The Smart Grids lab at the University of Liège

January 22nd, 2020 @ Parliament of Wallonia

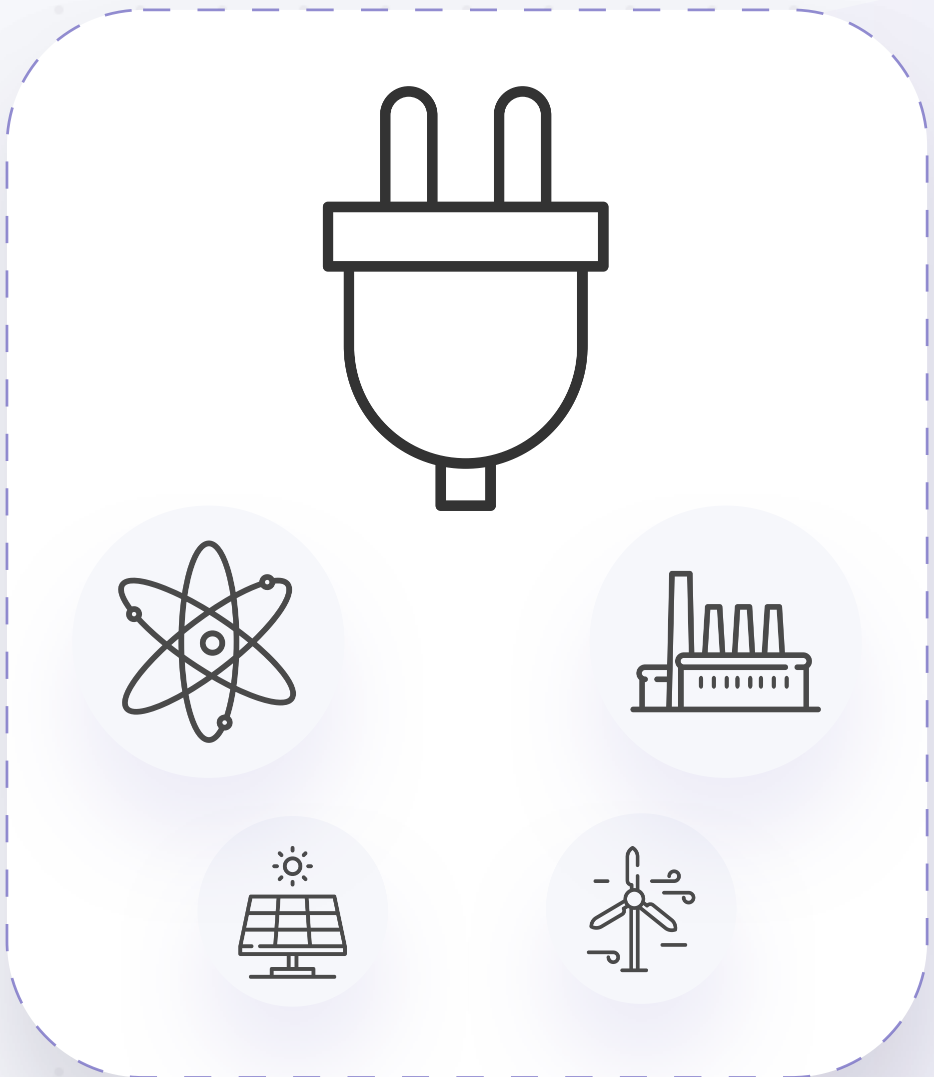
Professor Damien Ernst

Presentation by Dr Raphaël Fonteneau

The Smart Grids lab

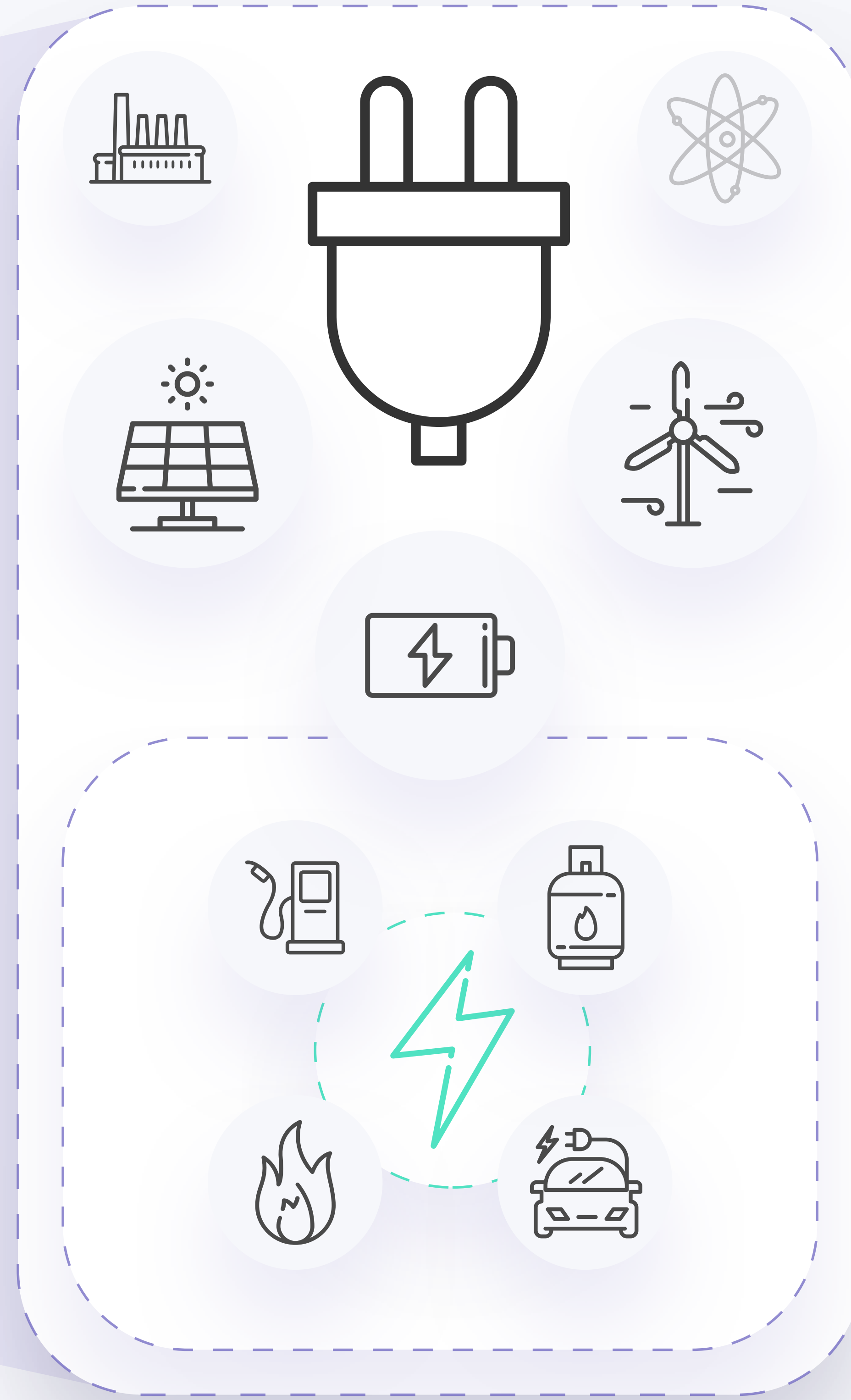
Prof. Damien Ernst

- From macro to micro power grids, and back
- From electricity, to sector coupling, using AI

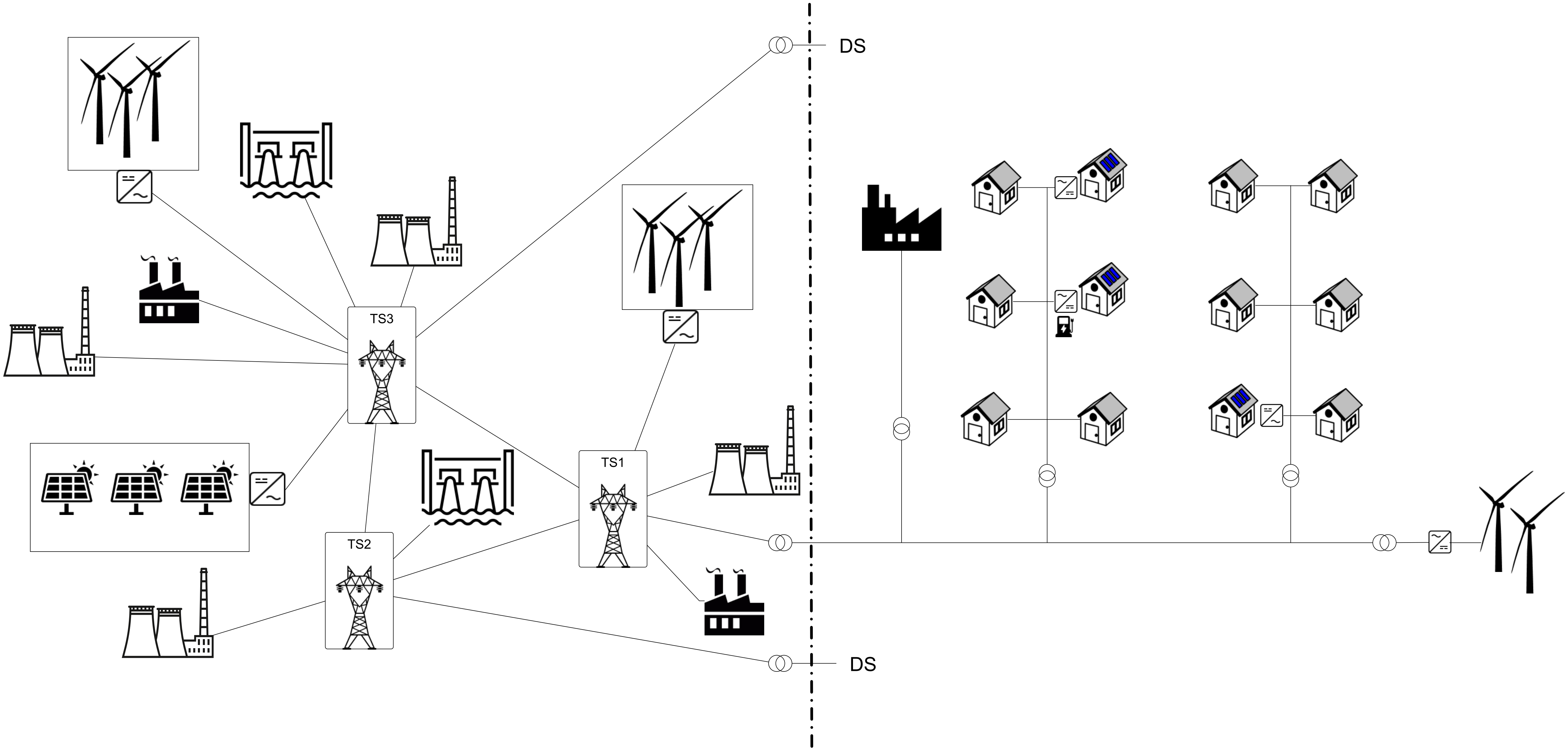


Our goal

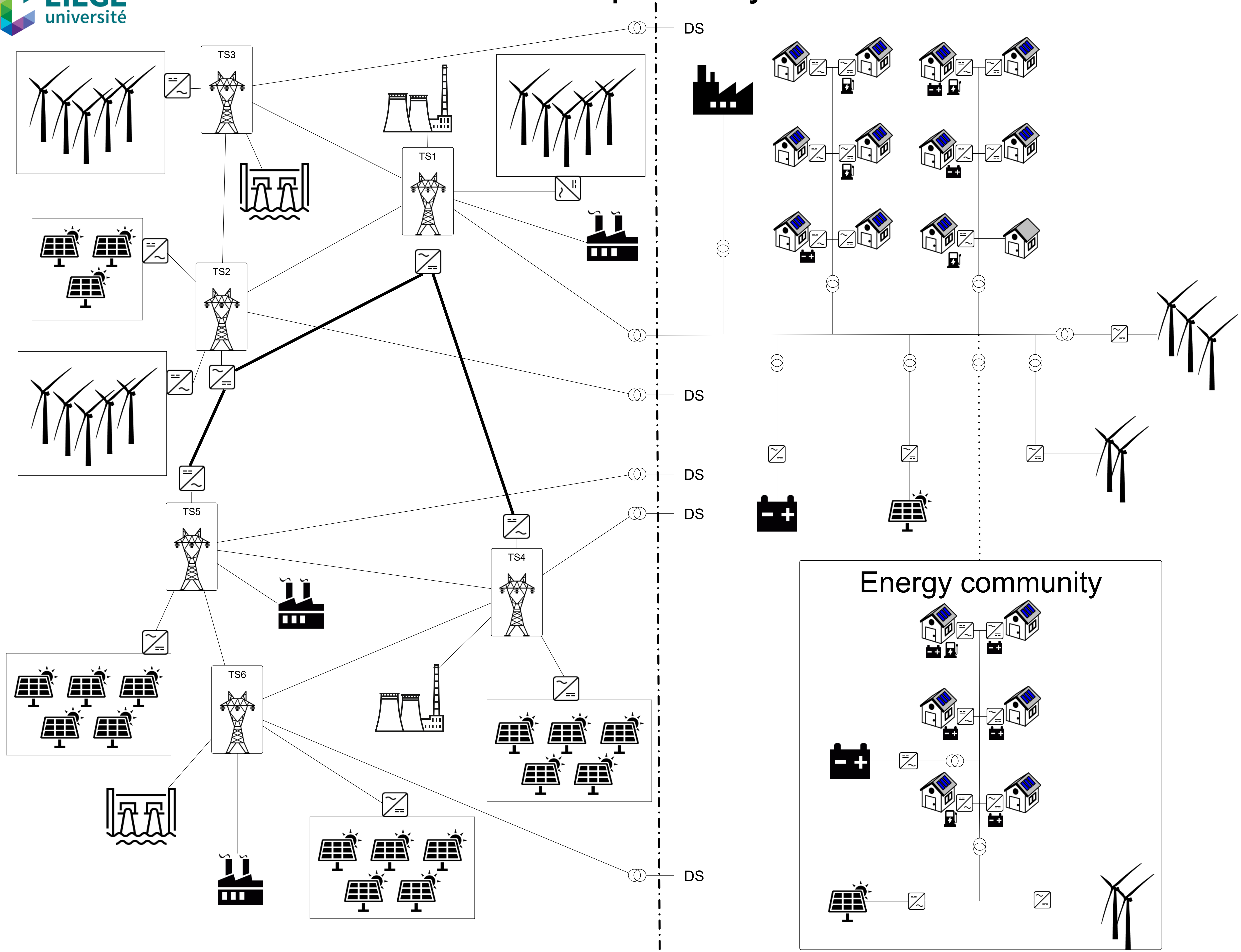
Developing **AI solutions** for the future of our energy systems.



From present...



... to future power systems.



Outline

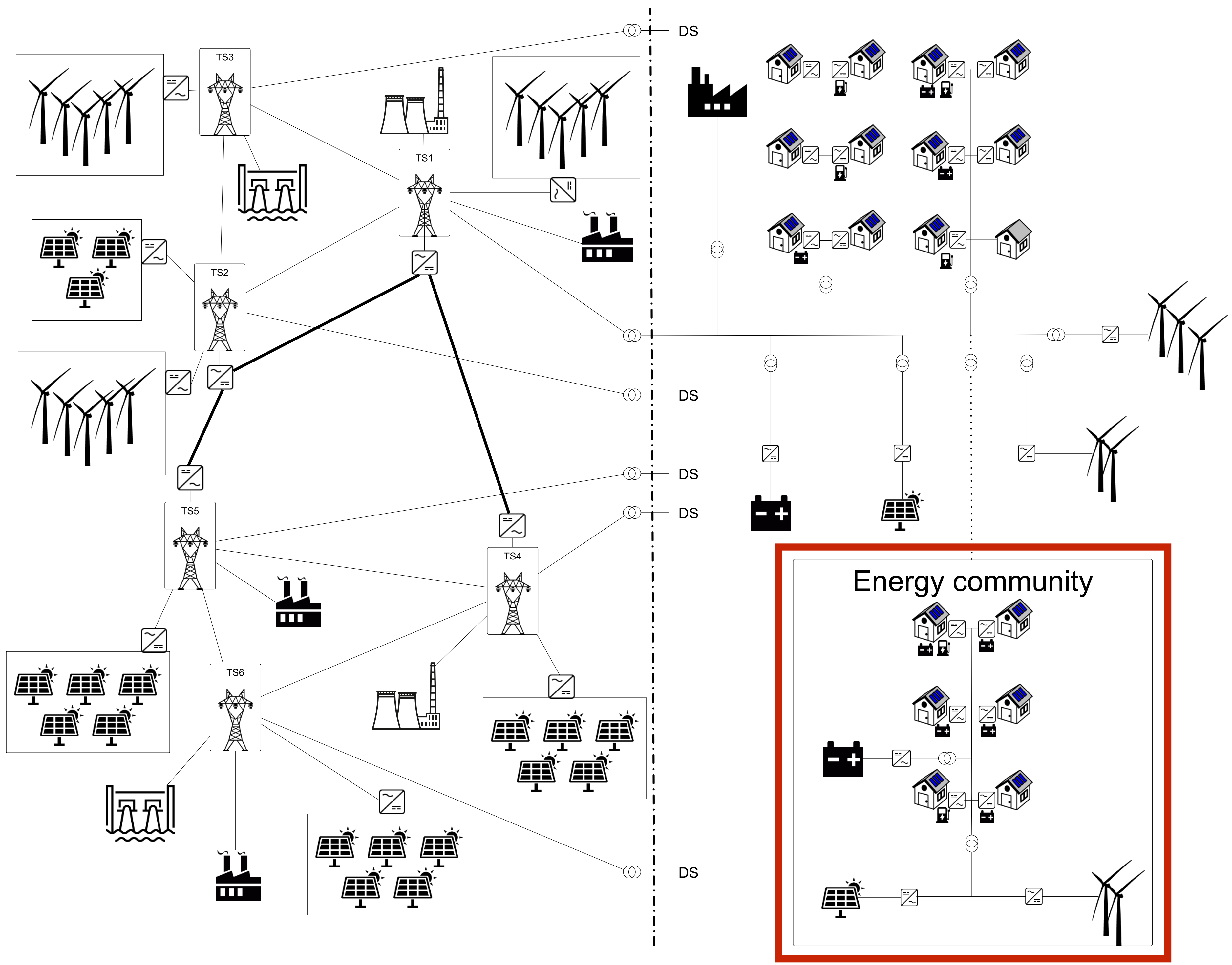
Microgrids, energy communities & distribution networks

Global grid and renewable resource complementarity

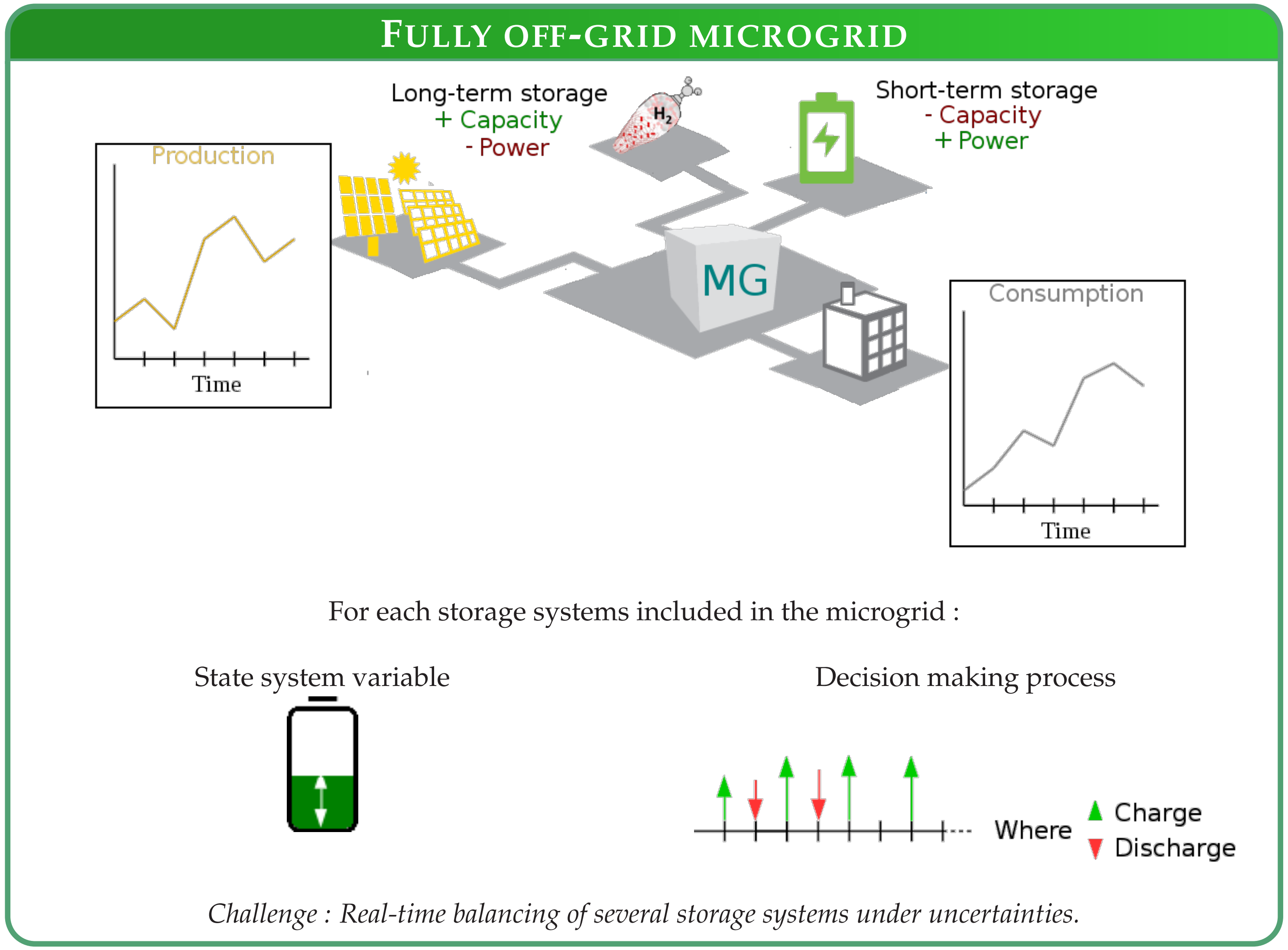
Sector coupling

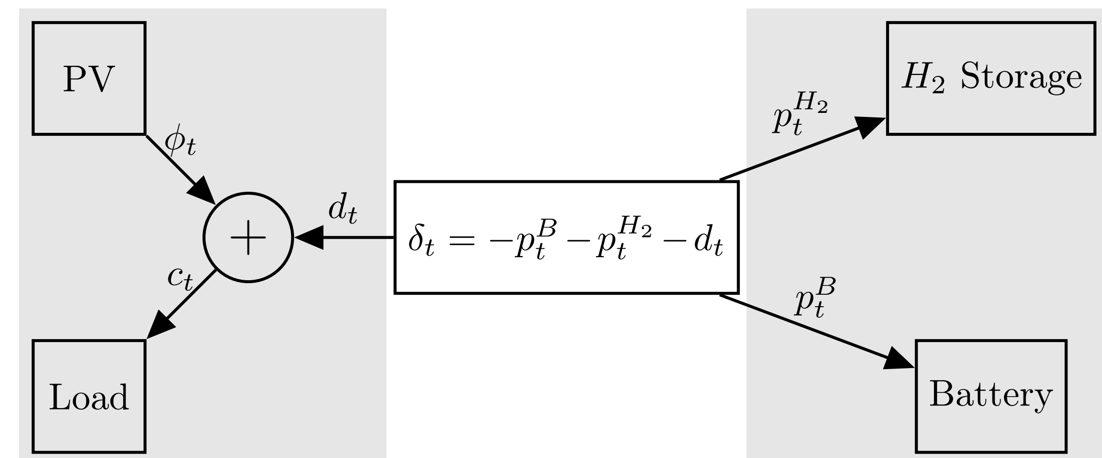
Other applications & research in AI

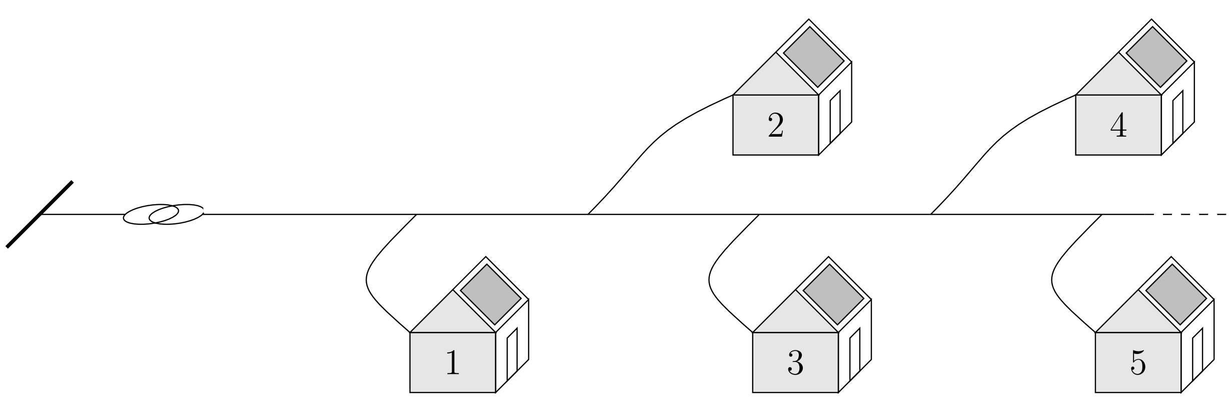
From a « micro » point of view

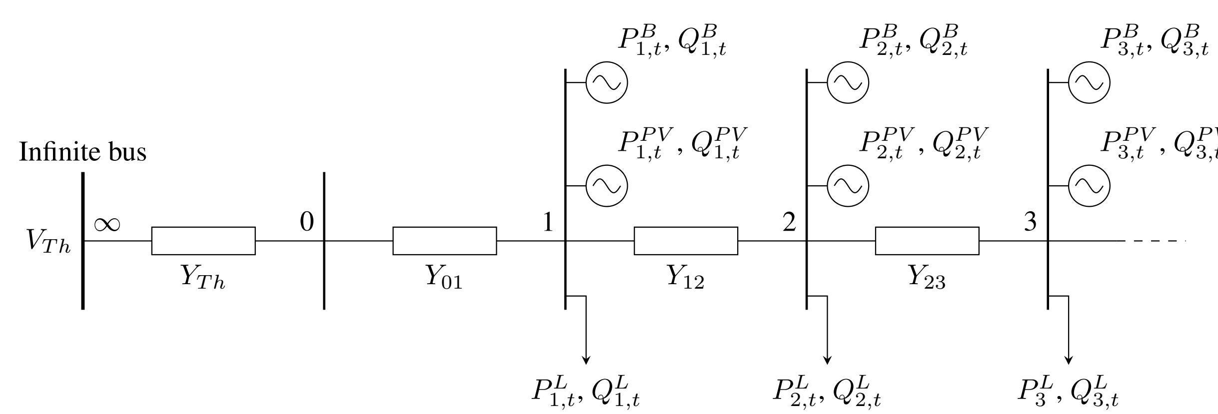


Multiple possible configurations

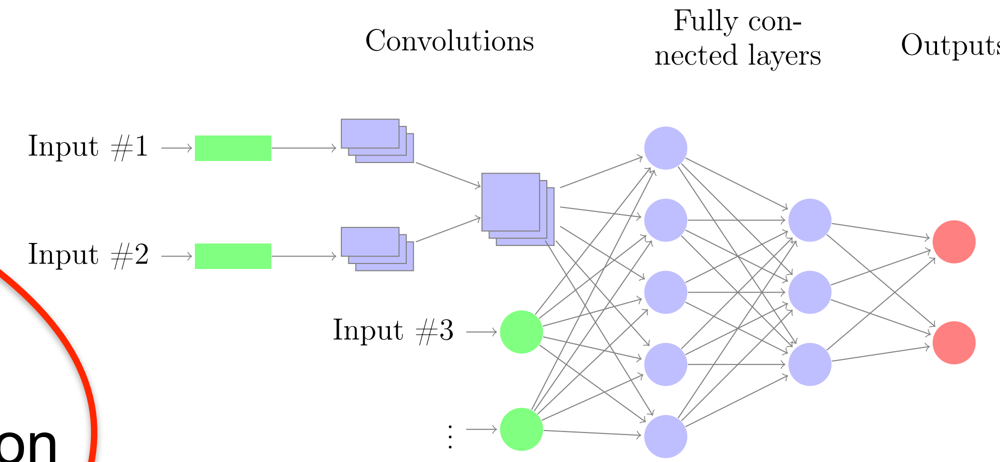




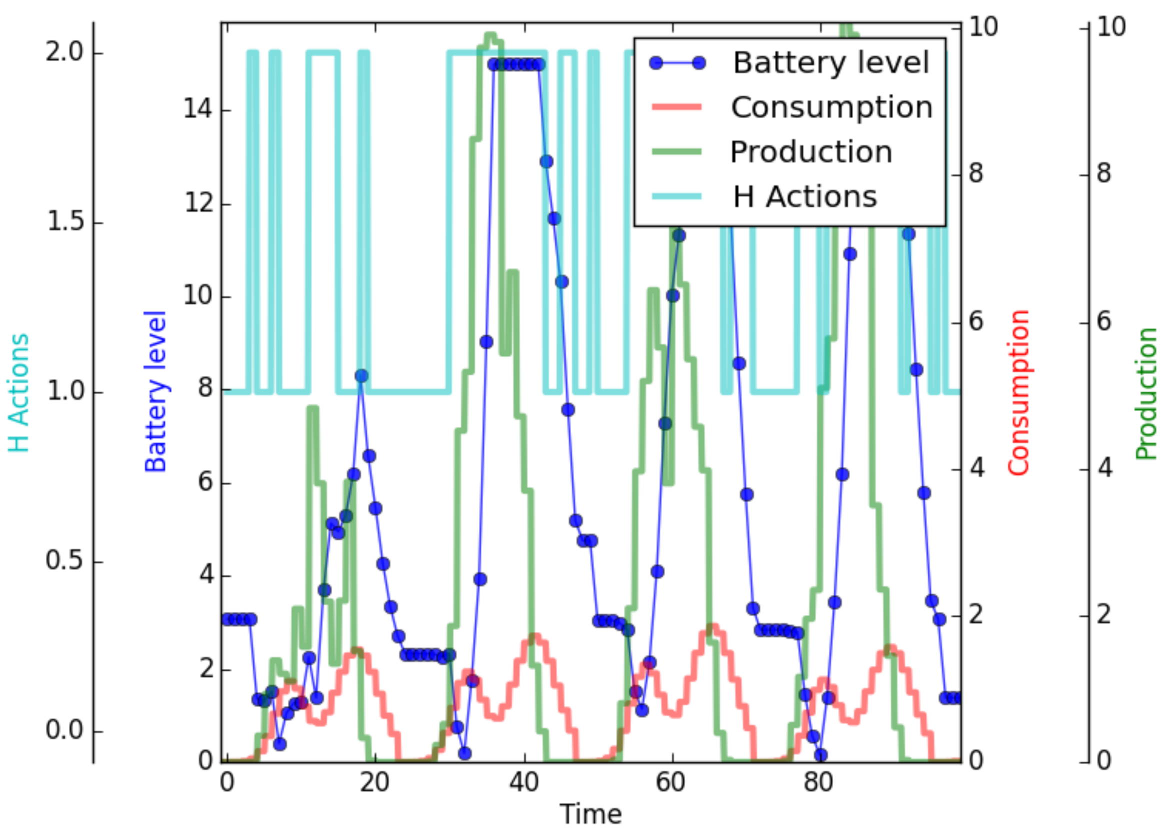




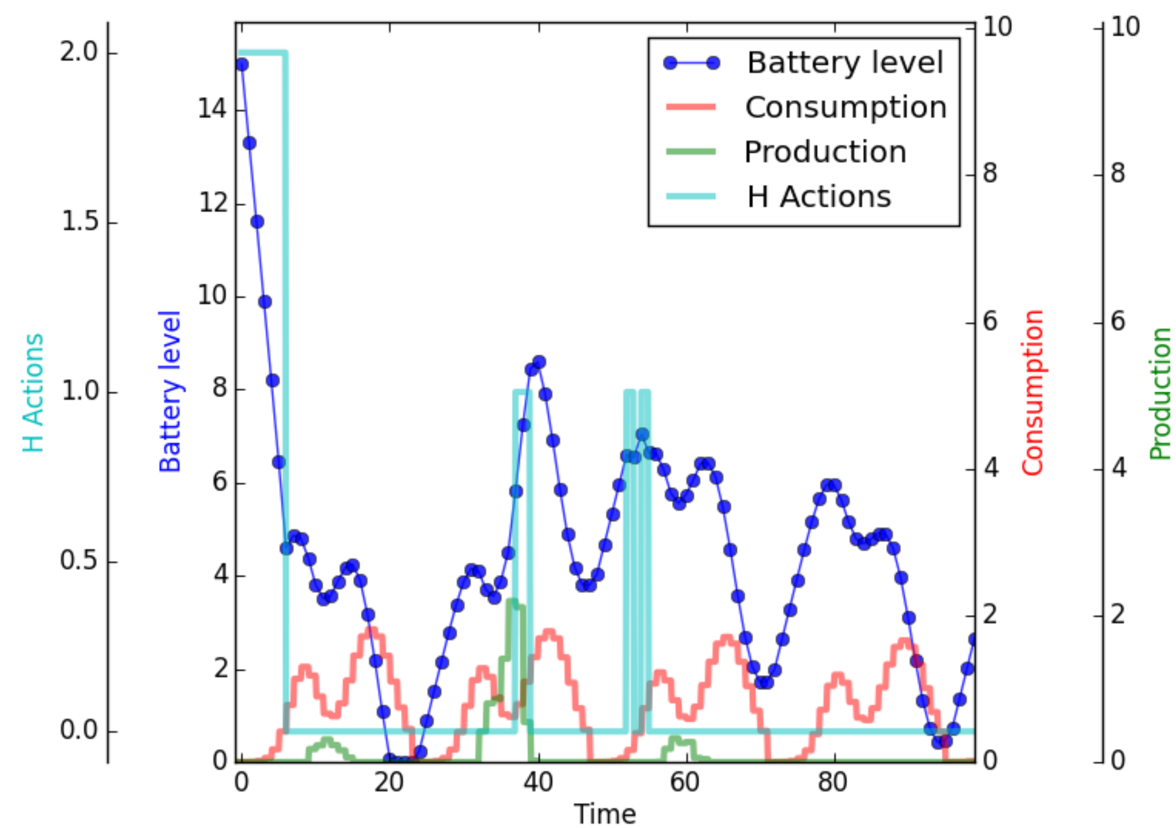
Reinforcement Learning



$$\forall (s,a) \in \mathcal{S} \times \mathcal{A},$$
$$Q^*(s,a) = \sum_{s' \in \mathcal{S}} T(s,a,s') \left[R(s,a,s') + \gamma J^*(s') \right]$$

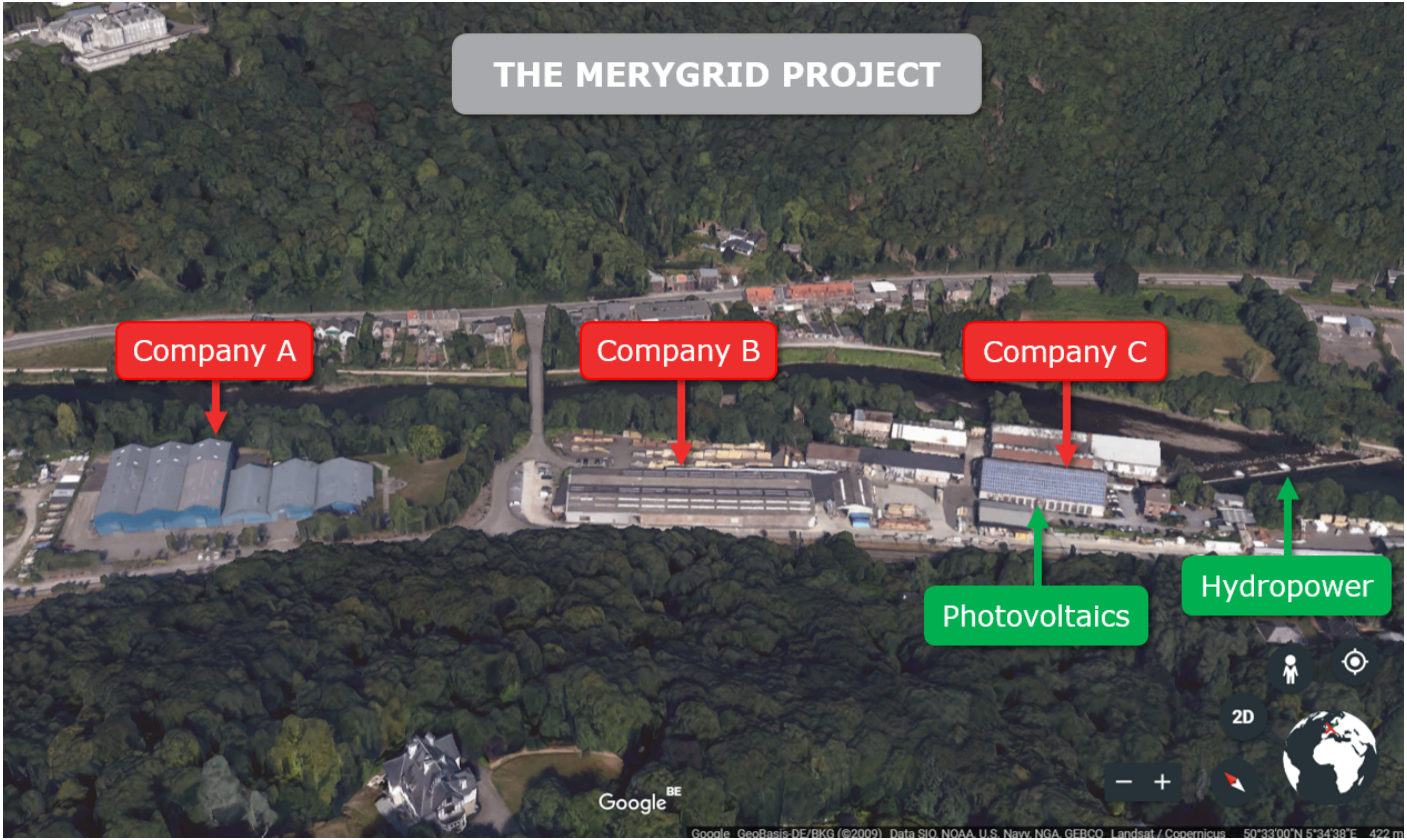


(a) Typical policy during summer



(b) Typical policy during winter

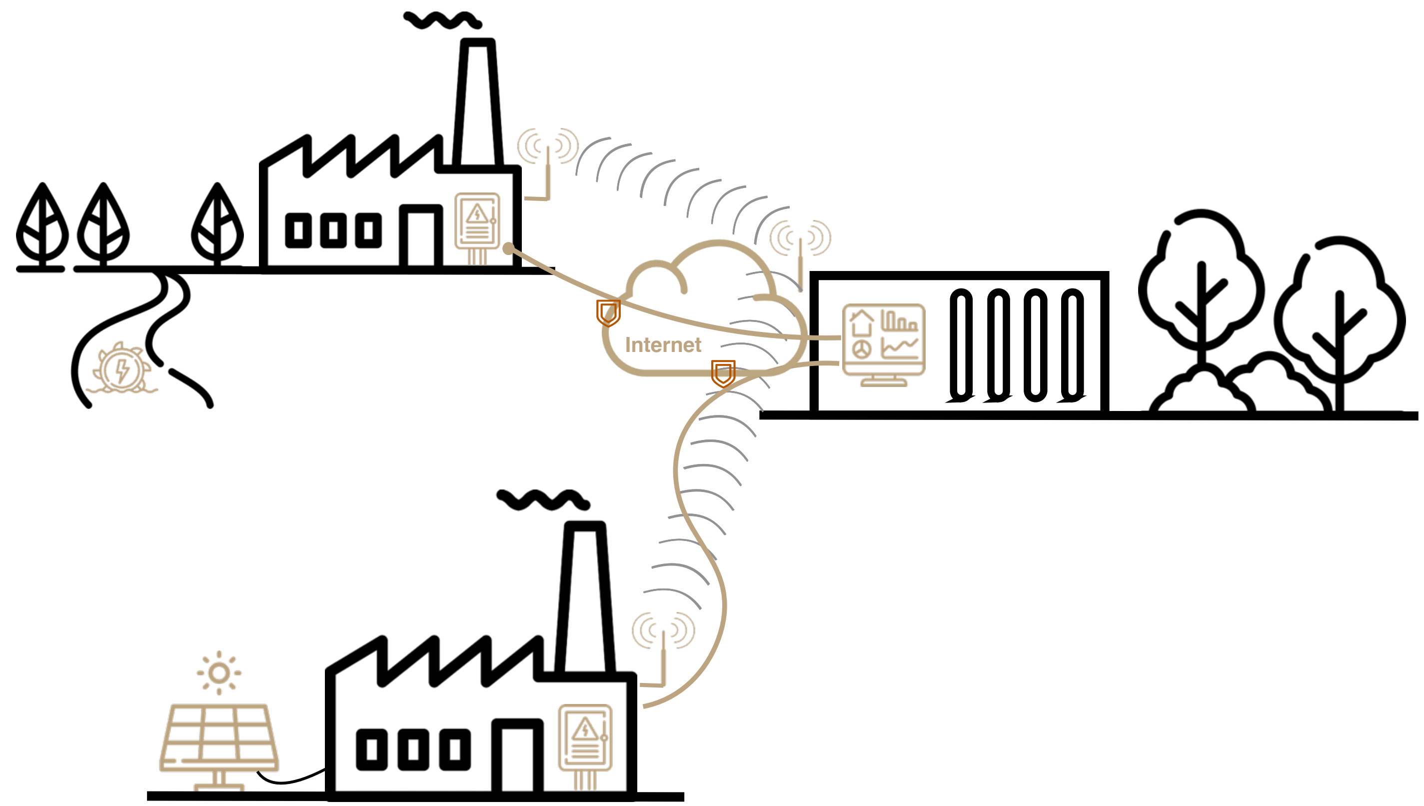
The MeryGrid project



Source: https://les-smartgrids.fr/merygrid-premier-micro-grid-belgique/

The MeryGrid project

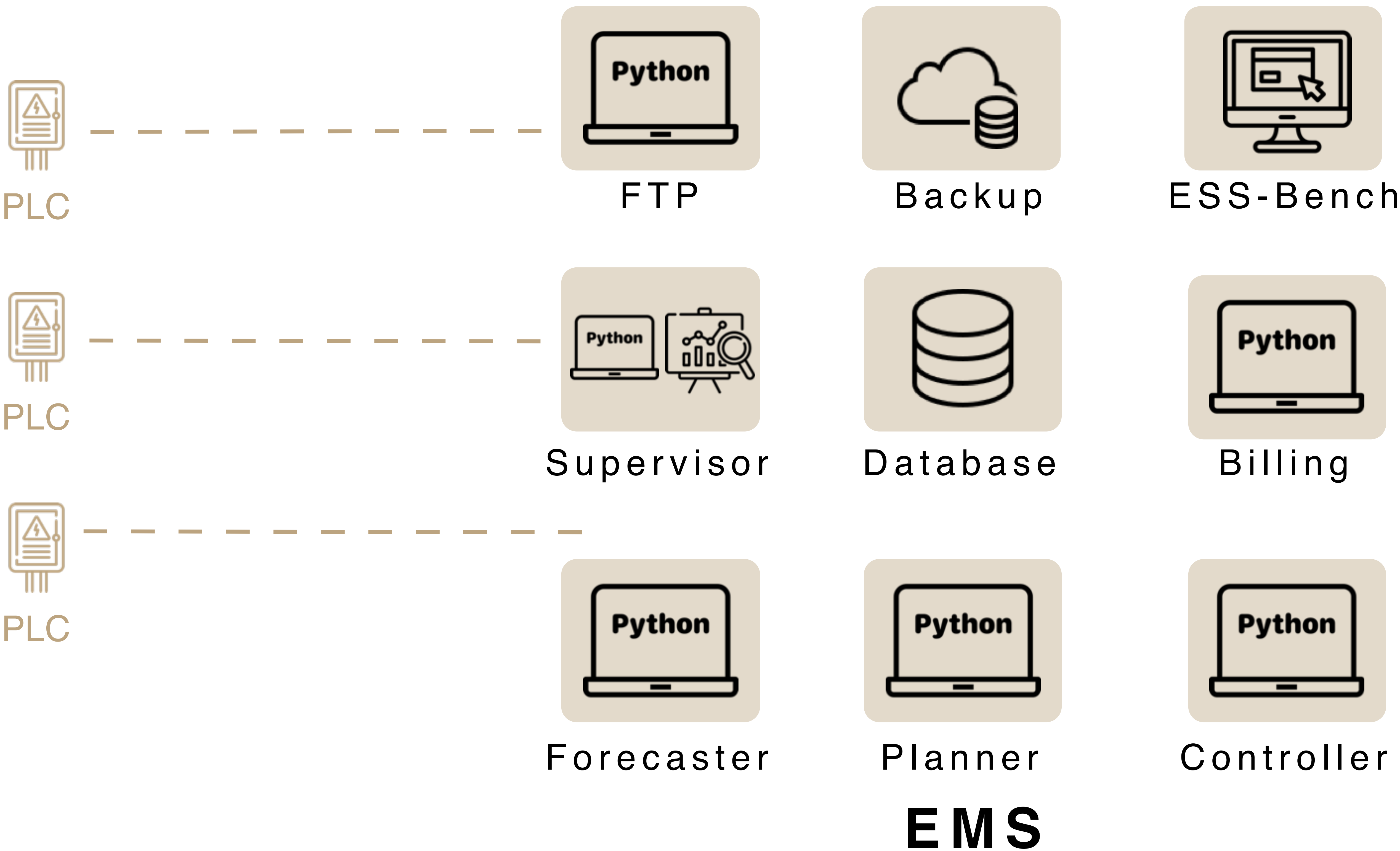
The microgrid is located in Méry, on the banks of the river Ourthe in the Liège area, and links three partner companies:



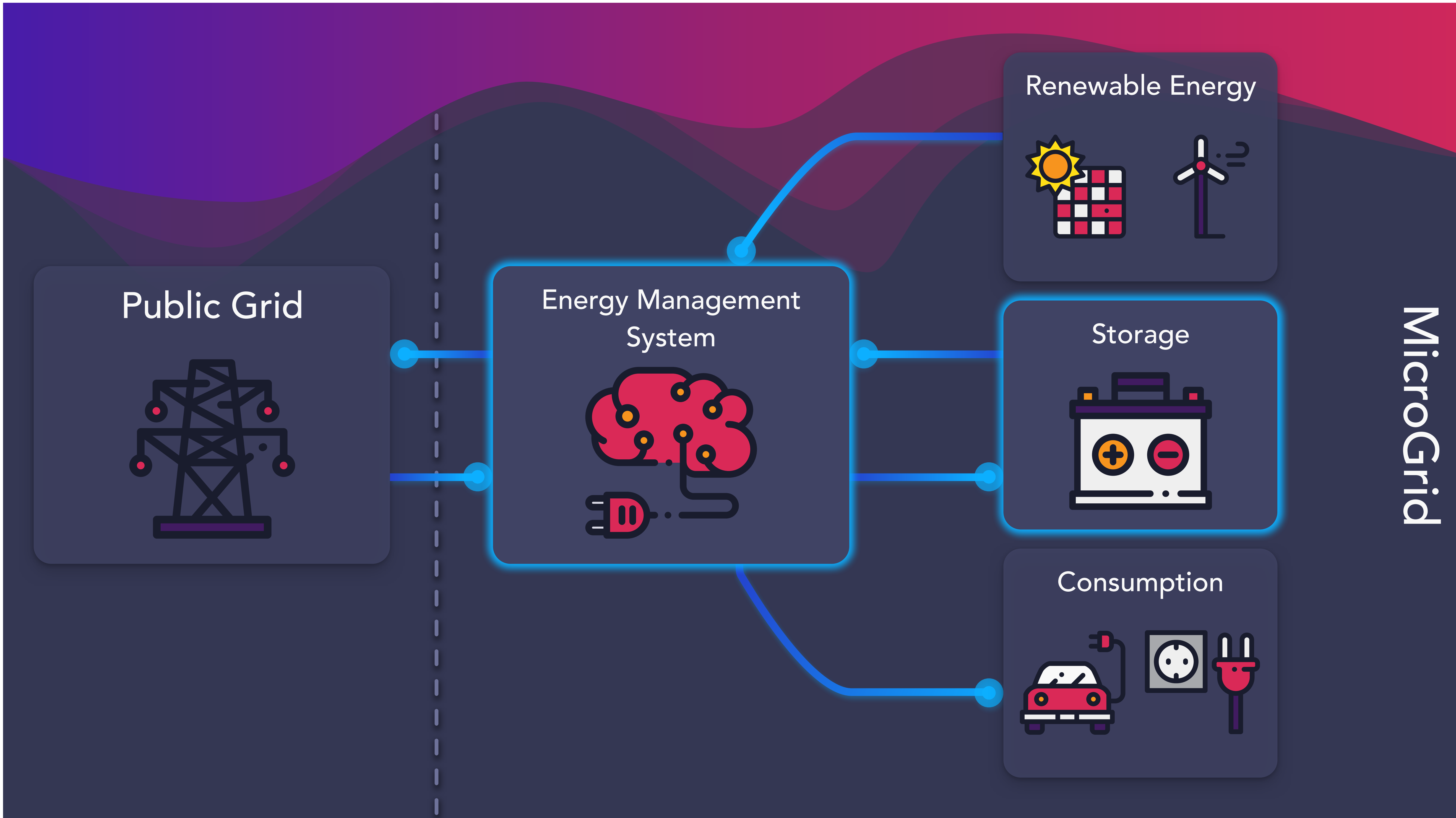
- MeryBois, a timber merchant equipped with a 60 kWp photovoltaic installation,
- MeryTherm, a company active in the thermal treatment of metals and equipped with a 200 kVA hydroelectric power station,
- CBV, active in industrial fans and consuming electricity, like the other two companies.

The site produces 1,200 MWh per year and consumes 800 MWh per year. It now features a lithium battery (capacity of 300 kWh and power of 600 kVA) and is connected to the distribution network managed by RESA via a single access point.

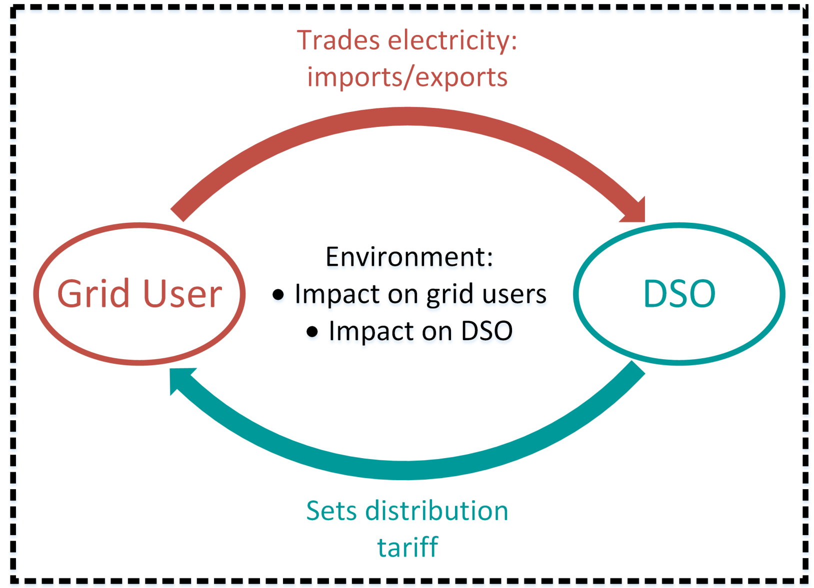
The MeryGrid project

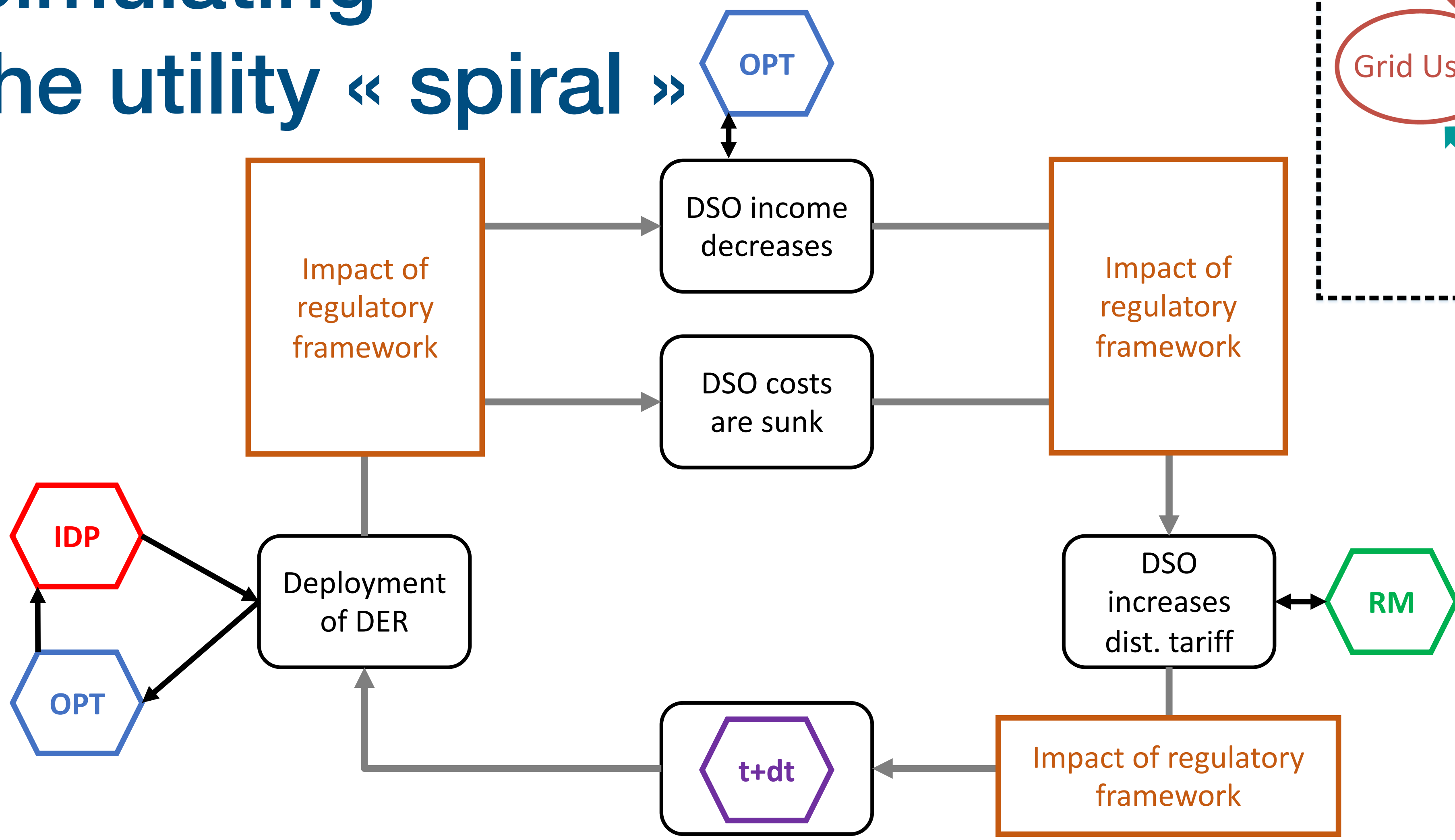


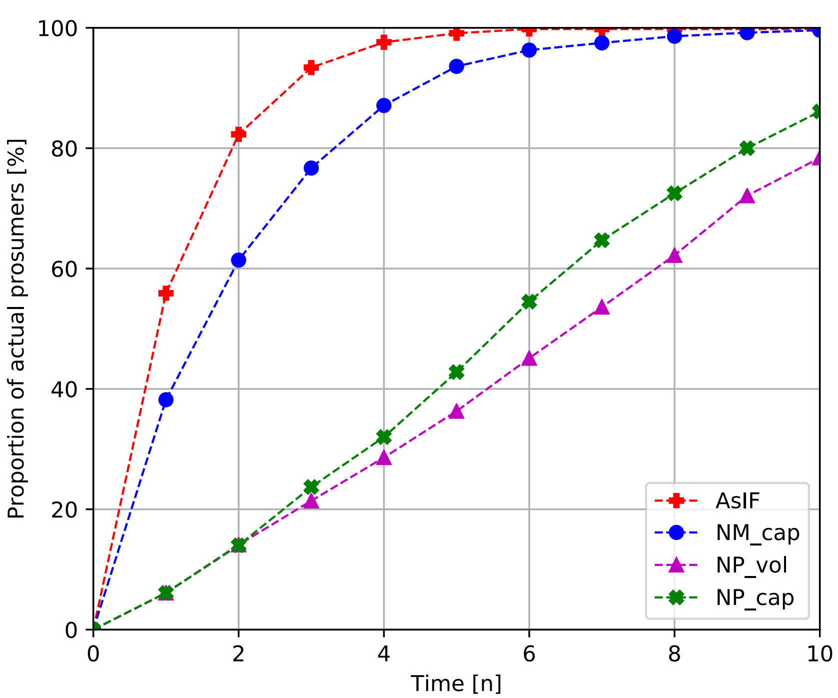
Next steps: going further with the AI integration

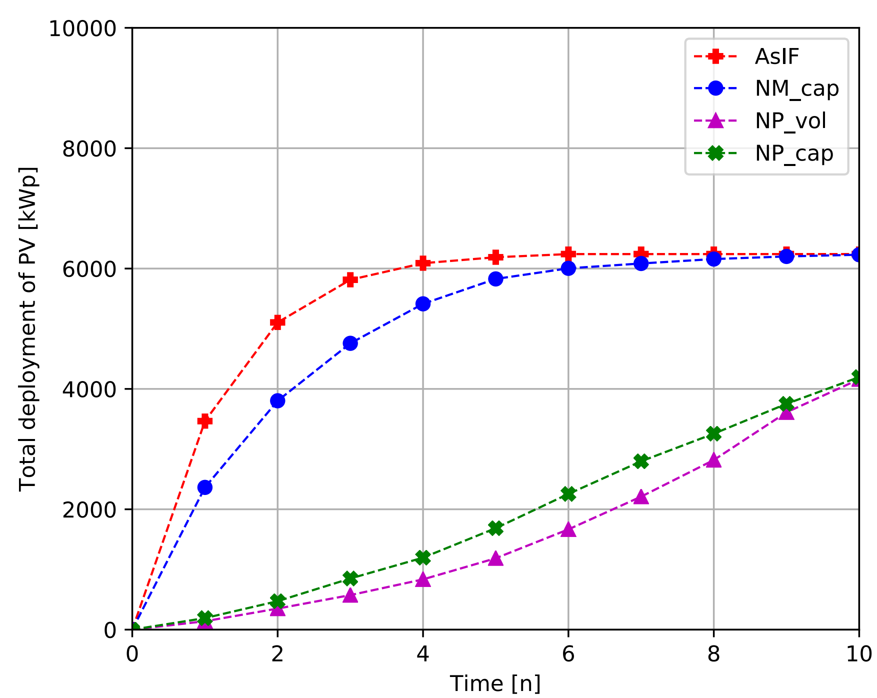


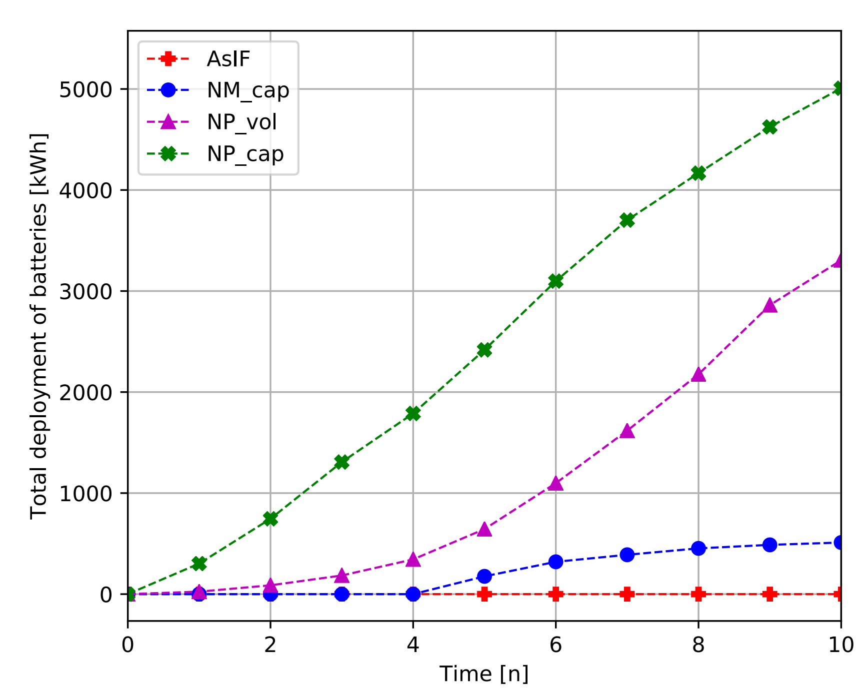
Simulating the utility « spiral »





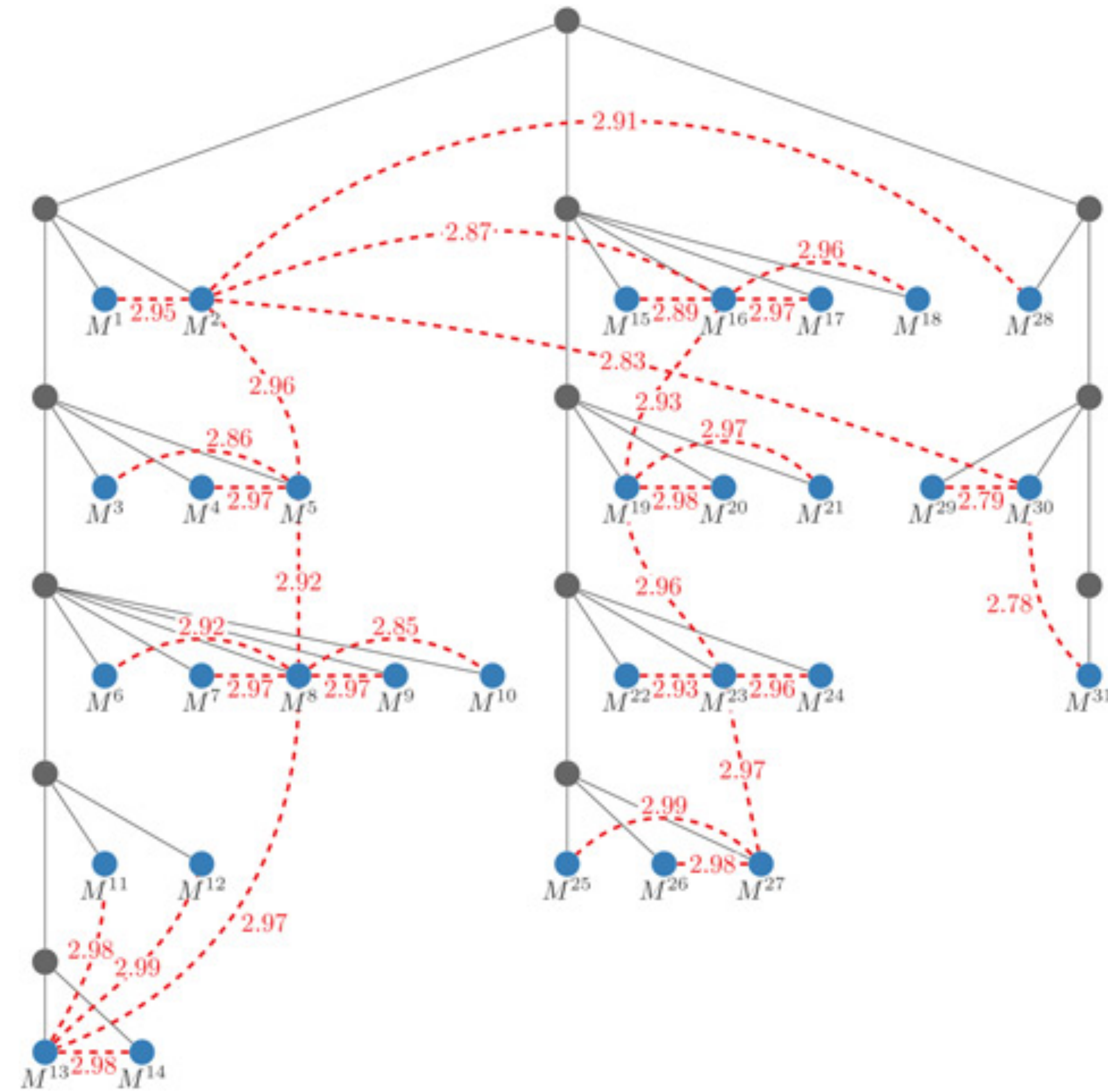


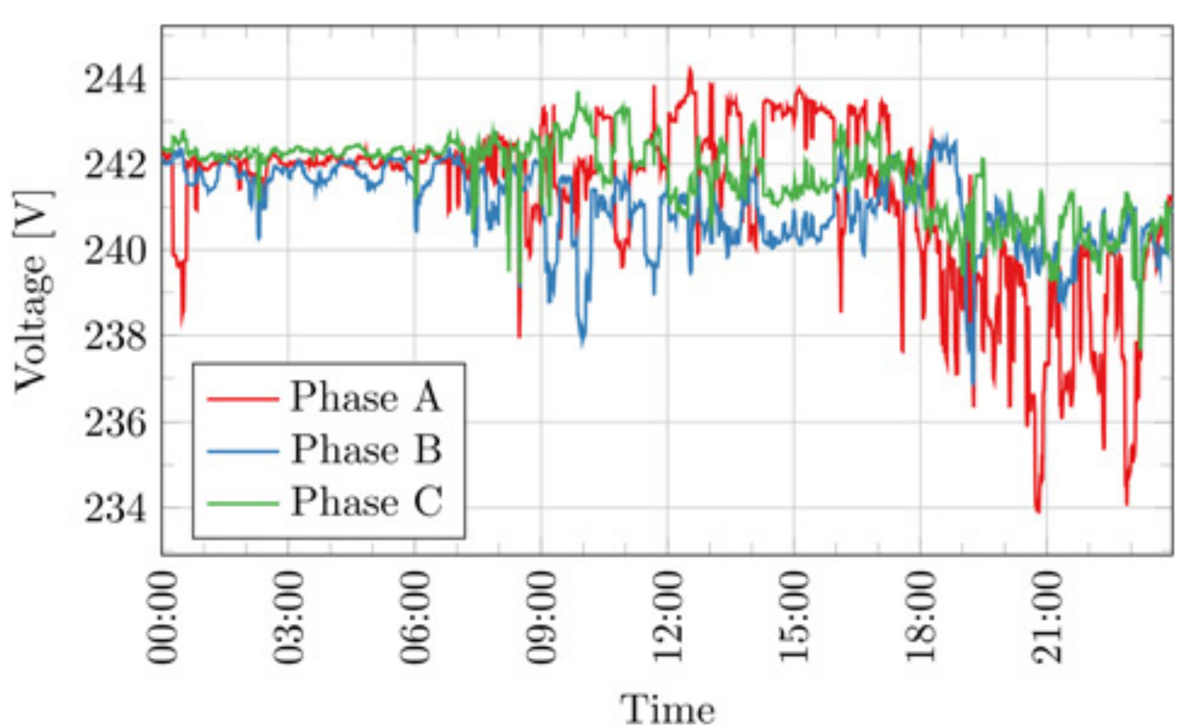


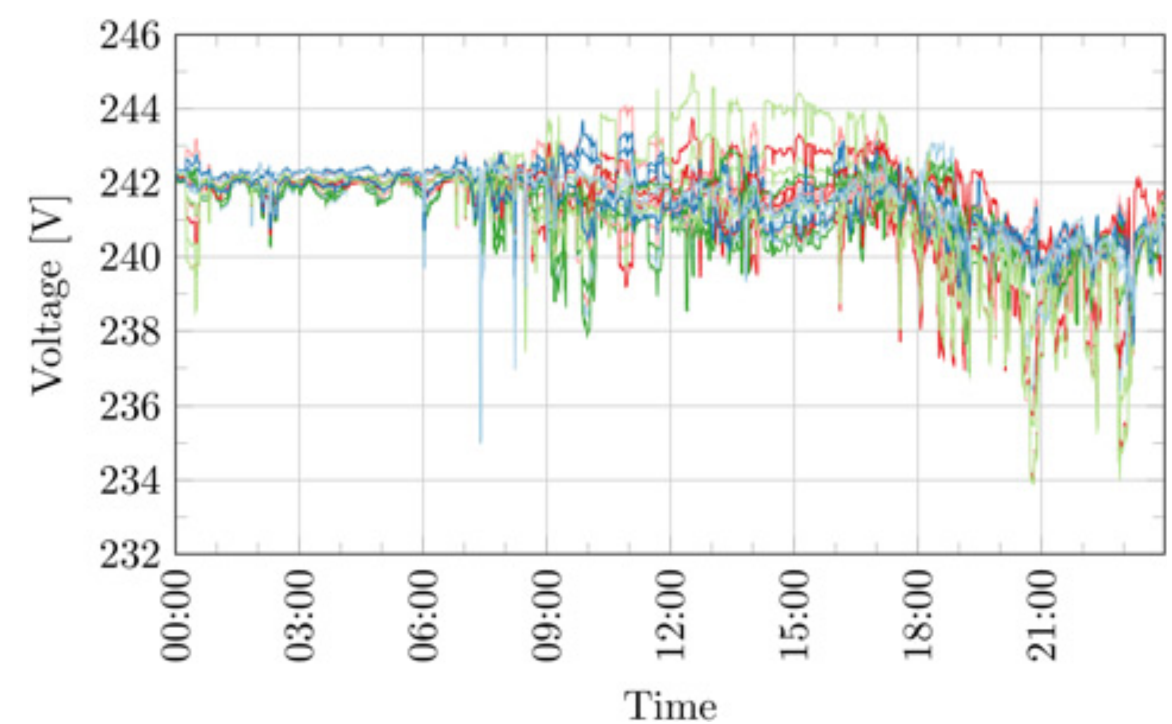


Discovering topologies

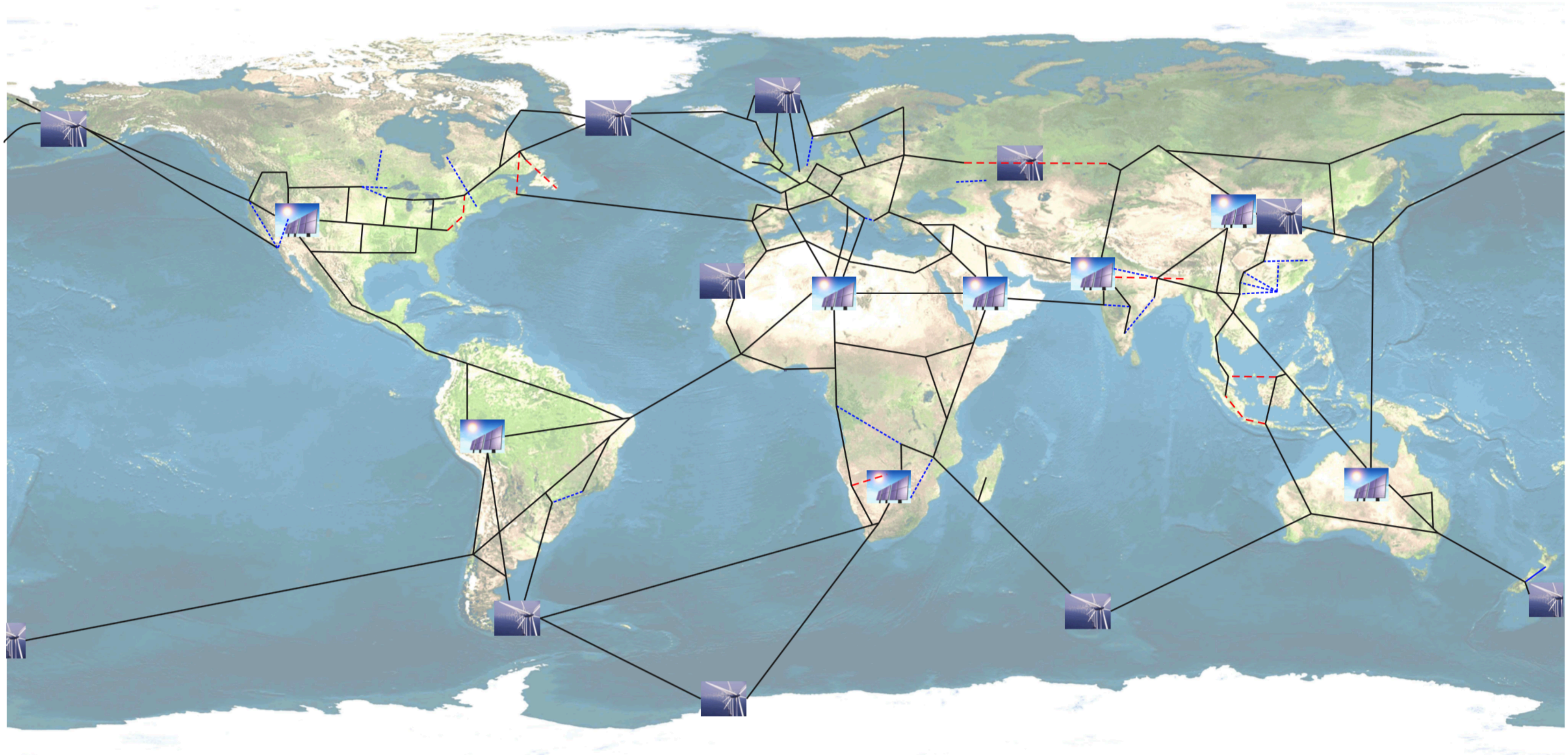
Automatic phase identification of smart meter measurement data





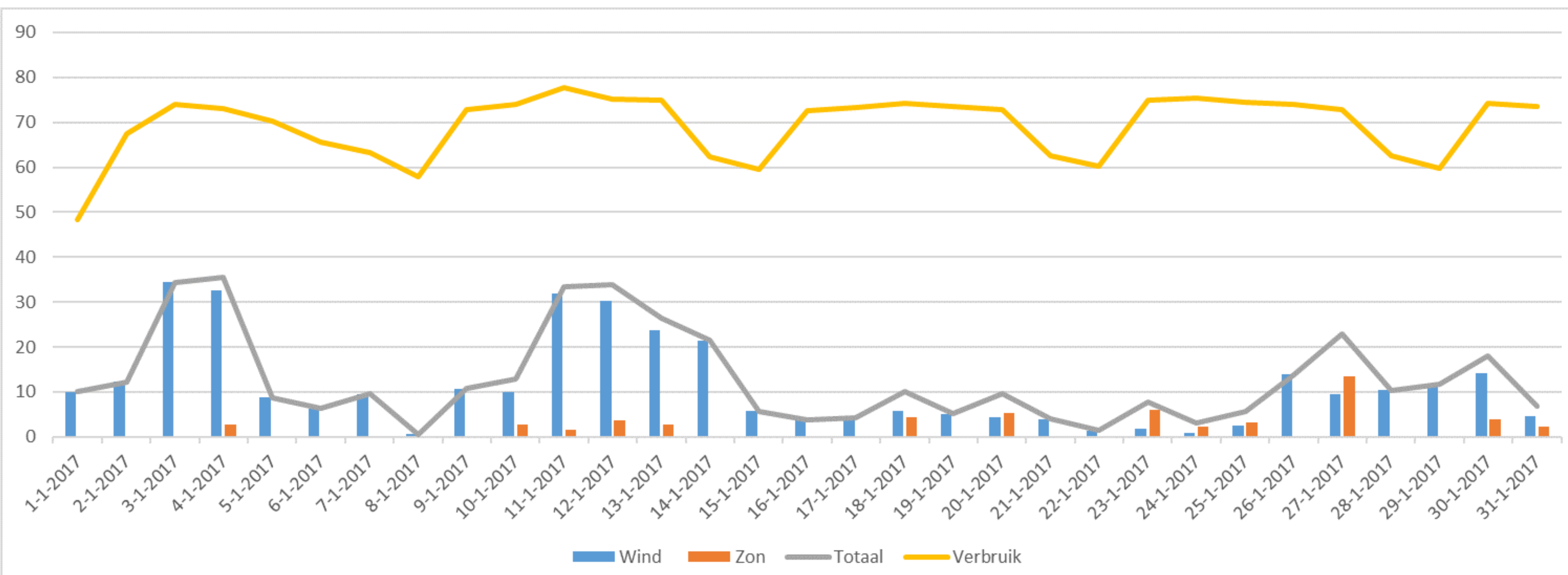


From a « macro » point of view



« Dunkelflaute »

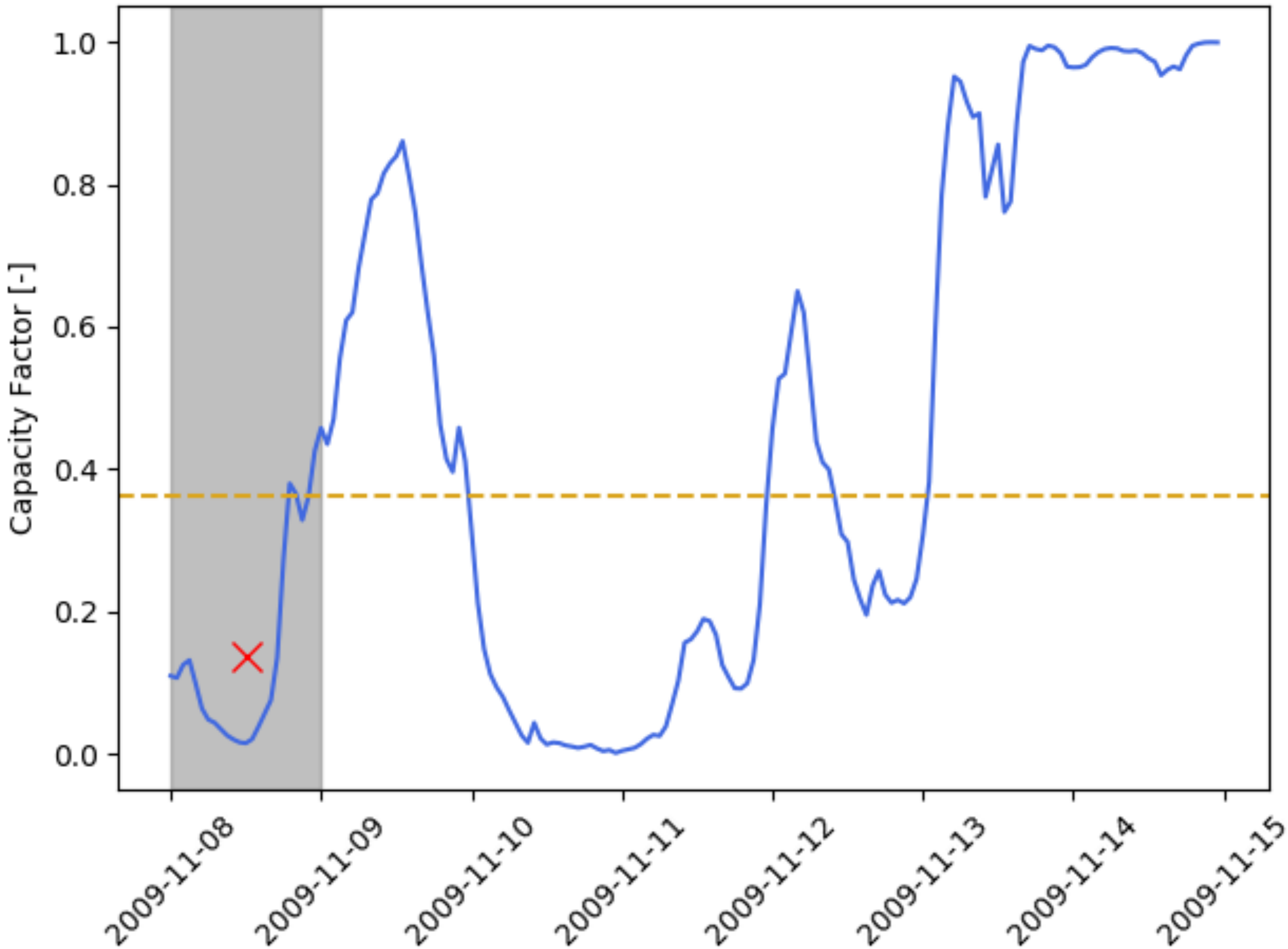
At the beginning of this research, the problem of the « Dunkelflaute », a german term for characterizing an event where there is no renewable production for a few days.
How to model it? How to avoid it?
-> Notion of « critical time windows ».

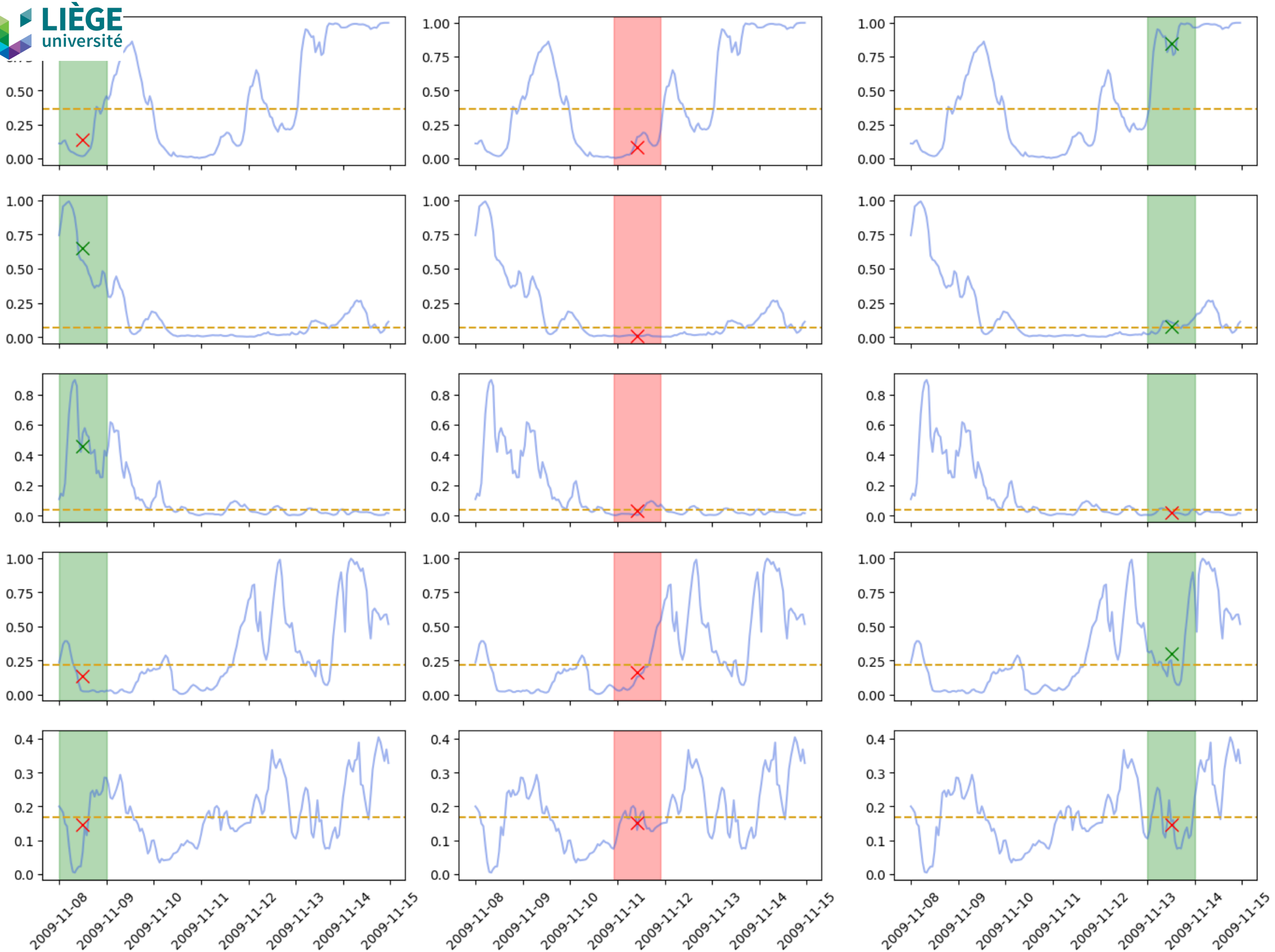


Source : WimAndersson through Wikipedia

Data: https://www.energy-charts.de

From time windows to critical time windows

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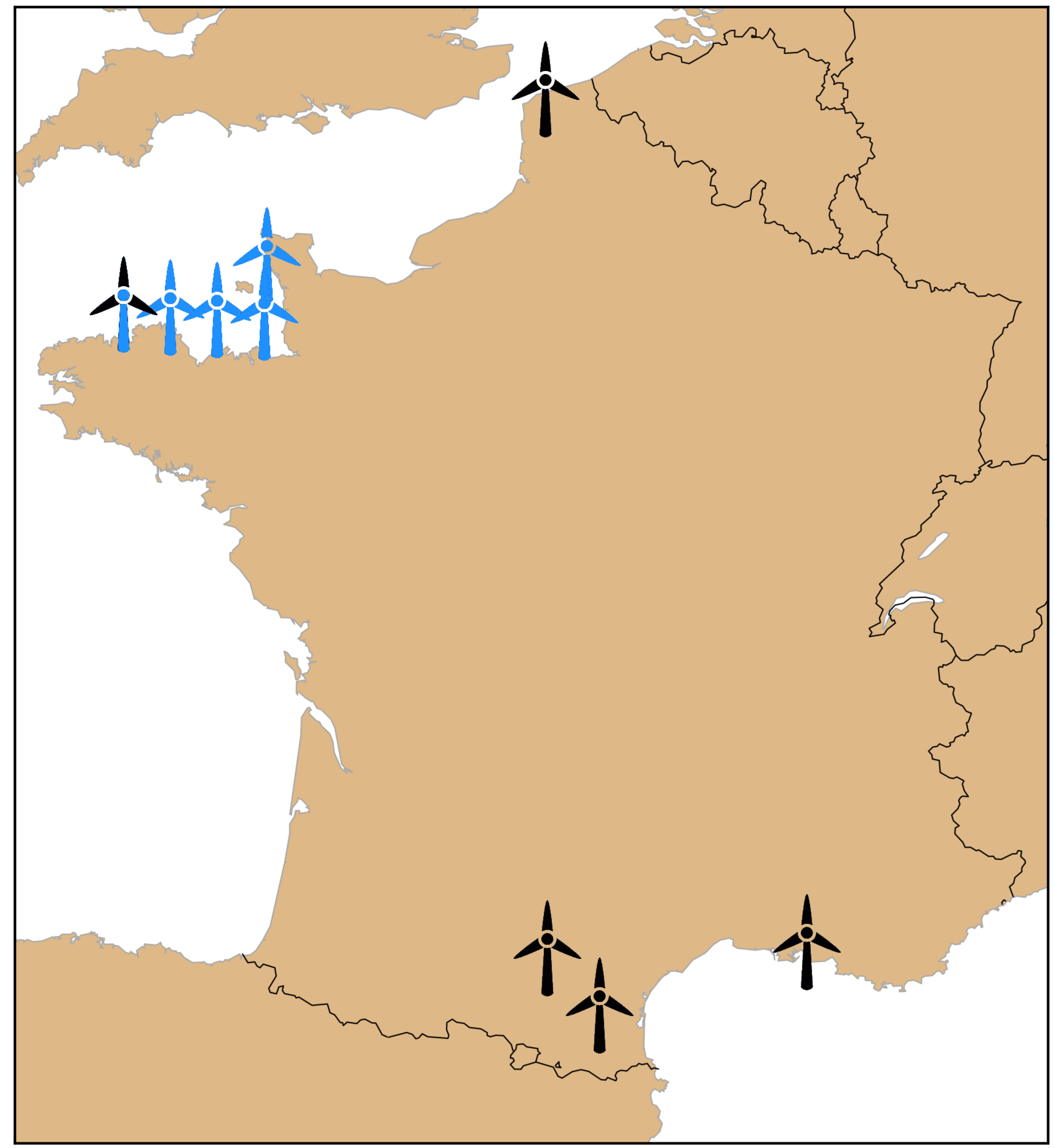
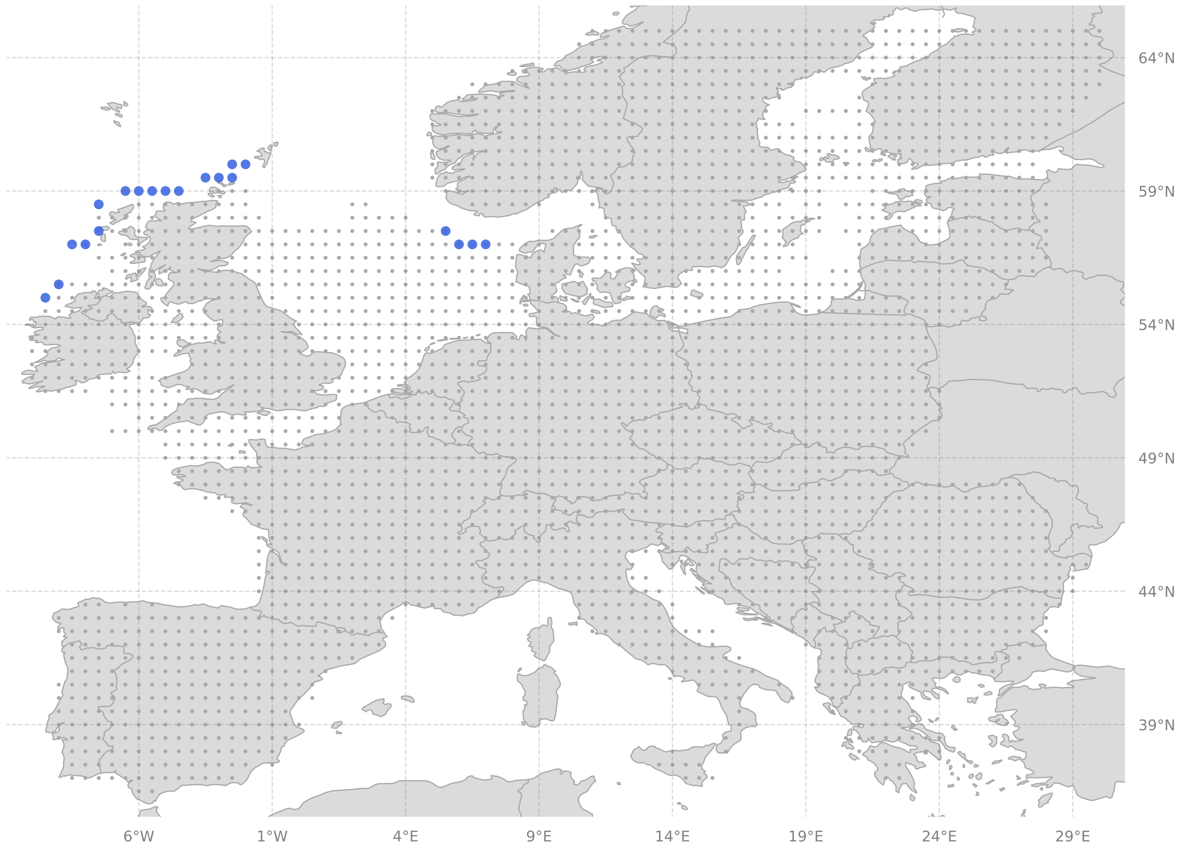
A new way to deploy generation capacities

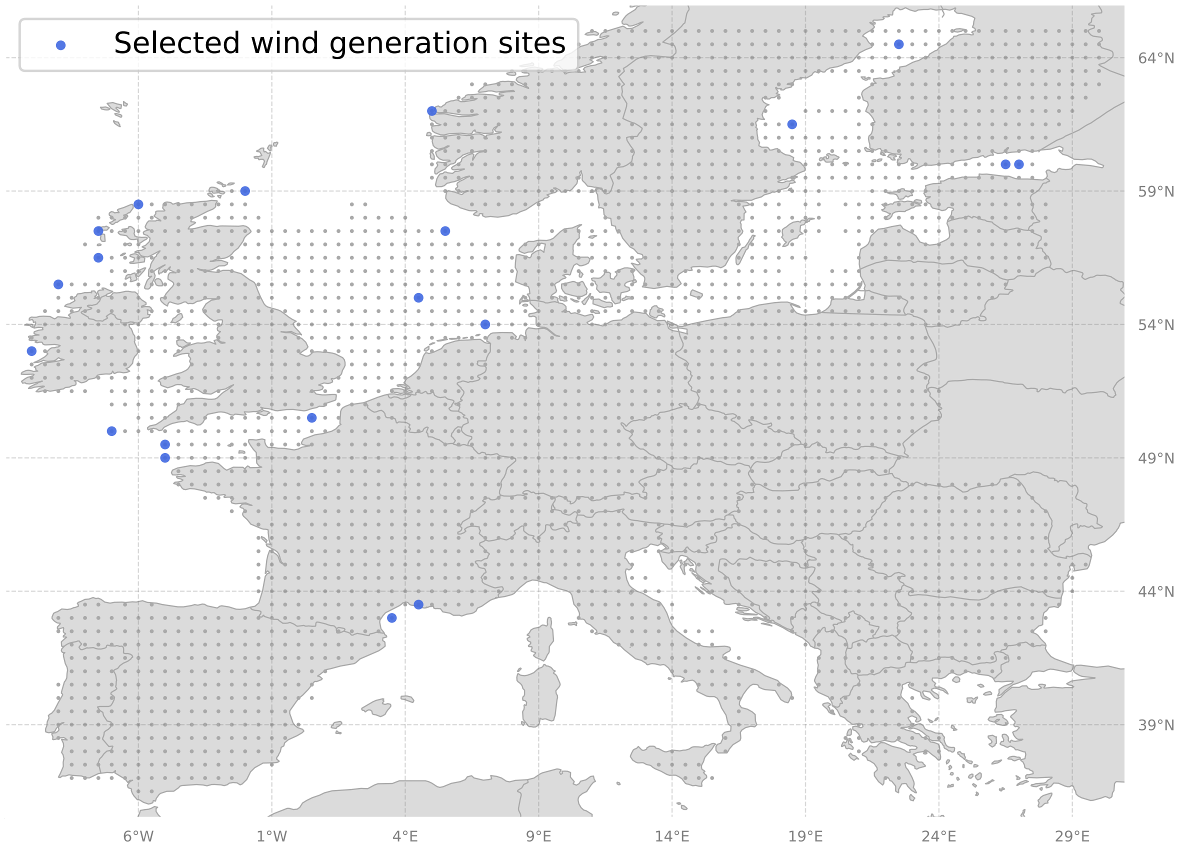
Does complementarity lead to different results than just optimizing the capacity factor?

The case of wind energy in France.

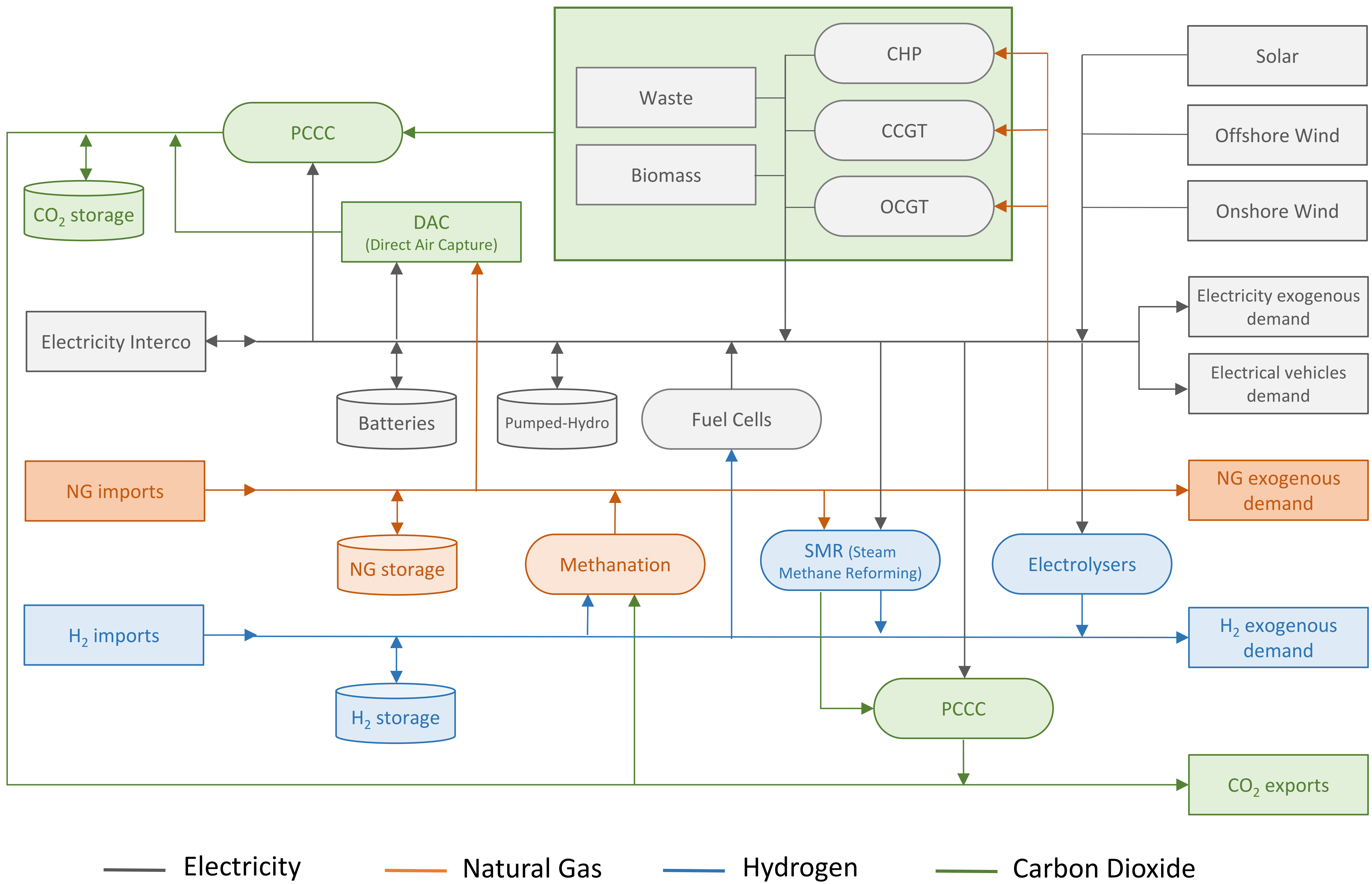


On a larger scale

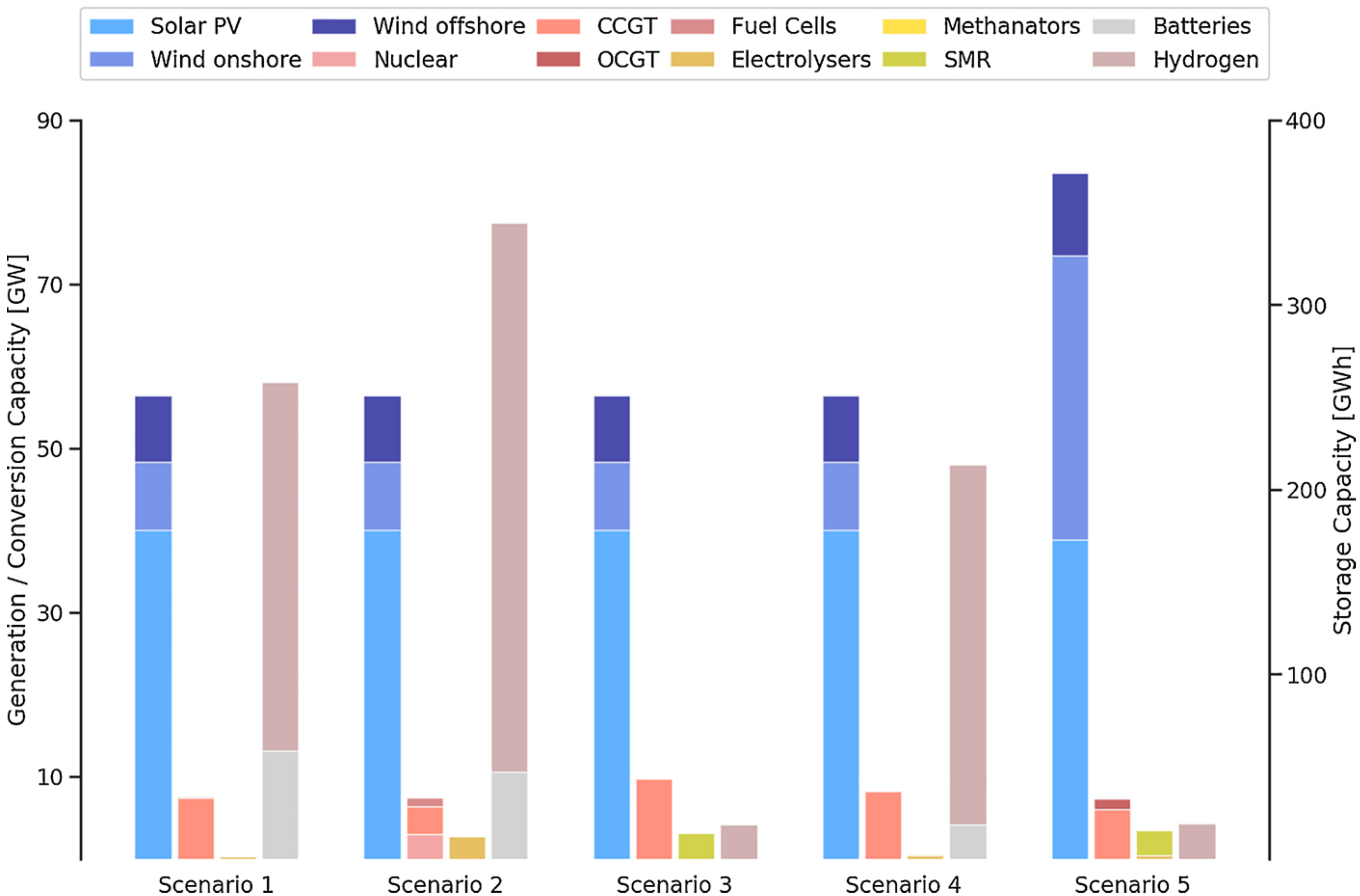




Assessing the potential of power-to-gas-to-power technologies



The Belgian Case



Post-combustion and direct air carbon capture deployments for each of the five scenarios. Figures representing capture rates are expressed in kt/h.

	S1	S2	S3	S4	S5
Technology					
OCGT	N/A	N/A	0.0	0.0	0.0
CCGT	N/A	N/A	3.07	2.55	1.84
CHP	N/A	N/A	0.31	0.13	0.13
Biomass	N/A	N/A	0.0	0.0	0.0
Waste	N/A	N/A	0.08	0.08	0.08
SMR	N/A	N/A	0.71	0.03	0.69
Direct Air CC	N/A	N/A	N/A	1.90	1.60

System-wide and electricity (E), natural gas (NG), hydrogen (H_2) and carbon dioxide (CO_2) sub-system costs associated with the five considered scenarios. Carbon dioxide costs are reported without energy-related expenses.

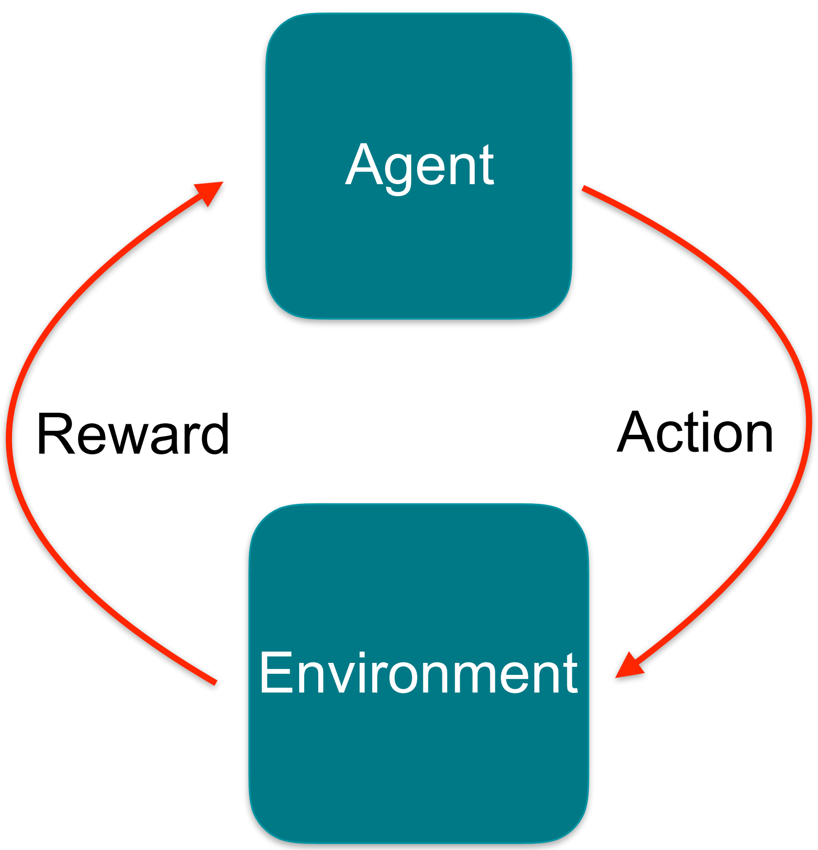
	Unit	S1	S2	S3	S4	S5
System	b€/year	67.1	50.8	41.2	14.7	9.6
E	€/MWh	67.1	52.4	40.8	46.0	45.6
NG	€/MWh	11.6	11.7	11.8	12.0	12.0
H_2	€/MWh	164.3	146.8	25.0	163.0	24.9
CO_2	€/t	N/A	N/A	35.1	49.2	46.6

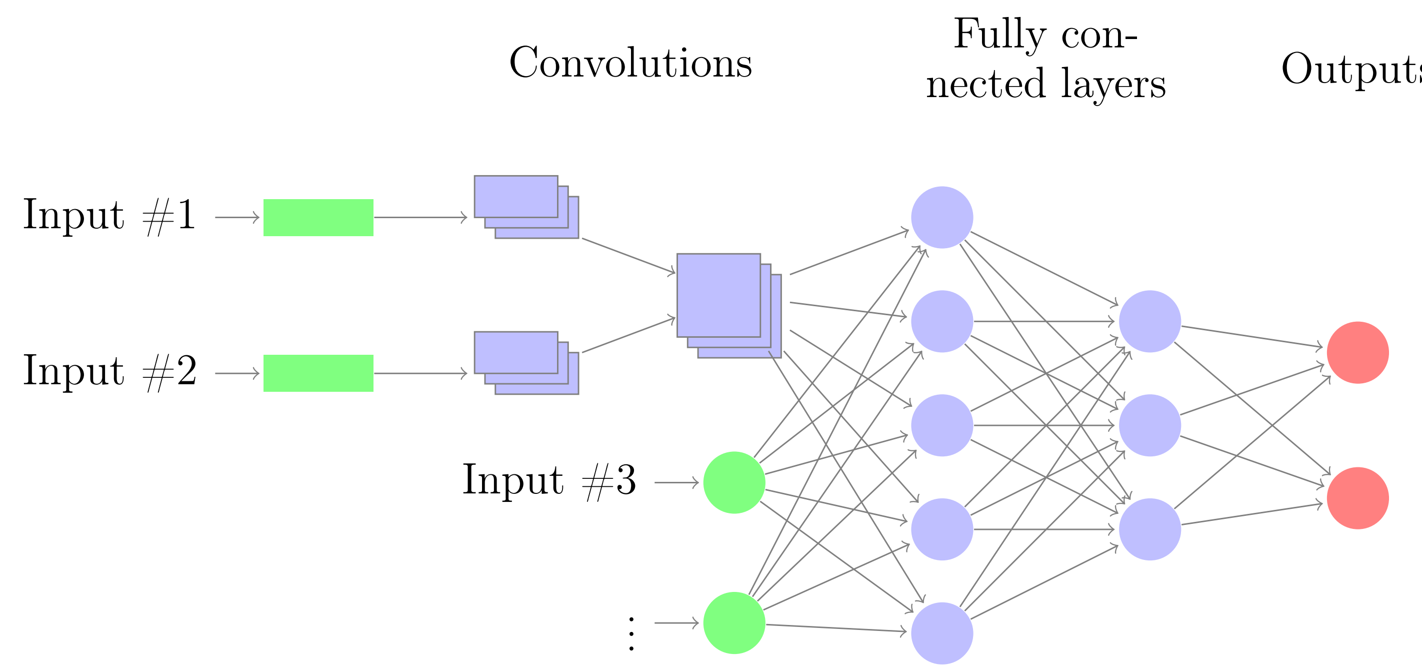
Import and energy not served (ENS) volumes of electricity (E), natural gas (NG) and hydrogen (H_2) across the five considered scenarios (TWh).

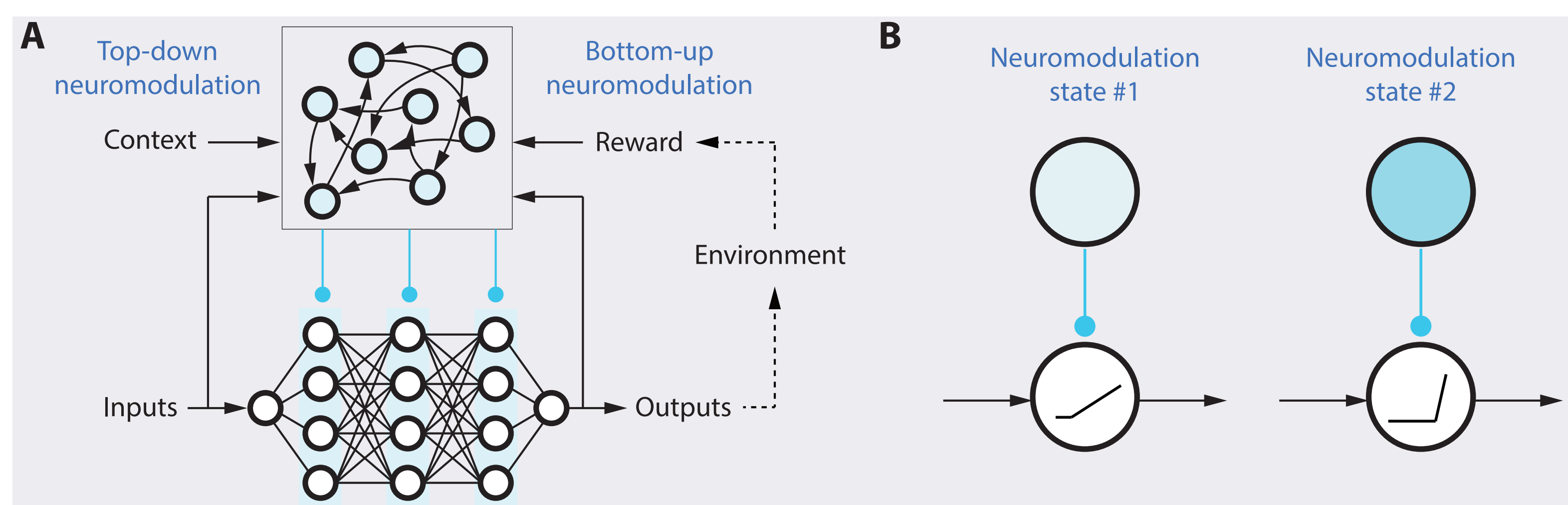
		S1	S2	S3	S4	S5
E	Imports	57.2	57.2	57.2	57.2	57.2
	ENS	0.0	0.0	0.0	0.0	0.0
	Curtailment	1.7	3.4	18.6	8.3	94.7
NG	Imports	365.8	365.8	855.4	1124.6	1124.5
	ENS	545.6	390.8	347.1	0.0	0.0
H_2	Imports	128.7	120.8	0.5	127.9	0.1
	ENS	2.0	1.9	0.0	0.1	0.0

« Deeper » deep RL and other applications

$$\forall (s,a) \in \mathcal{S} \times \mathcal{A},$$
$$Q^*(s,a) = \sum_{s' \in \mathcal{S}} T(s,a,s') \left[R(s,a,s') + \gamma J^*(s') \right]$$







Valorising flexibility; bidding on day-ahead and intra-day markets using storage capacities; investigating the potential of distributed ledgers, …

A few references

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- From electricity, to sector coupling, using AI

Our goal

Developing **AI solutions** for the future of our energy systems.