Management of Local Flexibilities in Distribution System Operation

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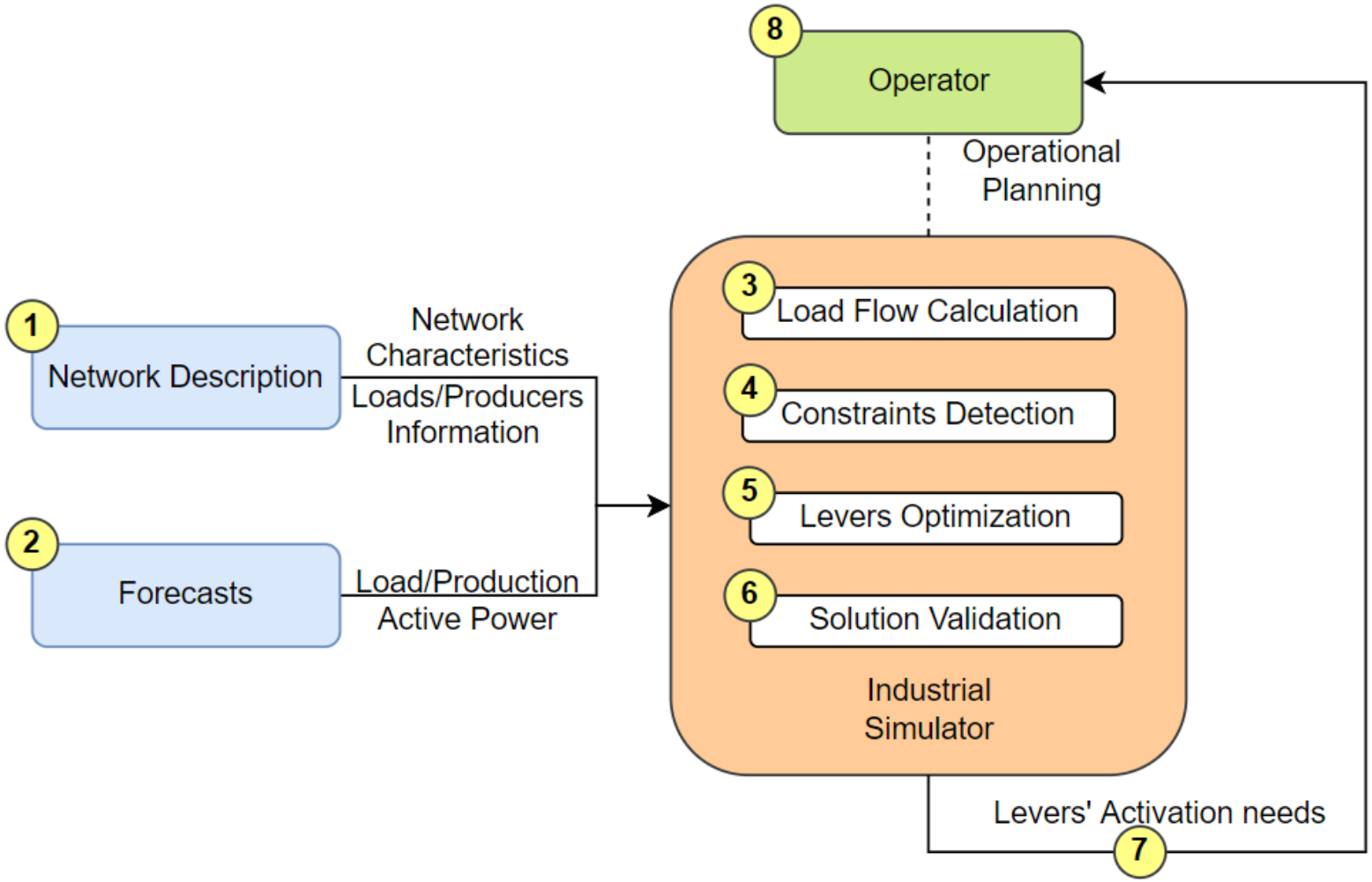
Agenda

- Management of Local Flexibilities Real applications
- TSO-DSO Co-Operation
- P2P Markets Considering System and Grid Services

Management of Local Flexibilities
Real applications

Management of Local Flexibilities – Real applications

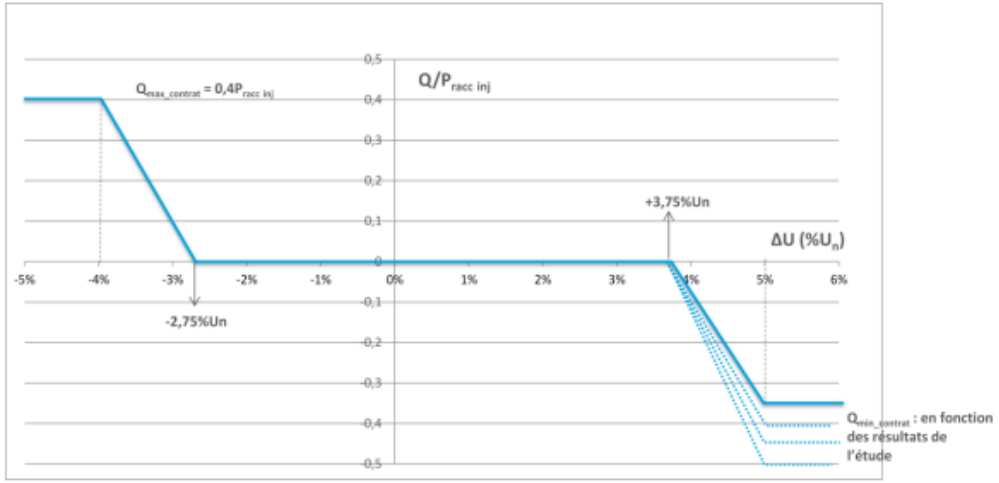


Morais, H., Paris, C., Carré, O., Carlier, M., & Bouzigon, B. (2019).
Levers optimization in short-term operational planning for real distribution systems.

Management of Local Flexibilities – Real applications

Local Flexibilities – Distributed Generation

- 3 Types of curtailment contracts with different activation rules
- In each type of contract, 3 levels of installed capacity are considered
- Some producers without curtailment contracts
- Rules concerning reactive power behaviour are also different



Loi de régulation locale Q=f(U)

Morais, H., Paris, C., Carré, O., Carlier, M., & Bouzigon, B. (2019).
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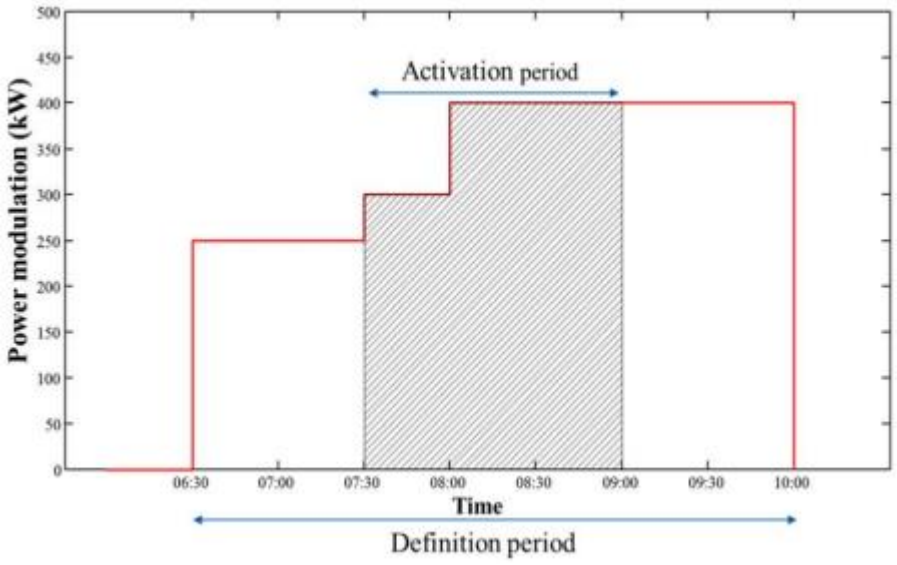
Management of Local Flexibilities – Real applications

Local Flexibilities – Flexibility Market (Not used in real tools)



- A definition time period divided into several time steps;
- A time step resolution (multiples of 30’);
- A flow direction, which indicates the type of power variation (increase or decrease);
- Minimal and maximal activation durations (half hour multiple)
- A power modulation cost for each time step.

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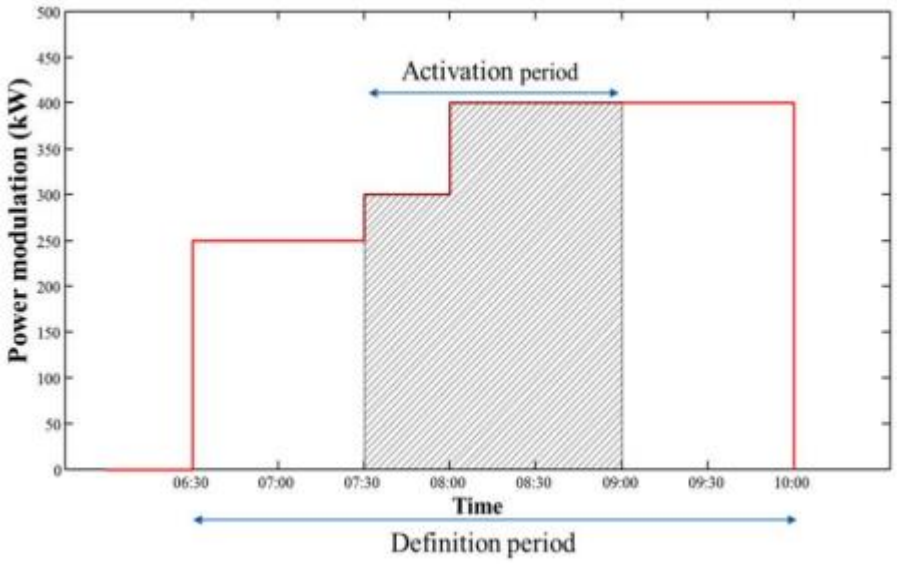

A pre-selection of the offers is implemented to reduce the size of the optimization problem:

- Connection point criteria
- Temporal criteria
- “Type of impact” criteria

Morais, H., Paris, C., Carré, O., Carlier, M., & Bouzigon, B. (2019).
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Management of Local Flexibilities – Real applications

Local Flexibilities – Network flexibilities

Voltage Level reference

Capacitor banks tap

Morais, H., Paris, C., Carré, O., Carlier, M., & Bouzigon, B. (2019).
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Management of Local Flexibilities – Real applications

Local Flexibilities

$$Z = \min f$$

$$\left[\begin{array}{l} \sum_{t}^{Time} \sum_{T=1}^{Nb_{Transfo}} \left(z_{T,t}^{Step} * C_{T}^{Step_{Change}} + x_{T,t}^{Step} * C_{T}^{Step_{Use}} \right) \\ \sum_{t}^{Time} \sum_{i}^{Nb_{Lever}} \left(\begin{array}{c} \Delta P_{i,t}^{Contracted} . C_{i,t}^{Contracted} \\ + \Delta P_{i,t}^{Not_Contracted} . C_{i,t}^{Not_Contracted} \end{array} \right) \end{array}\right]$$

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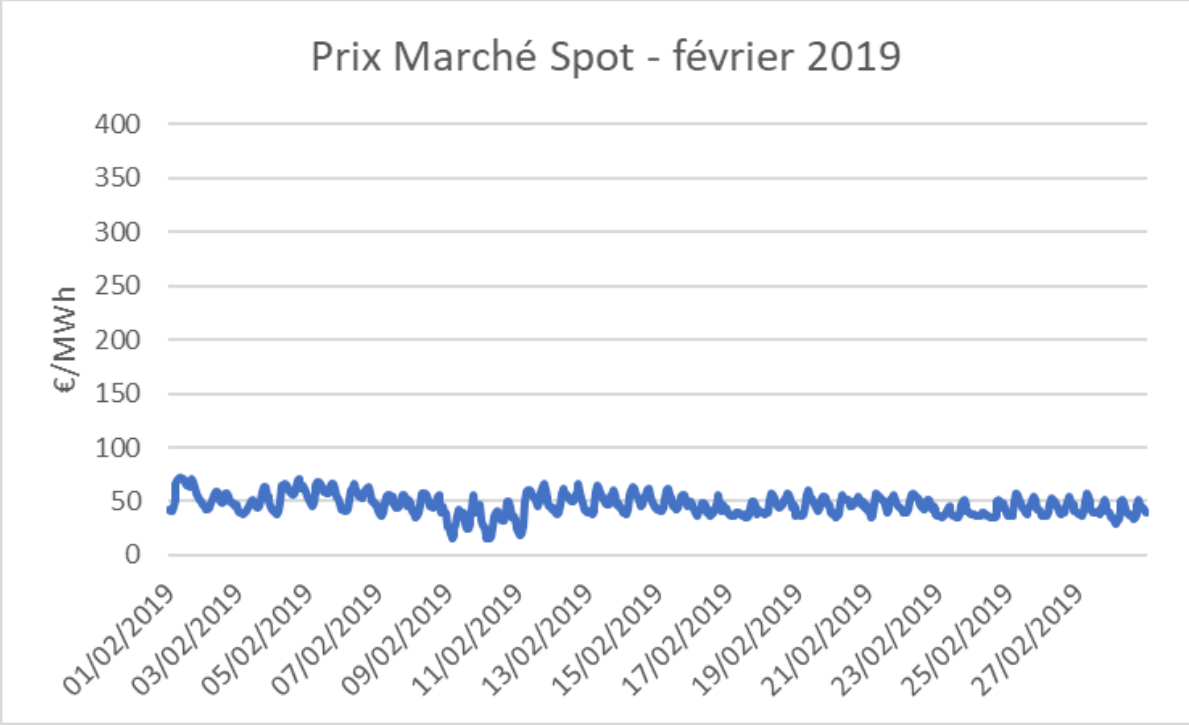
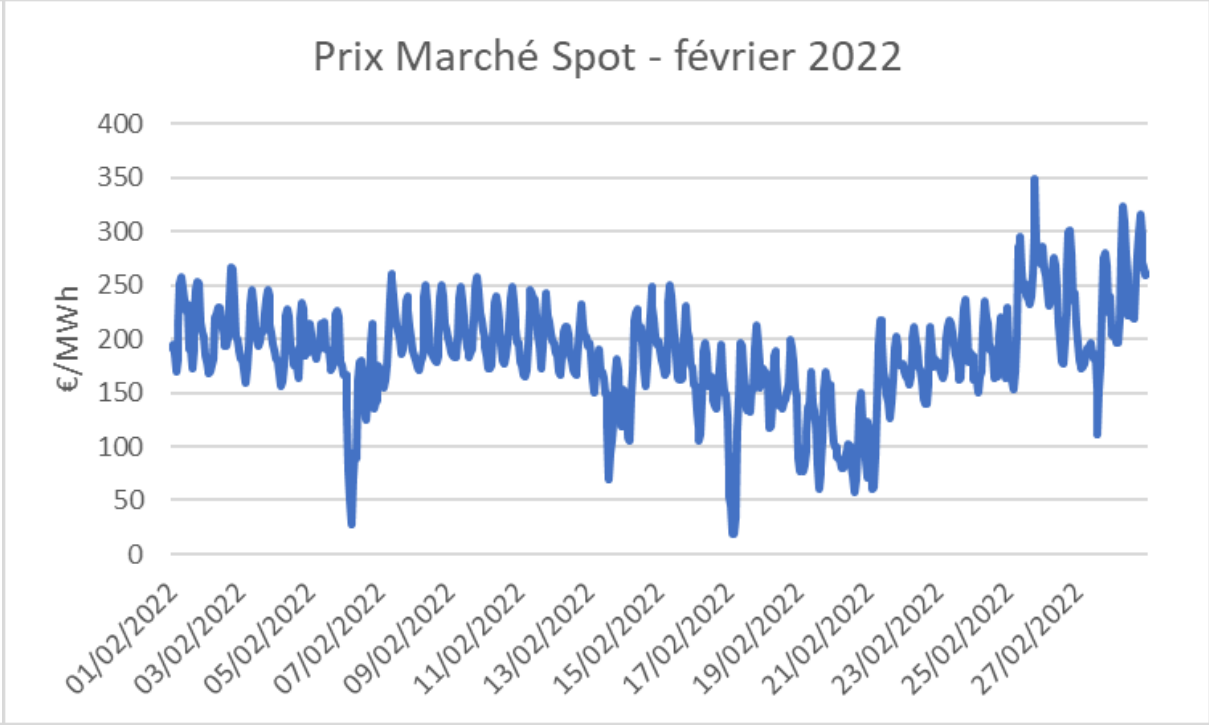
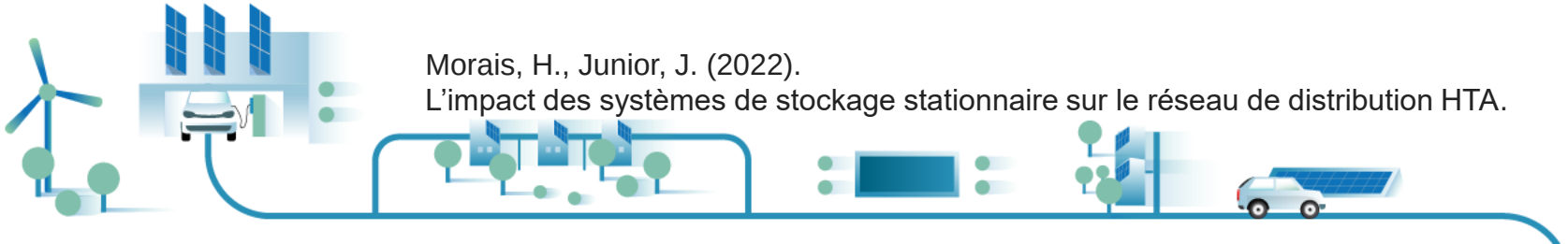
Management of Local Flexibilities – Real applications

Local Flexibilities – Battery Energy Storage Systems







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L'impact des systèmes de stockage stationnaire sur le réseau de distribution HTA.

Management of Local Flexibilities – Real applications

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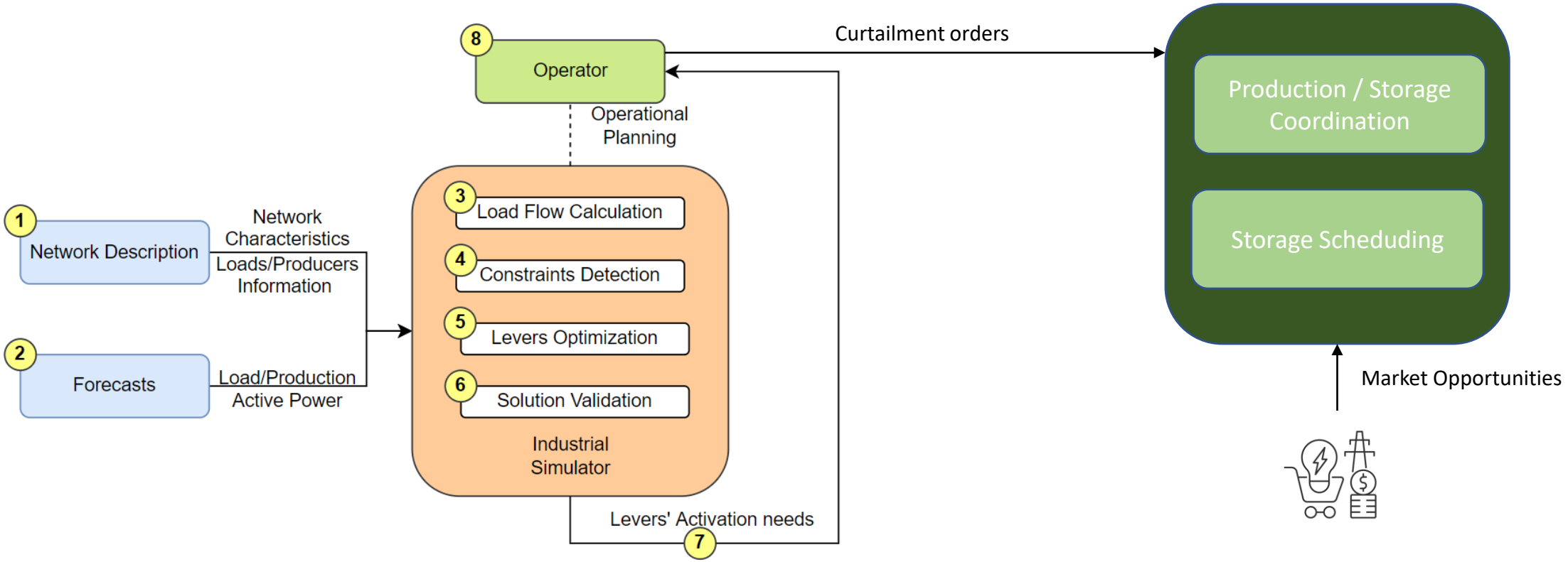

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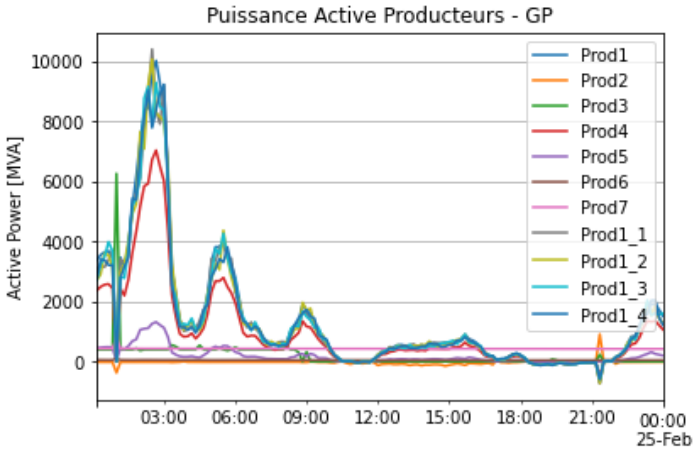
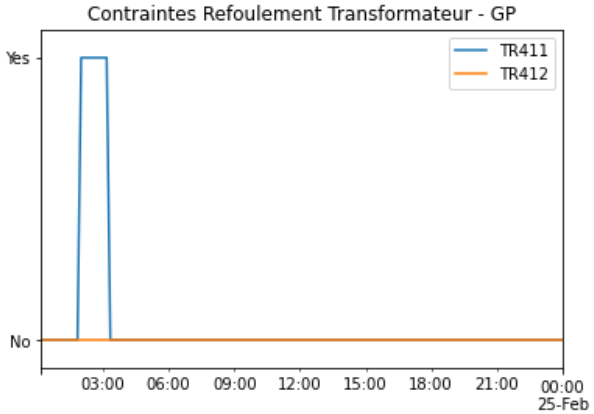
Local Flexibilities – Battery Energy Storage Systems

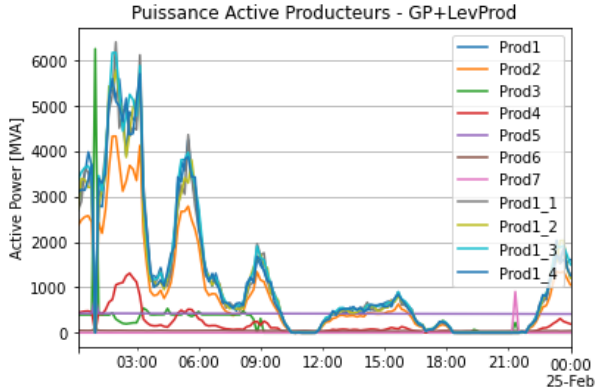
Forecast Operation



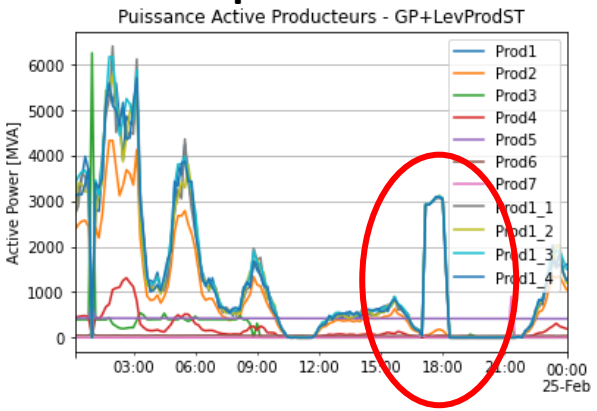
Constraints Detection



Realized Operation



Realized Operation with BESS



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Management of Local Flexibilities – Real applications

Local Flexibilities – Battery Energy Storage Systems

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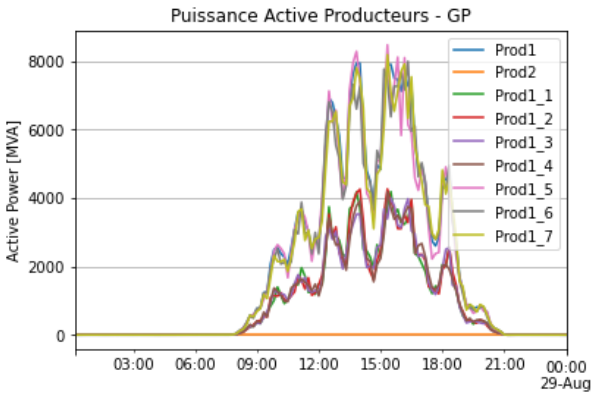

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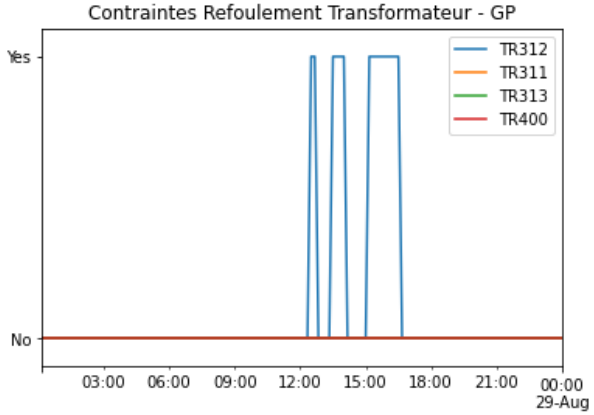

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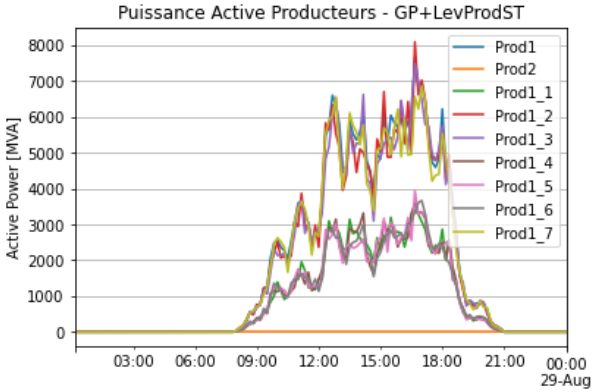
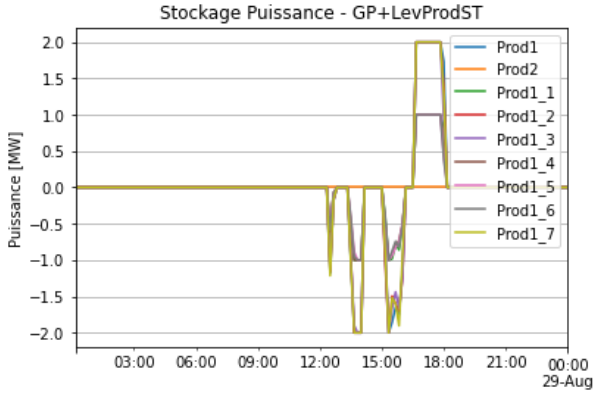
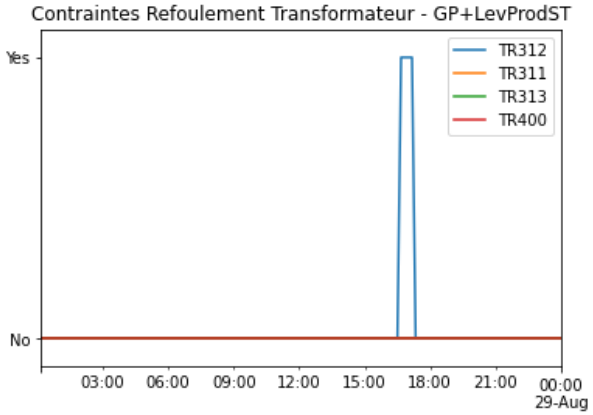
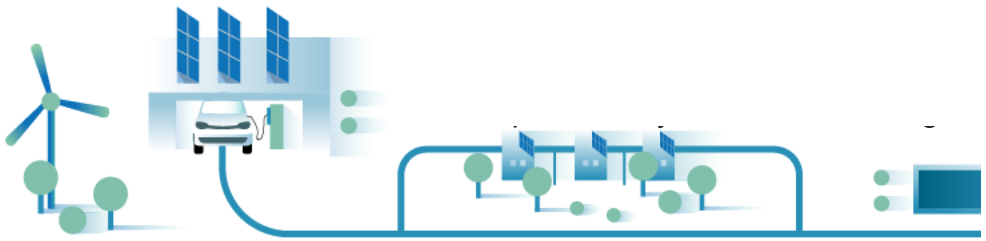


Storage Behaviour



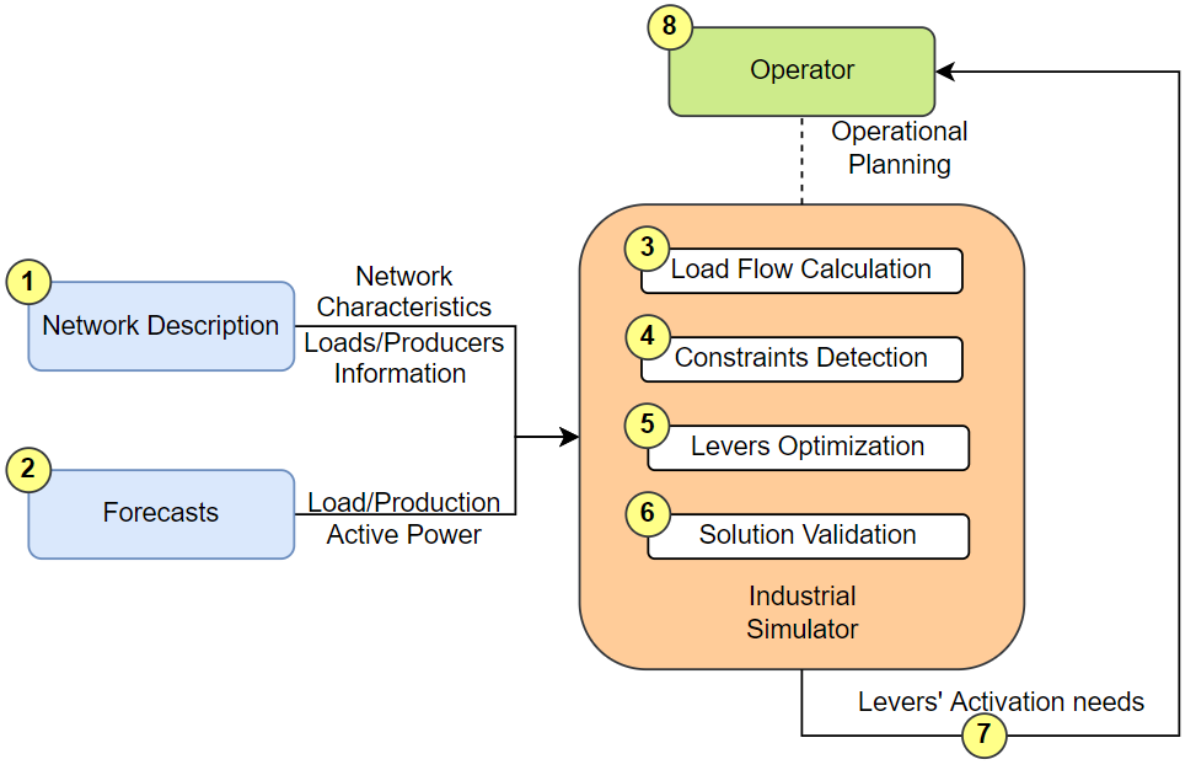
New Constraints

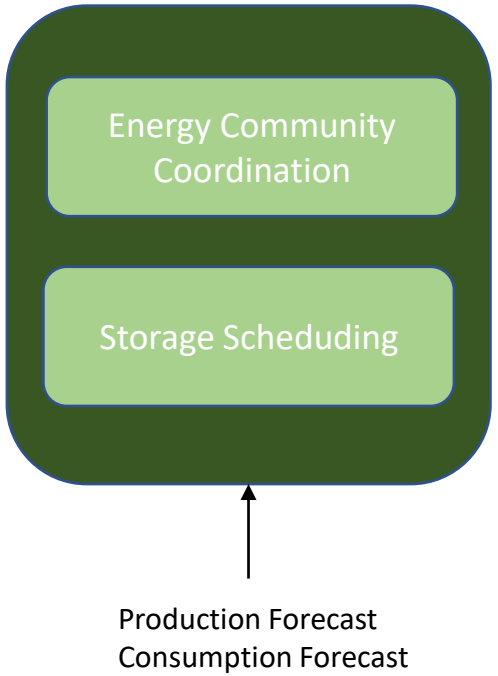




Management of Local Flexibilities – Real applications

Local Flexibilities – Energy Communities





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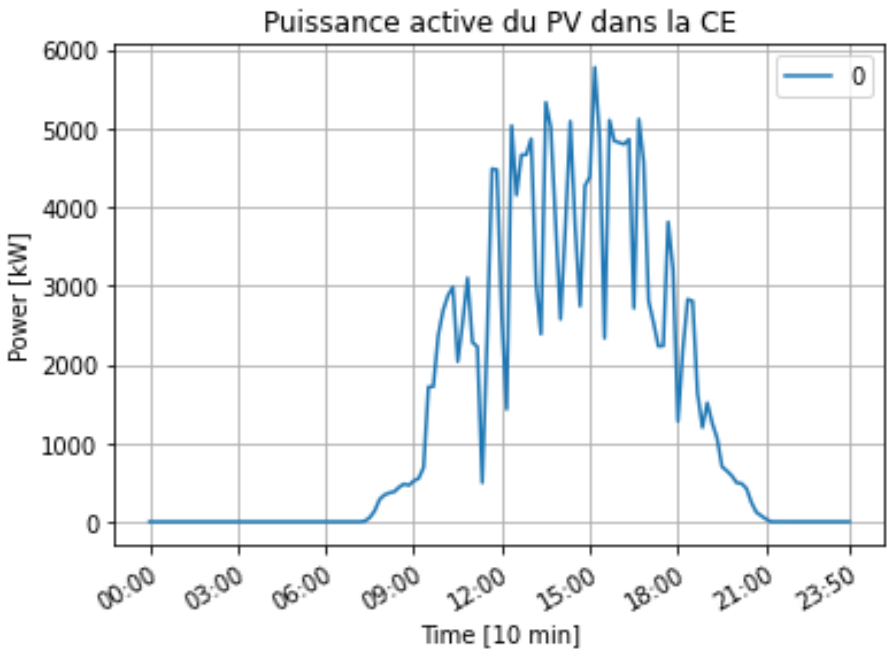
L'impact des Communautés Énergétiques sur le réseau de distribution HTA.

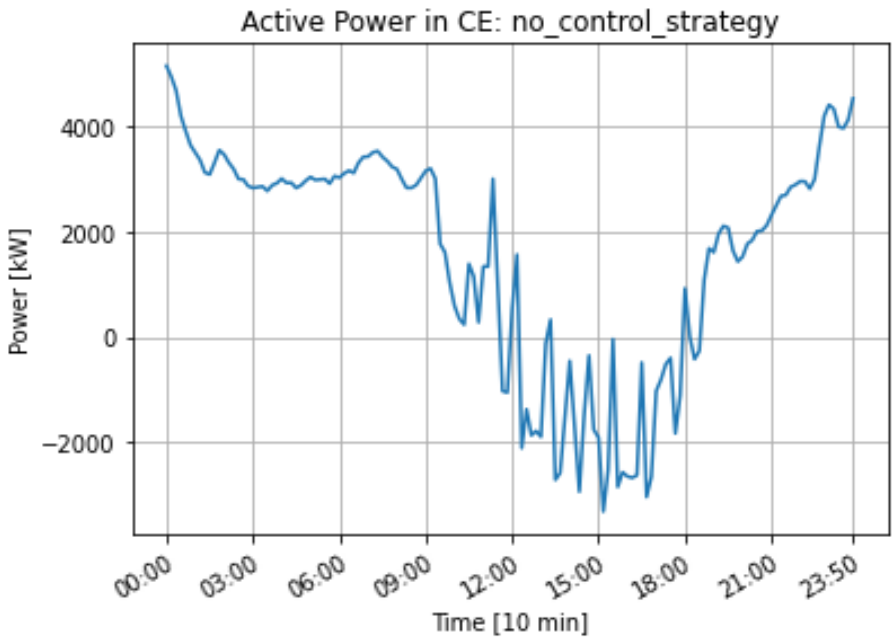
Management of Local Flexibilities – Real applications

Local Flexibilities – Energy Communities

PV Generation in EC



Total Power demand of EC (without control)



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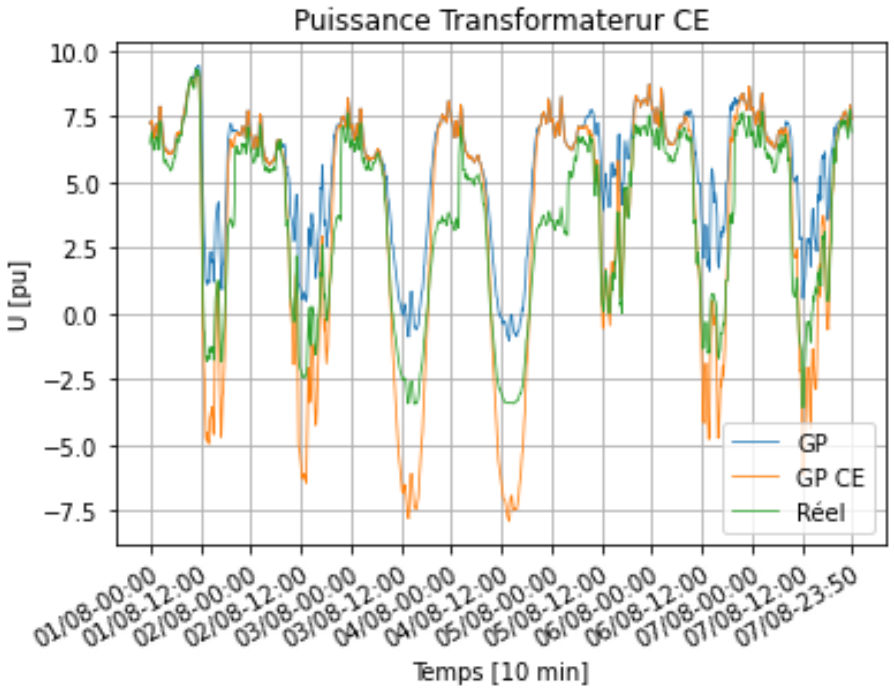

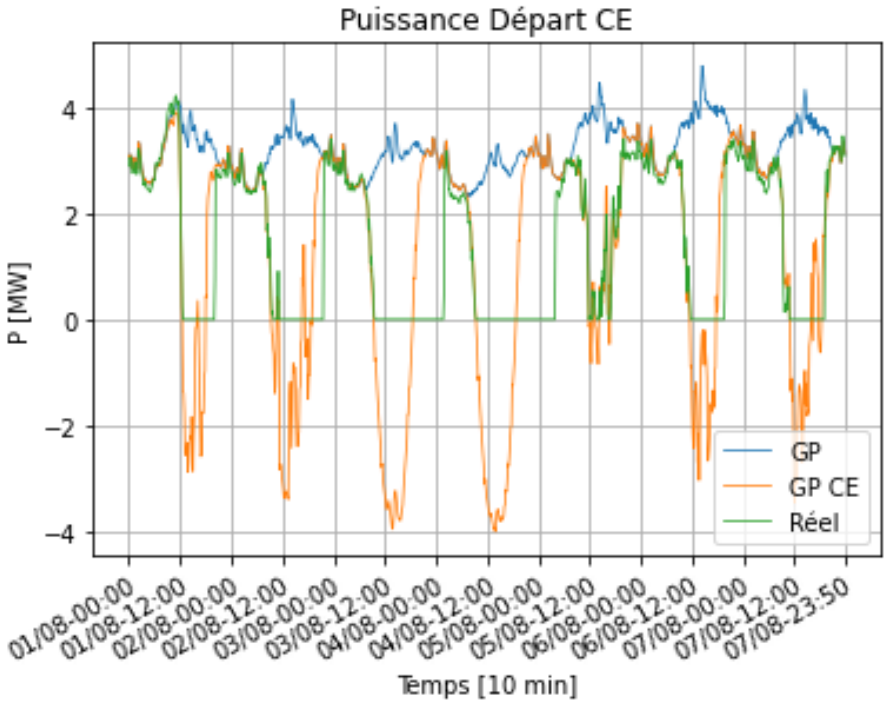

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L'impact des Communautés Énergétiques sur le réseau de distribution HTA.

TSO-DSO Co-Operation

Management of Local Flexibilities – TSO/DSO Co-operation

Are the current data exchange practices between TSO and DSO good enough?

- Yes, data is exchanged in an harmonized and systematic manner
- Yes, data is exchanged regularly but with potential for improvement
- Yes, data is exchanged regularly but practices need to evolve
- No, data exchange practices don't exist

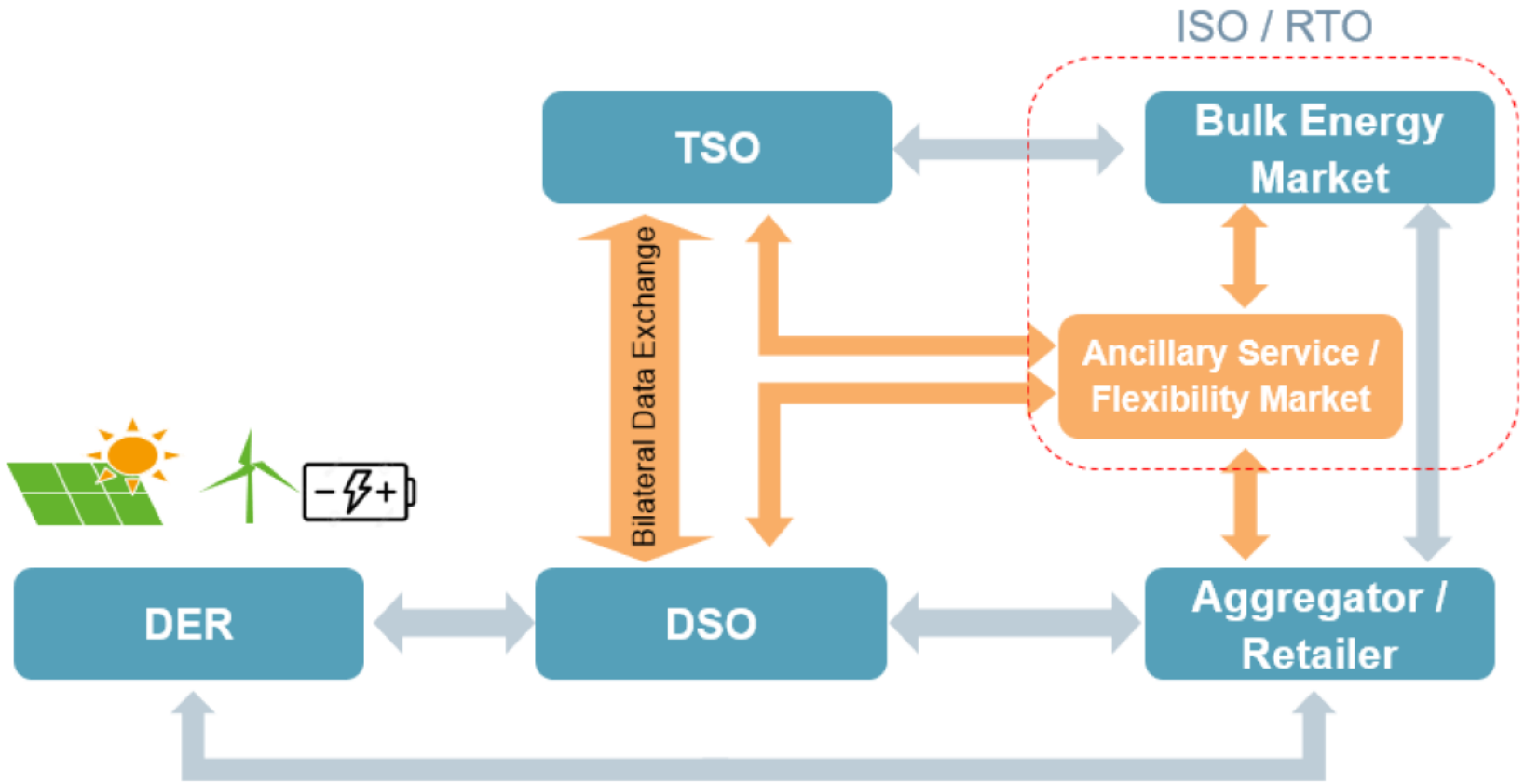
Do TSO and DSO coordination occurs on a voluntary basis or as a result of the existing legal framework?

- All coordination occurs on a voluntary basis
- All coordination occurs supported by legal framework
- Coordination is based on legal framework, but is did on a voluntary basis
- Other (please specify)

CIGRÉ WG C2.40, 2020
TSO-DSO Co-Operation Control Centre Tools Requirements.

Management of Local Flexibilities – TSO/DSO Co-operation

TSO – DSO data exchange and data flow
DSO centric world / common flexibility market



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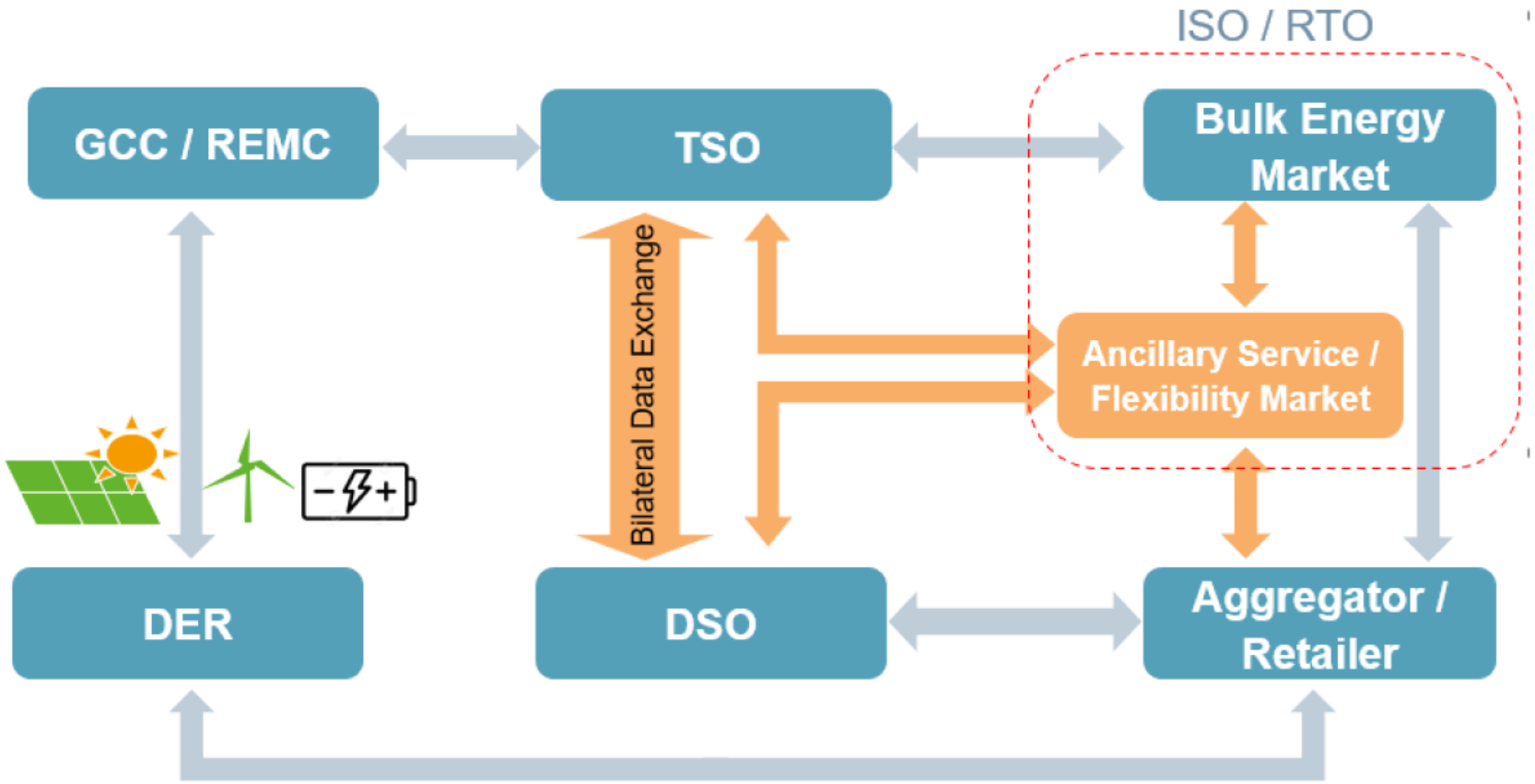

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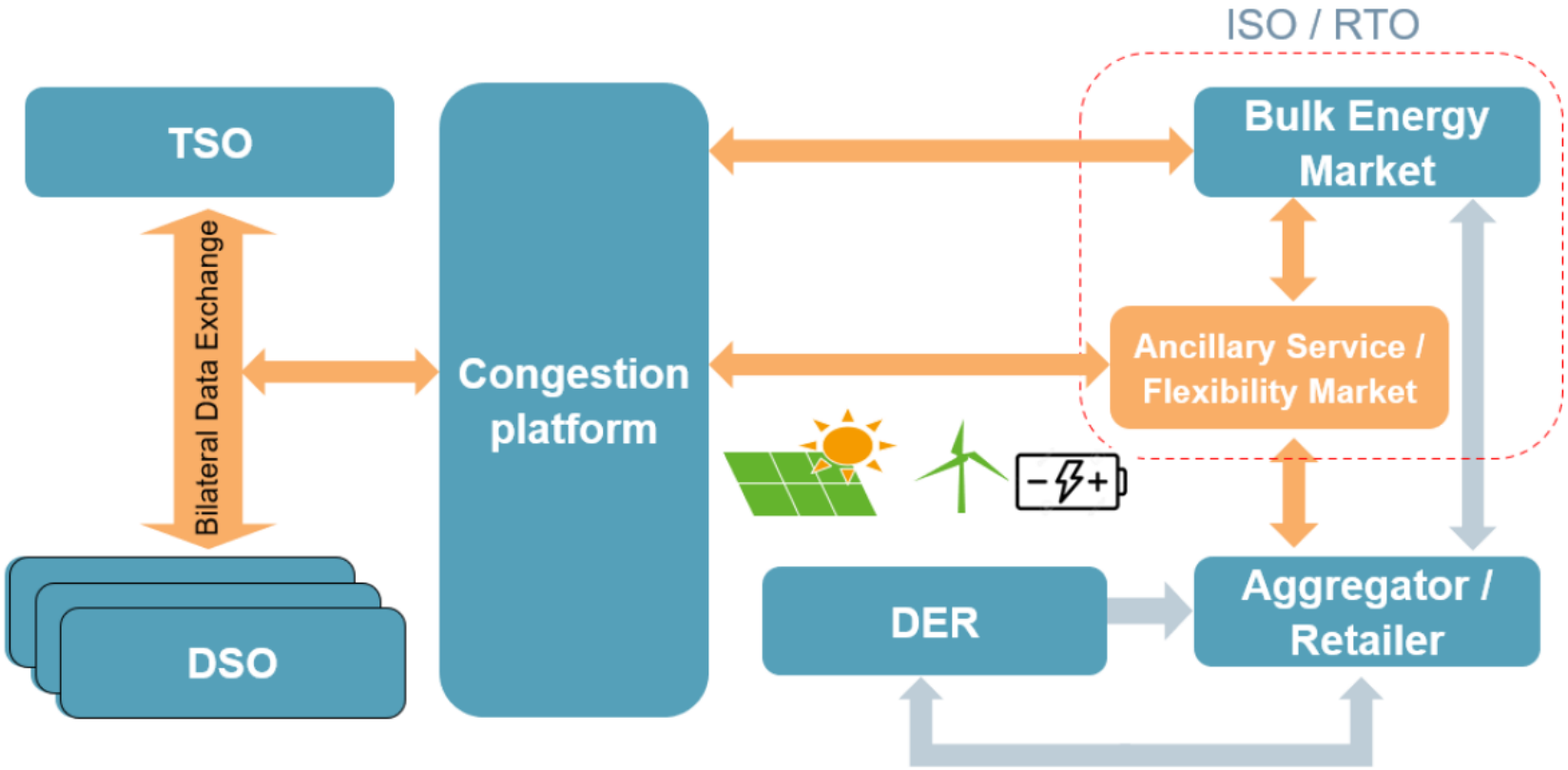
TSO – DSO data exchange and data flow
TSO and DSO / Congestion platform



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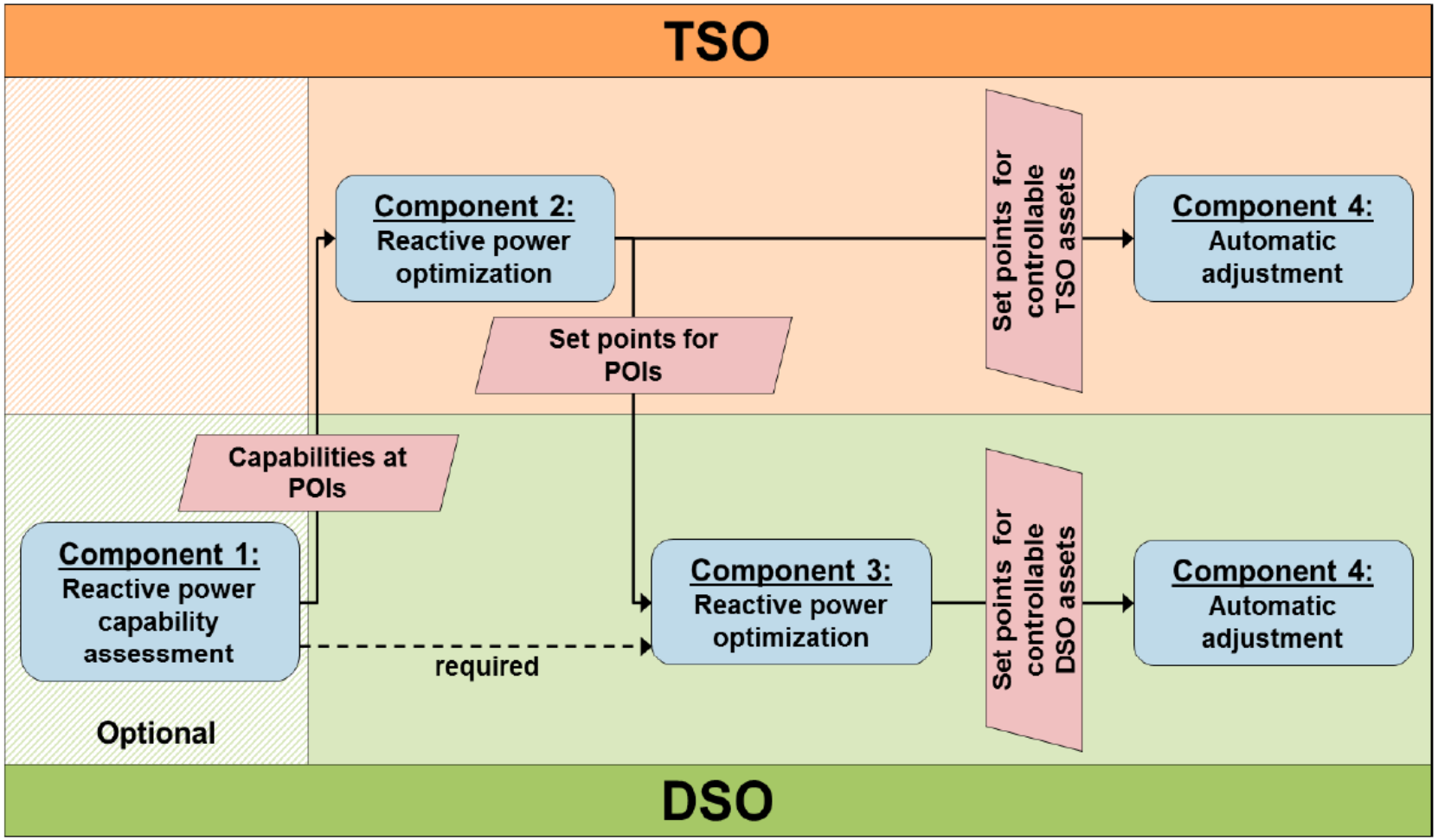

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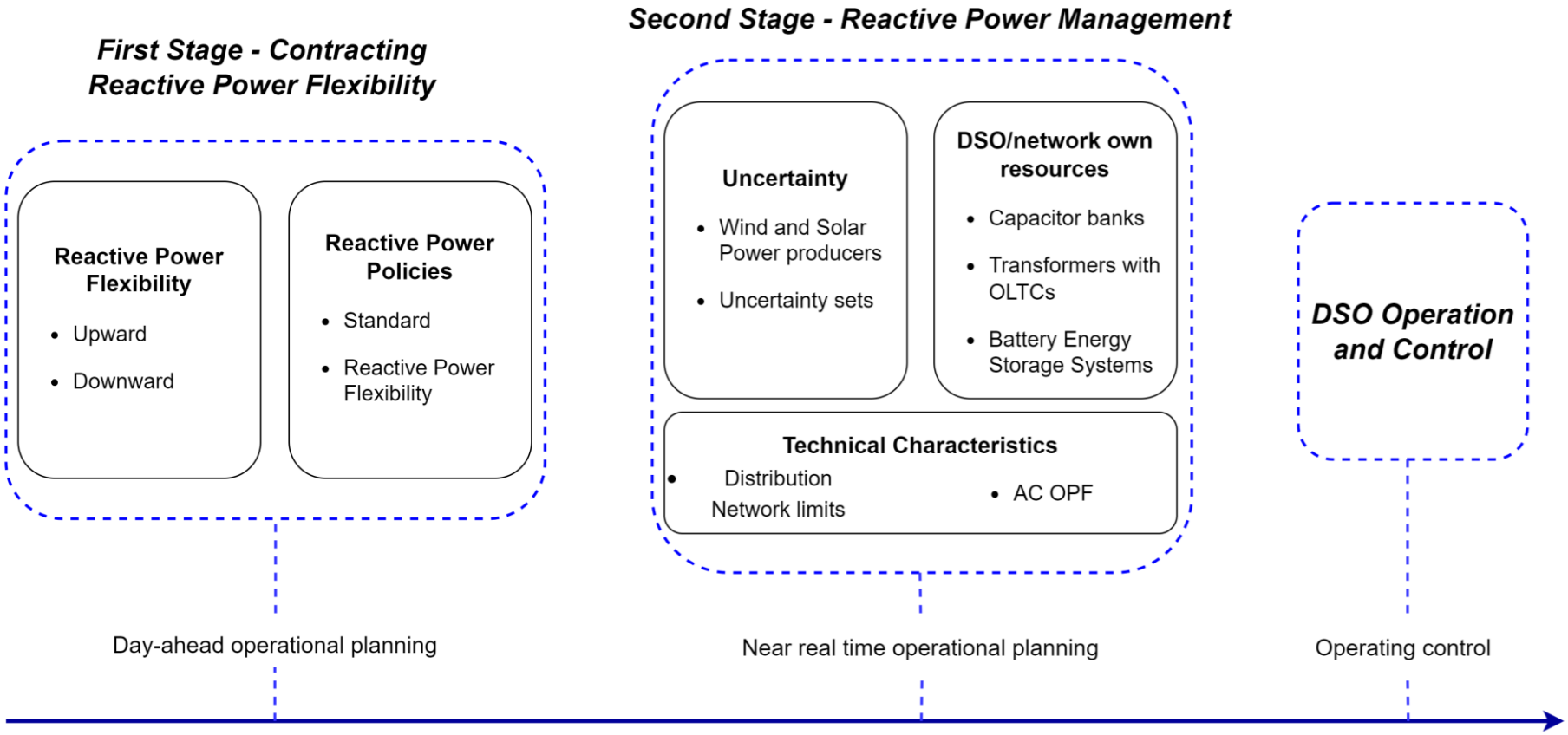
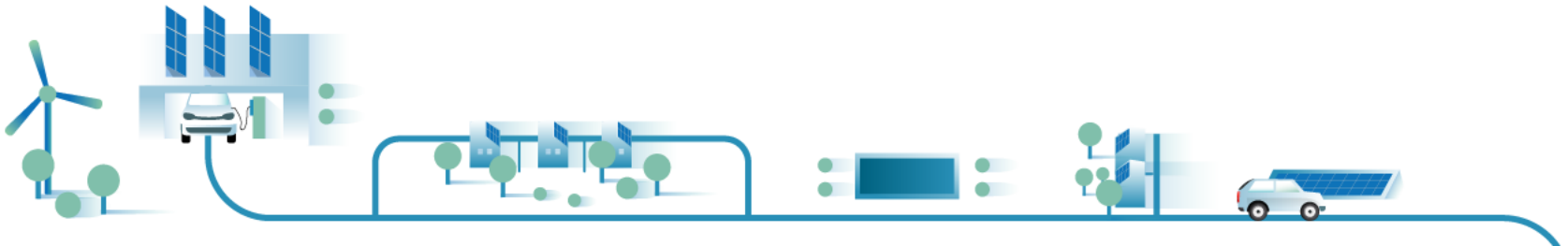
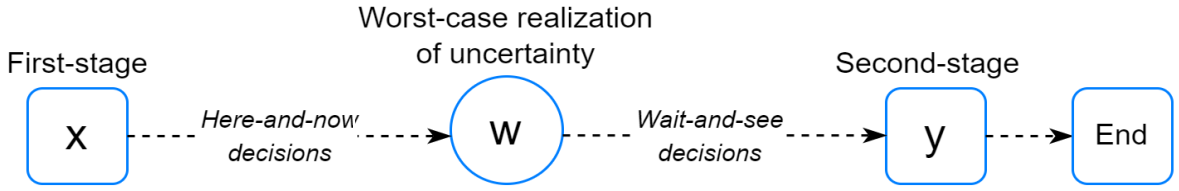




Management of Local Flexibilities – TSO/DSO Co-operation

Robust optimisation

- Two-stage optimisation;
- Min-max-min problem;
- Adaptive robust approach, using the duality theory;
- Uncertainty set composed of vertices, using convex hull.

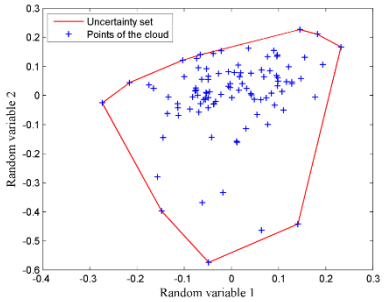


Adapted from: [9]

$$\underset{x}{Min} \quad C^{DA}x + \underset{u}{max}\,\underset{y}{min}\, C^{RT}y$$

$$\Downarrow$$

$$\underset{x}{Min} \quad C^{DA}x + \beta$$

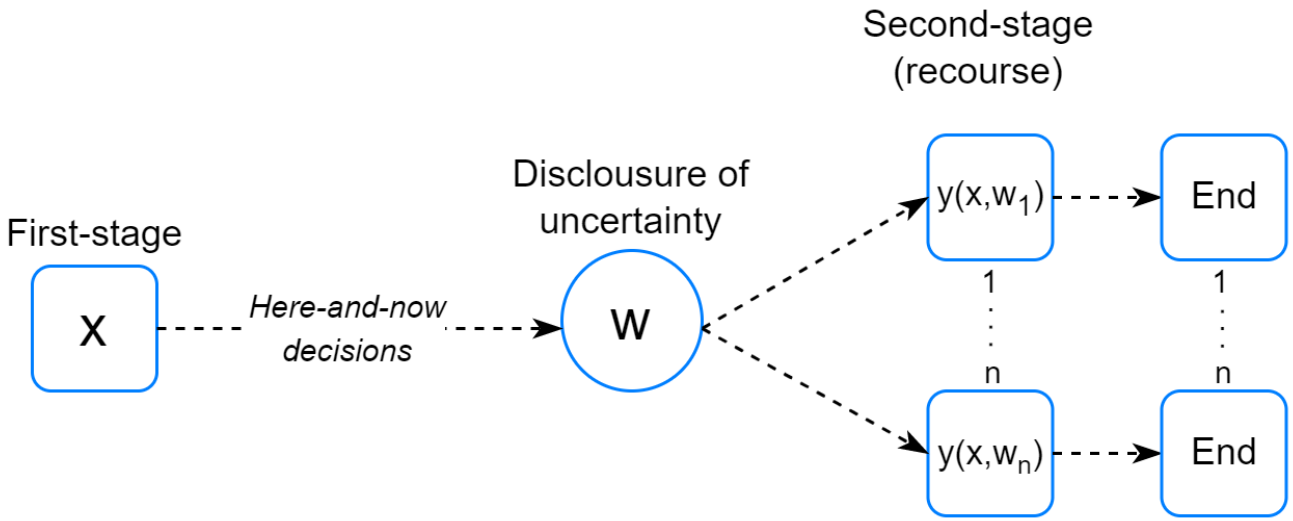


[9] S. Delikaraoglou, “Harnessing and coordinating flexibility through market-based mechanisms,” 2016.

Management of Local Flexibilities – TSO/DSO Co-operation

Stochastic optimisation

- Two-stage optimisation;
- Uses scenarios, associated with a probability of occurrence.



Management of Local Flexibilities – TSO/DSO Co-operation

Objective Function Robust Approach:

$$min \quad F^{DA} + F^{RT}$$

$$F^{DA} = \sum_{g=1}^{N_G} \left(C^{Q,UP}_{DER(g)} R^{Q,UP}_{DER(g)} + C^{Q,DW}_{DER(g)} R^{Q,DW}_{DER(g)} + X^{policy}_{DER(g)} C^{policy}_{DER(g)} \right) + \sum_{su=1}^{N_{SU}} \left(p^{Q,UP}_{TSO} RLX^{Q,UP}_{TSO} + p^{Q,DW}_{TSO} RLX^{Q,DW}_{TSO} \right)$$

$$F^{RT} = \sum_{g=1}^{N_G} \left(C^{act,UP}_{DER(g)} r^{Q,UP}_{DER(g,v)} - C^{act,DW}_{DER(g)} r^{Q,DW}_{DER(g,v)} + C^{cut}_{DER(g)} P^{cut}_{DER(g,v)} \right) + p^{act}_{TSO} \left(rlx^{Q,UP}_{TSO(v)} - rlx^{Q,DW}_{TSO(v)} \right) + p^{Extra}_{TSO} rlx^{Extra}_{TSO(v)} + \sum_{l=1}^{N_L} \left(C^{cut}_{L(l)} P^{cut}_{L(l,v)} \right) + \sum_{cb=1}^{N_{CB}} \sum_{lv=1}^{N_{levels}} C_{CB(cb)} Z_{CB(cb,v,lv)} + \sum_{trf=1}^{N_{TRF}} \sum_{lv=1}^{N_{levels}} C_{TRF(trf)} Z_{TRF(trf,v,lv)} + \sum_{stor=1}^{N_{stor}} \left(\Delta SOC^{UP}_{(stor,v)} C^{UP}_{stor} + \Delta SOC^{DW}_{(stor,v)} C^{DW}_{stor} \right)$$

Variables & Parameters:

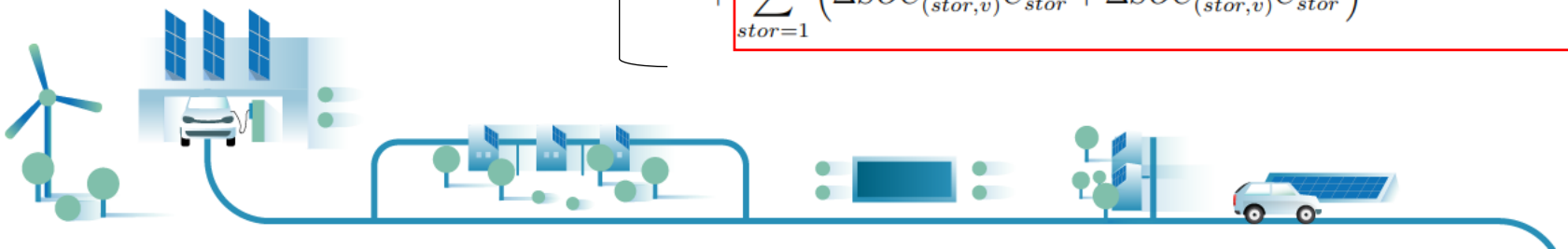
C: costs

R/r: flexibility quantities

rlx: relaxations

p: penalisations

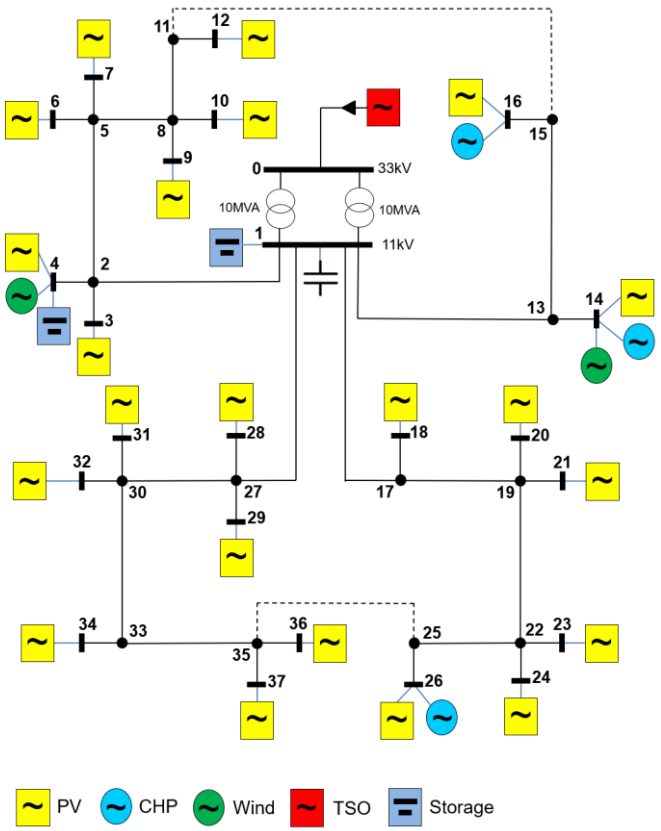
X: Binary variable



Management of Local Flexibilities – TSO/DSO Co-operation

Three simulations have been carried out:

- Robust optimisation with 5 vertices without BESS;
- Stochastic optimisation with 5 scenarios without BESS;
- Robust optimisation with 5 vertices including BESS.



Management of Local Flexibilities – TSO/DSO Co-operation

Robust optimisation with 5 vertices and BESS

- Load shedding and deviation from TSO request

Worst-case vertex	Period											
	1	2	3	4	5	6	7	8	9	10	11	12
5	0	0	0	0	0	0	0	0	0	0	0	0

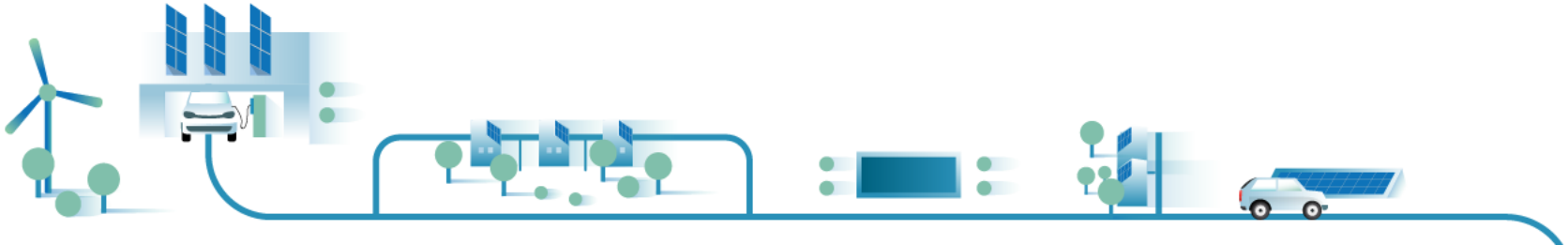
	Without BESS	With BESS
Total Cost, €	19739.6	16050
Total Time, h	~5	~1

Worst-case vertex	Period											
	13	14	15	16	17	18	19	20	21	22	23	24
5	0	0	0	0	0	0.14	0.455	1.204	1.13	0.873	0.633	0.228

Management of Local Flexibilities – TSO/DSO Co-operation

Achievements:

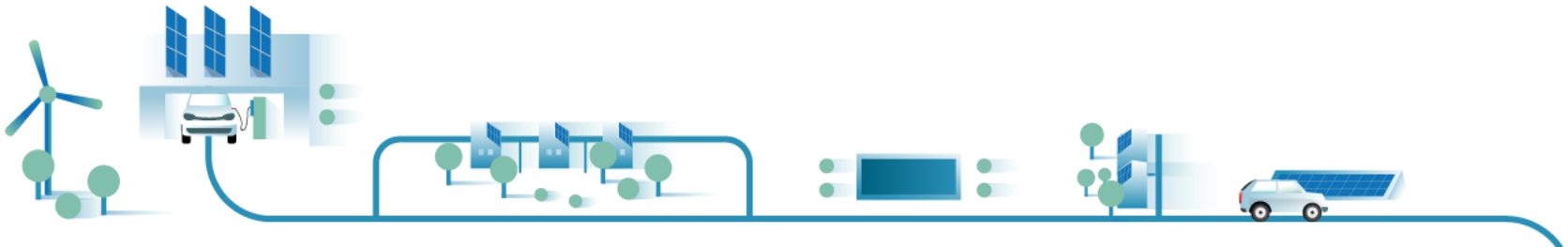
- Development of a reactive management model for distribution grids, which enable a better coordination between system operators;
- DER's generation and flexibility were not enough to provide the service (in the tested case);
- Concluded that robust approaches are more expensive than stochastic ones except in extreme cases of uncertainty;
- Verified that BESS may help managing the grids and providing the service to the TSO with lower costs.



P2P Markets Considering System and Grid Services

Management of Local Flexibilities – P2P Markets

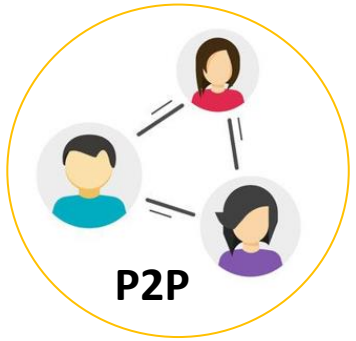
- P2P clearing market
- Grid operation and management



Management of Local Flexibilities – P2P Markets

Frequency Regulation

P2P market



Input
- Peers' bids
- Peers' flexibility

Output
- Bilateral trades
- Power set-point
- Clearing price

Maximization of the social welfare (SW)

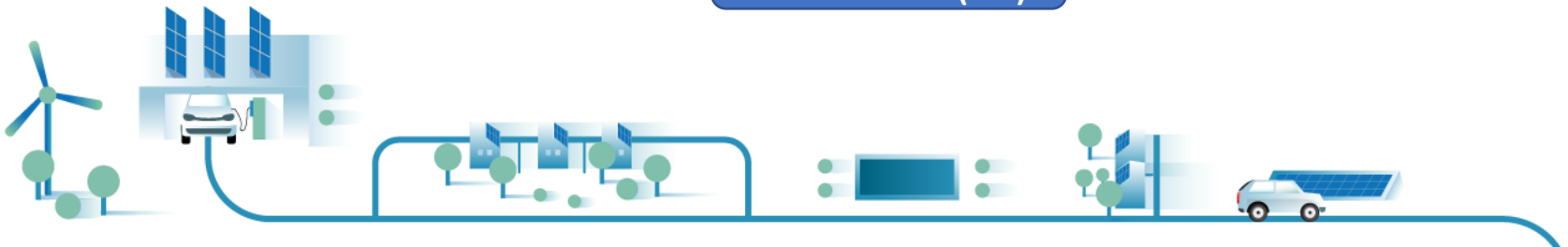
AC-PF validation

Input
- Power set-point
- Network topology

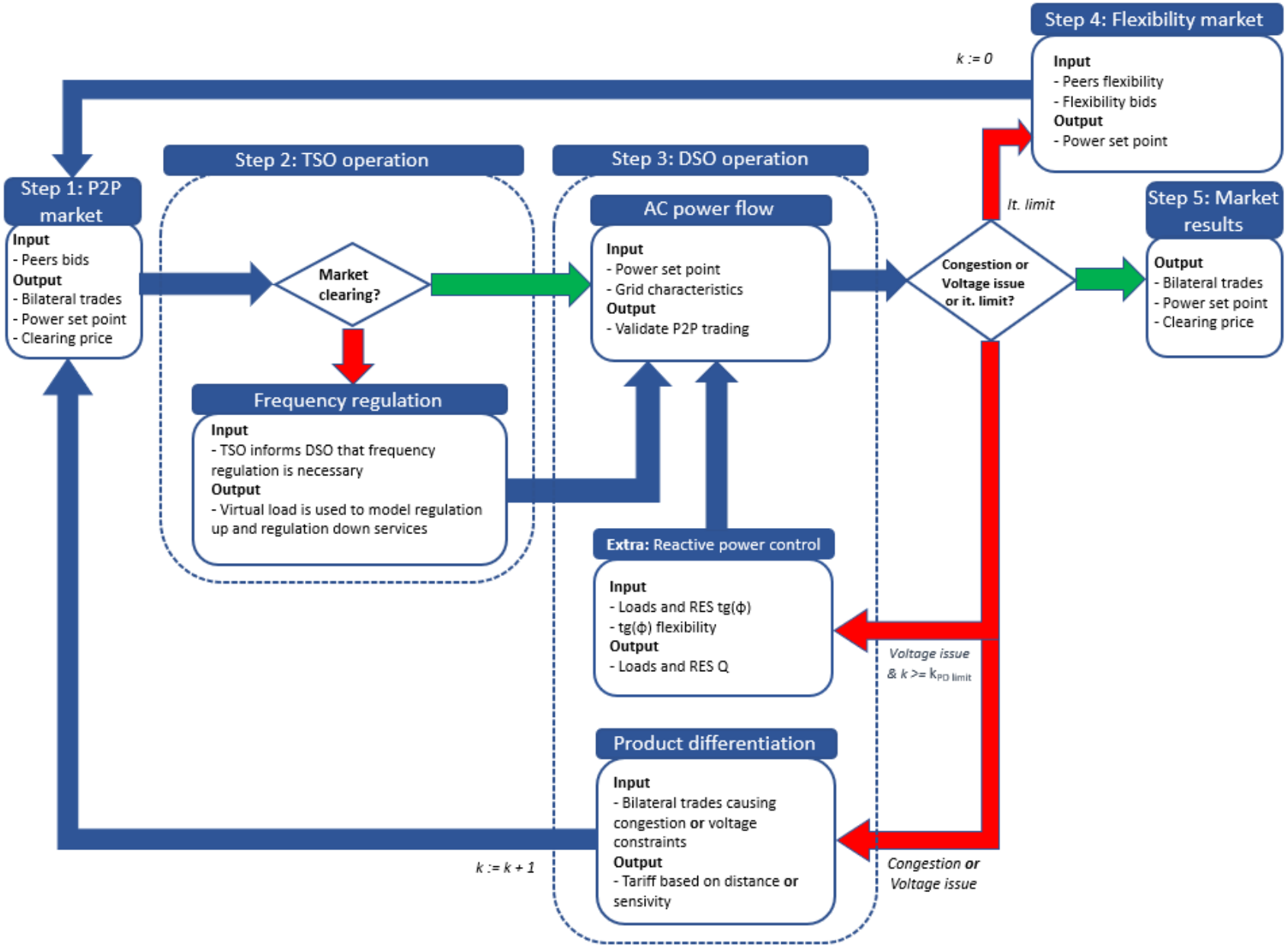
Output
- Line loadings
- Bus voltages

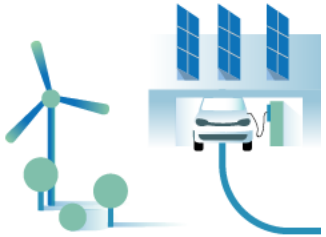
Implemented with the Pandapower tool

P2P clearing results



Management of Local Flexibilities – P2P Markets





Management of Local Flexibilities – P2P Markets

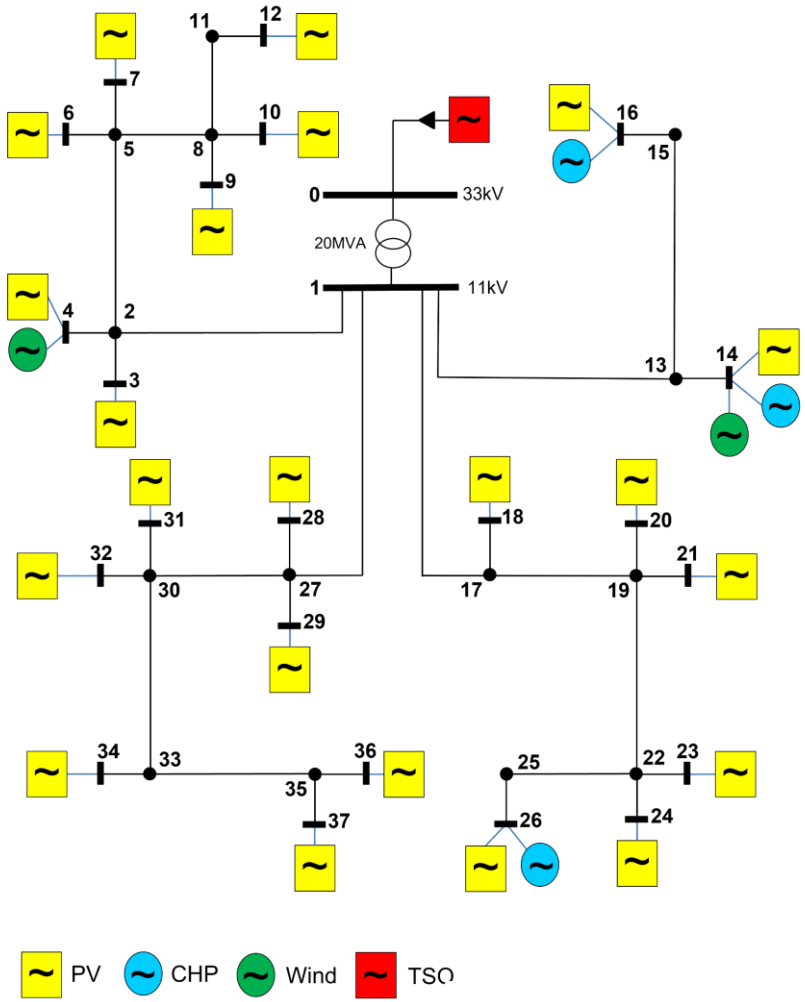
37-bus radial distribution network (MV)

External grid connection (20 MW)

27 DER generators

- 3 CHP plants
- 2 Wind farms
- 22 PV generators

22 loads: flexibility of +/- 30%

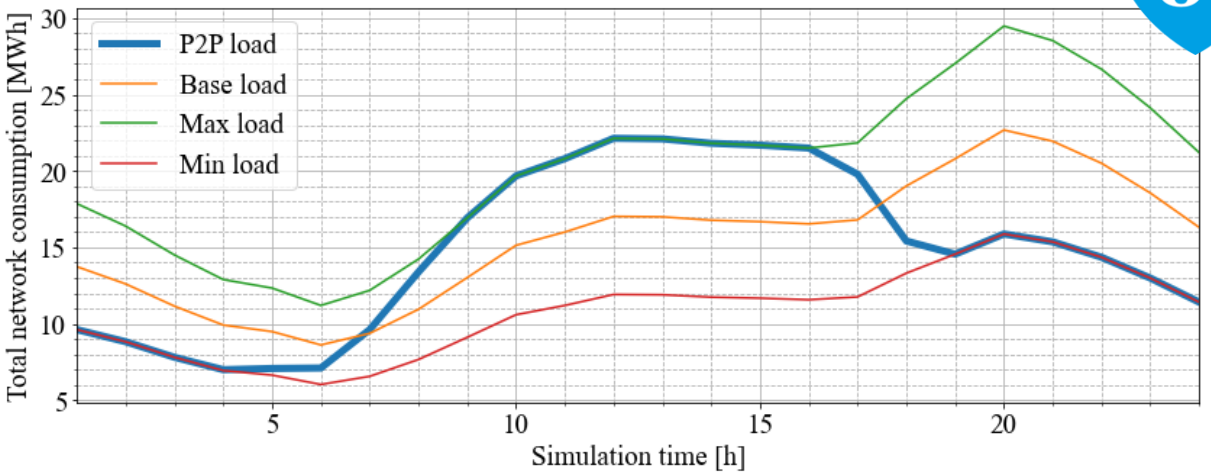


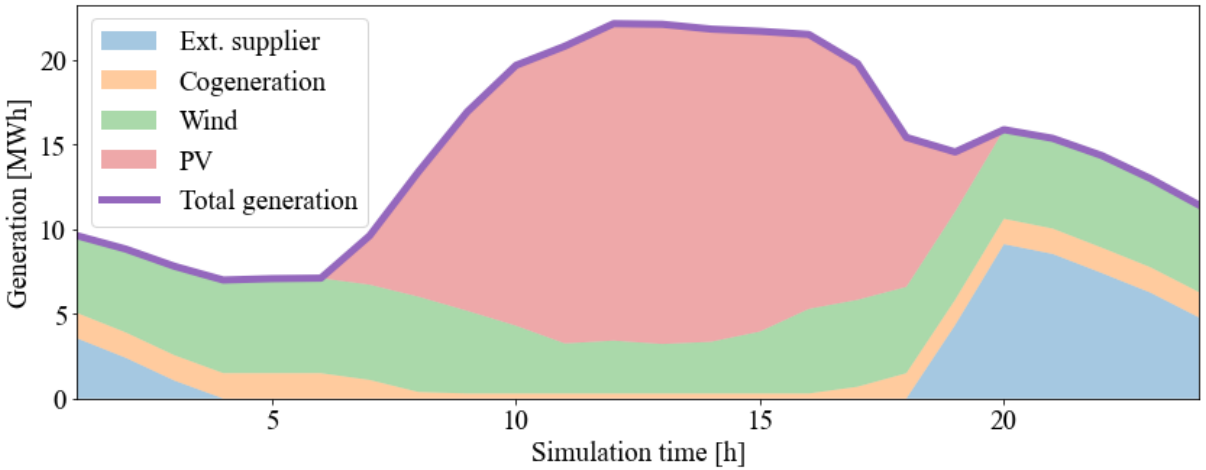
Management of Local Flexibilities – P2P Markets

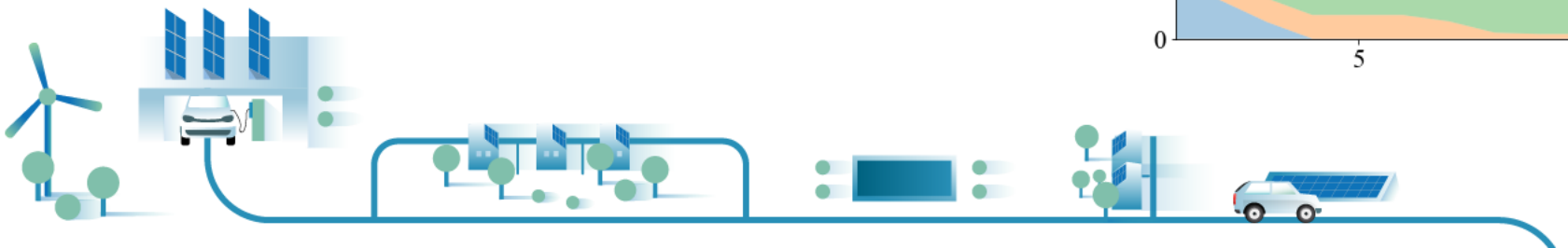
P2P clearing

Electricity price → Variation of load consumption using flexibility → Efficient inclusion of DER

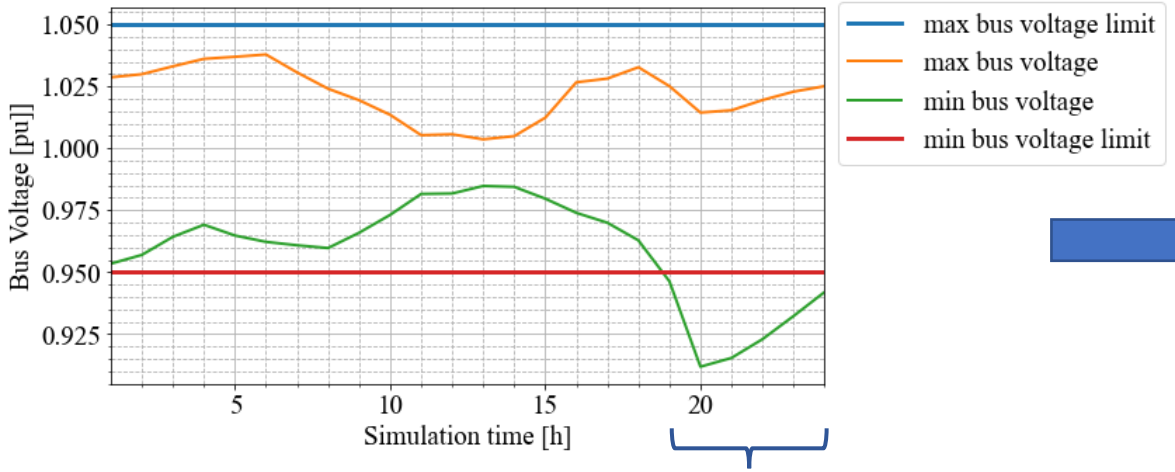
Hours 9 to 16 → RES generation



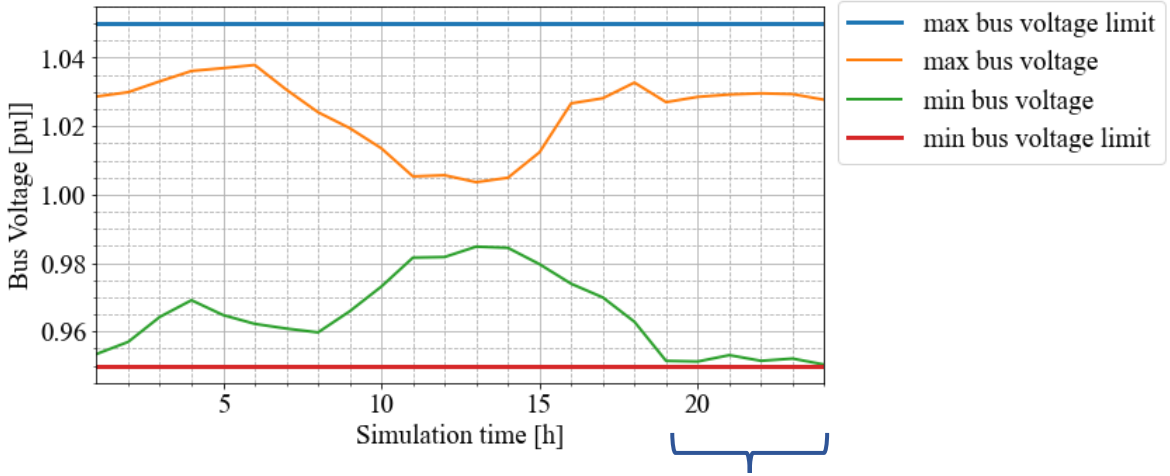




Management of Local Flexibilities – P2P Markets

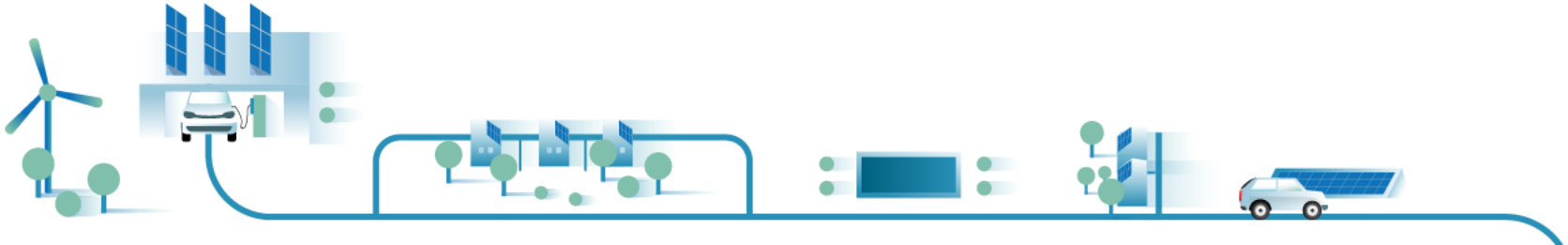


P2P_Volt



Management of Local Flexibilities – P2P Markets

Result	Benchmark	Scenario 3	
External supplier [MWh]	47.47	**22.57**	
CHP [MWh]	24.09	24.09	
Wind [MWh]	114.06	114.06	
PV [MWh]	171.20	171.20	
Consumption [MWh]	356.82	**331.92**	
Losses [%]	0.61	1.60	**+ 162%**
SW [€]	22 025.8	20 287.3	**- 8%**



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TradeRES

New Markets Design & Models for 100% Renewable Power Systems

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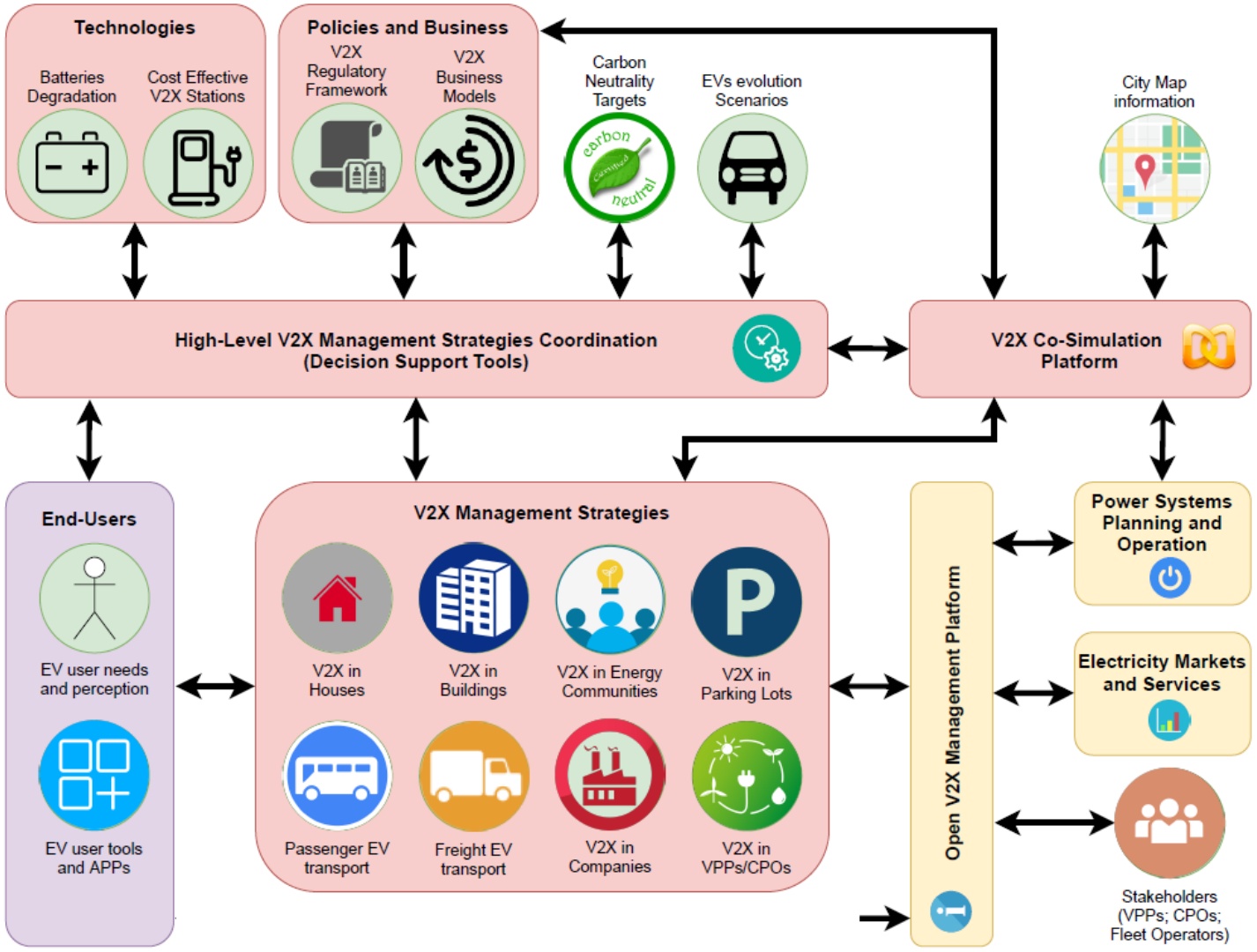
EV4EU Project



EV4EU Project

Use Case 1
Cost-effective V2X station
- Multi-Outlet management strategies
- V2X capability
- Sharing Charging Business Model

Use Case 2
Open V2X Management Platform
- Demonstrate the exchange of information
- Demonstrate the activation of services
- Standards evaluation

Use Case 3
New DR and Flexibility Contracts
- Test new demand response for V2X
- Flexibility capacity contracts for V2X
- Evaluate user adoption

Use Case 4
V2X management in Houses
- Dynamic control considering devices priority
- Test Opportunity Cost function
- User profiles / perception / interaction

Use Case 5
V2X management in Buildings
- Coordination of V2X and RES
- Maximize self-consumption

Use Case 6
V2X management in companies
- EVs fleet optimal management
- Coordination with RES/Storage
- Sharing Charging Business Model

Use Case 7
V2X management in Parking Lots
- Centralized vs Autonomous V2X management
- Advantages of V2X comparing with V1G
- Compare fast-charging with medium-charging

Use Case 8
V2X management by a CPO
- Evaluate the user' engagement in new services
- Green Charging Business Model
- Participation in services activated by the DSO

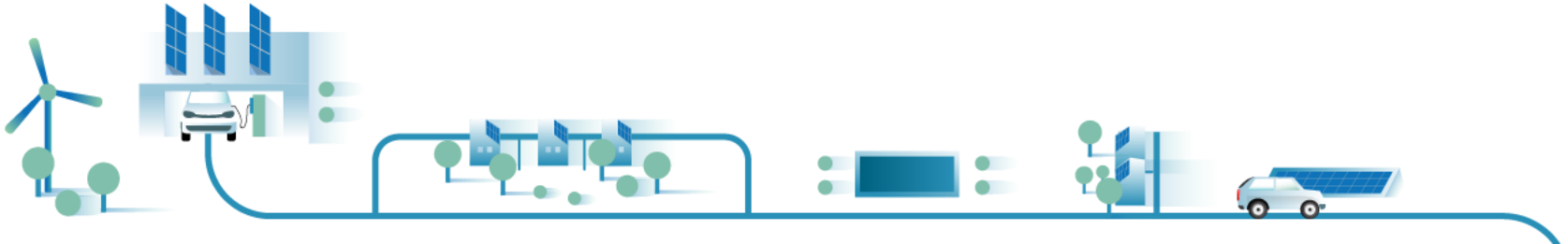
Use Case 9
V2X management by a VPP
- Aggregation with other resources (RES, ESS)
- New probabilistic algorithms for VPPs
- Participation in multiple-services and Markets

Use Case 10
Participation of V2X in electricity markets
- Participation in regional markets
- Participation in ancillary services markets
- Activation by the VPP of procured services

Use Case 11
Participation of V2X in grid services
- Participation in local energy markets
- Participation in grid services
- Services activation by the DSO and VPP

Use Case 12
Activation of V2X services by the DSO
- Manual activation of V2X services
- Automatic activation of V2X services
- Green Charging

WP6 – Portuguese Demo | WP7 – Slovenian Demo | WP8 – Greek Demo | WP9 – Danish Demo



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