

energy systems of the future

INESCTEC

FEUP Main Auditorium

May 29 ○ 14h00

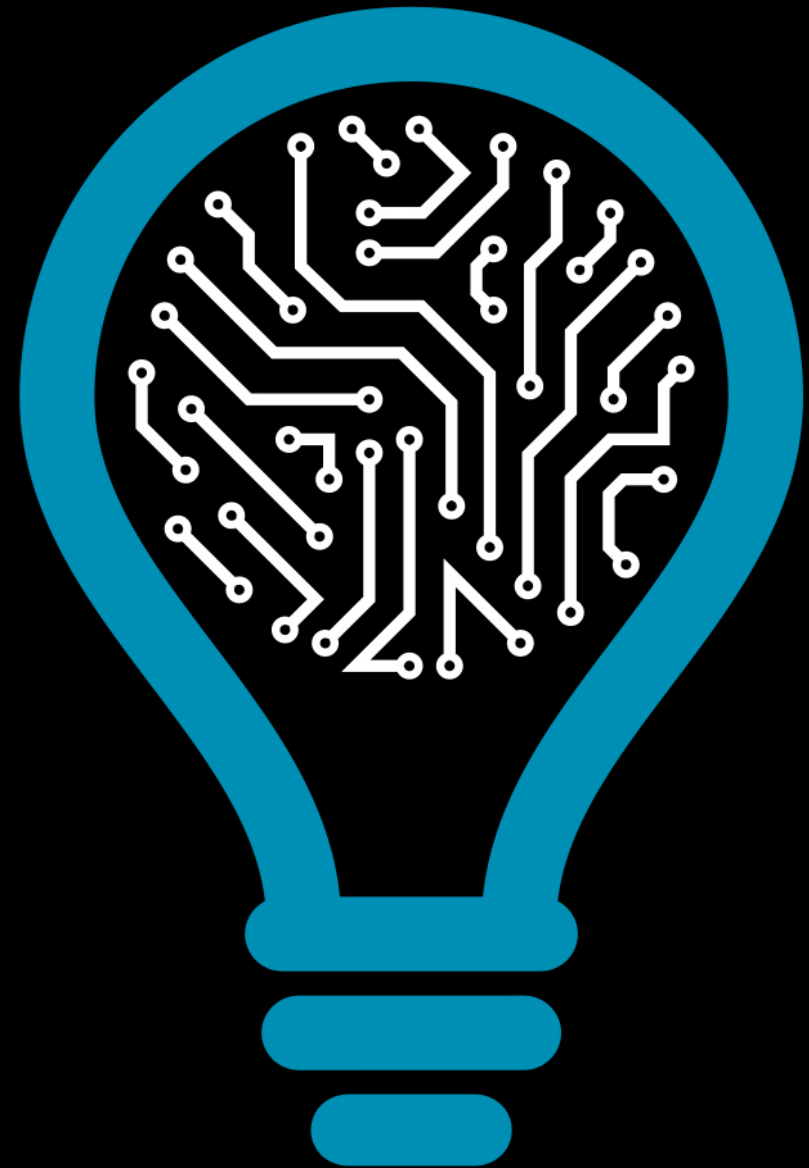


Electrification of energy systems: There shall be only one.

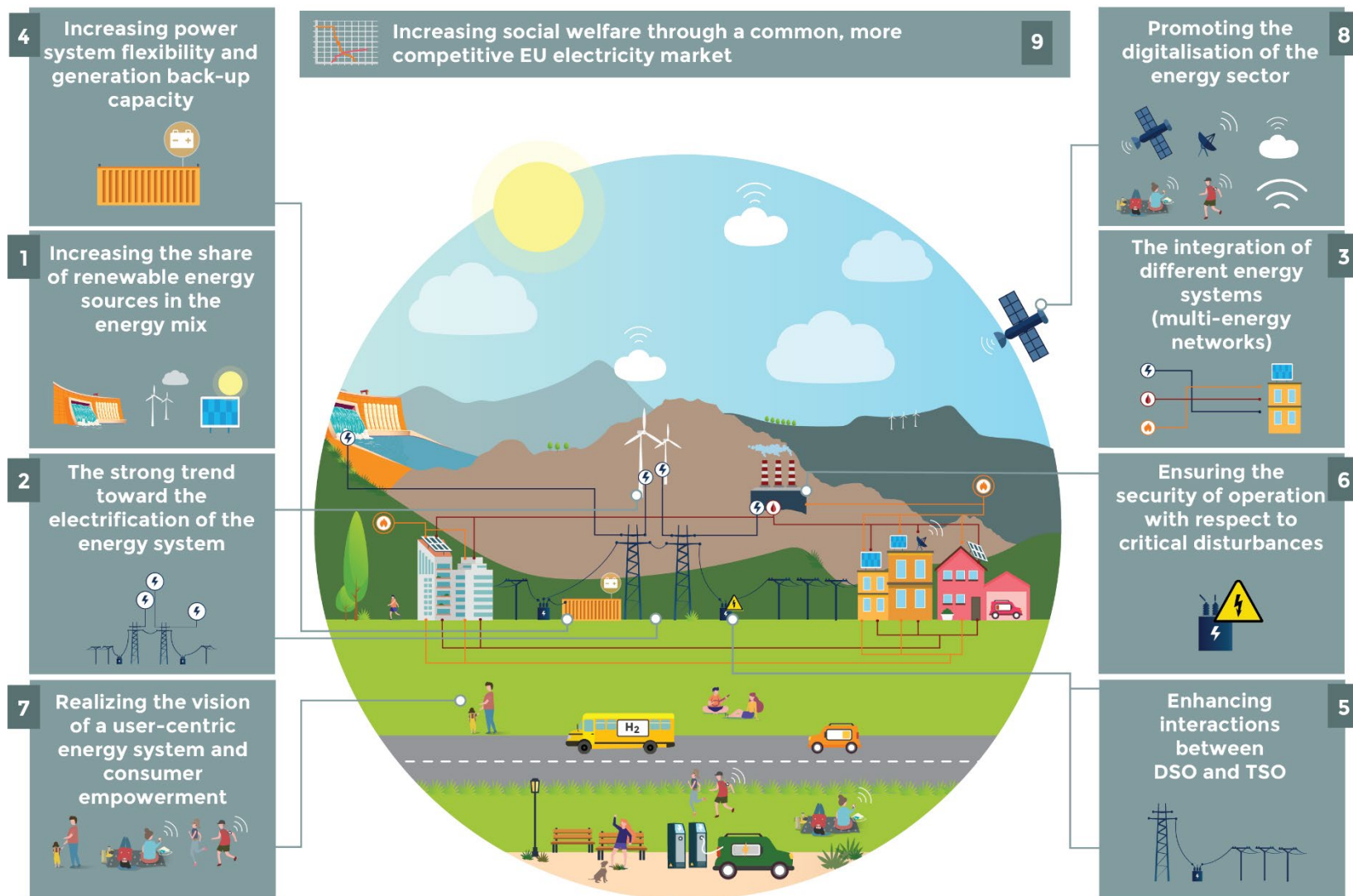
Filipe Joel Soares, fsoares@inesctec.pt

Energy Systems of the Future, FEUP, Porto

29th May 2019



The bright future



Electricity Network



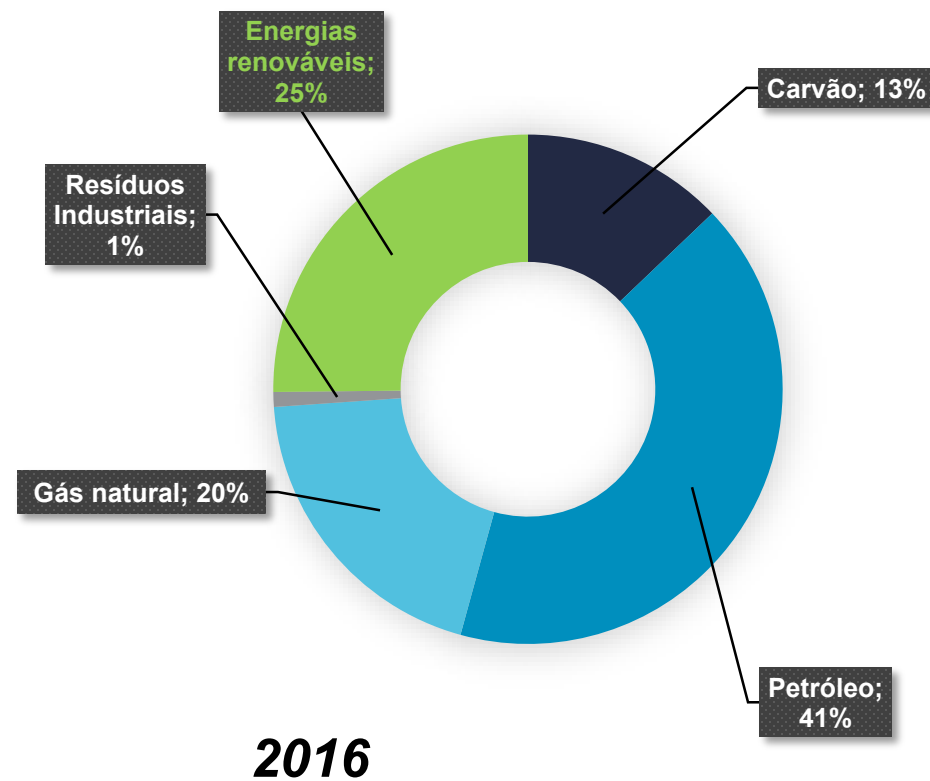
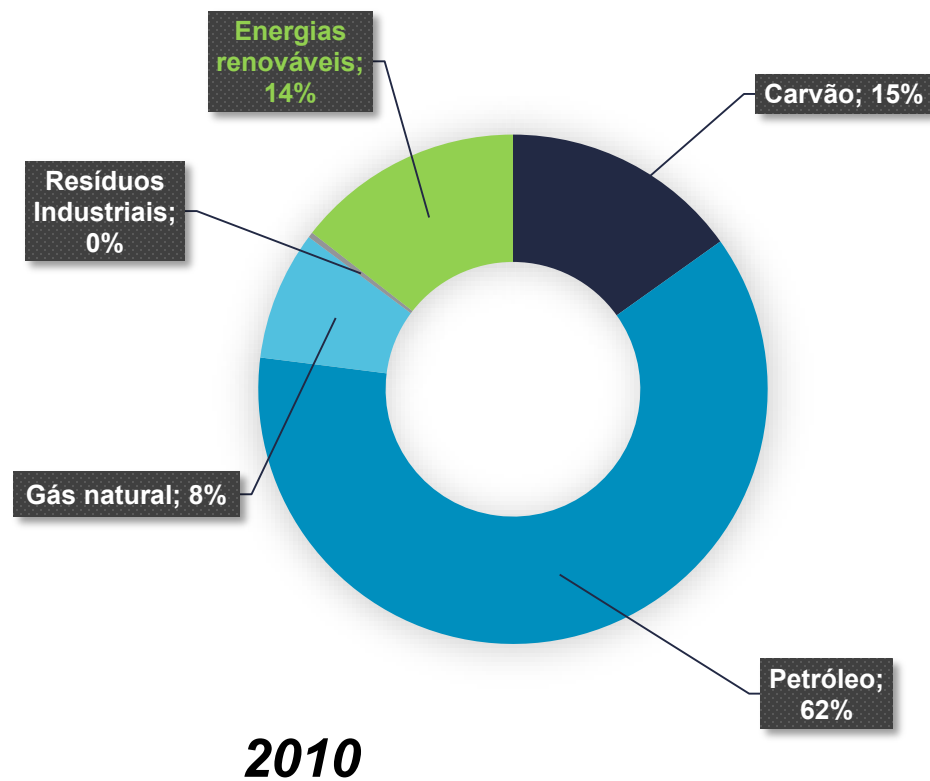
District Heating and Cooling Network



Gas Network



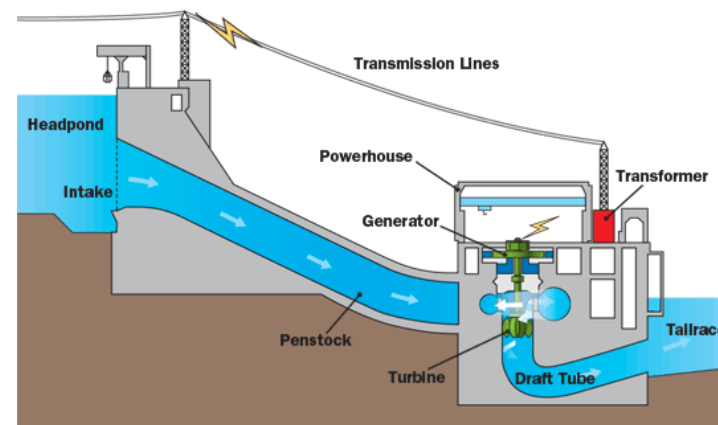
We're getting there, taking baby steps



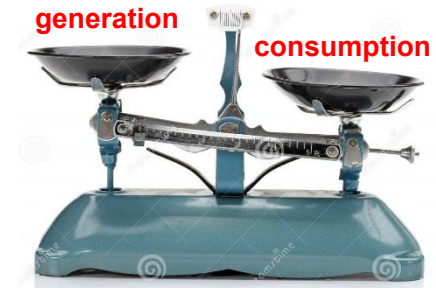
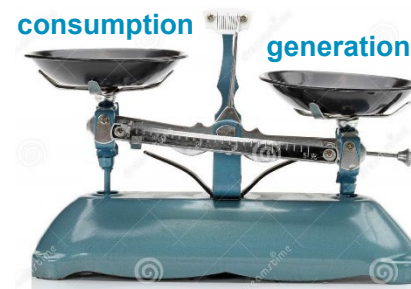
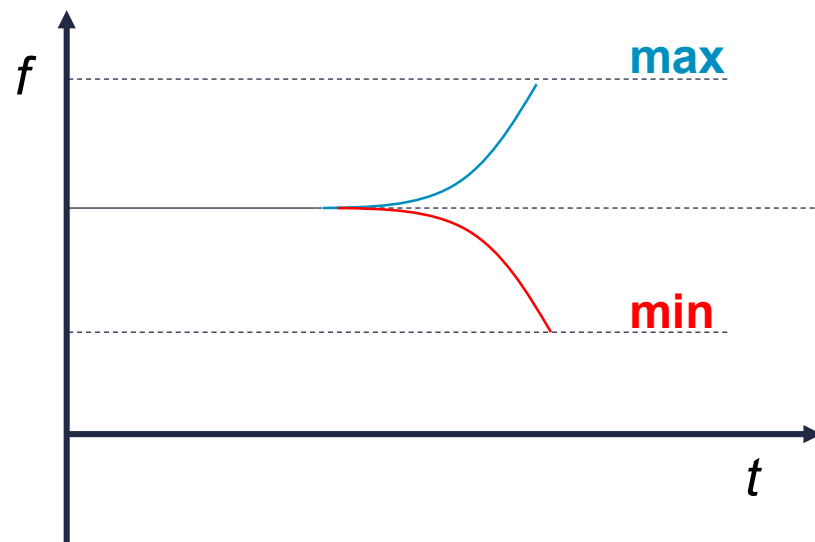
But there's a big challenge ahead



300 000 km/s



<https://giphy.com/gifs/from-power-plant-EcGEZwBJlbUFS>

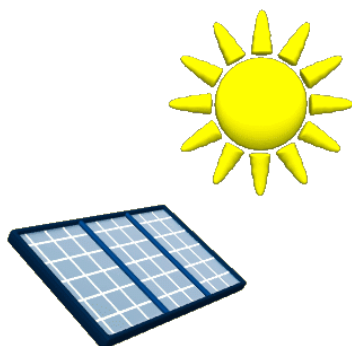


<https://www.dreamstime.com/classic-balance-weight-balance-classic-balance-weight-background-image124474119>

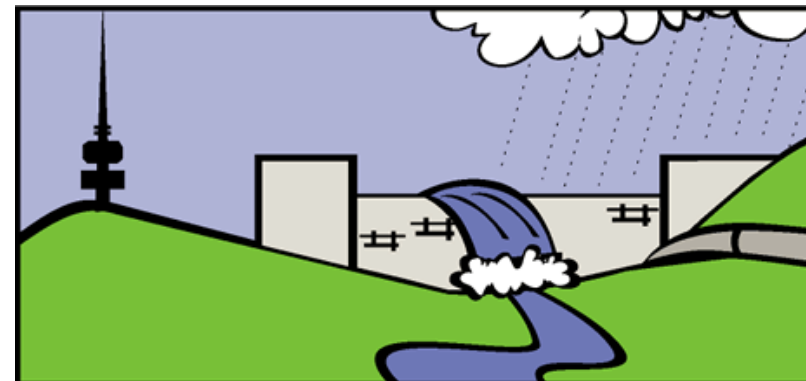
Is it a really big challenge?



<https://gifer.com/en/3lGf>



<https://scubasanmateo.com/explora/solar-panel-clipart-animated-gif/>

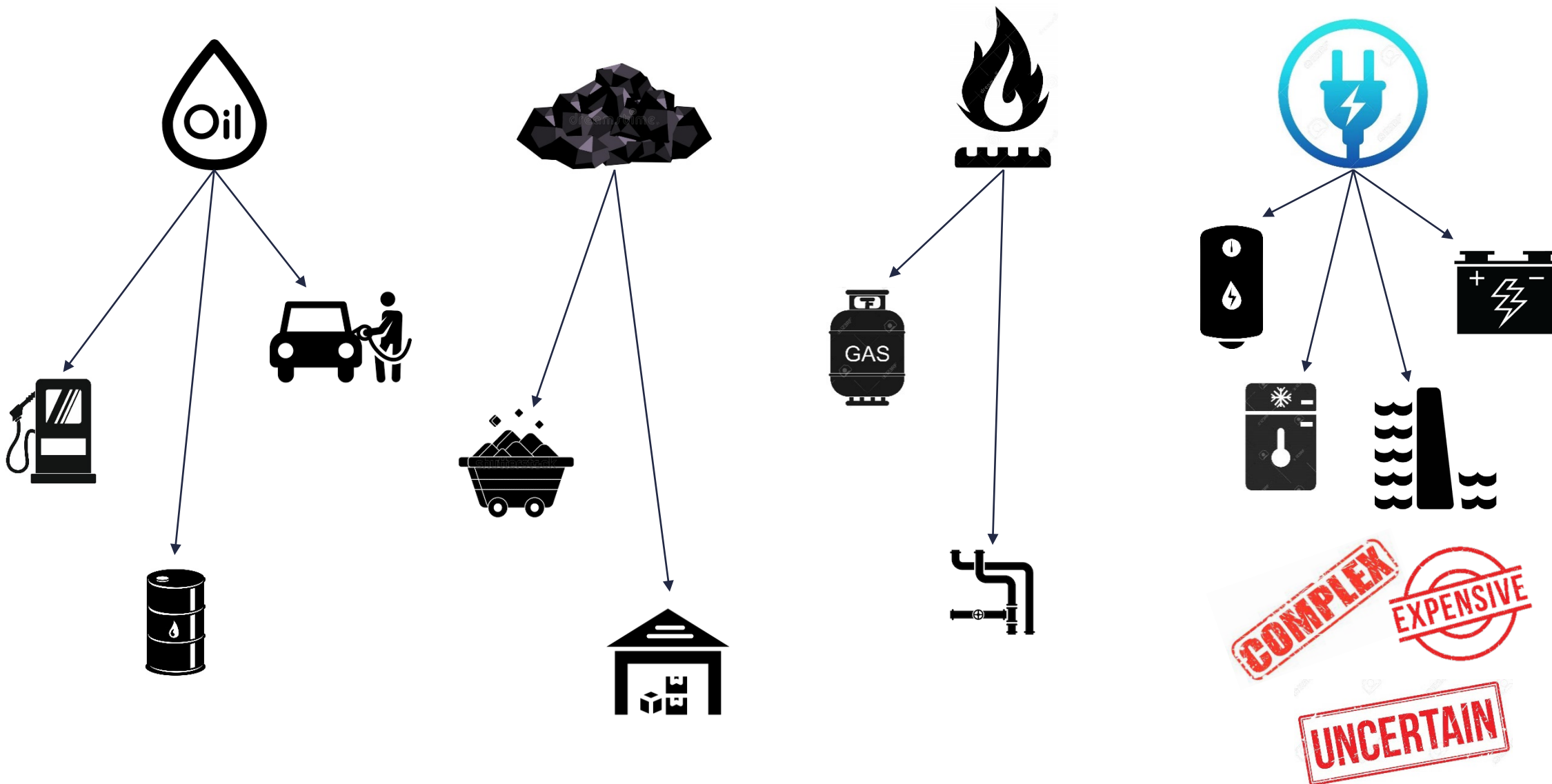


<http://energysourcesrightinyouhands.weebly.com/hydro-energy.html>

Too much → easy, just curtail

Too less → easy, just use stored energy

We need to store more energy





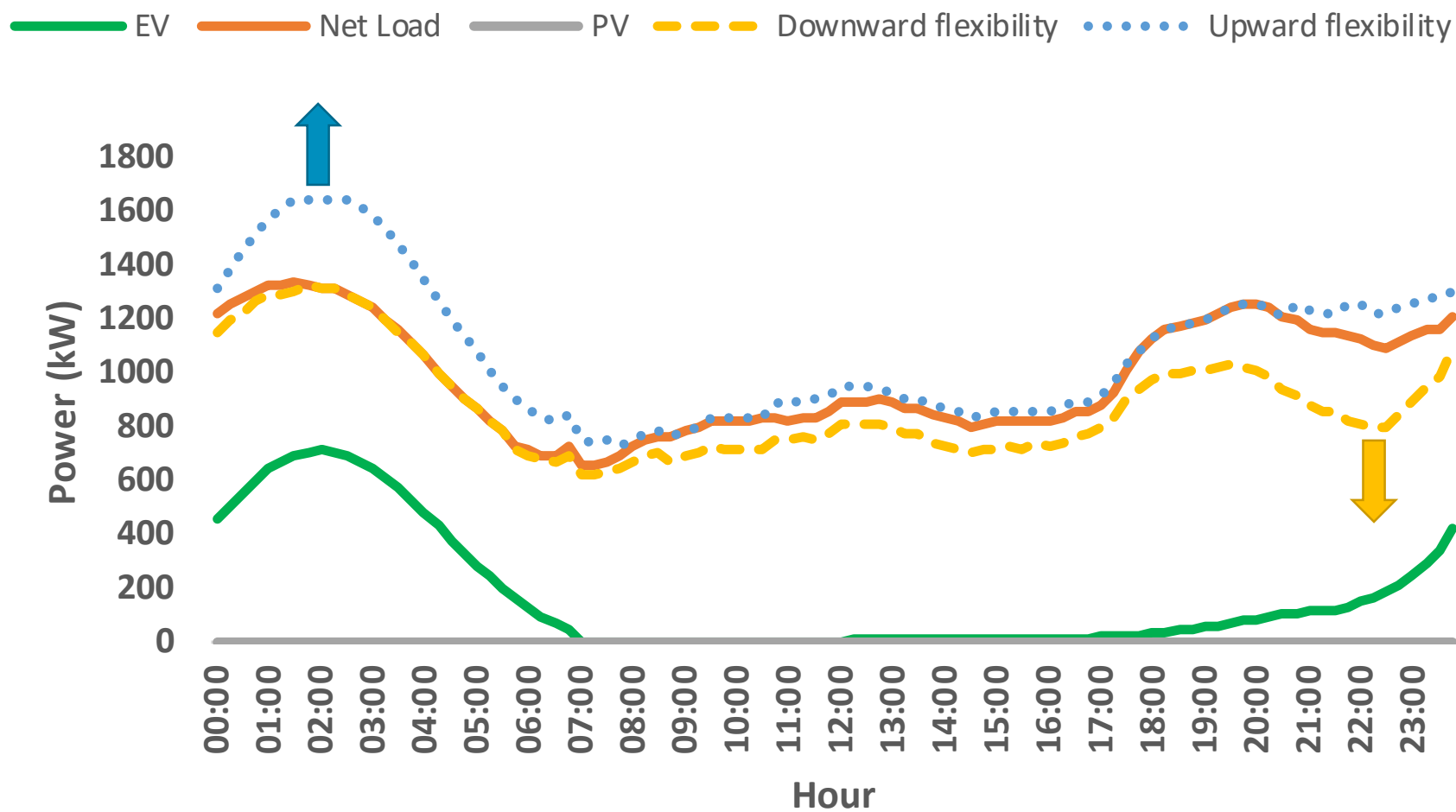
Flexibility is fashion

- The ability that a Distributed Energy Resource (DER) has to change its operating point (level of power consumption/injection) according to a set point received from a controller, without compromising its functionality.

Notes:

- DER includes all types of resources in electricity networks whose power consumption/injection can be controlled (e.g. electric vehicles, PV, storage, controllable loads, etc.).
- There are two types of controllers: market related controller (e.g. retailers and aggregators) and network related controller (e.g. DSOs and TSOs).
- “DER functionality” refers to the fulfilment of the equipment purpose according to its owner requirements.

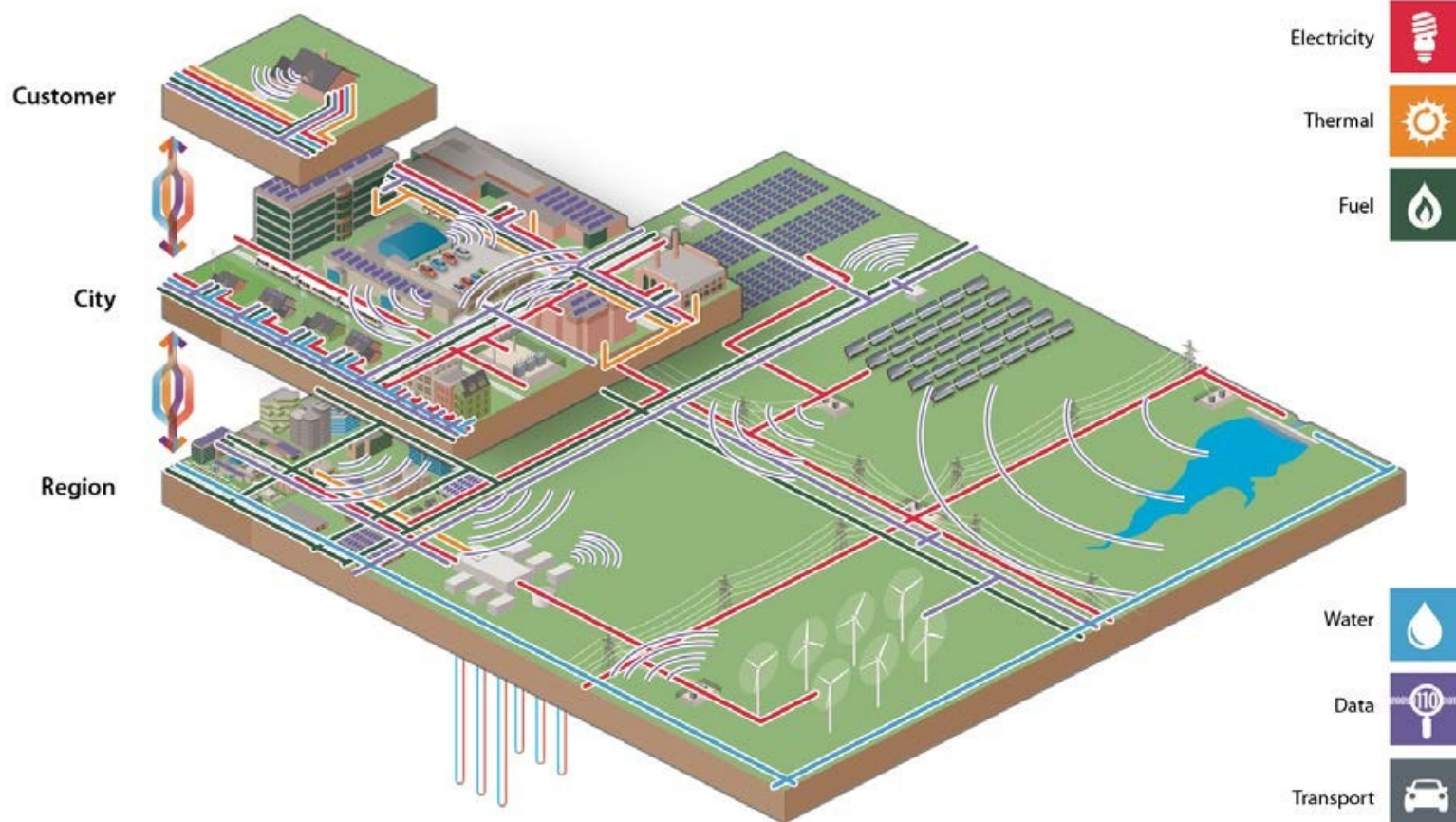
Flexibility is fashion



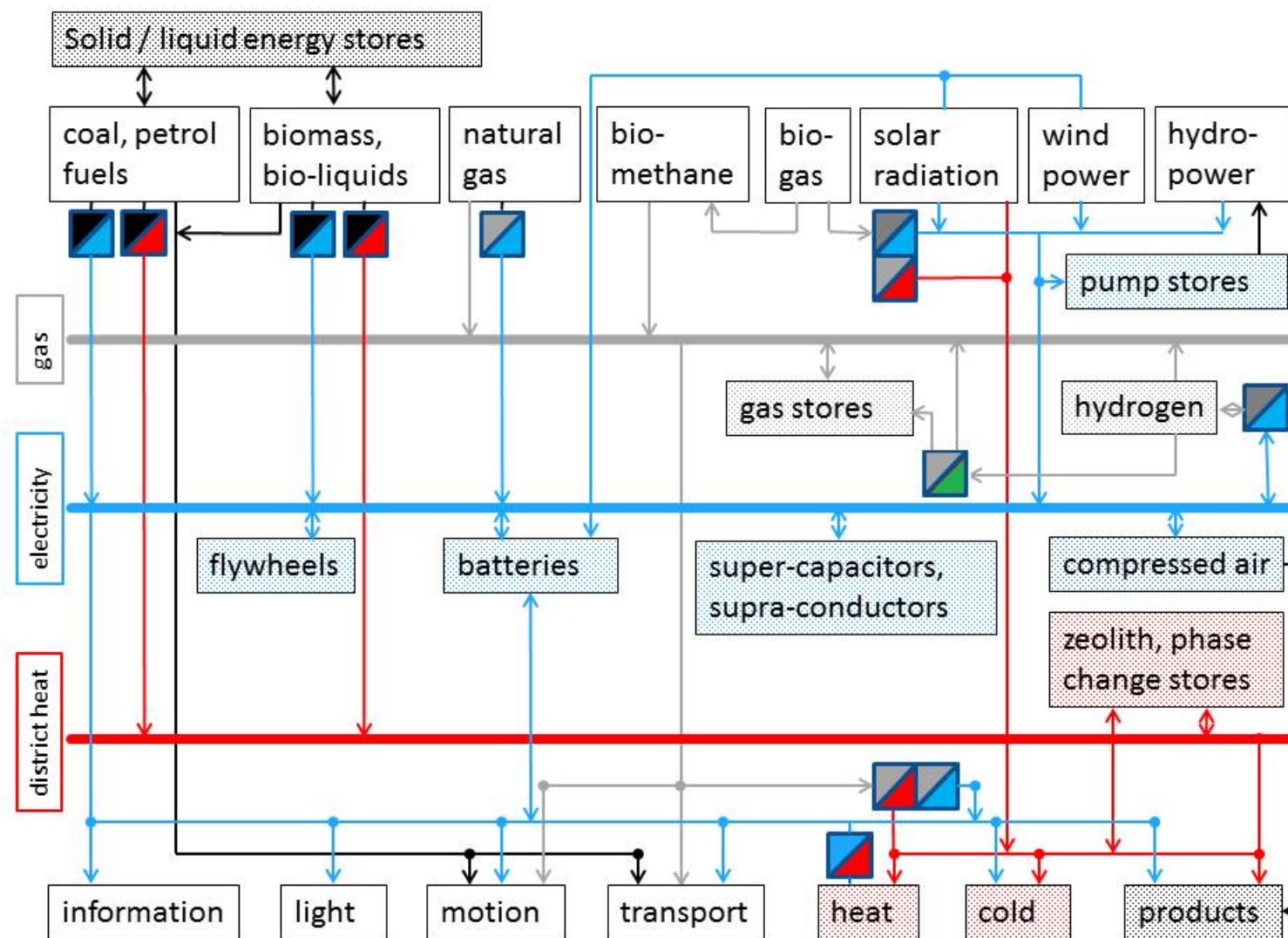


Multi-energy systems (MES) and networks (MEN) to increase flexibility

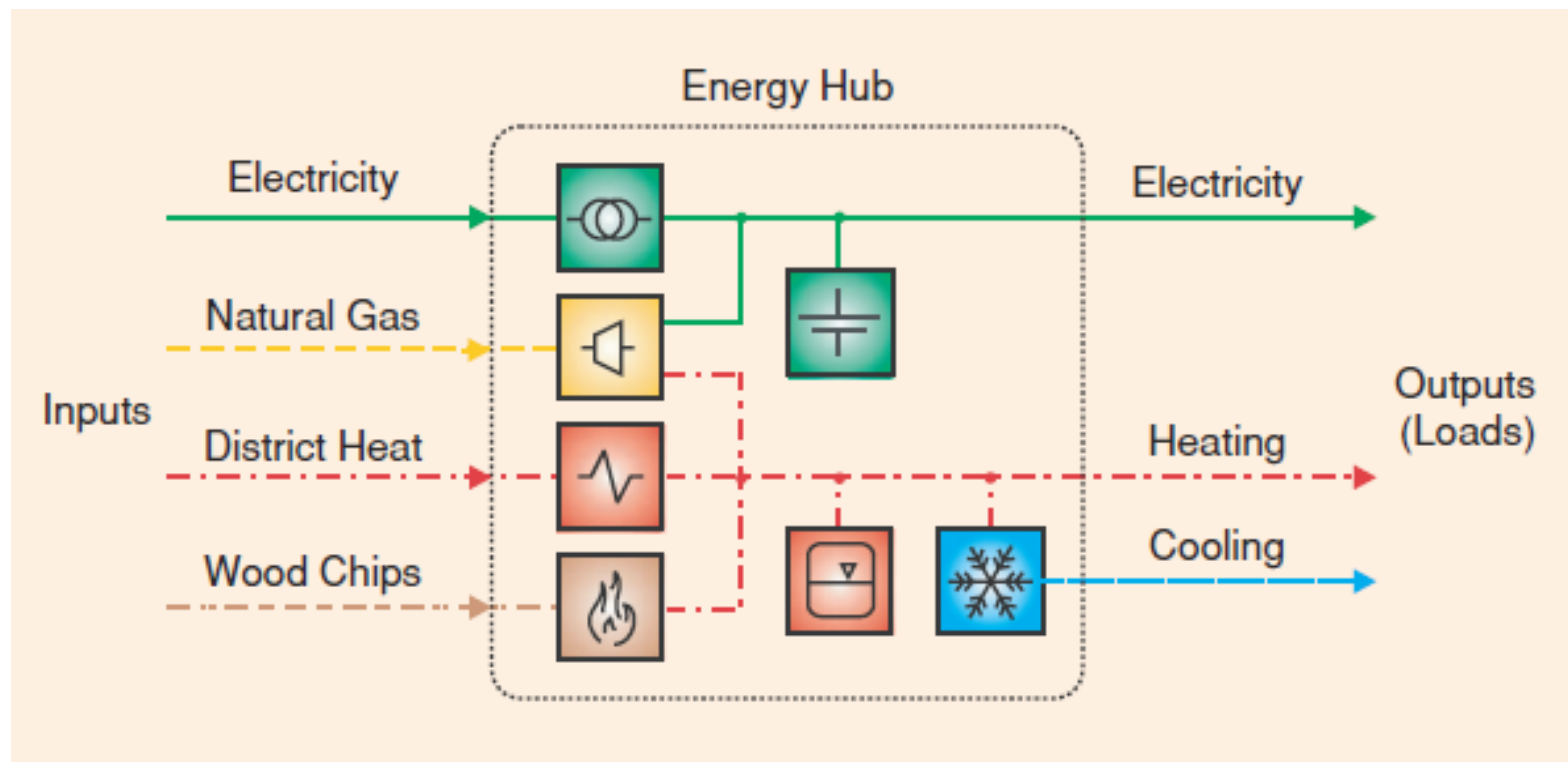
- Coordinated operation and planning of different energy systems.
- Delivering cost-effective, reliable energy services and trying to minimize the impact on the environment.



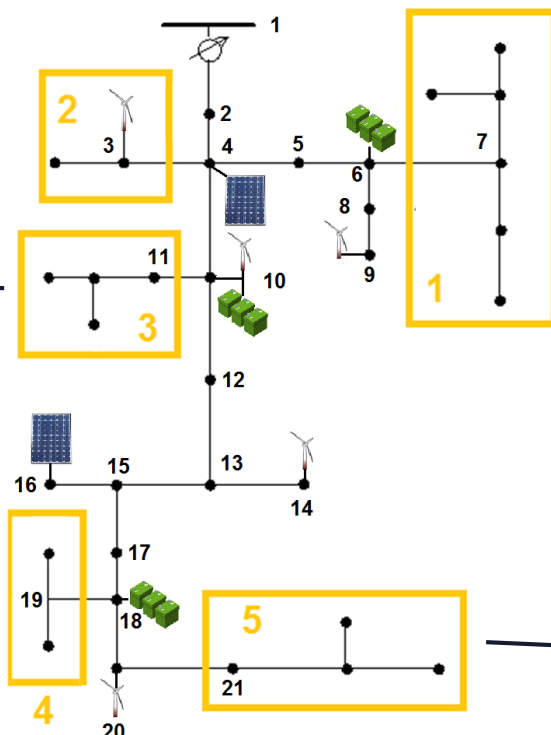
Multi-energy systems (MES) and networks (MEN) to increase flexibility



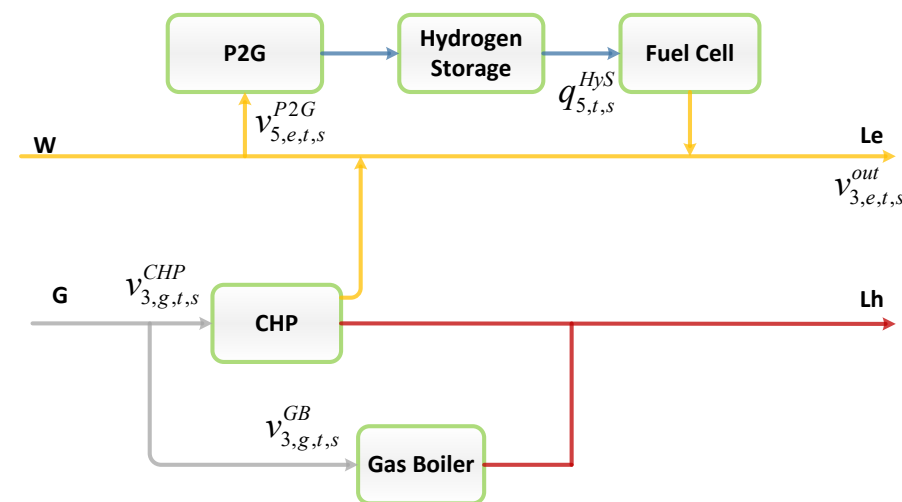
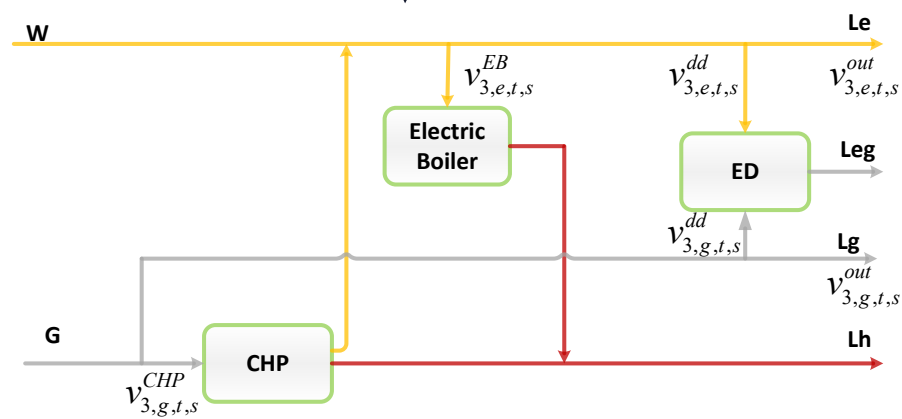
Modelling MES and MEN – The energy hub



A case study by INESC TEC

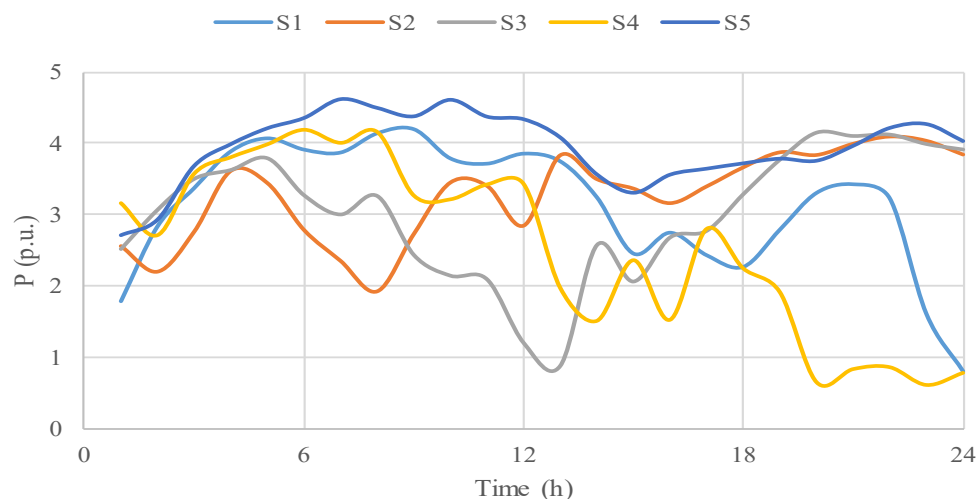


	Number	Total Installed Power (MW)
Loads	10	2.29
EHs	5	1.99
Storage	3	1.5
Wind	5	5.03
PV	2	1





Case study – Optimization



Wind power generation scenarios (5 MW)



Minimise curtailment
(robust design optimisation)

$$\min \sum_s \rho_s (C_s^{Energy} + C_s^{CO2} + C_s^{DR} + C_s^{sto} + C_s^{CBDR})$$

$$C_s^{Energy} = \sum_t P_{e,t,s}^{Total} \times \pi_{e,t} + \sum_t P_{g,t,s}^{Total} \times \pi_{g,t}$$

$$C_s^{CO2} = (\sum_t \sum_{n \in NW} \overline{P_{t,s,n}^{wind}} - P_{t,s,n}^{wind}) \times \pi^{CO2} + (\sum_t \sum_{n \in NPV} \overline{P_{t,s,n}^{PV}} - P_{t,s,n}^{PV}) \times \pi^{CO2}$$

$$C_s^{DR} = \sum_t \sum_{n \in NFL} |P_{t,s,n}^{DR}| \times \pi_{e,t}$$

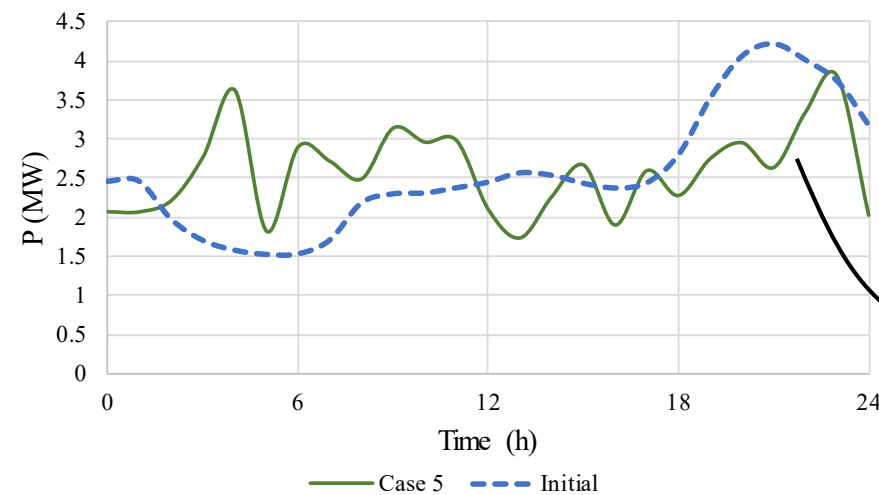
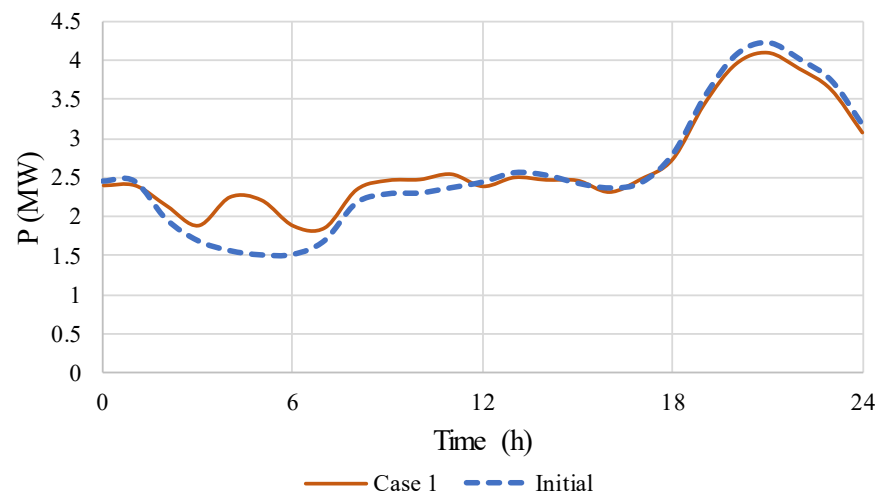
$$C_s^{sto} = \sum_t \sum_{n \in NS} P_{t,s,n}^{sto,cha} \times \pi_{e,t} - \sum_t \sum_{n \in NS} P_{t,s,n}^{sto,dis} \times \pi_{e,t}$$

$$C_s^{CBDR} = \sum_t \sum_{n \in NEH} |w_{t,s,n}^{ini} - w_{t,s,n}| \times \pi_{e,t} + \sum_t \sum_{n \in NEH} |g_{t,s,n}^{ini} - g_{t,s,n}| \times \pi_{g,t}$$

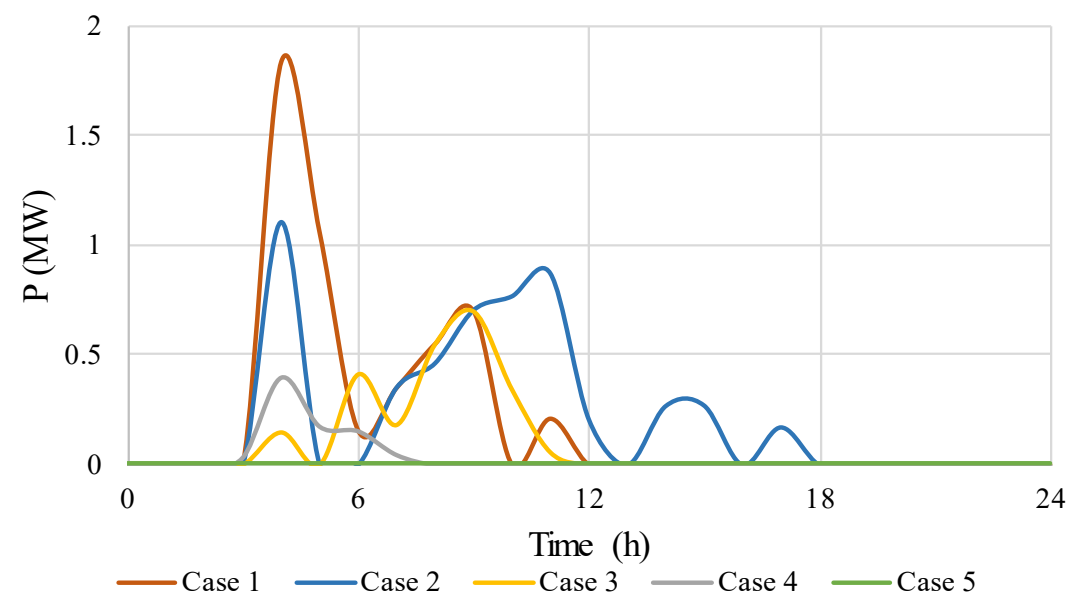


Case study – Results

Load diagrams



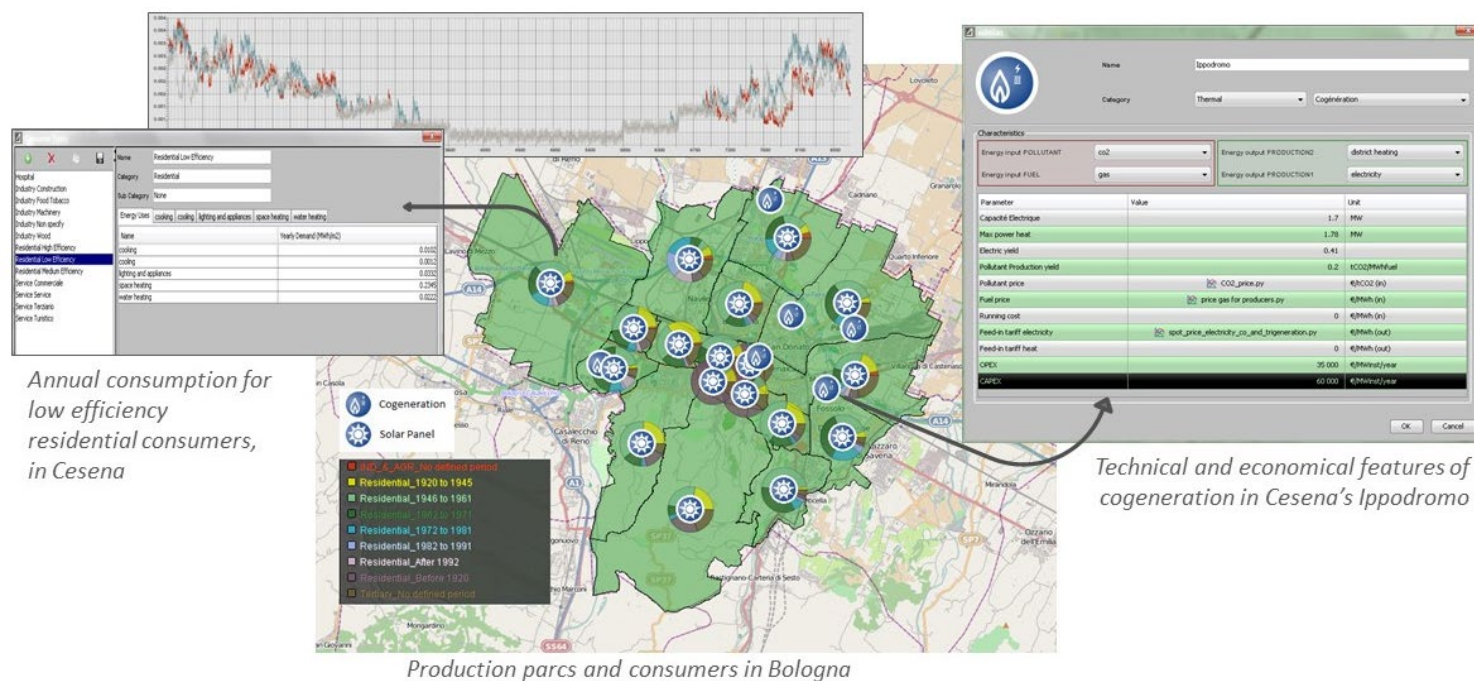
Wind power curtailed



This is flexibility!

CitInES – City and Industry Energy Strategy

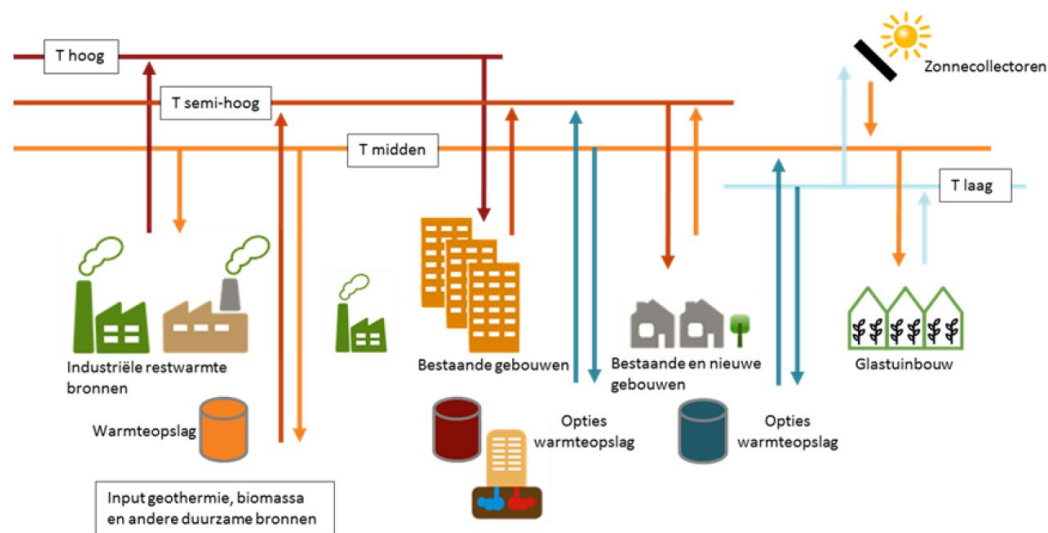
The objective of CitInES was to design and develop two multi-scale multi-energy decision-support tools to optimize the energy strategy of cities and large industrial complexes by enabling them to define sustainable, reliable and cost-effective long-term energy plans.



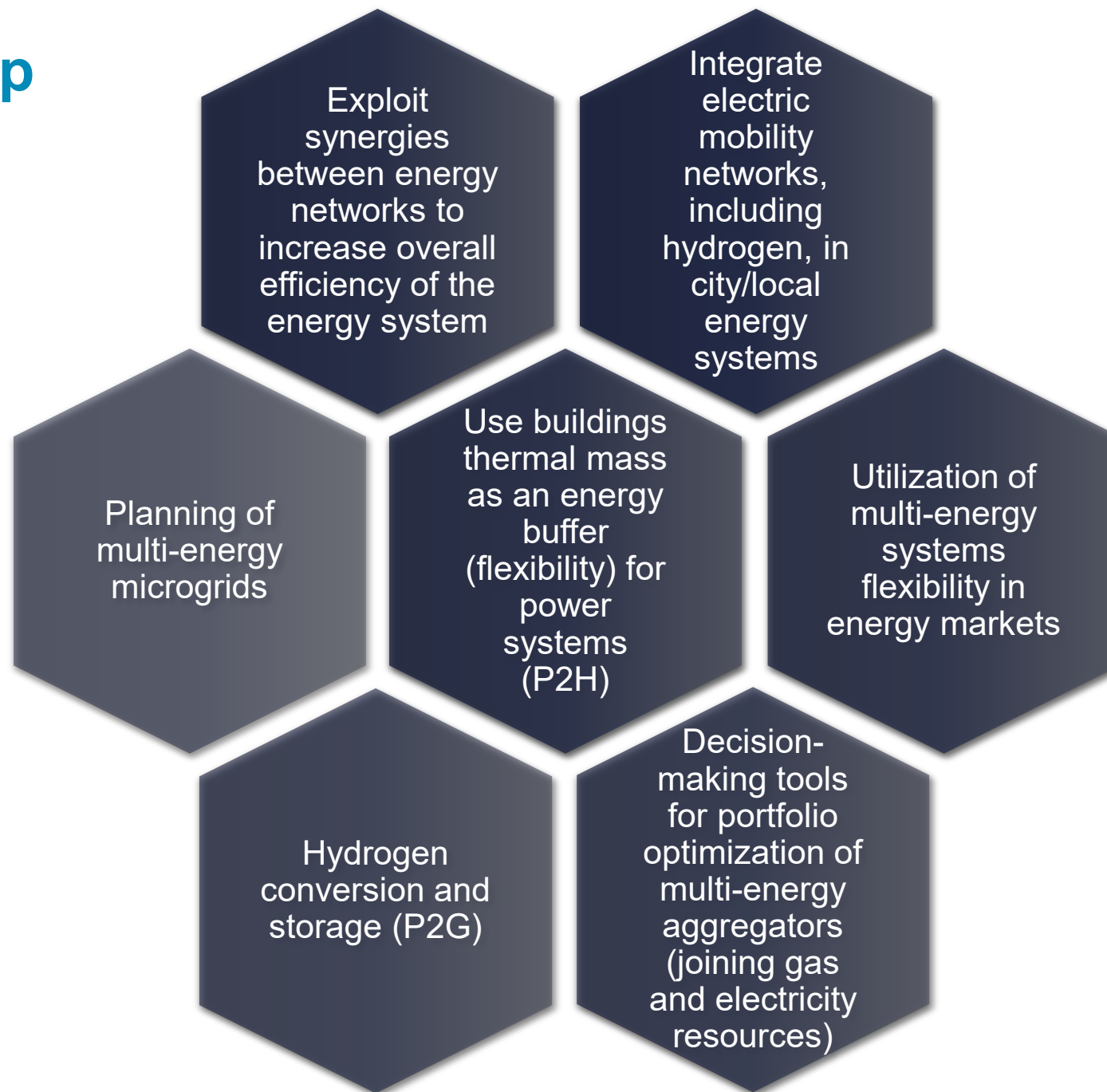


EMB3Rs – User-driven Energy-Matching & Business prospection tool for industrial Excess heat/cold Reduction, Recovery and Redistribution

This project will develop an open-source, platform agnostic and API-based tool to support a bottom-up characterisation of energy supply and demand and estimate the benefits of alternative options for recovery and use of excess heat/cold for a wide range of industries.



Roadmap



And in the end...



(renewable-based) electricity

ENERGY VECTOR PRODUCED

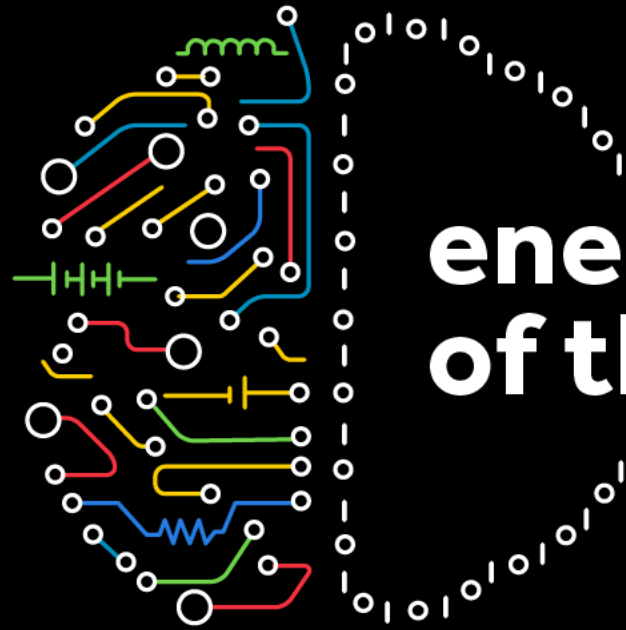
Stored under the form of:

- heat
- cold
- gas
- gravitational potential energy
- chemical potential energy

Managed in a
MES perspective

THERE CAN BE ONLY ONE

Duncan MacLeod, The Highlander



energy systems of the future

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