Focus Group 7 - Transformation of the Energy system: centralisation vs further decentralisation

EMP-E 2020: Modelling Climate Neutrality for the European Green Deal

David Greenwood, University of Newcastle
Vasiliki Katsiki, Hypertech Energy Labs
8th October 2020

Energy system: Current vs future status - Bridging the gap

System Value

Private Value

- **Decentralised** Energy System with DG and distributed demand-supply balancing mechanisms
- Competition and innovation
- Fully-enabled sector coupling and interoperability

Manage complexity

Coordinate different energy carriers

Bridge information gaps

Coordinate Distributed Flexibility Resources

- **Centralised** Energy System
- Inefficient RES support mechanisms
- Inadequate regulations for procurement and cost allocation for balancing

Today's regulations ⟷ Advanced regulations

Today's technology ⟷ Advanced technology

contribution to transition

planet

Software platform for optimal network coordination

Policy reform and Standarisation recommendations on an Integrated Energy System

MERLON

Distributed Energy Storage Optimal Planning and Sizing Tool

Distributed Flexibility Optimisation Platform for Local Energy Systems

**The value of aggregators in Electricity systems, S. Burger et al., MIT CEEPR, 2016*

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Planning and operational tools for optimising energy flows & synergies between energy networks

NEED:

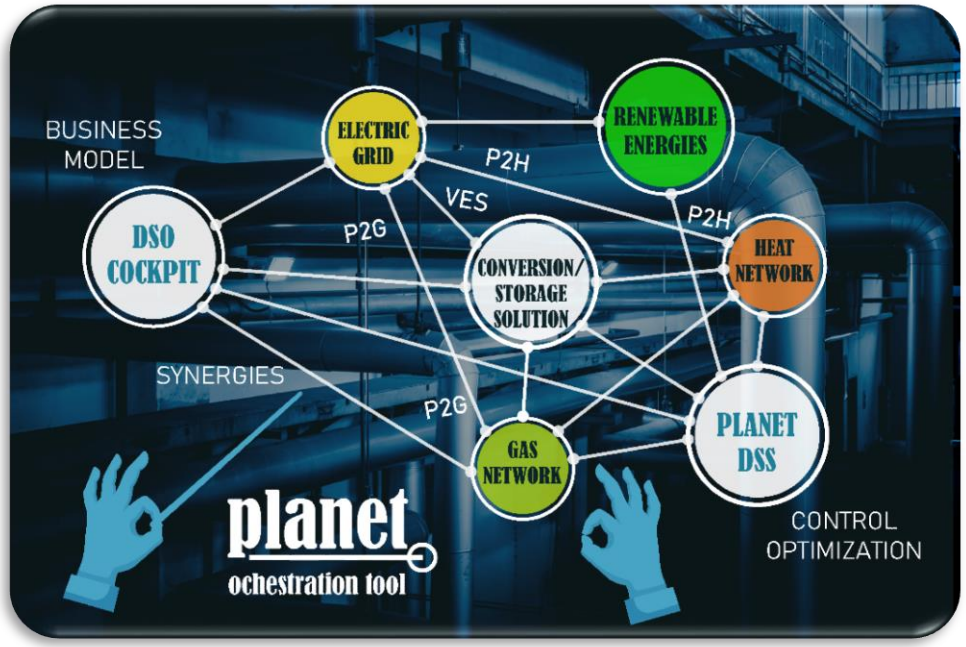
Informed decision making on optimal pathways of utilisation of local flexibility resources for energy system stability under high shares of renewable penetration at different geographical and institutional scales.

PLANET H2020 CONTRIBUTION:

A Decision Support System for planning operational synergies between different energy carriers for energy flow optimisation and vRES absorption maximisation on district-level.

“PLANET Orchestration software tool”:

Evaluation of the potential for leveraging e-network bottlenecks through the flexibility provided by energy conversion units, e.g. PtG & PtH, against traditional solutions of grid reinforcement and expansion. The ICT system constitutes a useful tool for validation of policy-induced impact.



November 2017 - January 2021

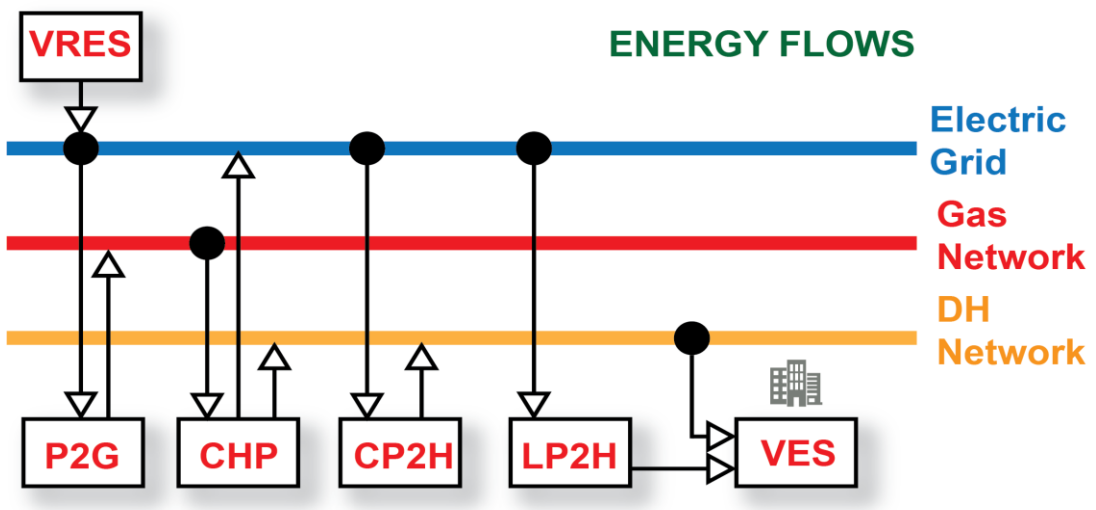
PLANET Energy Networks, Technologies and Optimisation Objectives

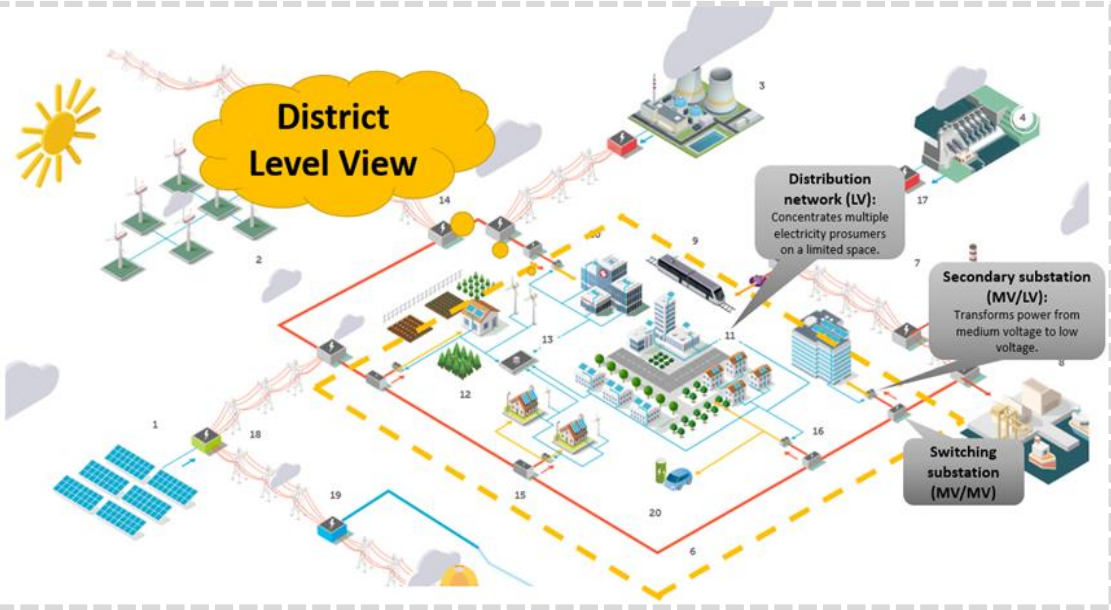
Scope:

- Three major energy carriers: **Electricity**, **DH&NG**
- **District-level** granularity
- **Medium Voltage** portion of Electricity Distribution Grid

Technologies:

Storage/ conversion technologies [P2G, P2H, VES] enabling **sector coupling**.





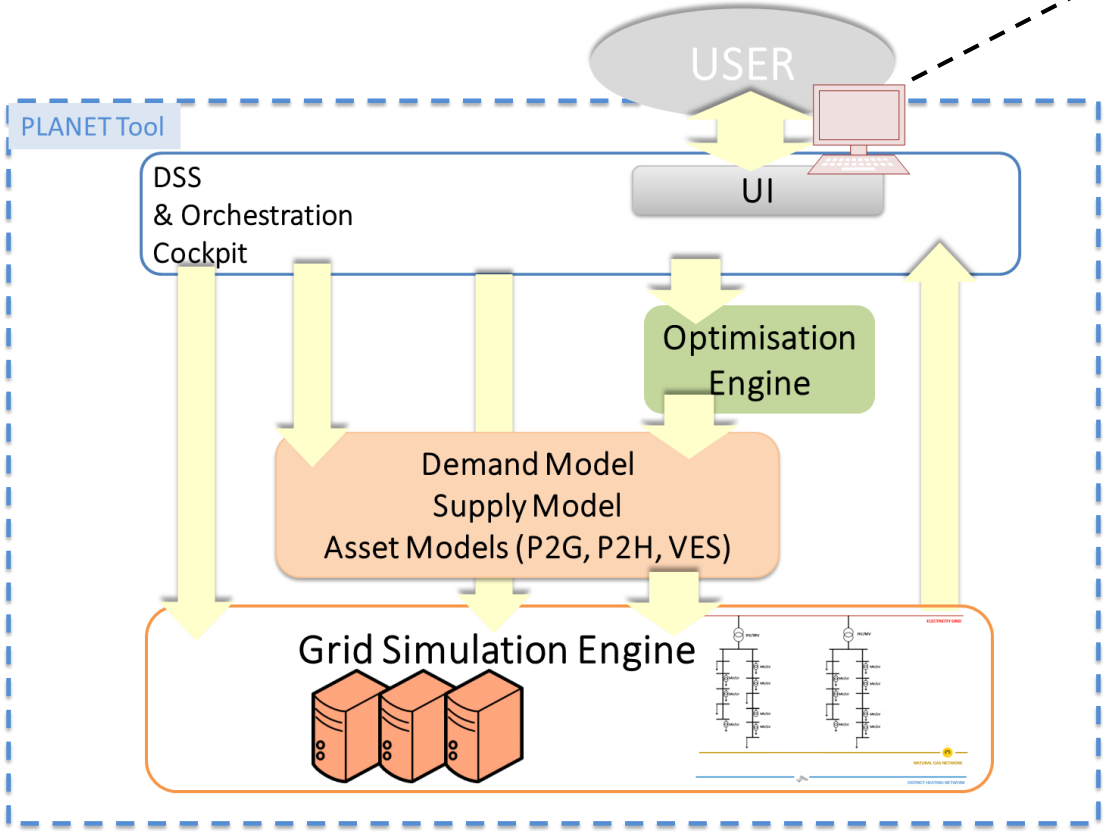
Objectives:

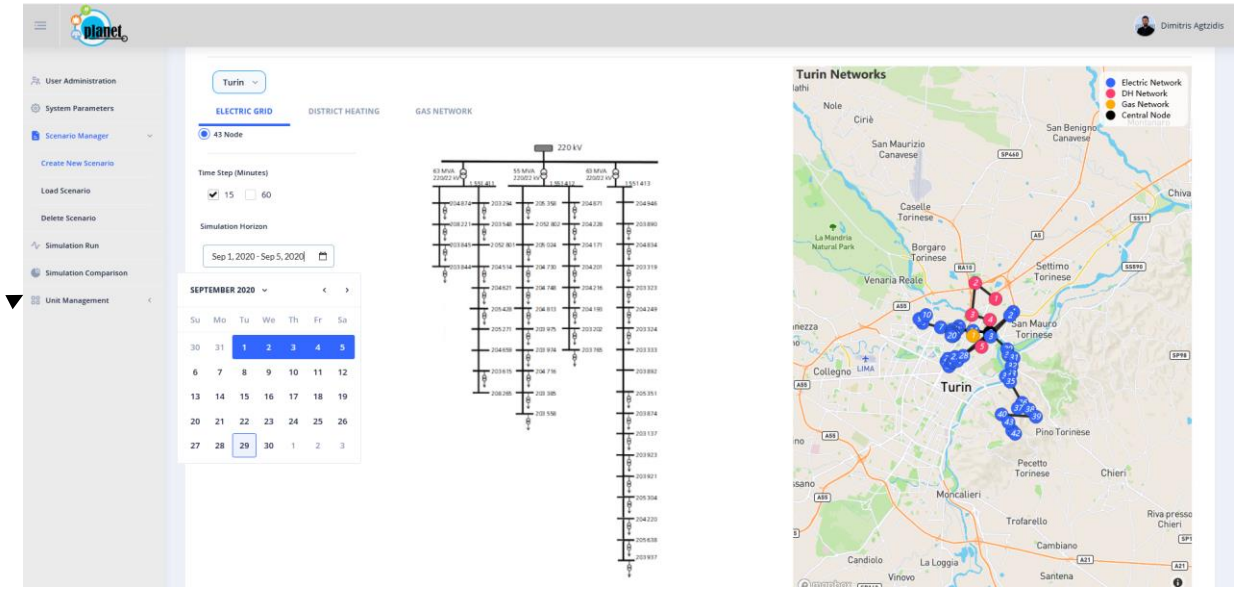
- Maximum vRES penetration in the electrical distribution grid.
- Minimisation of expensive interactions with the transmission grid through energy flow channelling from EL into DH and NG distribution grids.
- Alleviation of network expansion requirements through optimal planning of distributed flexibility utilisation.

PLANET Decision Support System: System Architecture

DSS comprises:

- Network Simulation engine
- Optimisation and Flexibility Scheduling Engine
- Asset models (conversion/ storage units, distributed generation and district-level demand models)
- Orchestration Cockpit incl. User Interface





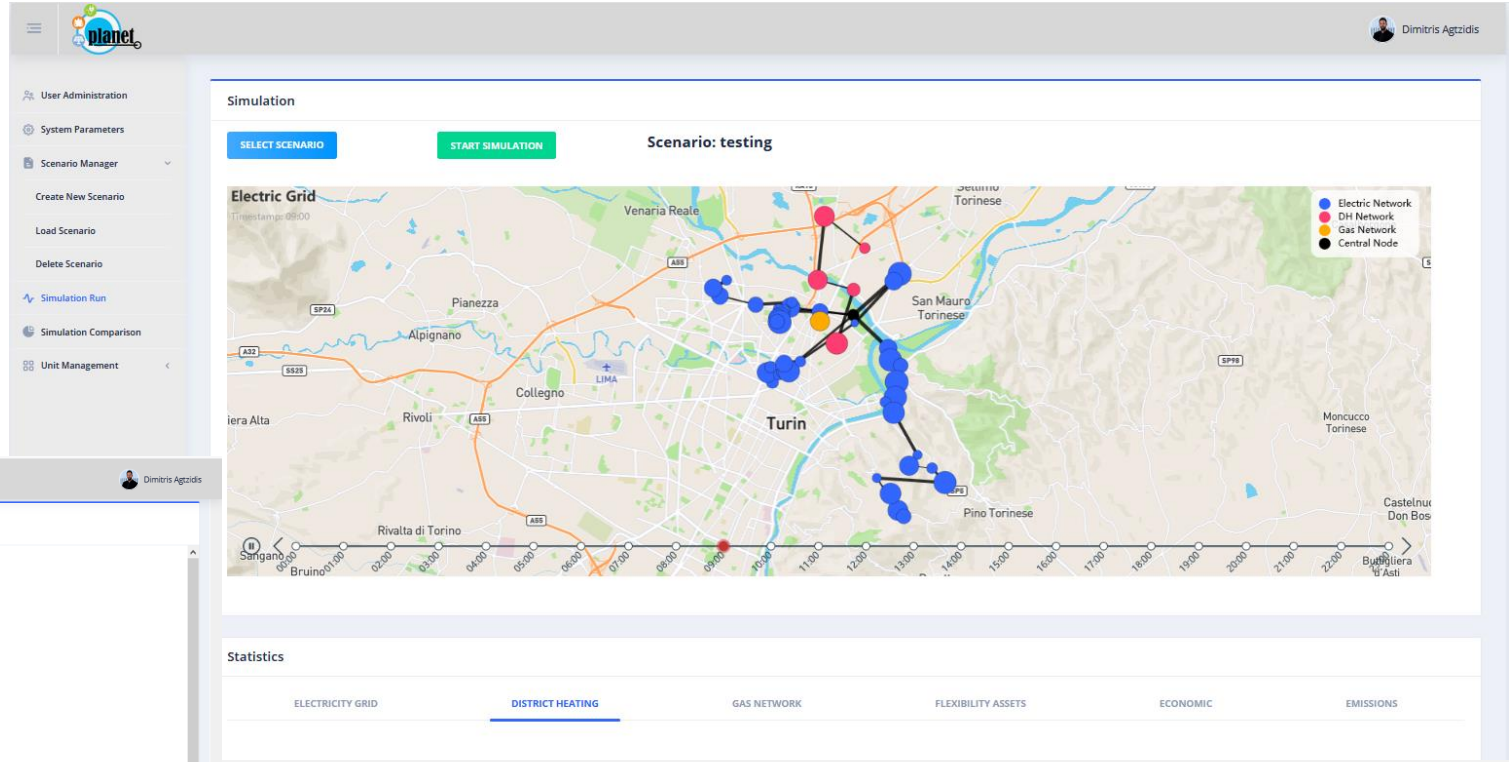
DSS facilitates:

- Assessment of electricity grid balance & stability for different FES
- Technical evaluation of business models for conversion/ storage assets
- Development of policy recommendation for sector coupling
- ICT planning tool for electrical grid optimization and impact assessment upon network synergies

PLANET Decision Support System: Scenario Configuration

Simulation scenario configuration

- Selection of different energy vectors
- Configuration of energy networks
- Configuration of time parameters of simulation
- Configuration of connected DERs to each vector per node



Unit Registration of storage/ conversion technologies, incl. P2G, P2H, VES, etc., as district-level flexibility resources for utilisation in each scenario.

Cost parameters referring to storage/ conversion technologies as well as energy market price projections.

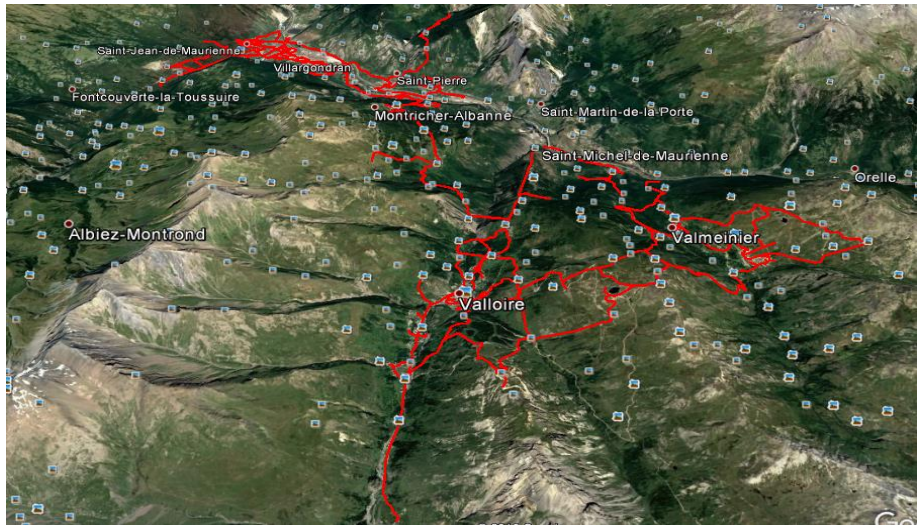
Decentralised, VES-enabled Demand Flexibility Optimisation: PLANET DSS results from French Pilot

Local Electrical Distribution Network of SOREA, the local DSO-e:

- Eight (8) towns in the local region
- Total grid length of 400km
- Total number of MV/LV substations is 305
- Total clientele of 14,000 with 12,700 energy meters

Simulation involved the town of St. Julien Montdenis with 1,110 end-users connected to 31 MV/LV nodes.

PV plants are connected in 14 of the nodes and the sum local renewable energy production is 30% of total annual energy consumption.

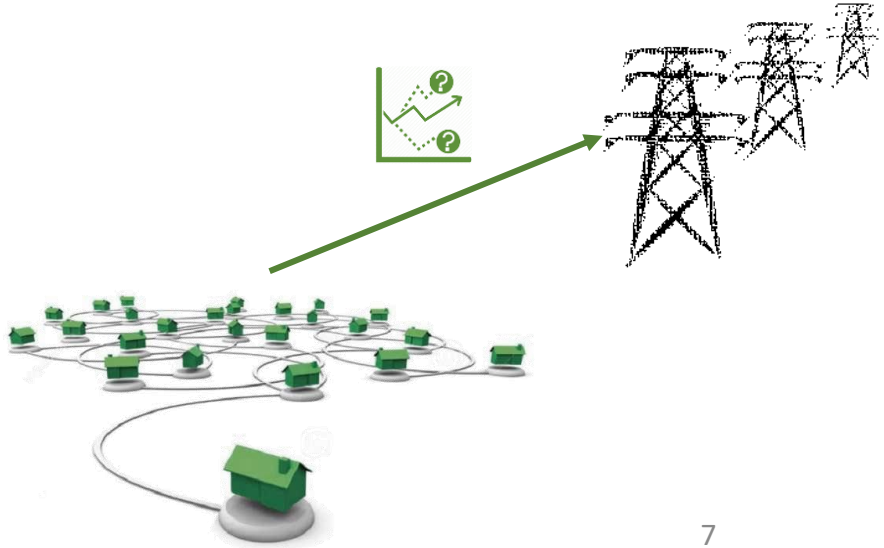


PROBLEM

The integration of intermittent renewable electricity sources will raise new constraints on the distribution grid in case of future penetration increase.

ALTERNATIVE SOLUTIONS

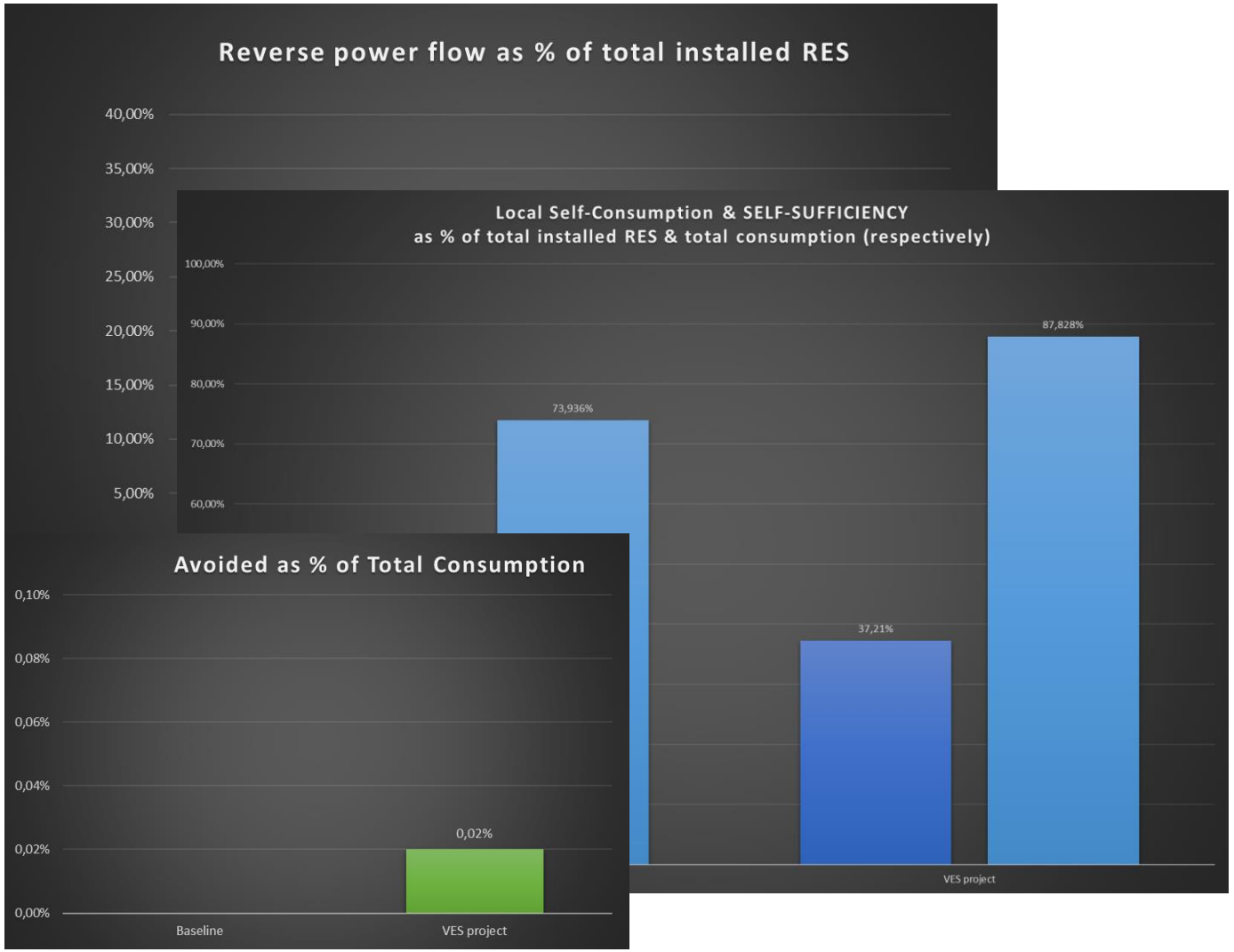
Grid expansion for congestion management VS Optimal demand modulation on district-level based on context-aware VES-enabled demand flexibility forecasts from local prosumers.



Decentralised, VES-enabled Demand Flexibility Optimisation: PLANET DSS results from French Pilot

Local P2H–related local flexibility potential and the essential amount for optimal local grid operation is on annual basis have been estimated in a VES scenario that comprises maximum RES absorption with energy efficiency in order not to increase the overall consumption

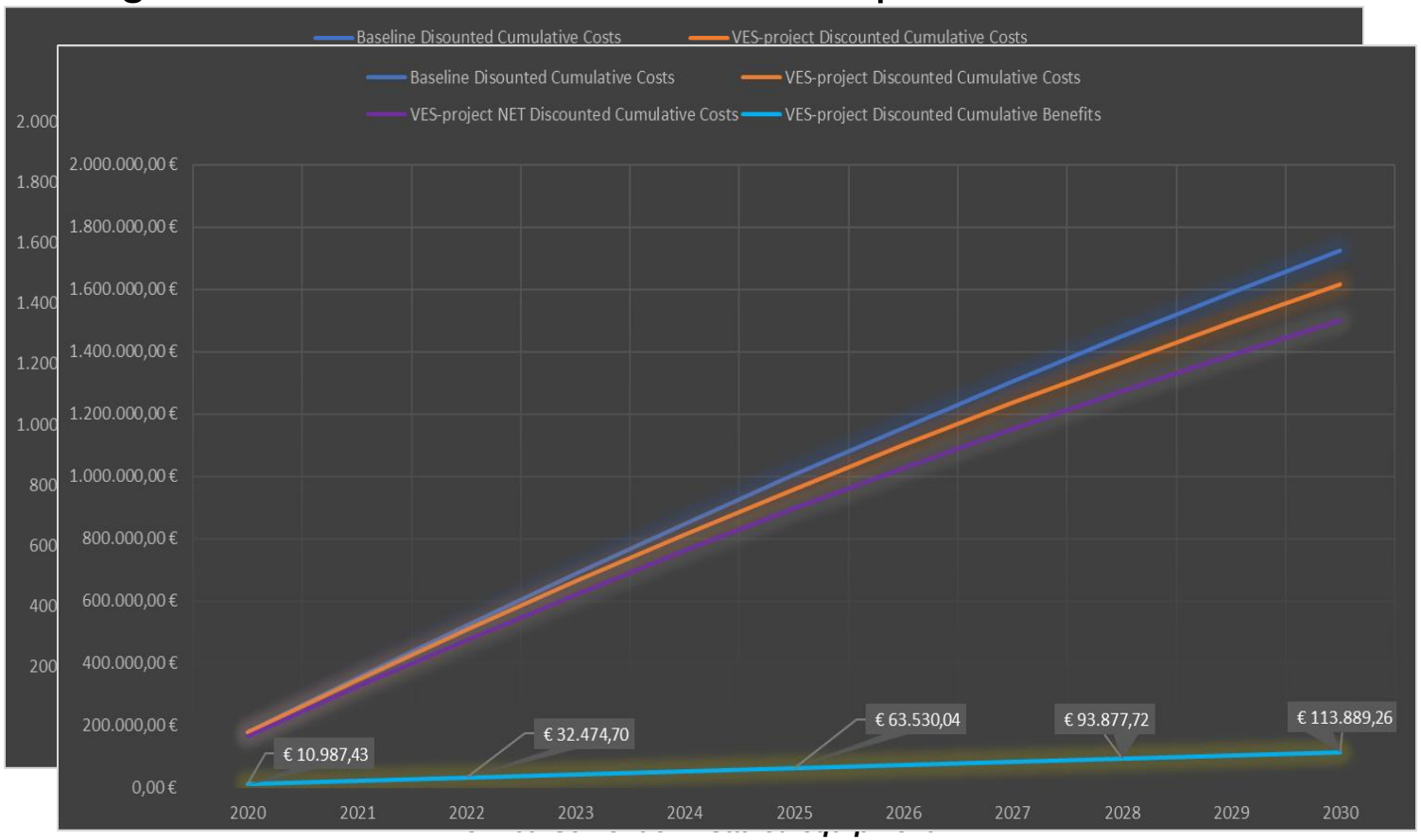
Flexibility Potential in SOREA pilot site	
Total Flexible Load (%)	**38,53%**
Total Fixed Load (%)	**61,47%**
Annual Availability of Total Flexibility (as % of the installed flexible load)	**22%**
Utilisation of Upwards Flexibility within a year (as % of the total consumption)	**10%**
Utilisation of Downwards Flexibility for energy efficiency within a year (as % of the total consumption)	**70%**



Decentralised, VES-enabled Demand Flexibility Optimisation: PLANET DSS results from French Pilot

For result monetisation, a cost-benefit analysis on a 10-year basis considered future energy scenarios concerning demand and RES growth as well as for several cost parameters.

- Grid expansion infrastructure cost for the case of the baseline project
- Two alternative scenarios for demand flexibility exploitation:
  - The DSO-e funds the decentralization strategy through bearing the costs of installation of the equipment for load control and flexibility extraction.
  - IT infrastructure and marketing expenses for Demand Response Market configuration are incurred by the DSO-e while the flexibility is remunerated for availability and utilization through market mechanisms



Evolution of the Discounted Cost and Benefit Values of Baseline vs VES project with Remuneration Programme

Decentralised, VES-enabled Demand Flexibility Optimisation: Conclusions

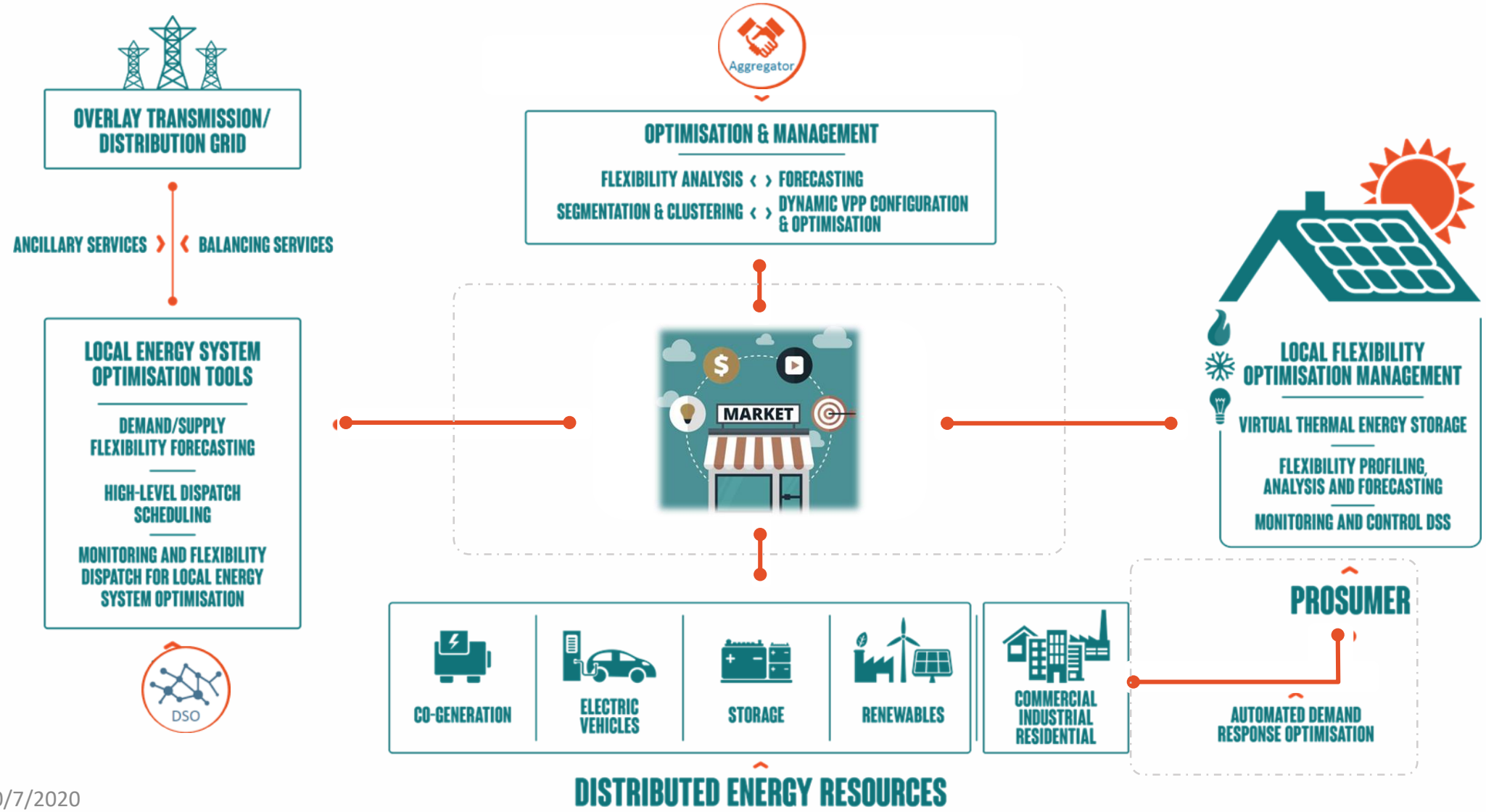
The additional benefits arising from decentralized balancing due to distributed flexibility optimization that were quantified include

i. Avoidance of PV Curtailment
ii. Technical losses optimisation due to self-consumption
iii. CO_2 emission avoided cost due to increased RES consumption

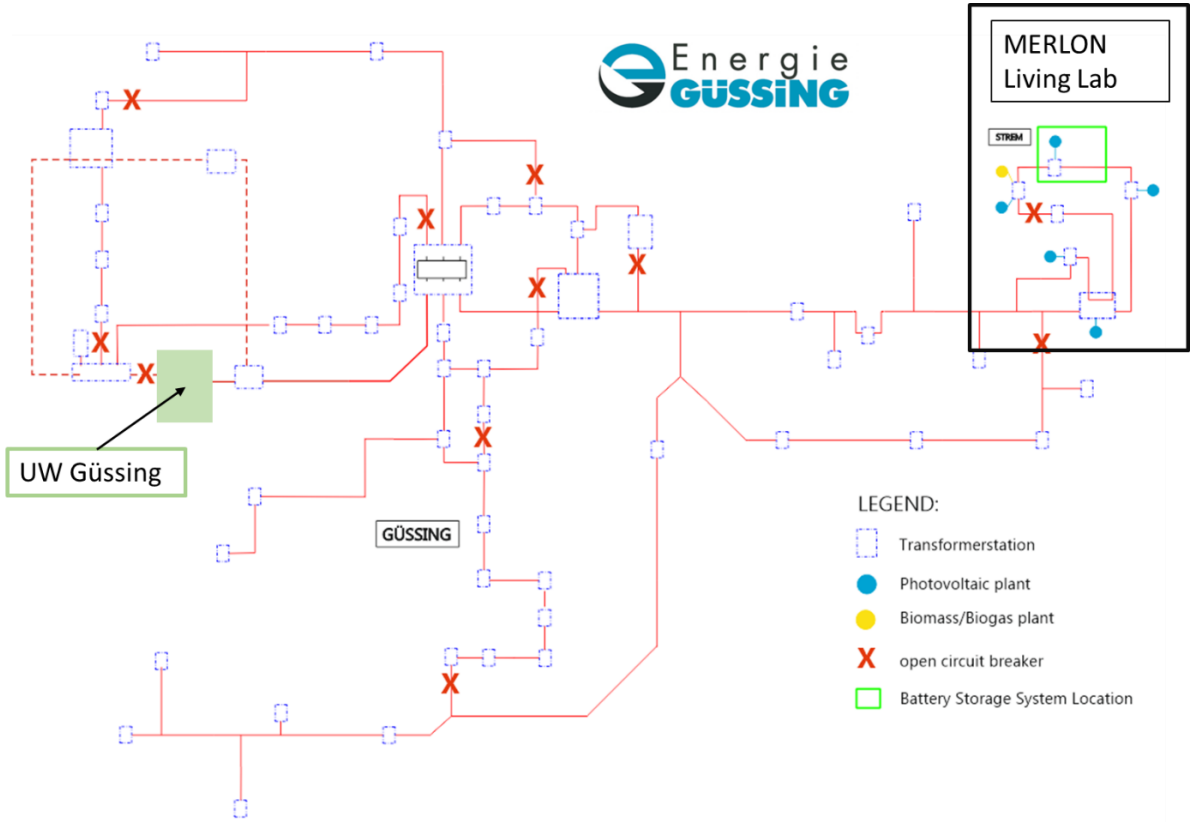
- *Provided proper aggregation and smart load clustering, demand flexibility from residential and commercial sector can be exploited for decentralised system balancing.*

- *The configuration of a flexibility market at distribution level is confirmed as beneficial. However, there is a requirement for motivation of prosumer participation in such Demand Response programs. Such motivation could take the form of subsidising of the essential IoT equipment for electric heating/cooling controllability, enhancing the importance of the flexibility-load controllability in indices of Energy Performance Building Directive (EPBD), etc.*

The MERLON Concept



OPTIMAL PLANNING AND SIZING - AIMS AND SCOPE: AUSTRIAN PILOT PERSPECTIVE



CHALLENGES AT THE STREM PILOT

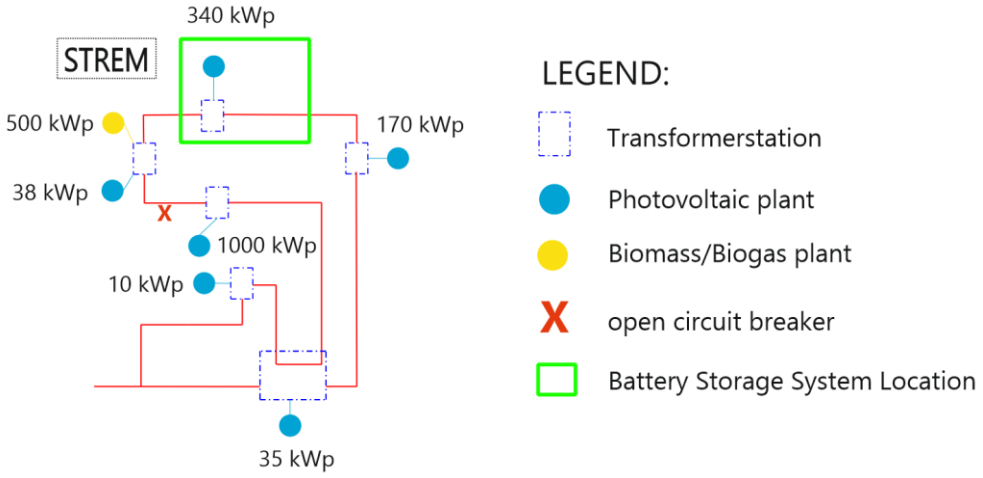
- High penetrations of local distributed generation
- Incoming supply to STREM vulnerable to failure on the Energie Gussing and wider transmission and distribution networks
- Energy supplied by Distributed Energy Resources is high, but unavailable in the event of a fault
- Restrictive voltage regulations (± 2% of nominal) limit opportunities for future renewable generation or low-carbon technologies
- Potential future opportunities via ancillary service markets

THE MERLON SOLUTION CAN MEET THESE REQUIREMENTS, BUT PLANNING AND SIZING ACTIVITIES ARE REQUIRED

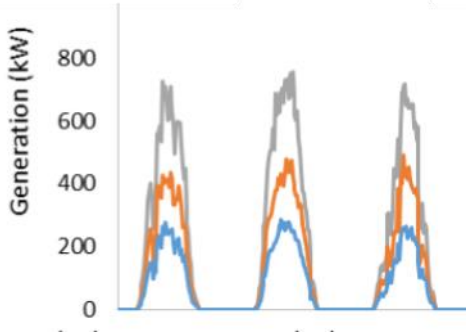
WP5 – PLANNNING AND SIZING REQUIREMENTS

PLANNING AND SIZING ACTIVITIES REQUIRE

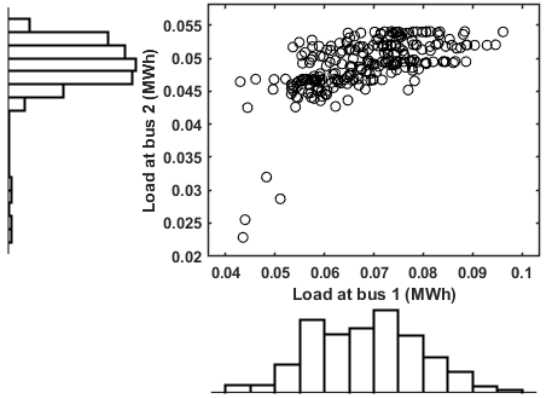
- Understanding of the system



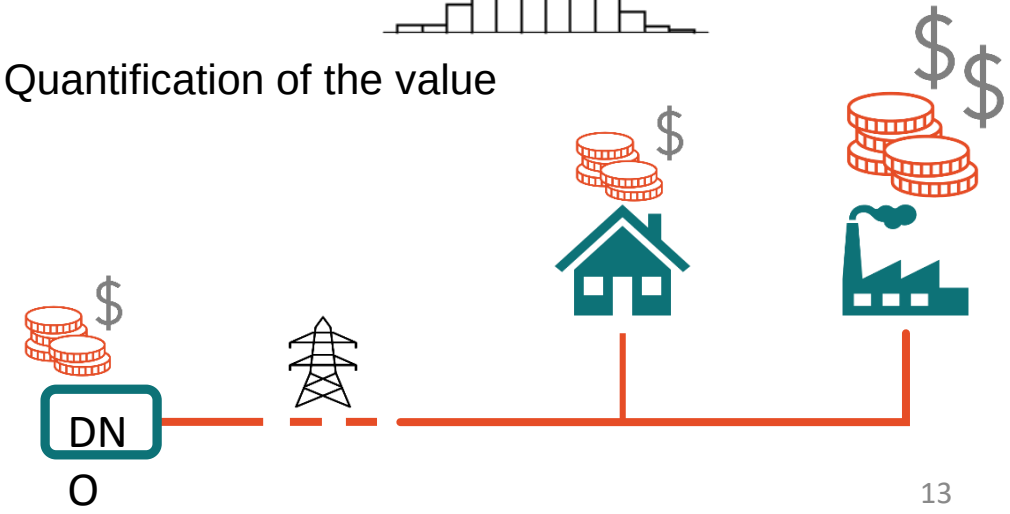
- Prediction of how the system will evolve



- Confidence that any constraints will be met

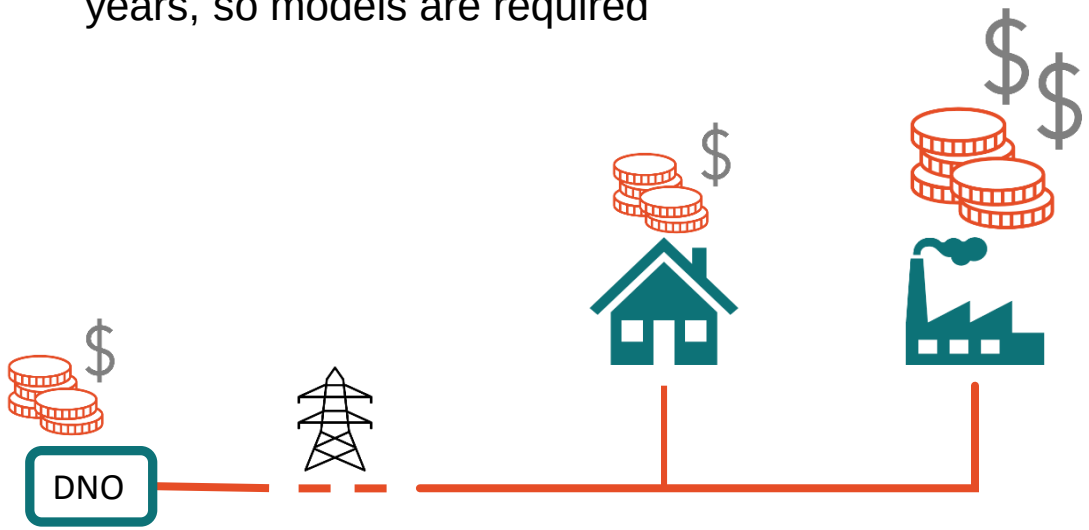


- Quantification of the value

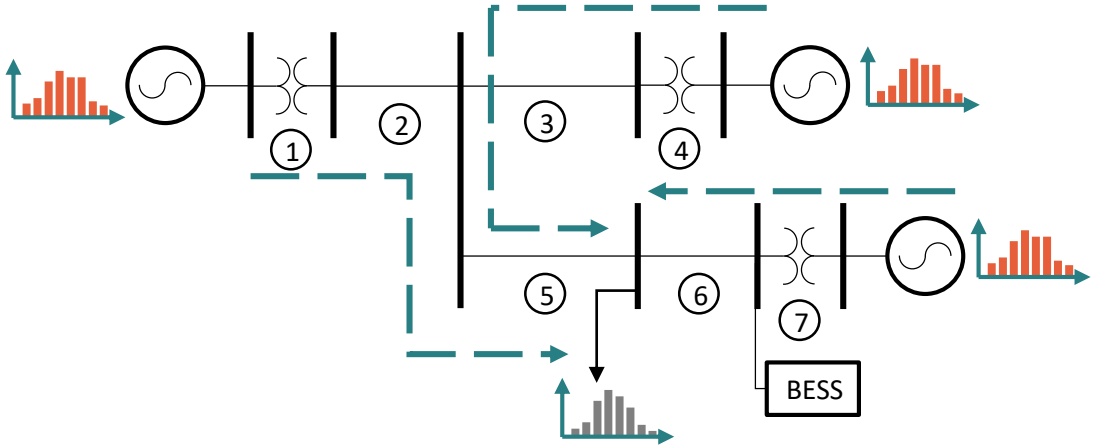


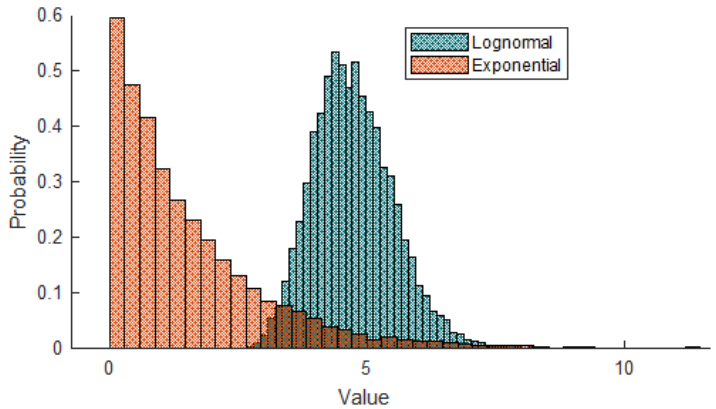
UNDERSTANDING SYSTEM RELIABILITY

- Definition of reliability in electric networks:
  - Ability to operate adequately and securely; supplying the loads with few interruptions
- What is the value of reliability ($$$s)
- Measuring reliability would take many (hundreds) of years, so models are required



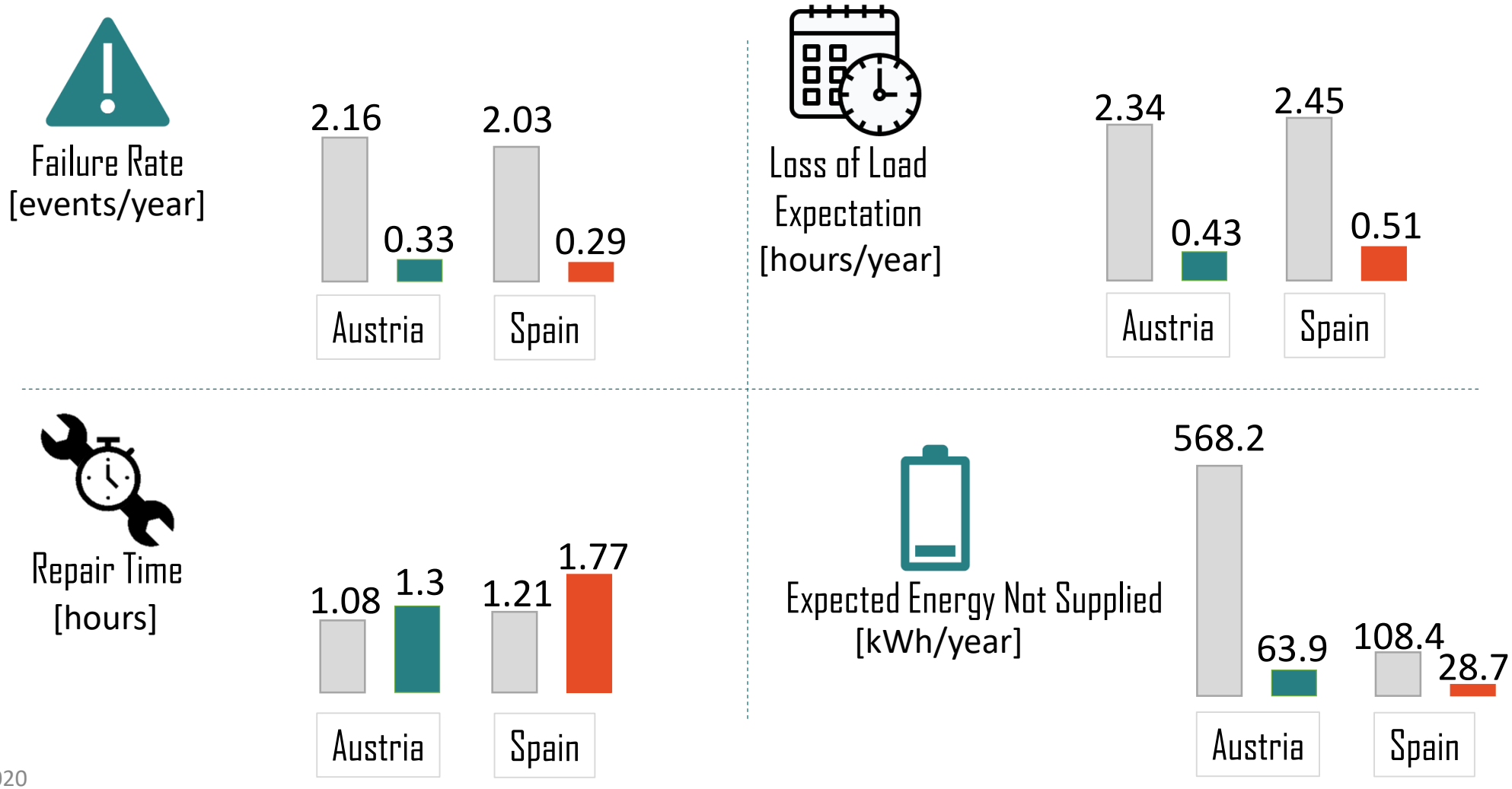
ILES are more complex than standard distribution systems – more like a small transmission system





Probabilistic methods are needed to address the uncertainty and variability of system parameters

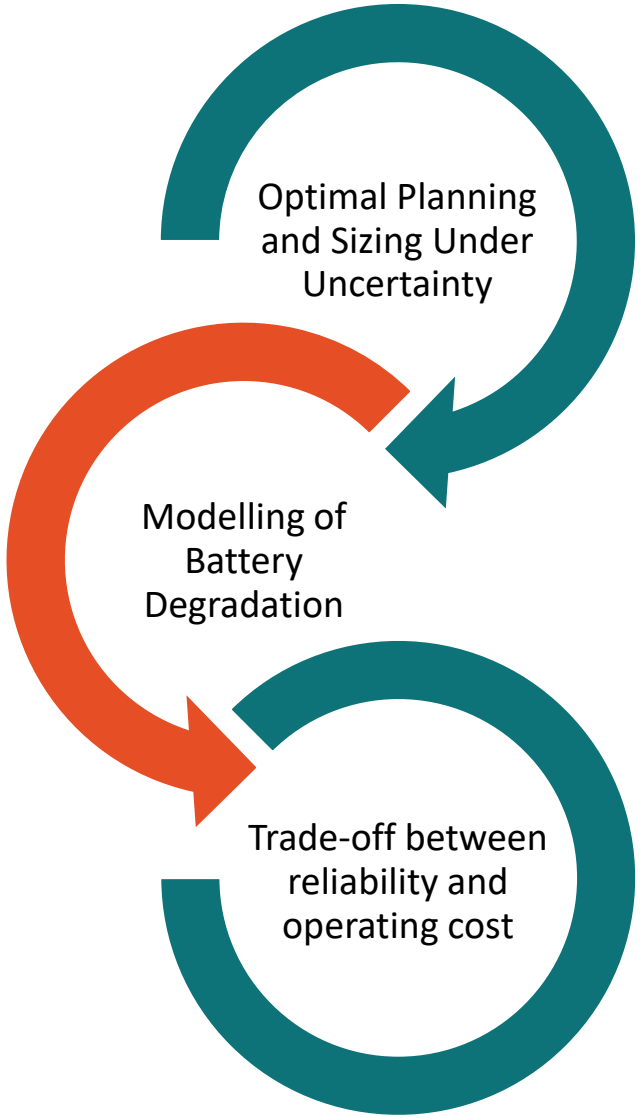
RESULTS – RELIABILITY BENEFITS OF MERLON



OPTIMAL PLANNING AND SIZING

Why is this important?

- ILES Assets – and Battery Energy Storage in particular – have high capital costs
- Future operating patterns are uncertain
- The MERLON solution needs to strike a balance between certainty of achieving its goals and affordability

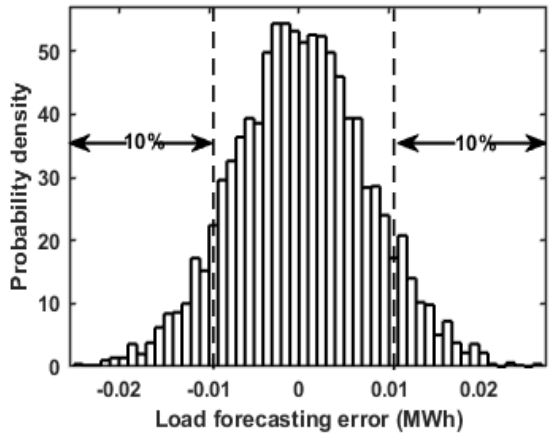


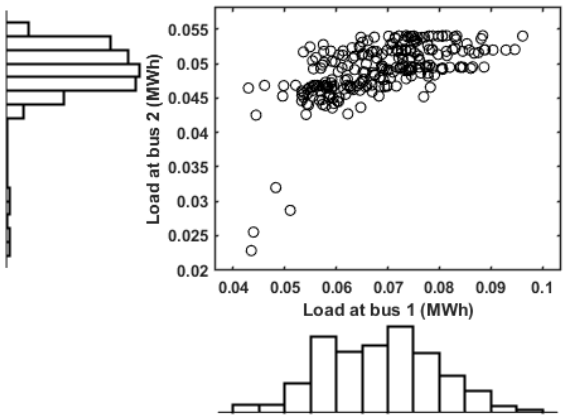
OPTIMAL PLANNING AND SIZING

- **Chance constraints**

It is uneconomical to plan and size for the most extreme events – chance constraints allow the BESS to reach its State of Charge limits with a known probability.

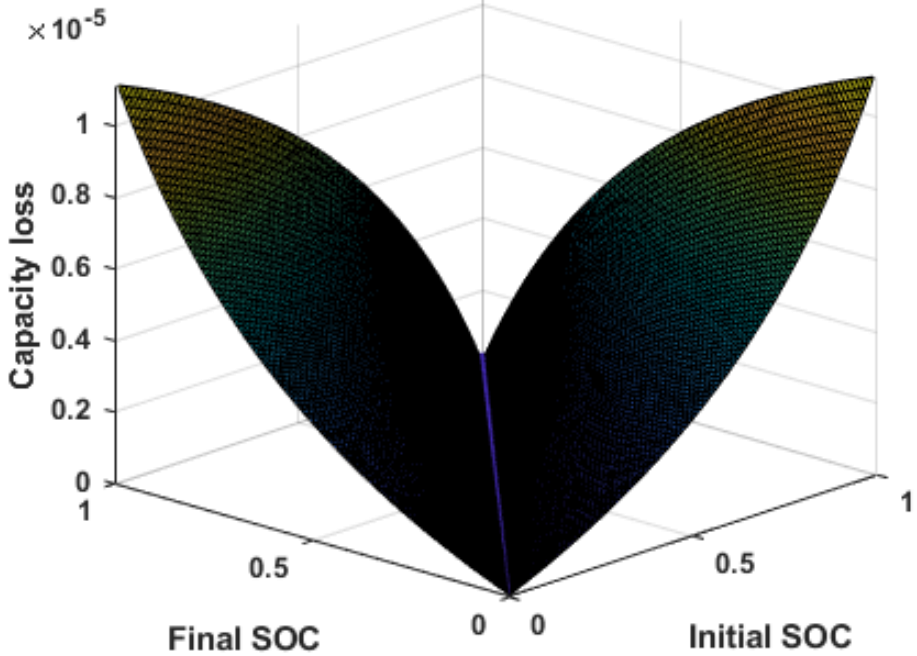
- $\Pr(E_b(t) \geq E_{b,min}(t)) \geq \alpha$
- $\Pr(E_b(t) \leq E_{BESS}) \geq \beta$
- α and β also restrict the battery availability, linking the optimal sizing and network reliability



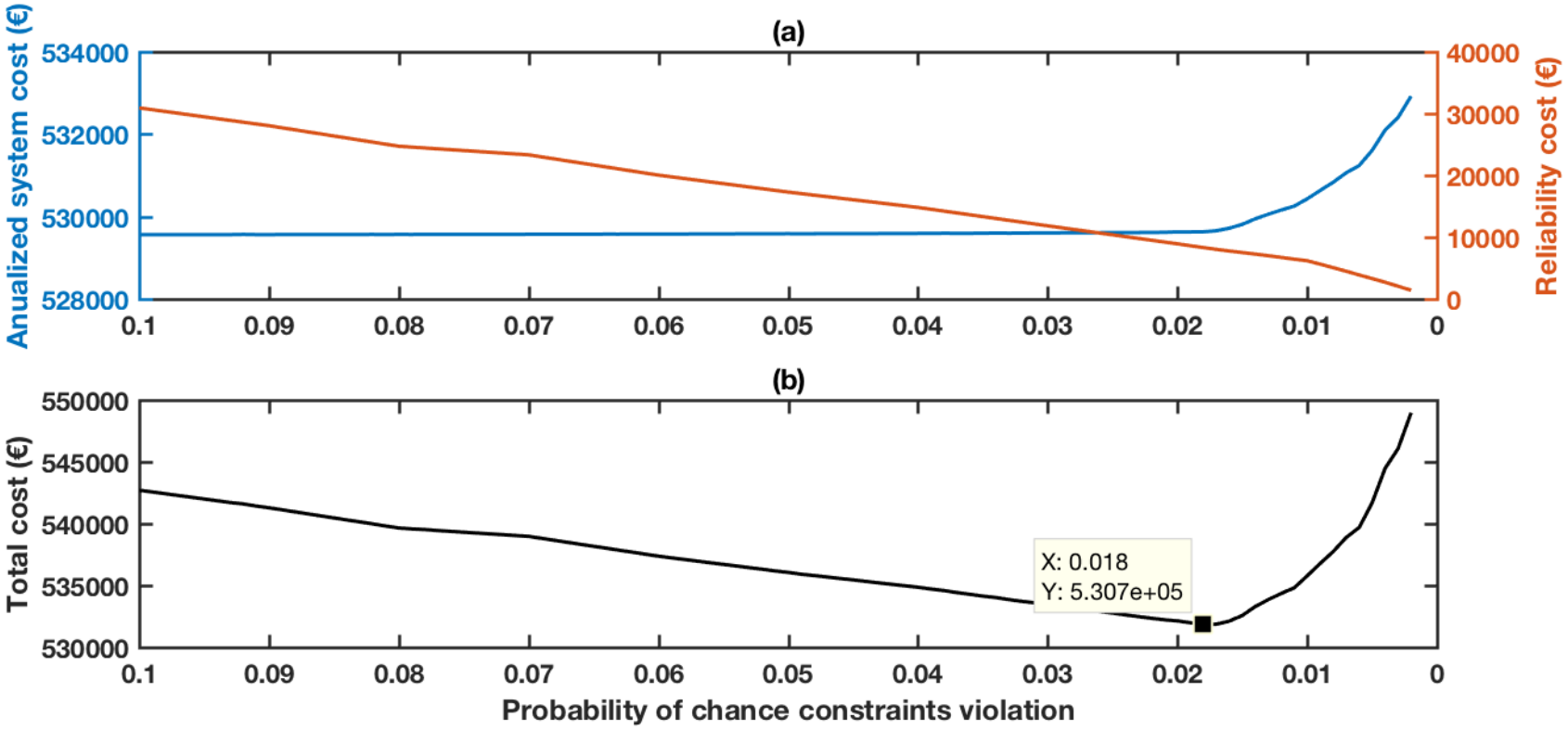


- **Battery Degradation is represented by Global Wear Coefficient**
  - Degradation is a function of final and initial state of charge
  - Linear representation with high accuracy

$$\Delta E = E_0 \left| D_{ini} K_{D_{ini}} - D_{fin} K_{D_{fin}} \right|$$

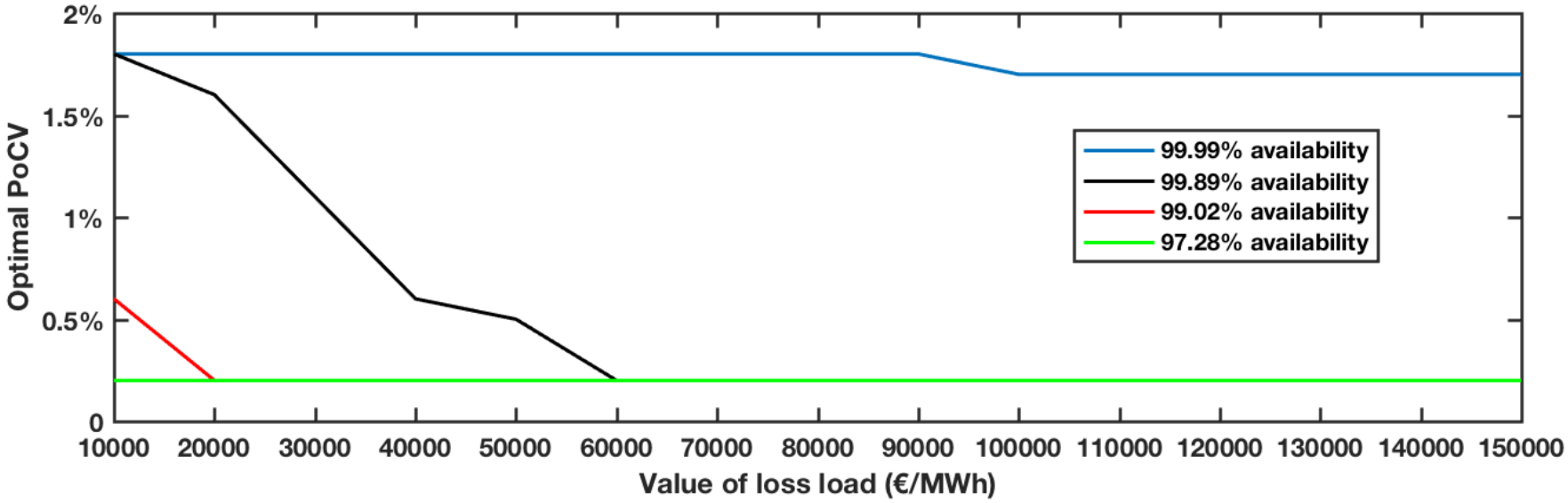


TRADE OFF BETWEEN COST AND RELIABILITY



- MERLON Optimal Planning and Sizing module can find an optimal trade-off between reliability improvement and operating cost
- Optimal trade off is dependent on the reliability of the connection to the wider system and the Value of Lost Load (VoLL)

IMPACT OF VOLL AND INCOMING SUPPLY RELIABILTY



Reducing the reliability of the wider network forces the ILES to operate more conservatively, reducing its ability to participate in energy and service markets, particularly if there are sensitive loads on the network.

REGULATORY AND MARKET BARRIERS

- Island Mode Operation
- Network Regulations
- Ownership of ILES Technologies (ESS, for example)
- Internal Energy Markets
- Participation in Ancillary Service Markets (DSO and TSO)

Discussion Points

- Decentralised systems will deliver better value for customers than centralised systems (strongly agree to strongly disagree)
- Decentralised systems will deliver better reliability for customers than centralised systems (strongly agree to strongly disagree)
- Decentralised systems will enable a higher penetration of renewable generation than centralised systems (strongly agree to strongly disagree)
- To what extent will a decentralised system need conventional transmission and distribution networks? (Not at all to Same as now)
- Which seems to be the most promising decentralisation strategy that should be prioritised in terms of regulation incentivisation?
  1. Energy Communities – Integrated Local Energy Systems
  2. Demand Response for Distribution Network Constraints Management
  3. Distributed energy storage through Battery Energy Storage Systems
  4. Energy Carrier Coupling (Electrical – District Heating – Natural Gas) through P2G/P2H units
- Demand flexibility from residential and commercial sector, when properly aggregated and clustered, can be exploited in order to optimise power flows within a local energy system. An essential requirement for the success of the decentralized demand-supply balancing is the massive prosumer engagement in DR programs and local flexibility Markets. What appears to be the most effective strategy for this?
  1. Subsidy of prosumer investment in smart building/ IoT infrastructure that facilitates monitoring, measurement and control of flexible loads.
  2. Accessible local flexibility markets that facilitate prosumer participation and remunerate the available and utilized flexibility through cost-reflective prices.
  3. Intermediation of a third party Aggregator/ESCO between prosumer and local flexibility markets that manages the electrical heating or other critical loads based on a “comfort-as-a-service” business model and in parallel extract flexibility for grid balance related services.