné-Collado and P. Lloret-Gallego, "A novel hybrid home energy management system considering electricity cost and greenhouse gas emissions minimization," in IEEE Transactions on Industry Applications, doi: 10.1109/TIA.2021.3057014.

Planning

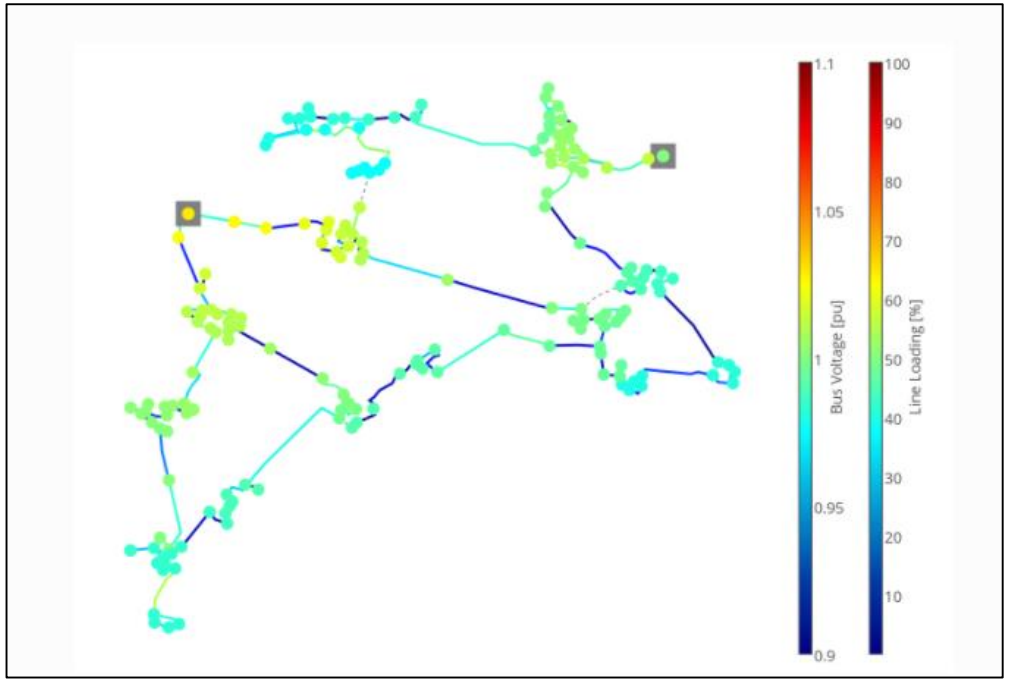
BD4OPEM

ESP TUR BEL DNK SVN

Description: To determine the optimal sizing and location of lines and transformers in the MV grid, considering the available flexibility and expected demand growth in a long-term horizon. The aim of this planning optimization is to minimize the investment cost of feeder branches and transformers, costs of capacity upgrades, operating costs and energy losses.

Execution: Offline

Techniques: Statistics, Optimization, Deep learning



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Implementation

BD4OPEM

ESTEBANELL
SPAIN

ELEKTRO CELJE
SLOVENIA

OEDAS
TURKEY

VRIJE UNIVERSITEIT
BELGIUM

NUVVE
DENMARK

CITCEA

ESTEBANELL ENERGIA

SPAIN

Estabanell is both a Distribution Systems Operator (DSO) and retailer. The main business activity is electricity distribution. With a network of over 1.100 km, it supplies more than 56.000 power points, with two substations where it connects to the transmission network at 220kV, distributing electricity through more than 800 secondary substations. Generating sources include PV and micro-hydro.

- Smart meters (55,400)
- Topology & Observability of MV network
- SCADA, GIS, Analysers
- Consumer profiles (patterns & consumption)
- PV generation
- Large scale battery
- EV charging infrastructure data

ELEKTRO CELJE

SLOVENIA

Elektro Celje is one of five DSOs in Slovenia, covering 22% of the territory. Its electricity infrastructure is extensive and it supervises, manages and operates the electricity distribution network supplying over 170.000 customers of which 125.800 (75%) are equipped with smart meters.

- Client clustering and consumer profiles (patterns & consumption)
- SCADA, GIS, Analysers
- PV, Hydro generation

OEDAS

TURKEY

The region consists of urban and rural areas where the 3 TSO substation and 9 High Voltage Medium Voltage transformers supply a variety of customers. In this area, the PV penetration is very high. Daily production and consumption are constantly changing, and meeting supply and demand is a challenge.

- Topology & Observability of MV network
- SCADA, GIS, Analysers
- Energy storage infrastructure
- PV, Hydro, Geo-thermal, wind generation

NUVVE

DENMARK

As a customer of the local DSO, NUV operates some 30 bidirectional 10kW chargers on the Danish island of Bornholm. This represents a scaled model of the Danish renewable integrated power system operating in grid-connected and island mode.

- EV data
- EV charging infrastructure data

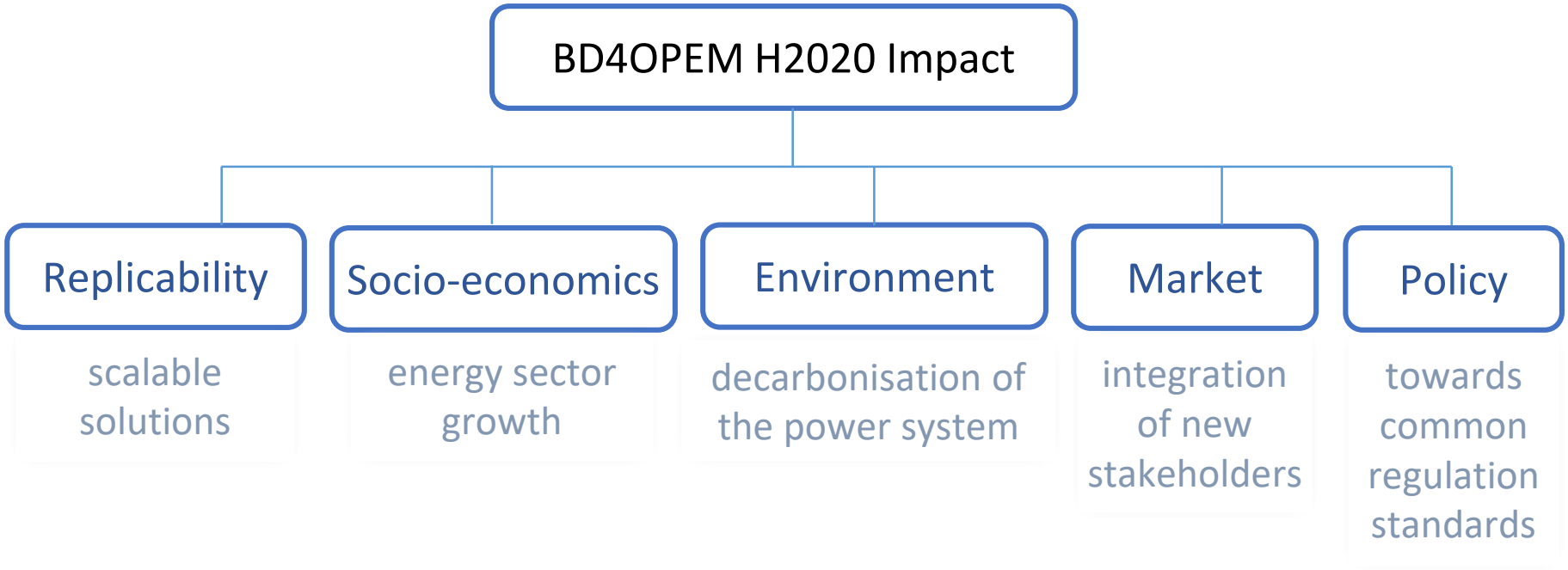
VRIJE UNIVERSITEIT BRUSSELS

BELGIUM

As a customer of the local DSO, the Brussels Health Campus is a well-advanced energy island owning and running a micro-grid that is able to operate in “island” mode for five consecutive days. The hospital and part of VUB is a critical environment where grid security is highly prioritised.

- Smart meters
- Topology & Observability of
- LV network
- Client clustering and consumer profiles (patterns & consumption)
- SCADA, GIS, Analysers
- PV generation + Energy storage + EV charging

BD4OPEM H2020 impact



FINE

Flexible Integration of Local Energy Communities into the Norwegian Electricity Distribution System

- Create scenarios for the development of regulations and financial incentives for energy communities.
- Develop models of energy communities and distribution networks.
- Analyse the interaction between local energy communities and the distribution network in operation and planning, by including the energy community as a flexibility provider
- Analyse the consequences of different regulations and incentive structures and provide overall recommendations.

https://www.sintef.no/en/projects/2020/fine/

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Thank you for your attention

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Technology and knowledge transferred from the University to the Industry