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6TH INTERNATIONAL CONFERENCE ON SMART ENERGY SYSTEMS
6-7 OCTOBER 2020
#SESAAU2020

Integration of Intermittent renewable :
Different flexible actors for the power grid.

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GRØN ENERGI
kamstrup
LOGSTOR
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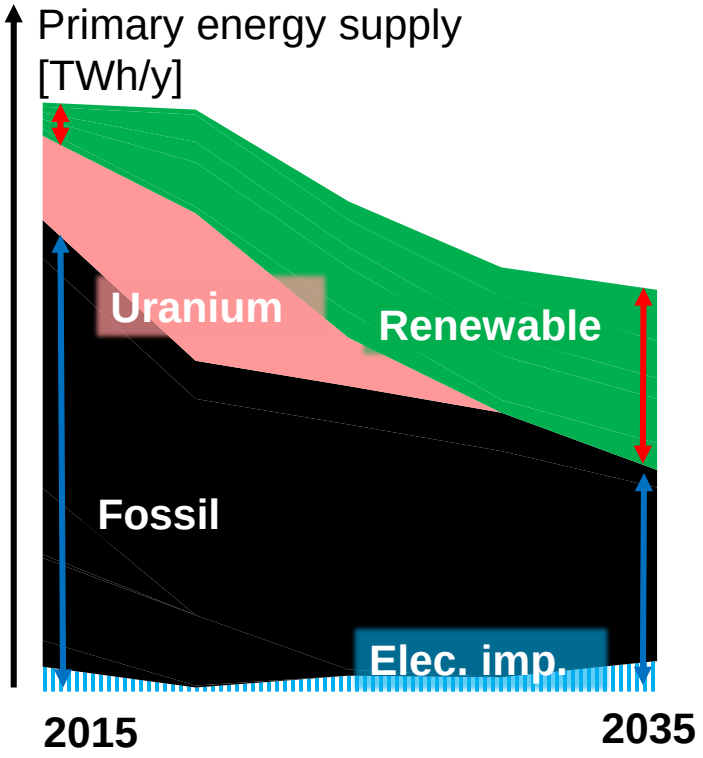
Aalborg Forsyning

Bibliography:
[1] Limpens, G. Transition Pathway Optimisation. Thesis (under preparation)

Context

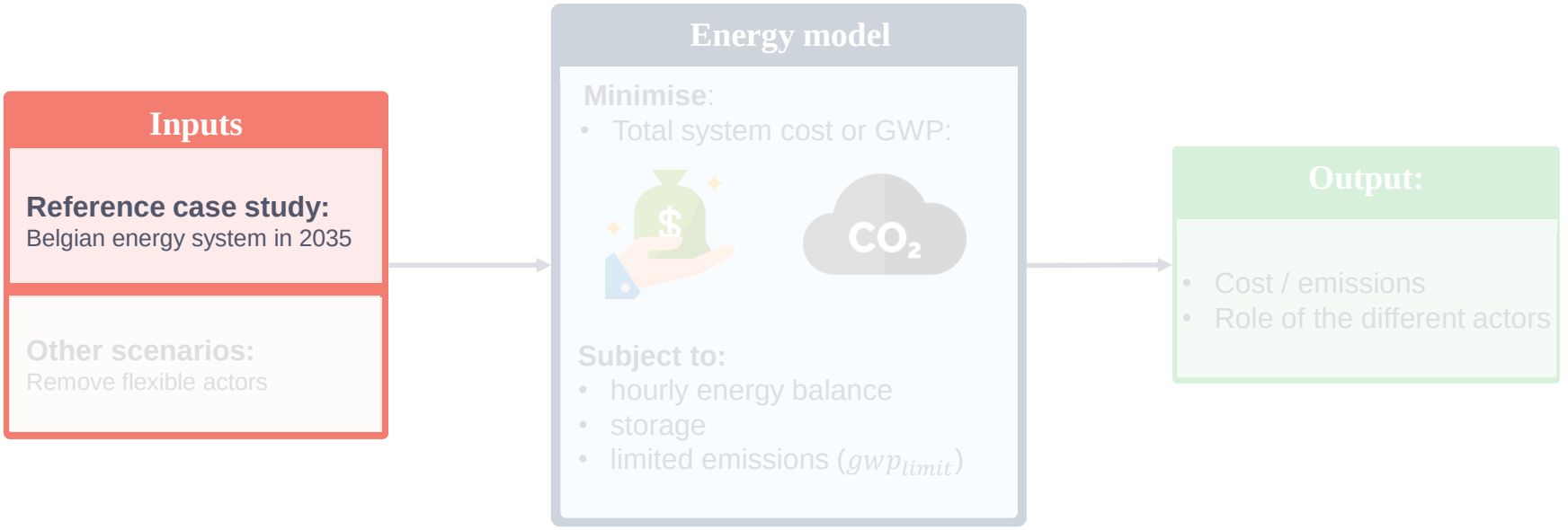
➔ Energy transition (Belgium)[1]:

- 2015:
  - **80%** dispatchable
  - **5%** intermittent
- 2035:
  - **50%** disptachable
  - **50%** intermittent



=> How to **deal** with this **intermittency**?
=> What will be our **new** sources of **flexibility**?

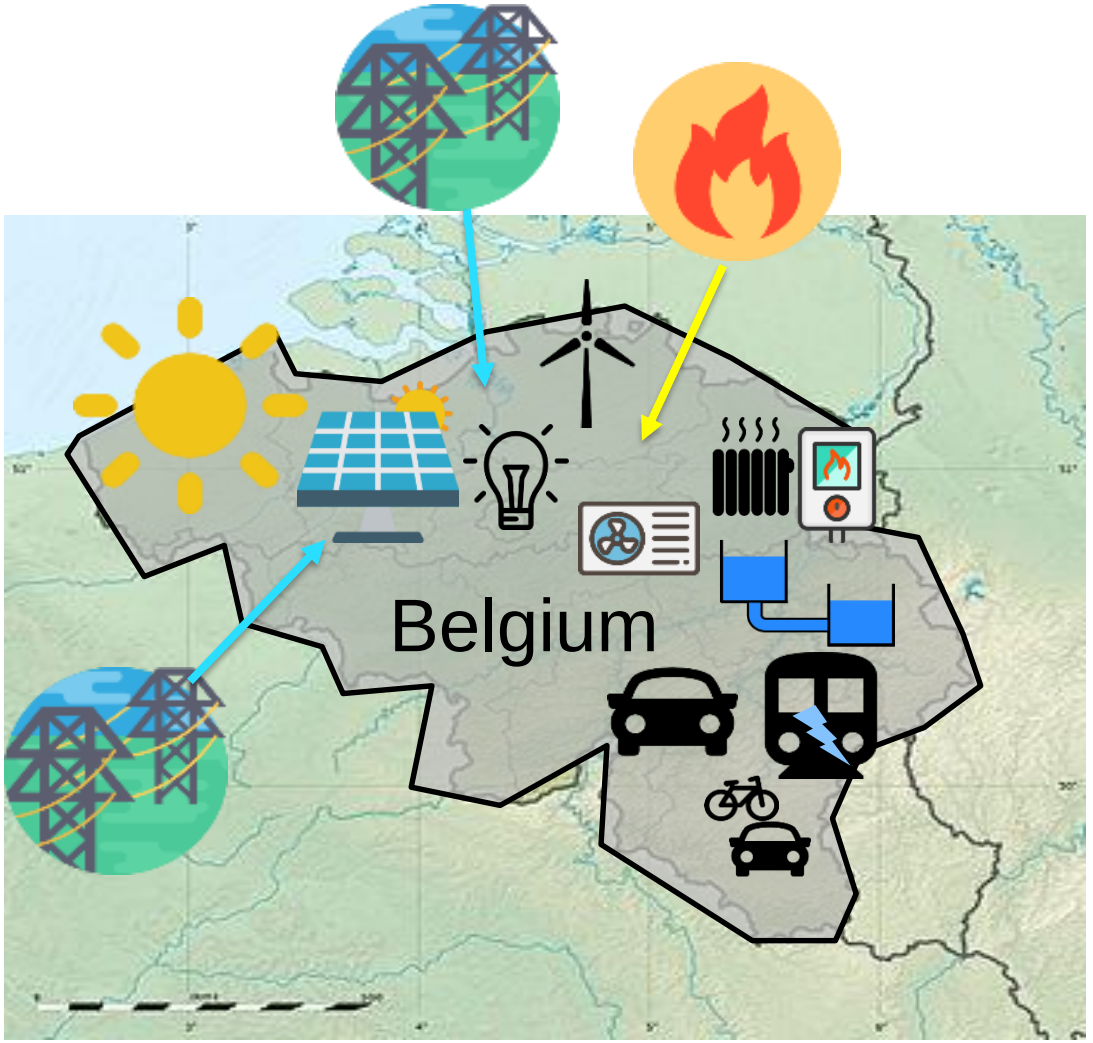
Belgian energy system



What is an energy system ?

➔ Concept illustration:

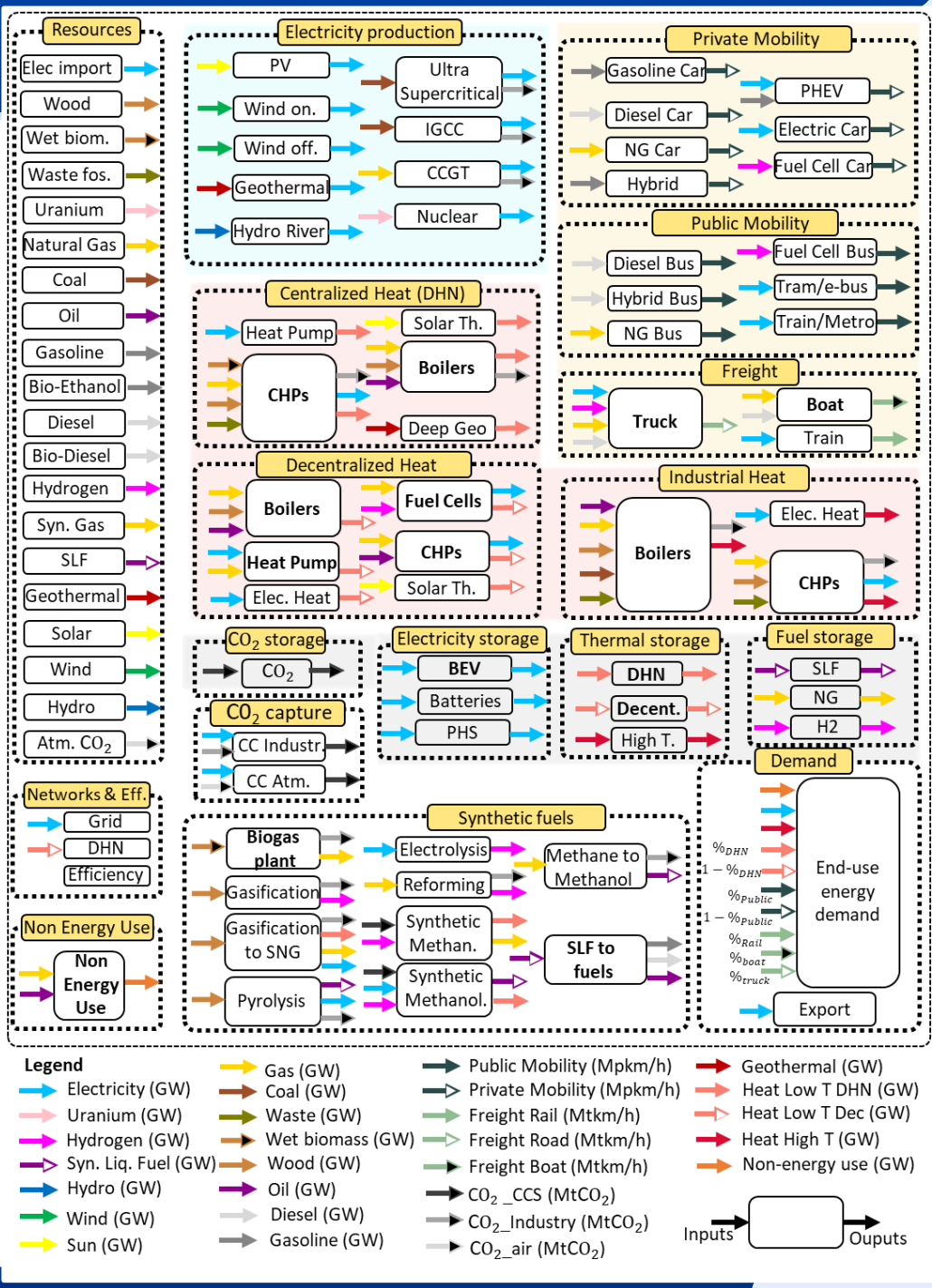
- Resources:
  - Electricity
  - Gas
  - Solar, wind …
- Demands:
  - Electricity
  - Heat
  - Mobility
- Energy conversion:
  - Gas turbine
  - HCCI engines
  - Heat pumps
  - Trucks
  - …



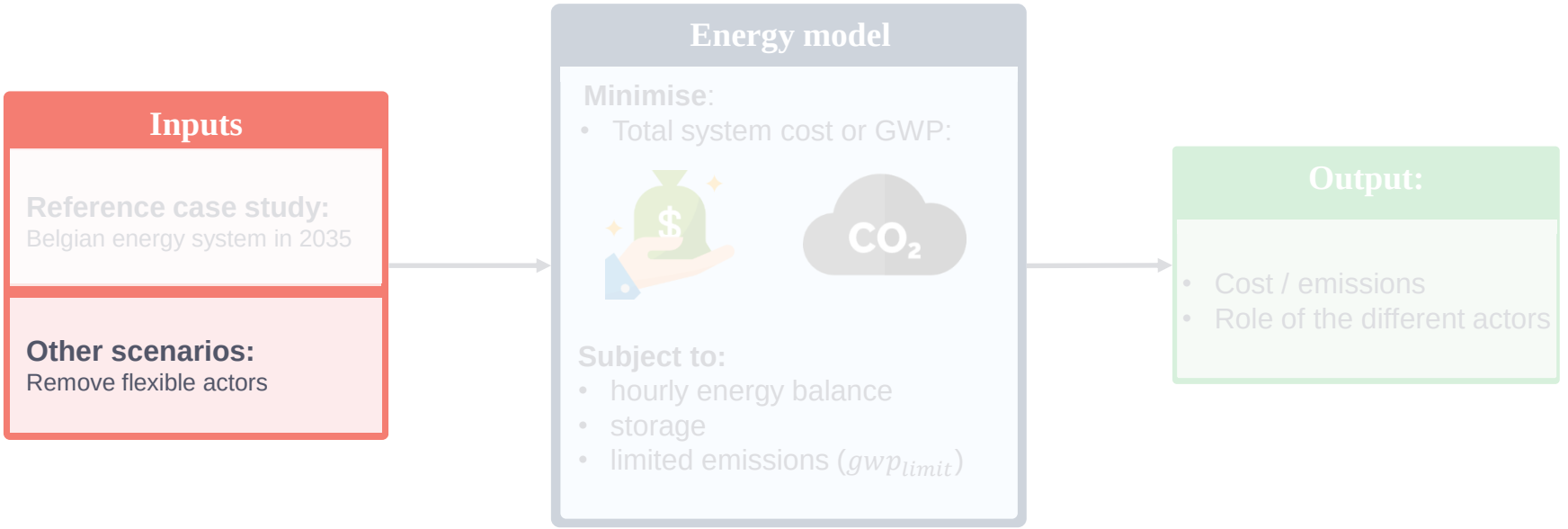
What is an energy system ?

➔ Real energy system

- Resources (20):
- Demand (10):
- Energy conversion (>100):
  - Elec (9)
  - Heat (30)
  - Mobility (20)
  - Storage (28)
  - Synthetic fuels (13)
  - Infrastructure (3)



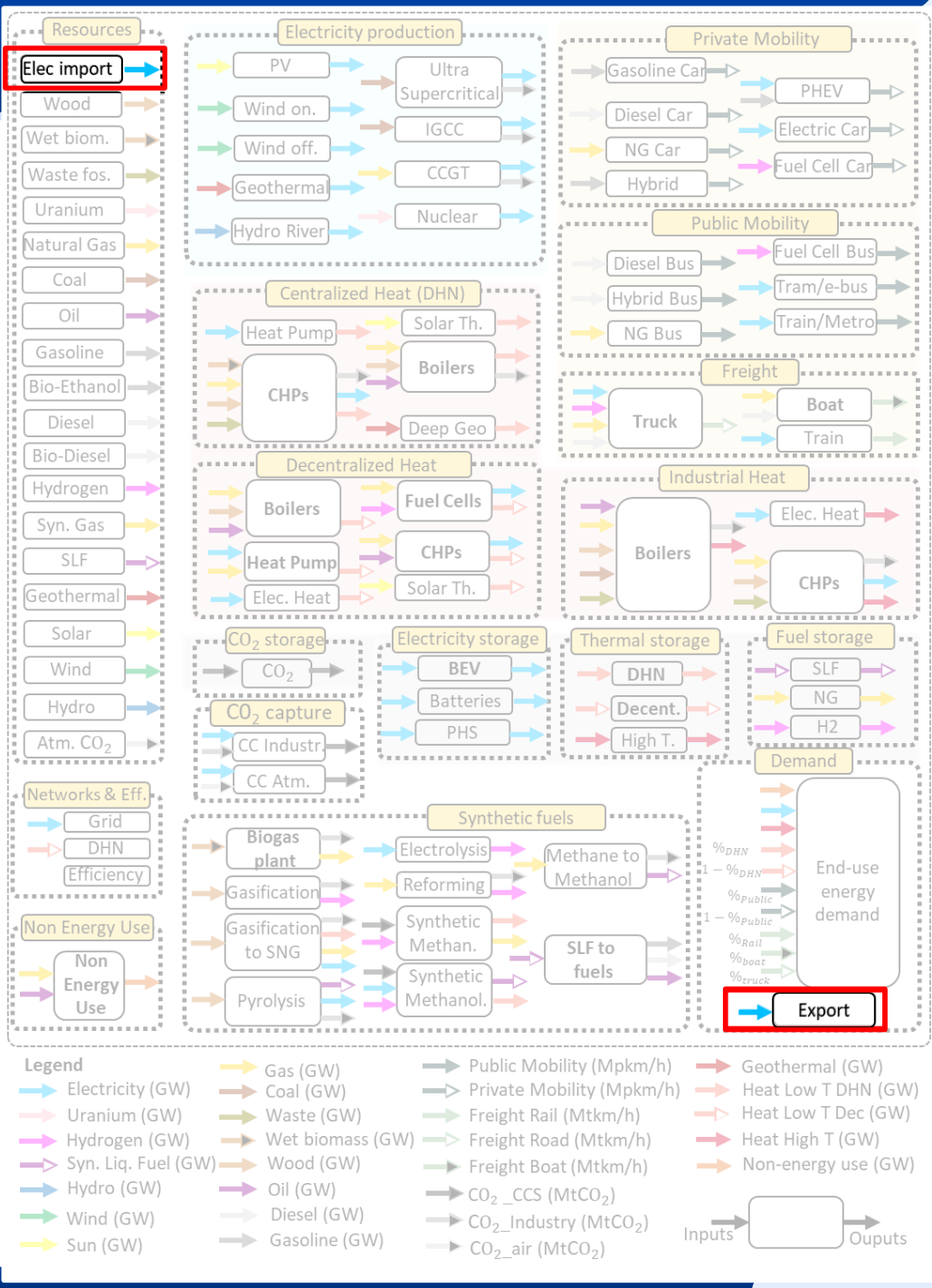
Flexible actors



Flexibility pillars

➔ To integrate massively intermittent RE:

1. Use electricity import/export



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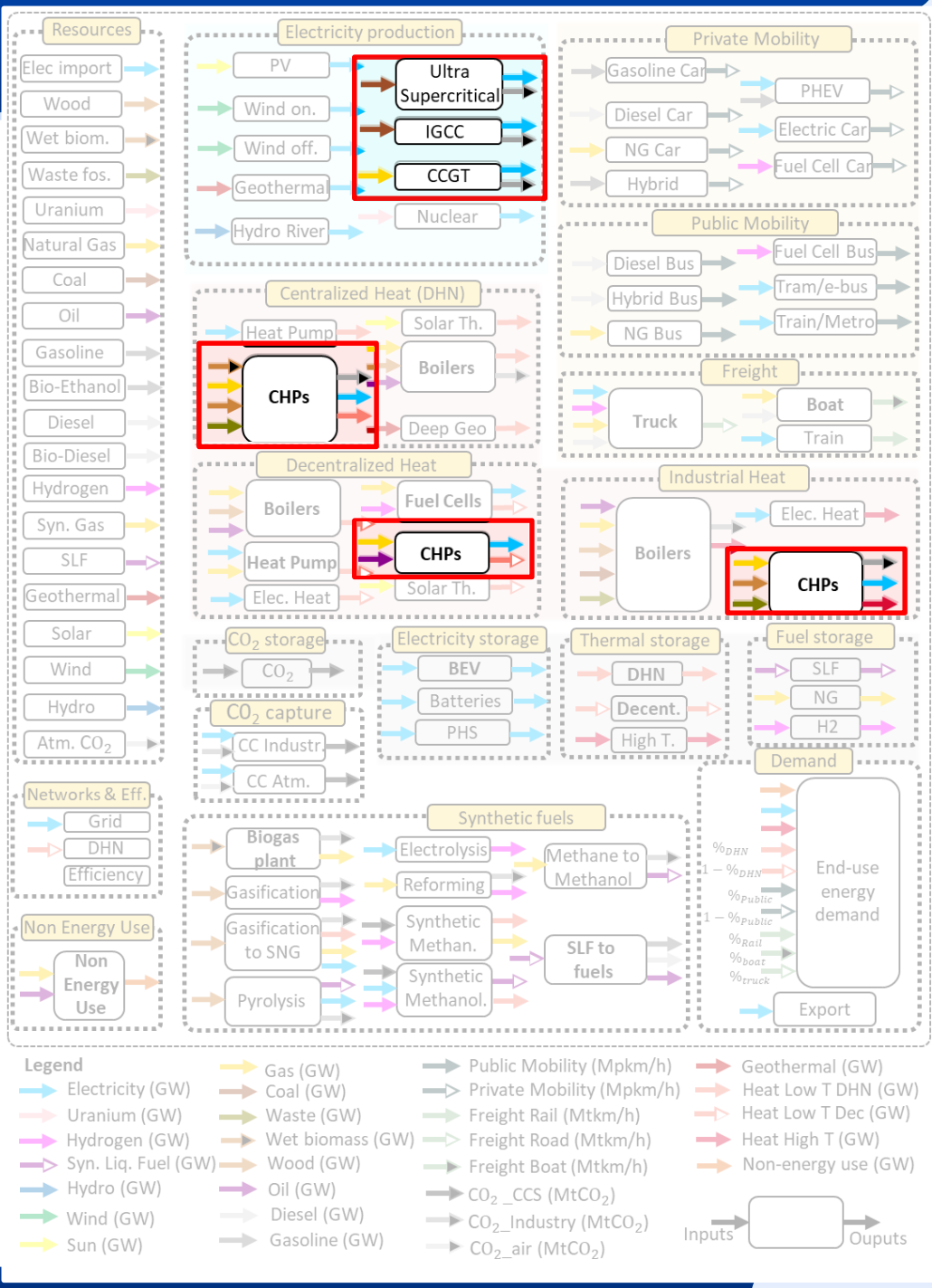
Flexibility pillars

➔ To integrate massively intermittent RE:

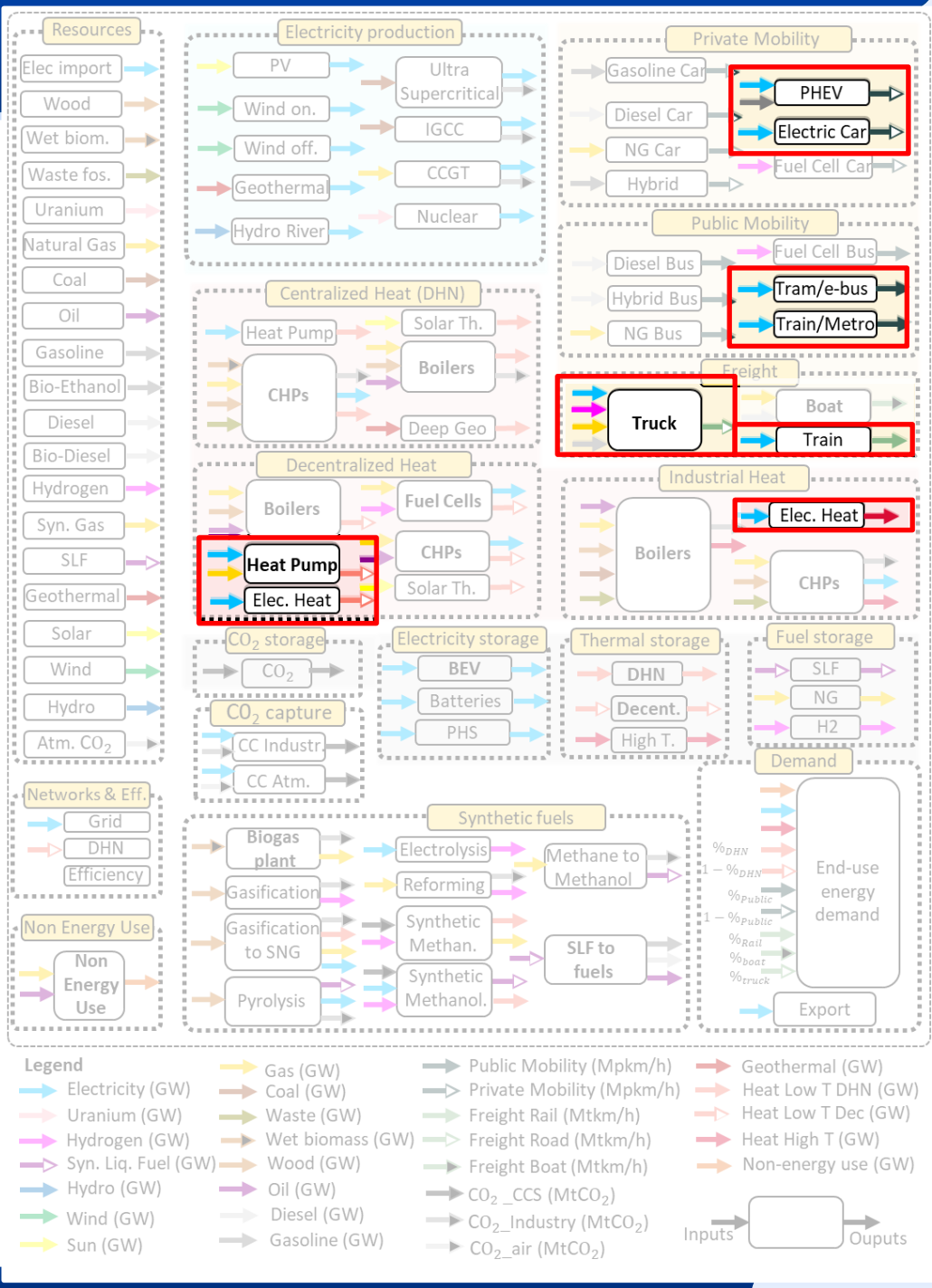
1. Use electricity import/export
2. Flexibility of the production
   - Power plants
   - Cogeneration plants



Flexibility pillars

➔ To integrate massively intermittent RE:

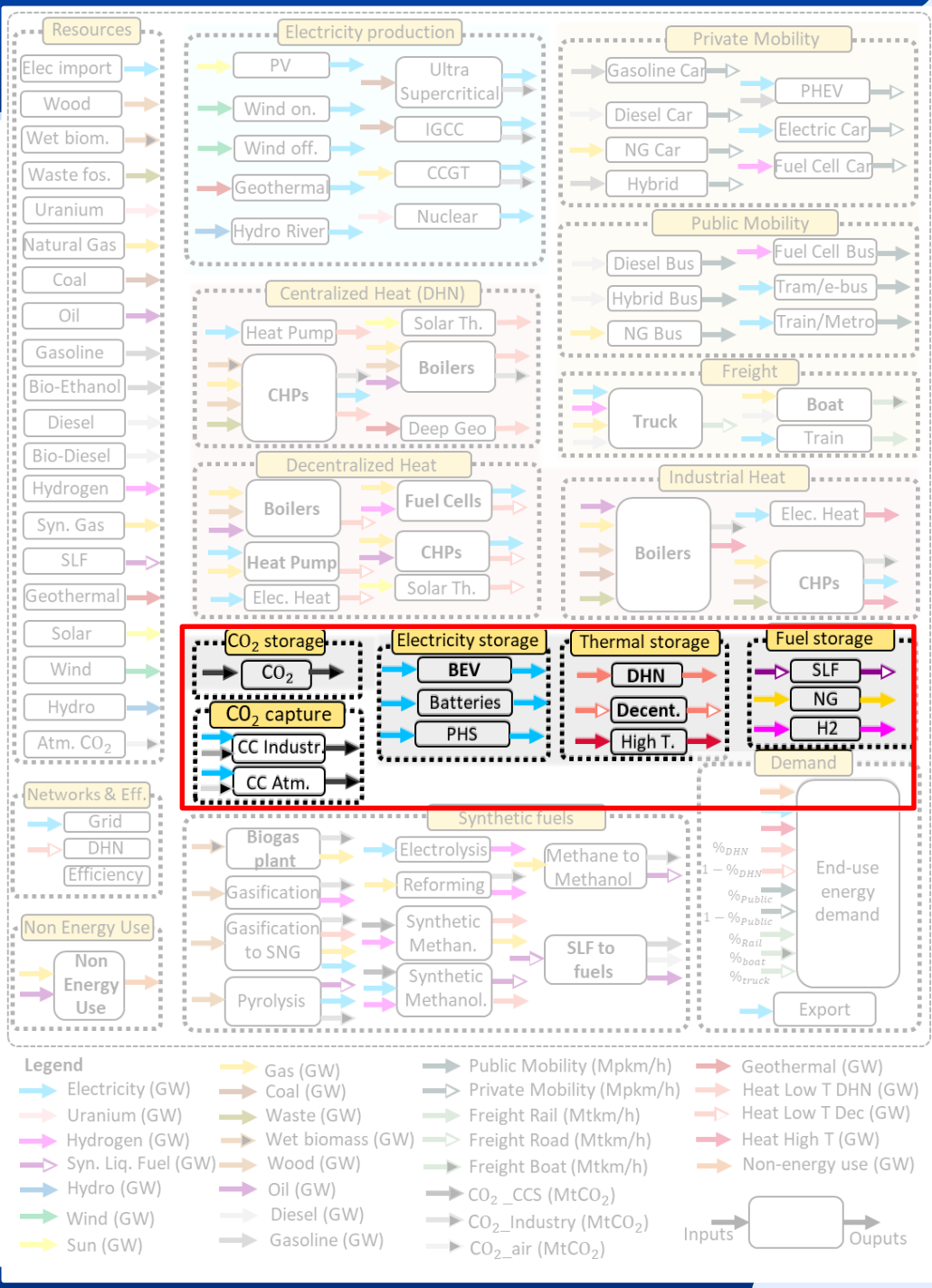
1. Use electricity import/export
2. Flexibility of the production
3. Electrification (sector coupling):
   - Mobility
   - Heat



Flexibility pillars

➔ To integrate massively intermittent RE:

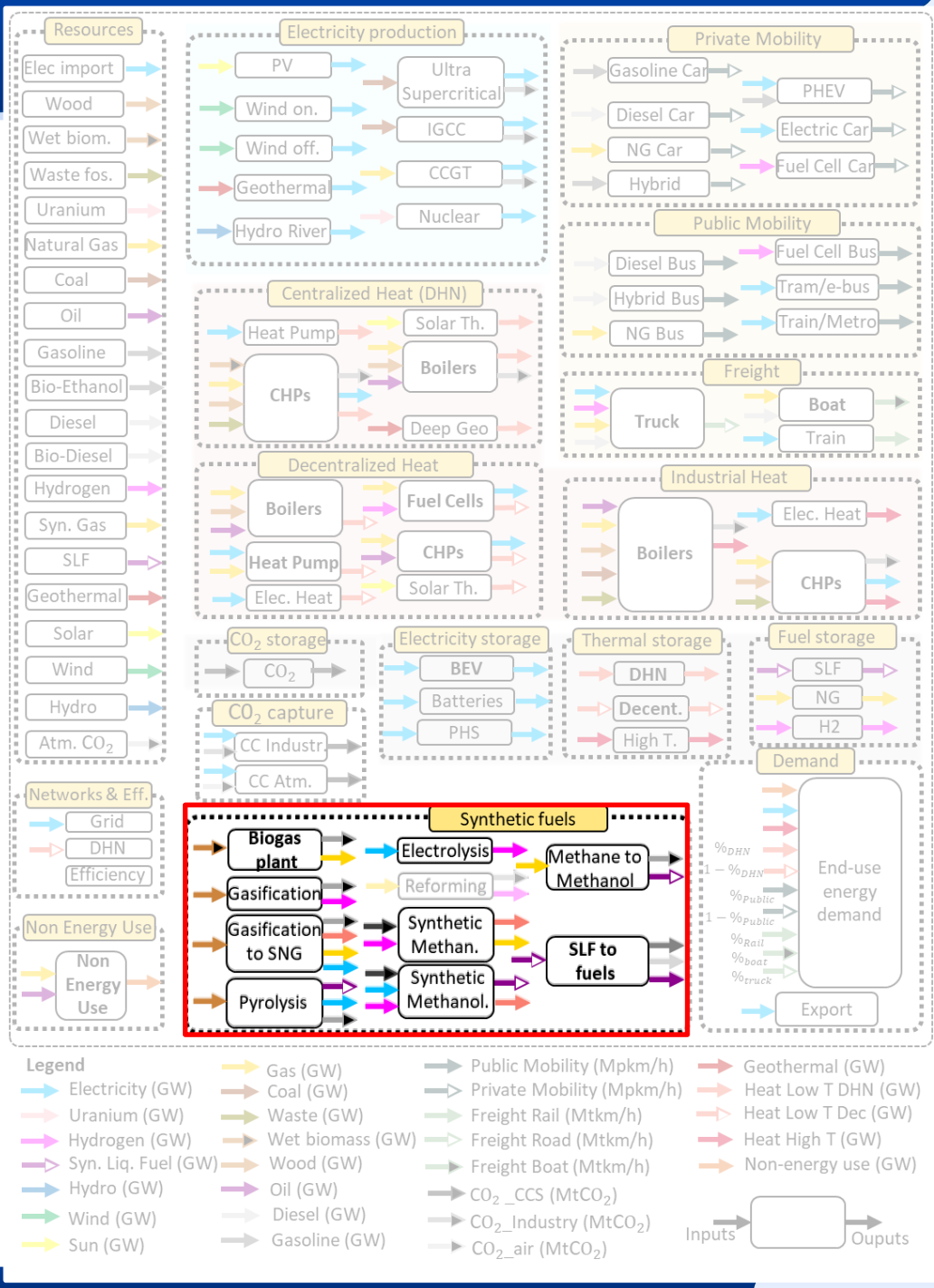
1. Use electricity import/export
2. Flexibility of the production
3. Electrification (sector coupling)
4. Storage:
   - Electricity
   - Heat
   - Fuels
   - CO2



Flexibility pillars

➔ To integrate massively intermittent RE:

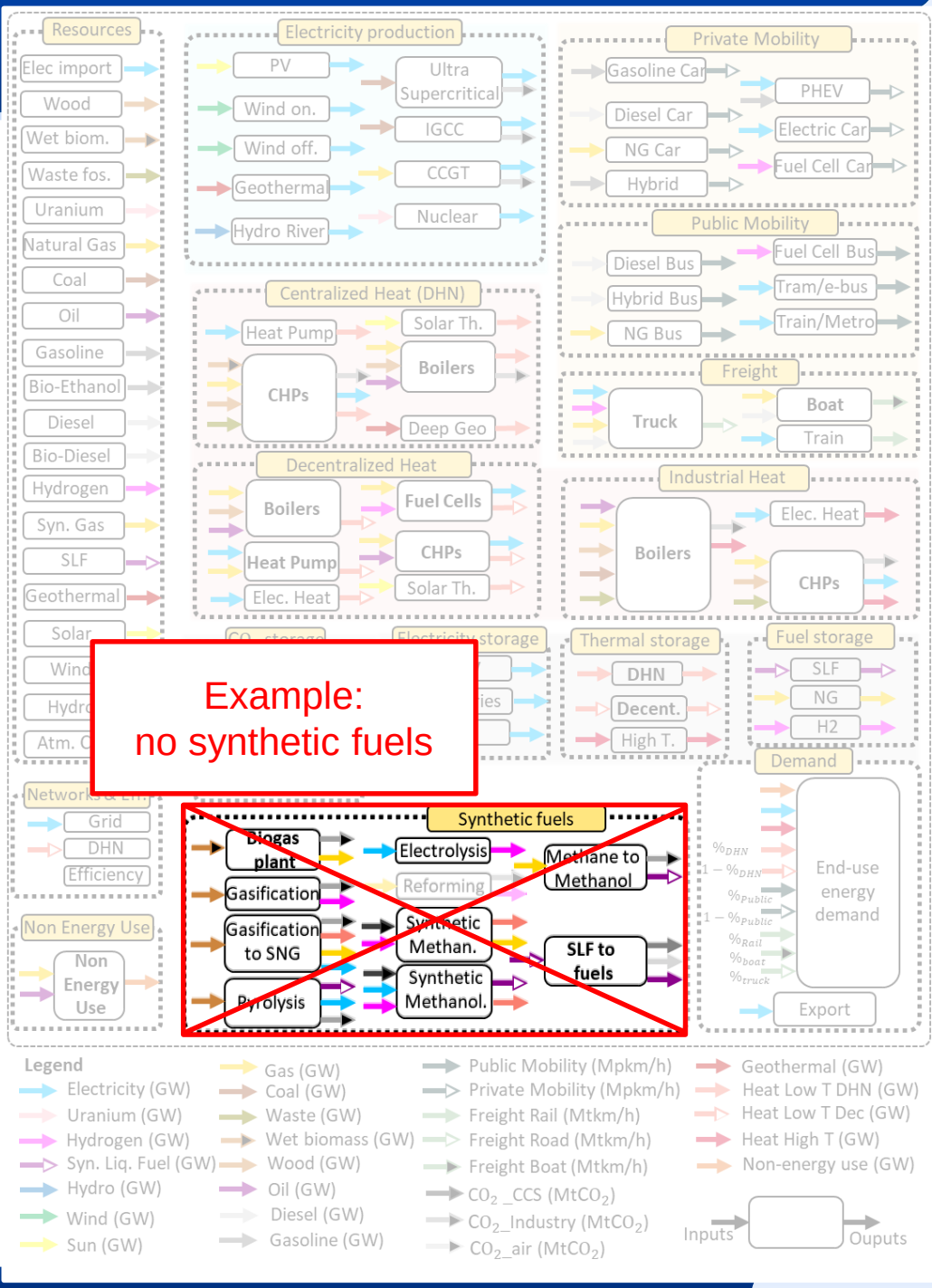
1. Use electricity import/export
2. Flexibility of the production
3. Electrification (sector coupling)
4. Storage
5. Synthetic fuels:
   1. Electro-fuels
   2. Biofuels



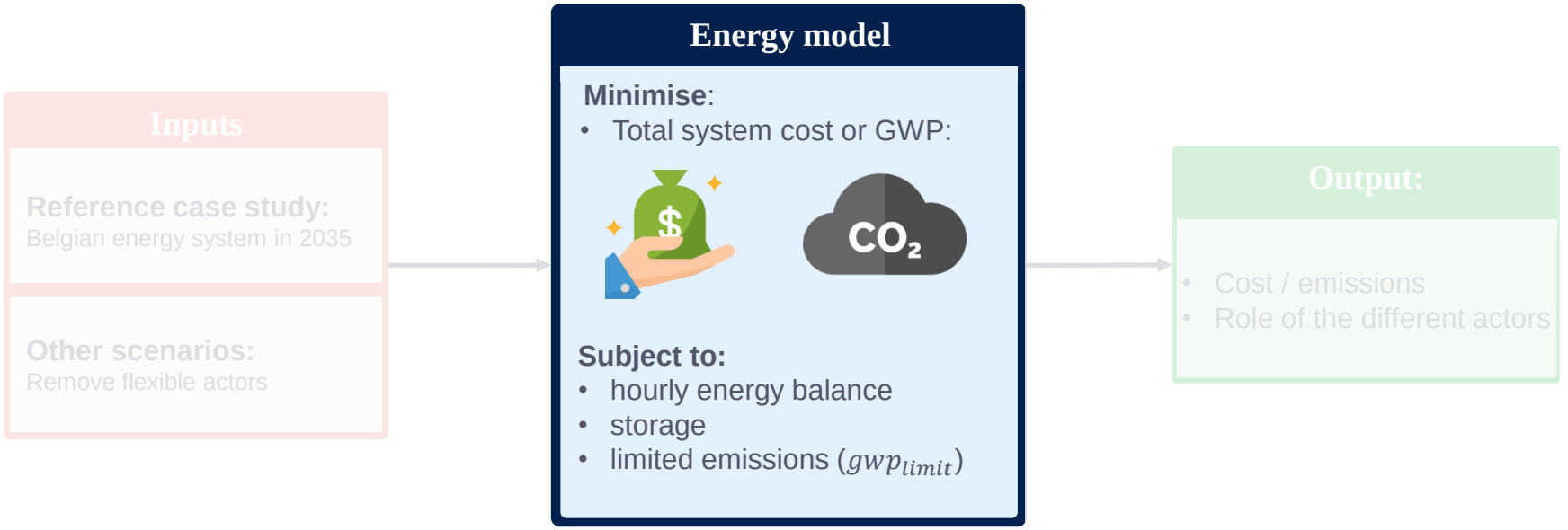
Methodology

➔ Influence of :

1. Use electricity import/export
   - No electricity import/export
2. Flexibility of the production
   - Fossil power plants are not flexible
3. Electrification (sector coupling)
   - No sector coupling technologies
4. Storage
   - No sector coupling technologies
5. Synthetic fuels:
   - No synthetic fuels production technologies



Energy model



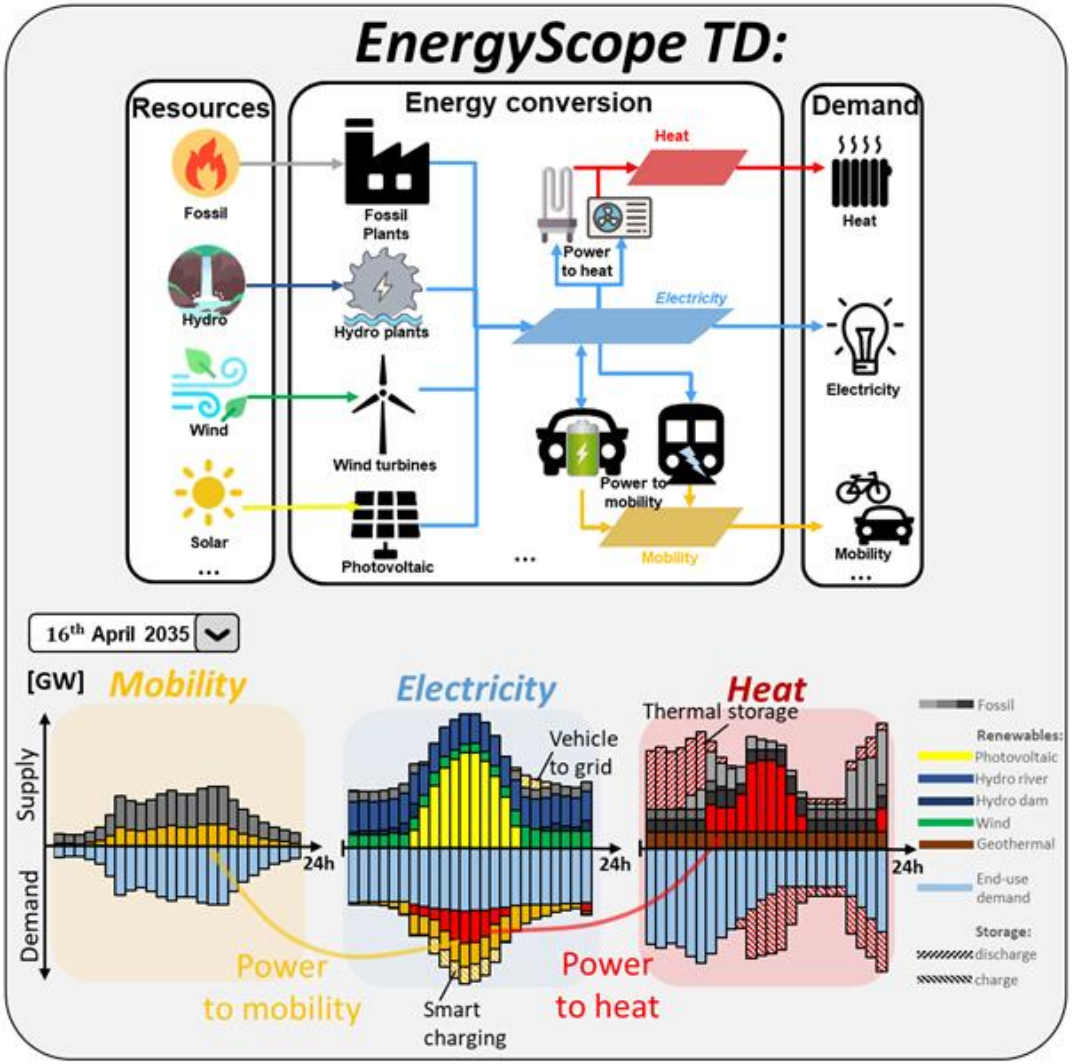
Bibliography:
[1] Limpens, G.; Moret, S.; Jeanmart, H.; Maréchal, F. EnergyScope TD: A novel open-source model for regional energy systems. Appl. Energy 2019

The model:

➔ EnergyScope TD[1]:

- *Advantages:*
  - **Hourly** resolution over a **year**
  - **Whole-energy system**: heat, elec. mob…
  - **Optimisation** of design & operation
  - **Open** source & documented[1-2]

- *Disadvantages:*
  - Space resolution: **1 cell**
  - Technico-economic: **simplified** representation of **technologies**
  - **No market** equilibrium
  - **1 year** resolution (no transition)



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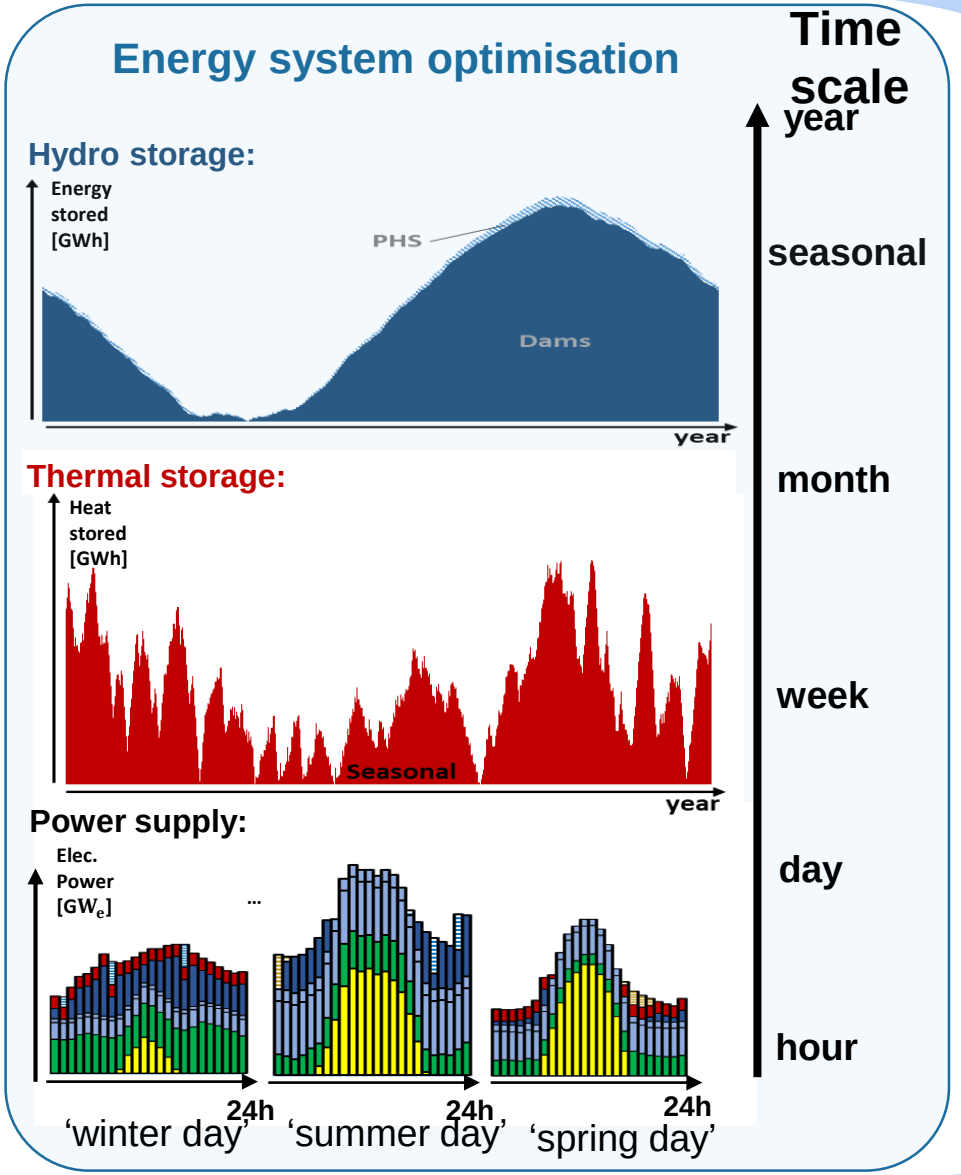

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[2] Prina, M. G., Manzolini, G., Moser, D., Nastasi, B., & Sparber, W. (2020). Classification and challenges of bottom-up energy system models-A review. Renewable and Sustainable Energy Reviews, 129, 109917.

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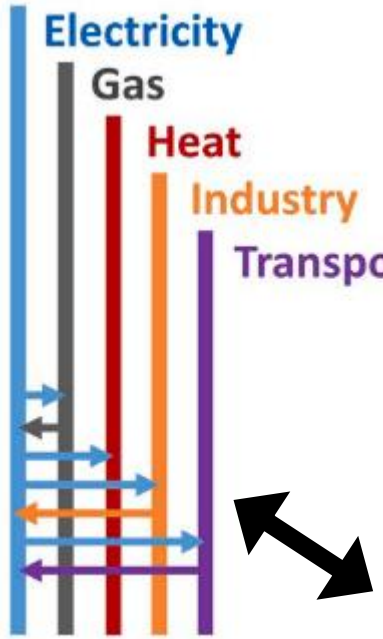
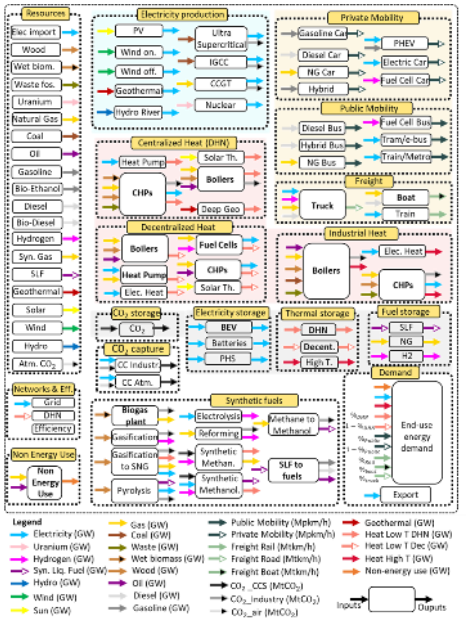


Source: [2]



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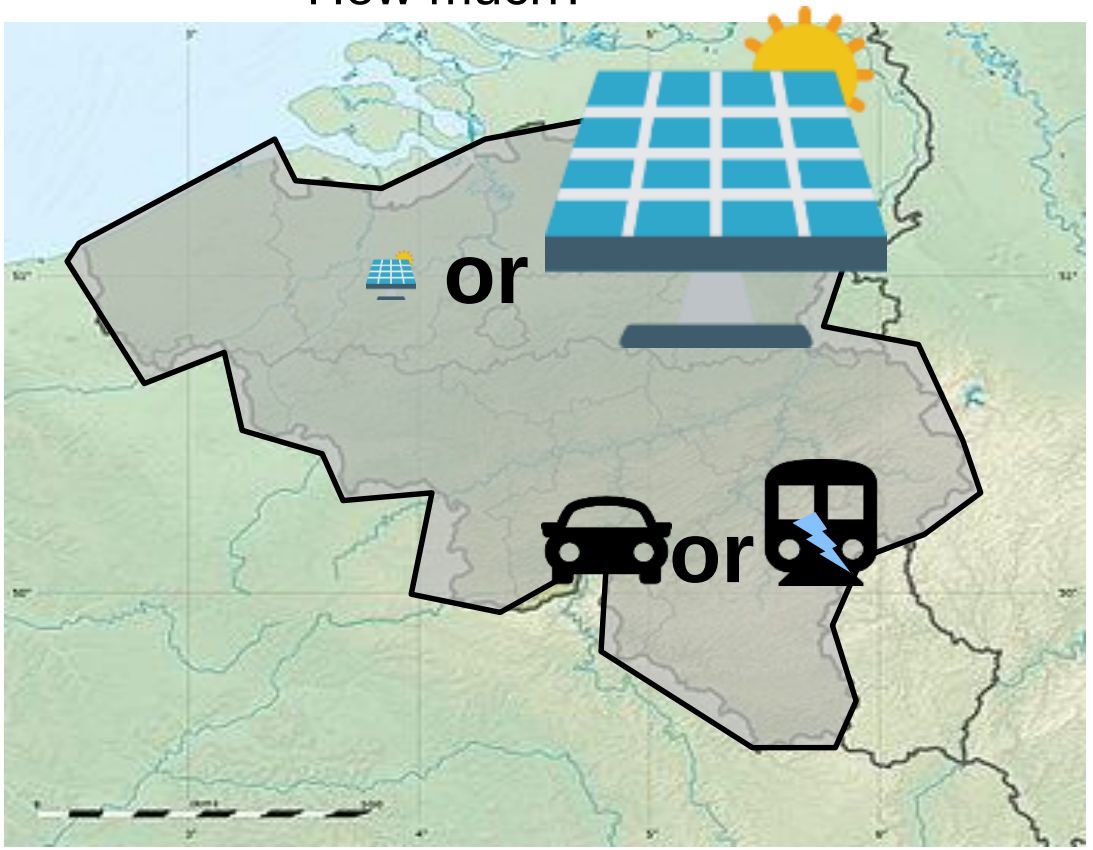
Design:

- Which technology?
- How much?



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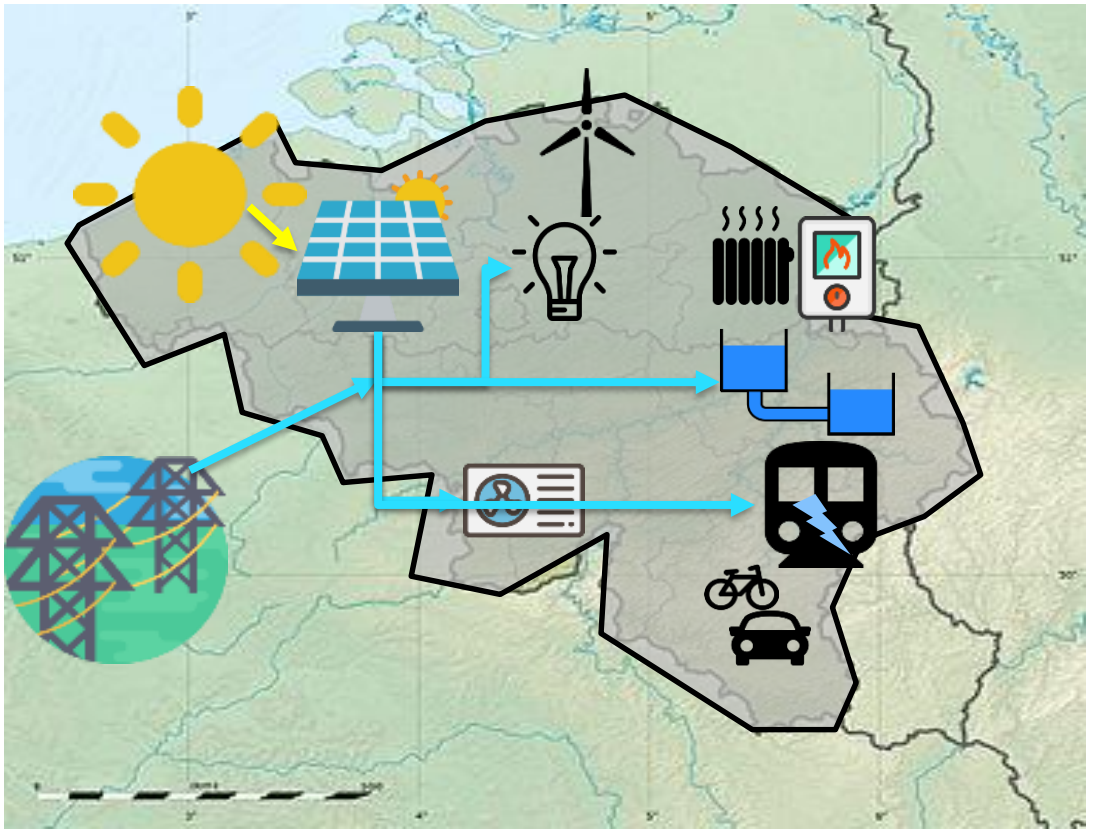
Operation:

- Hourly power balance



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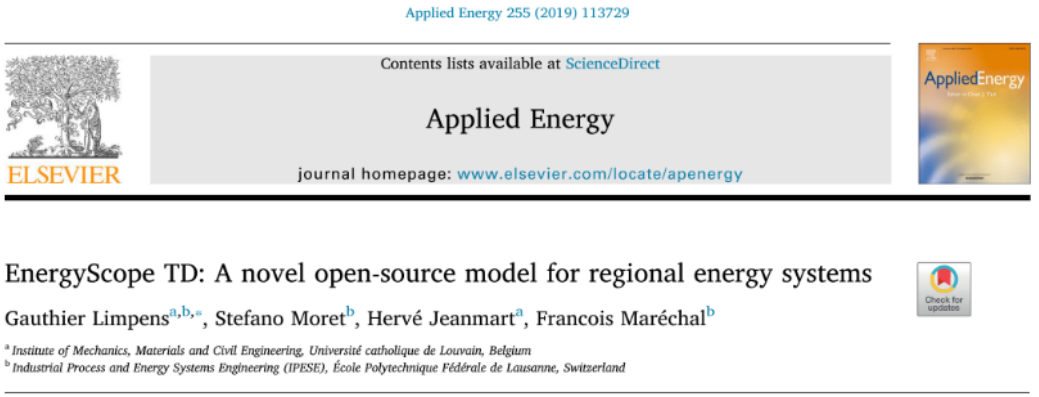
Code & documentation:

[1]https://github.com/energyscope/EnergyScope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EnergyScope TD: A novel open-source model for regional energy systems

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[b] Industrial Process and Energy Systems Engineering (IPESE), École Polytechnique Fédérale de Lausanne, Switzerland

Publications:

[2] Limpens, G., Moret, S., Jeanmart, H., & Maréchal, F. (2019). EnergyScope TD: A novel open-source model for regional energy systems. Applied Energy, 255, 113729.

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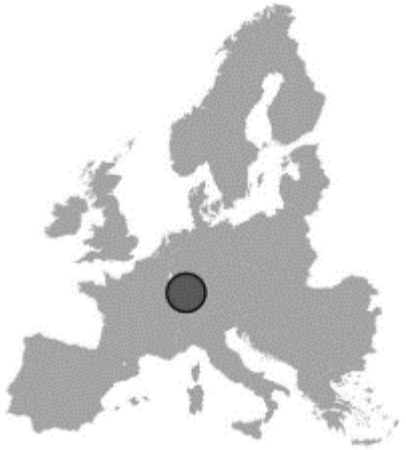

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- **Time-dependent start-up costs and decay of efficiency for power plants**
- **Tank model with self-discharging for electric storage**
- **Primary, secondary, tertiary reserve**

Source: [2]

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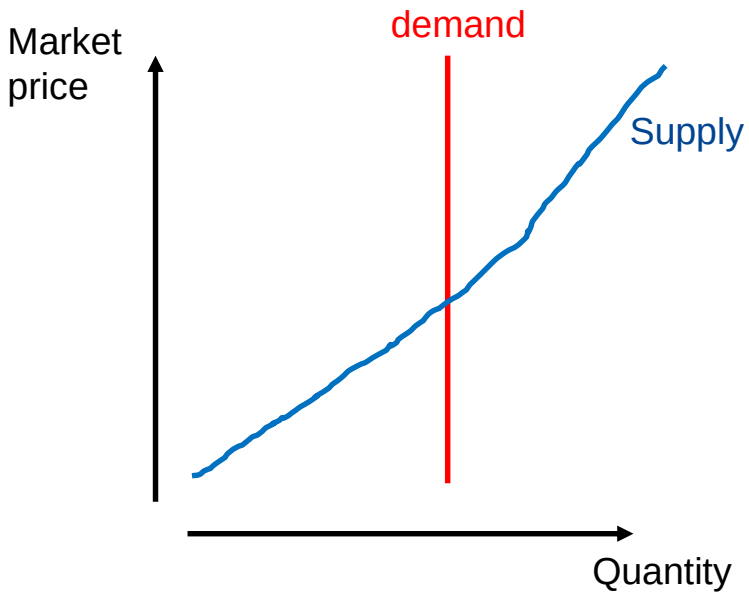

Imposed end use demand:
(GW, km-pass/h, ton-km/h …)

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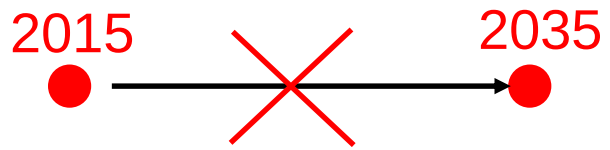
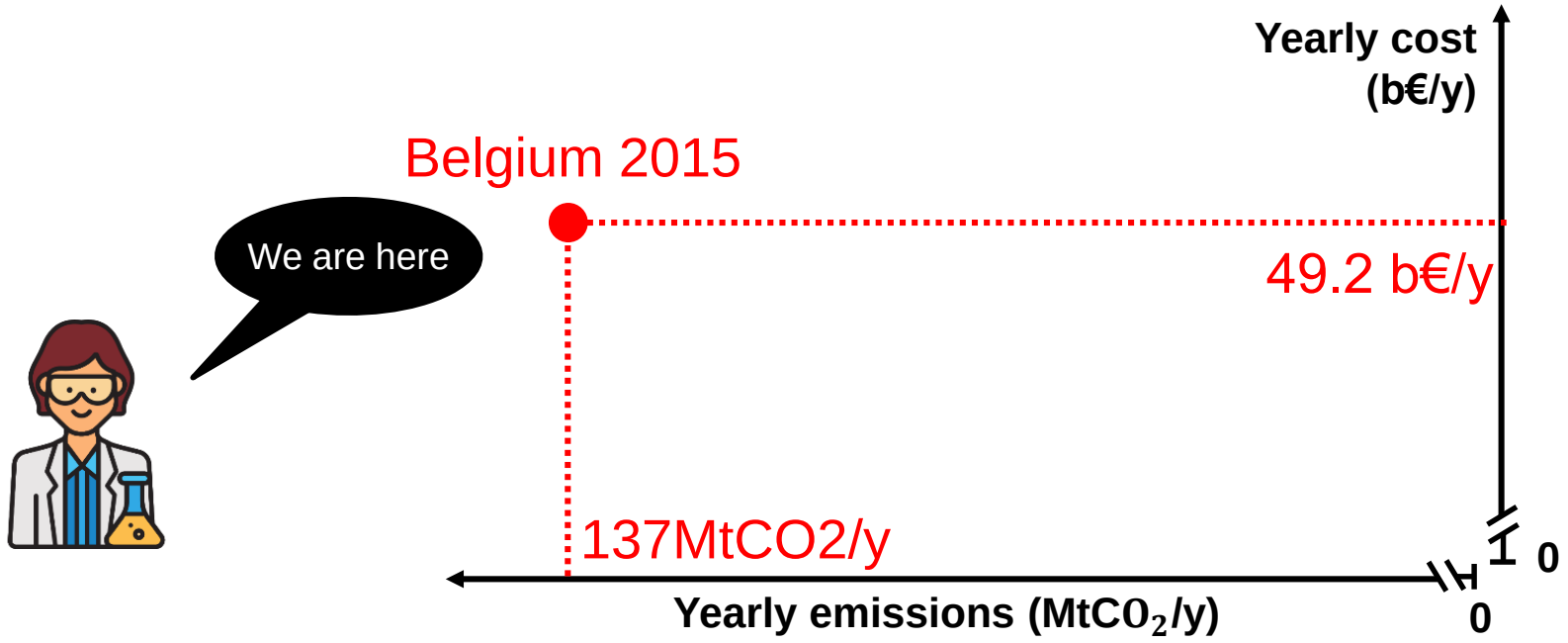


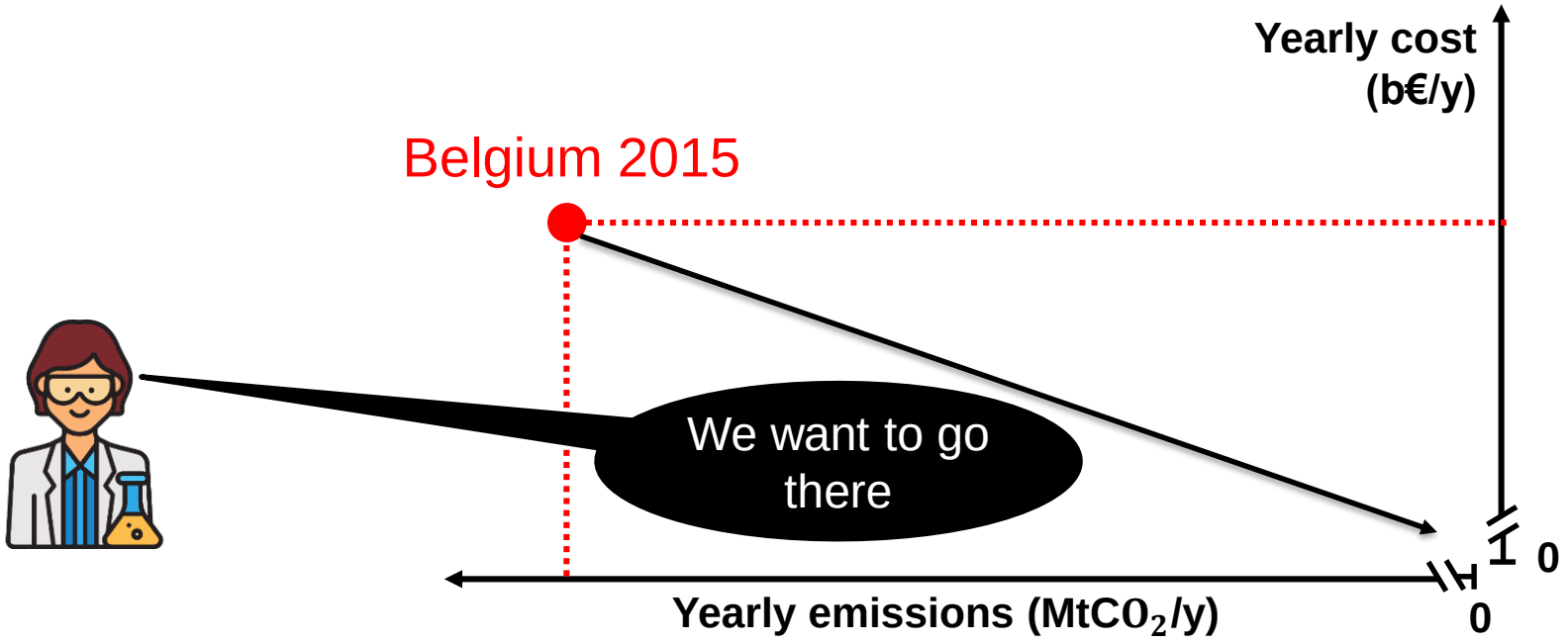
Model future *independently* to what exists

Results

Pareto Cost-CO2 optima

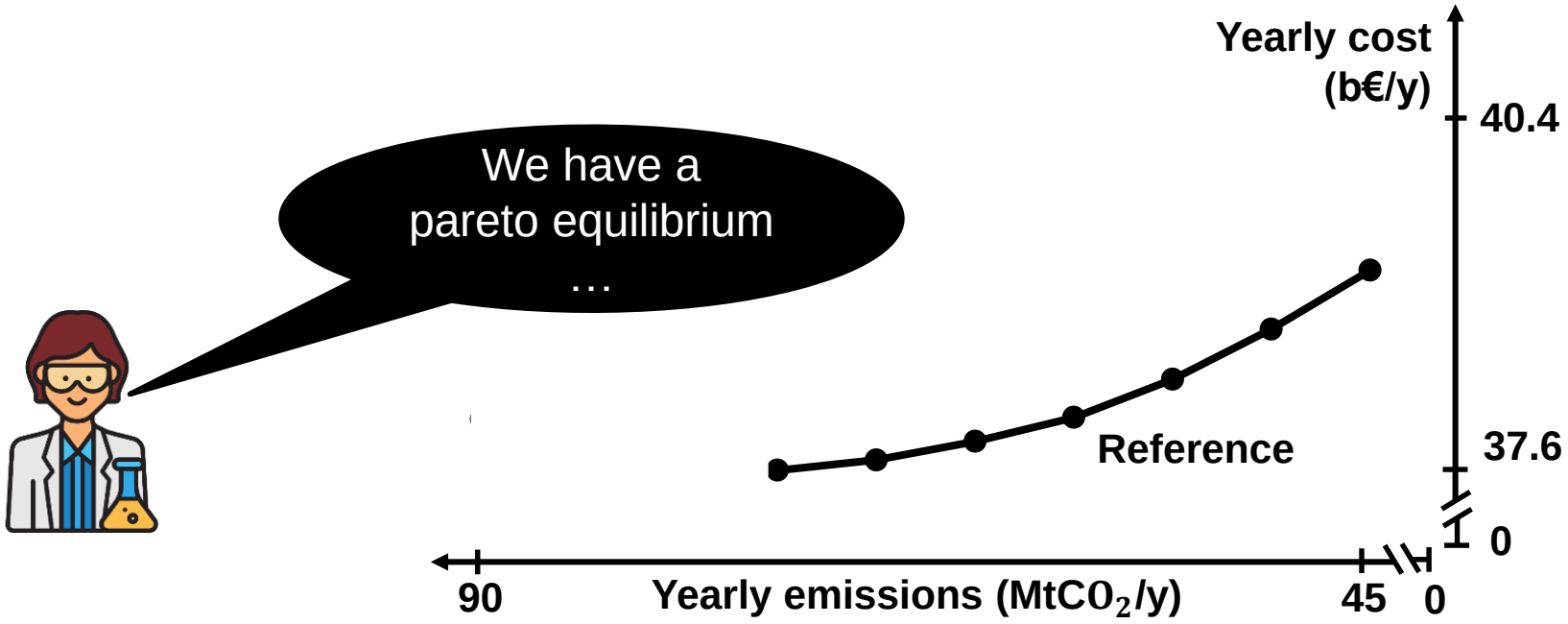


Pareto Cost-CO2 optima



Pareto Cost-CO2 optima

➔ **Reference case:**



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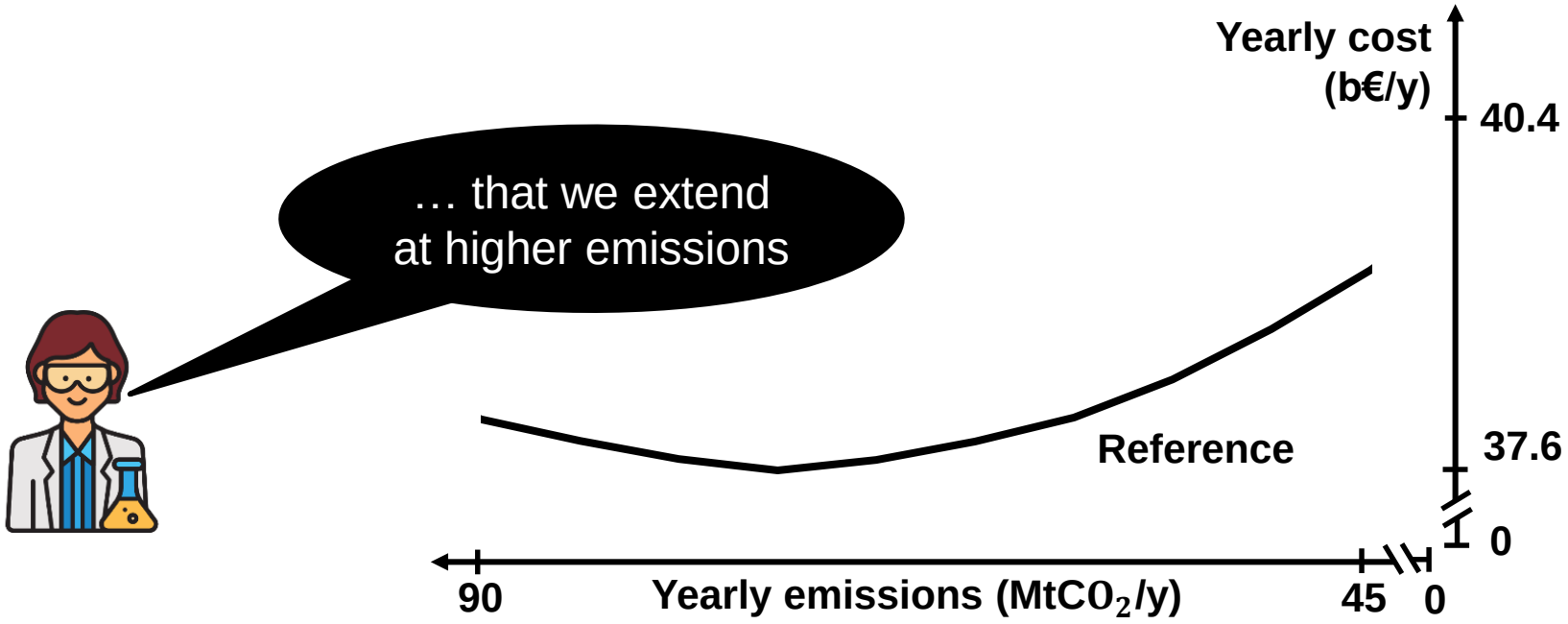
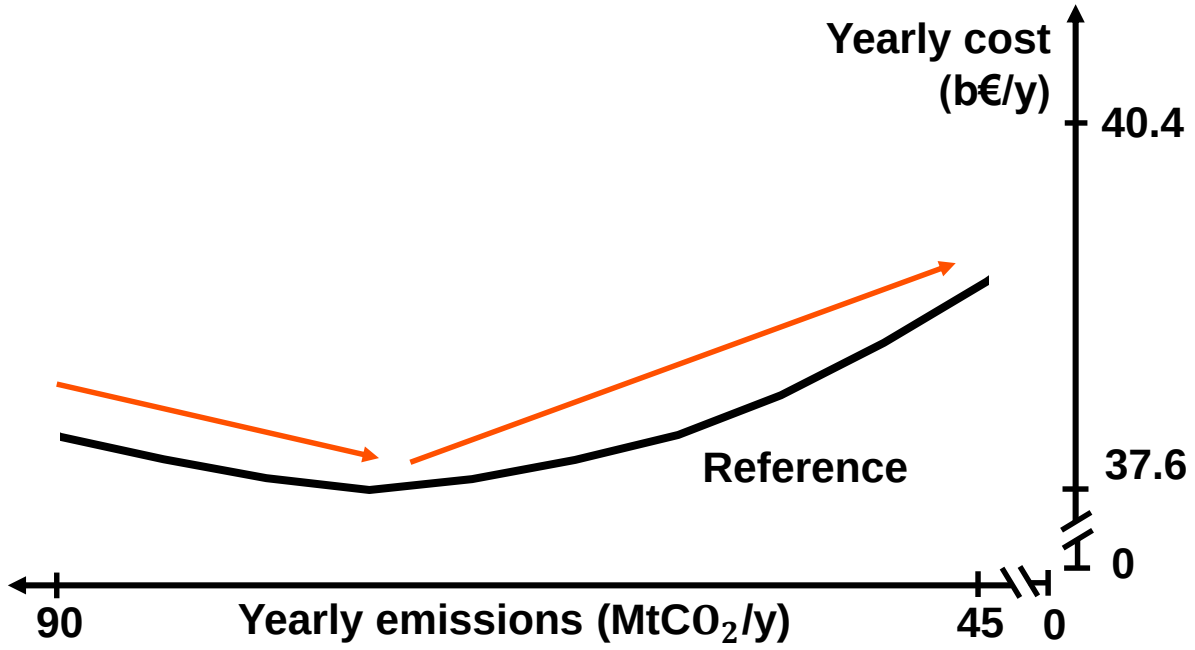


Pareto Cost-CO2 optima

➔ Reference case:

- Efficiency measures
- Intermittent integration costs

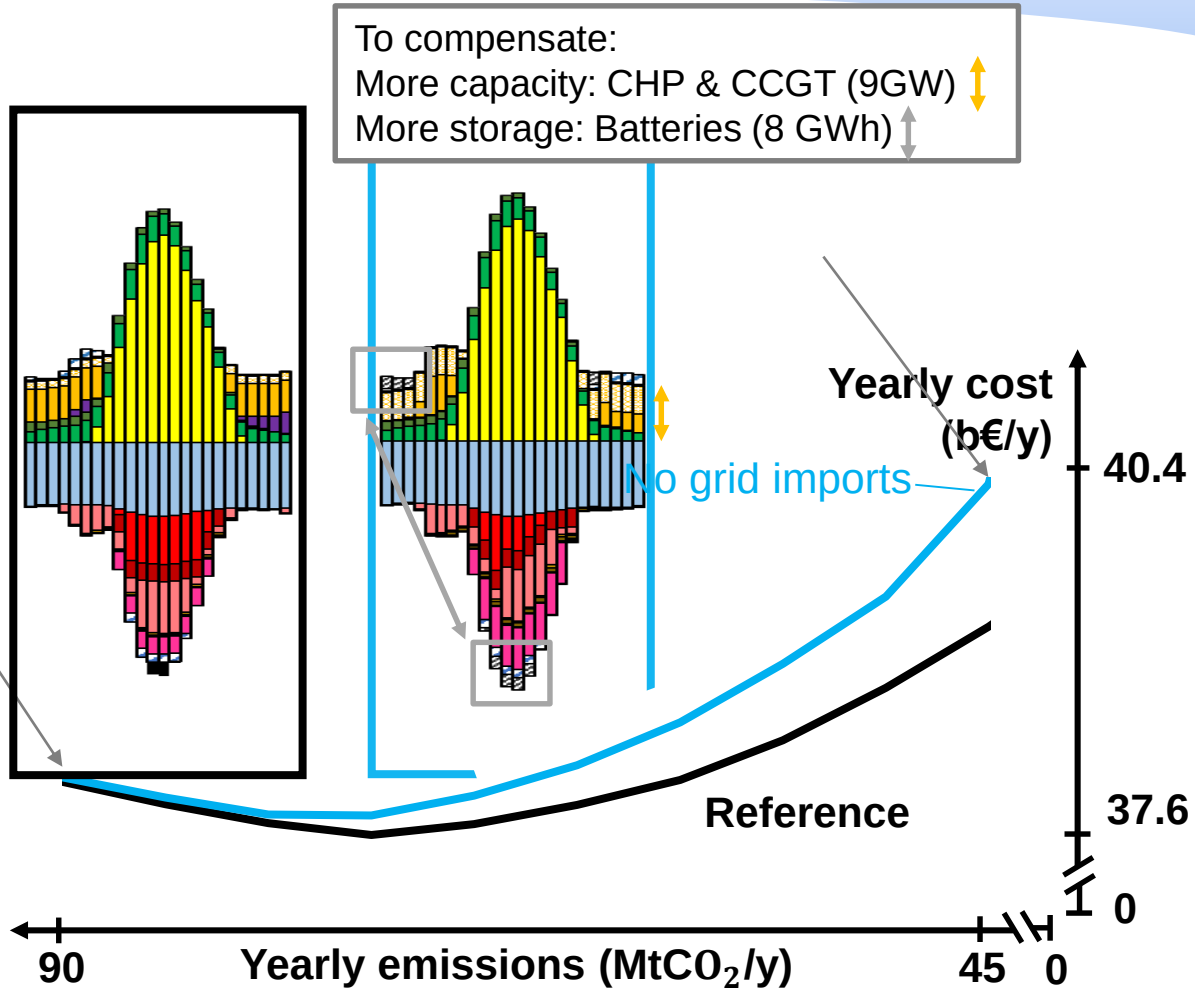
- Minimum emissions:
  45MtCO2/y
  (no imports of renewable fuels)



Pareto

➔ Pillars:

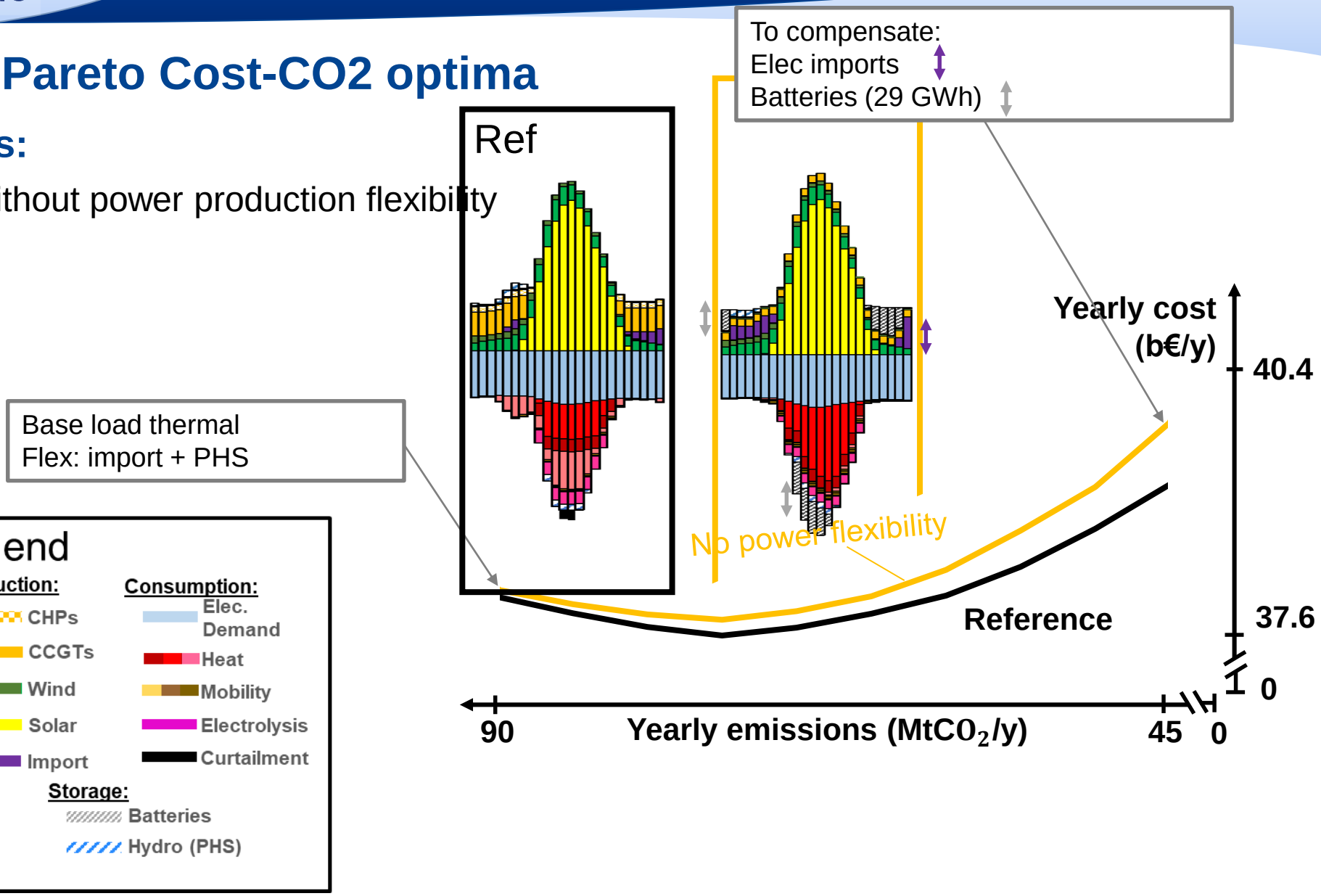
1. Without power flexibility:



Pareto Cost-CO2 optima

➔ **Pillars:**

2. Without power production flexibility

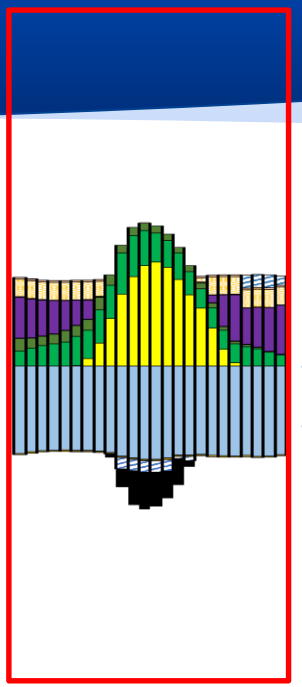


Pareto

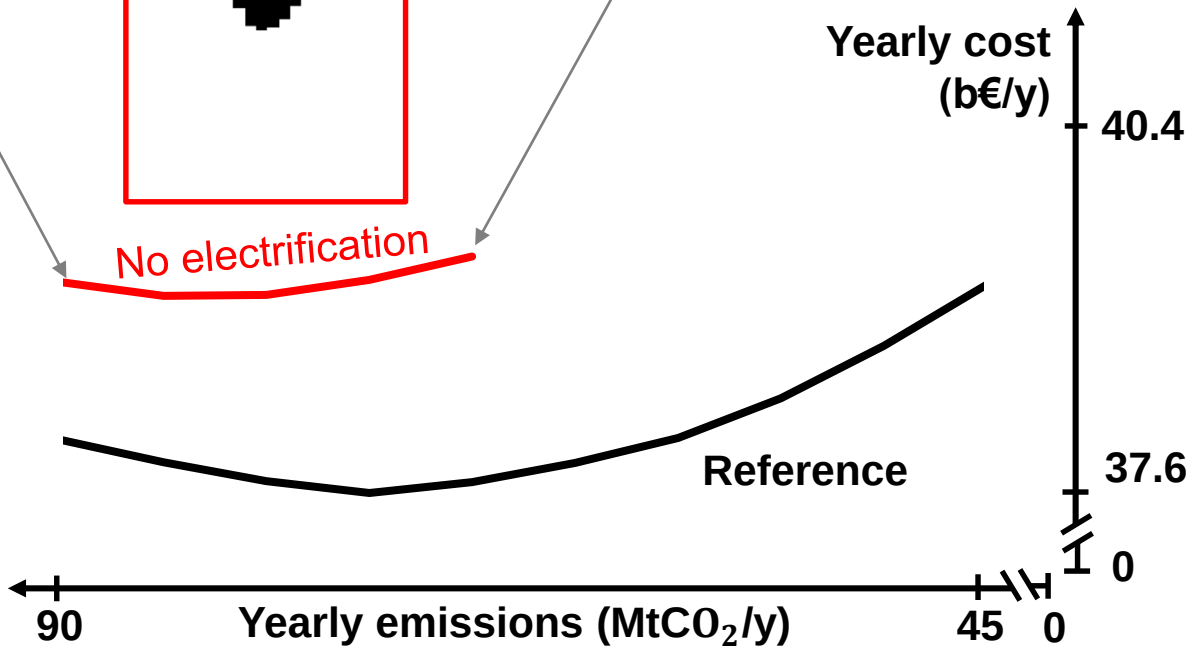
➔ Pillars:

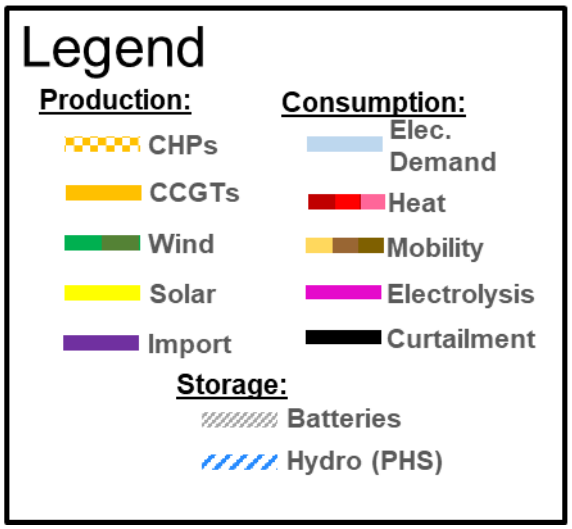
3. Without electrification

More expensive mobility:
No trams/trains, but CH4 buses



Elec demand cannot increase ↕
=> Cannot deploy more renewable (PV & Wind)

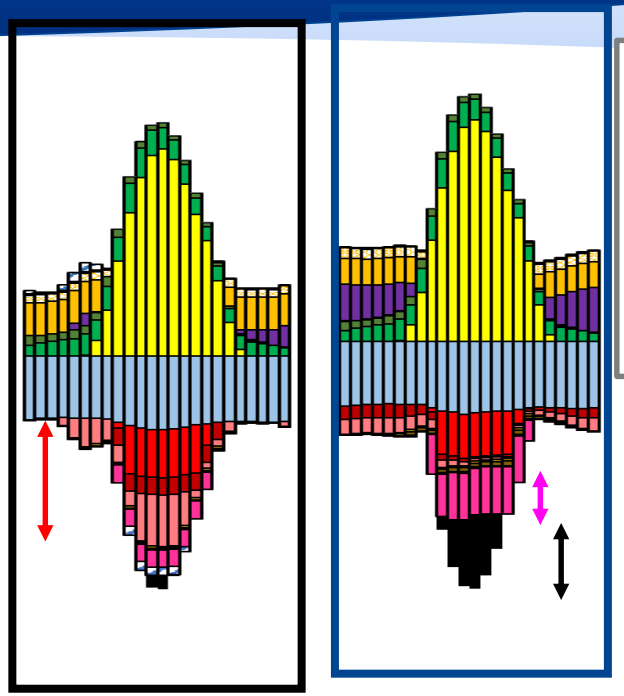




Pareto

➔ Pillars:

4. Without storage

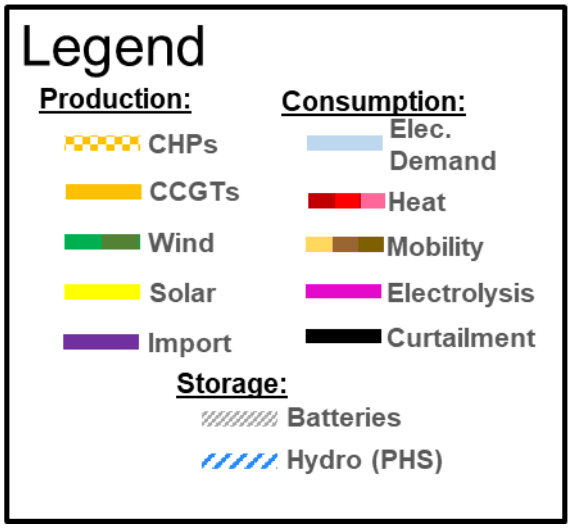


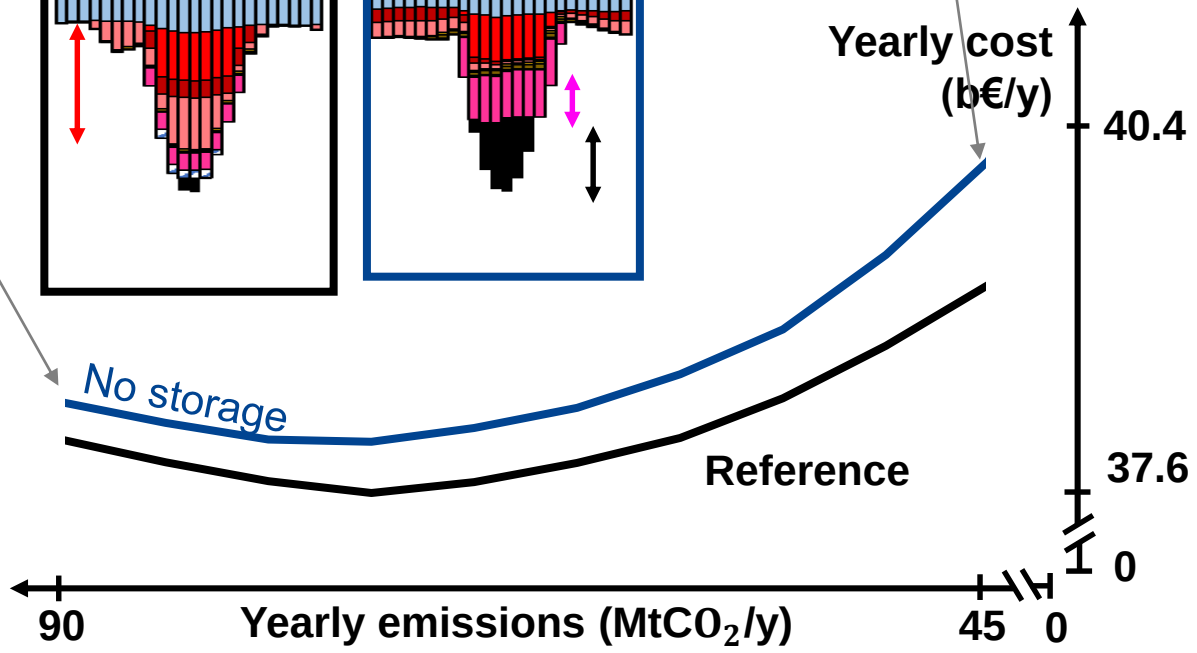
More curtailment ↕
=> more production

PtH not flexible consumer ↕

More electrolysers ↕

More expensive:
Oversizing technology
to fit peak demand

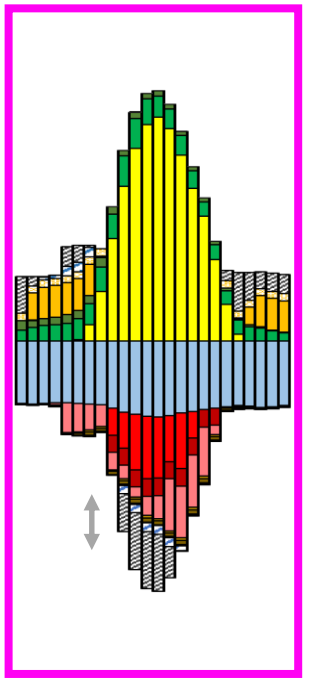




Pareto

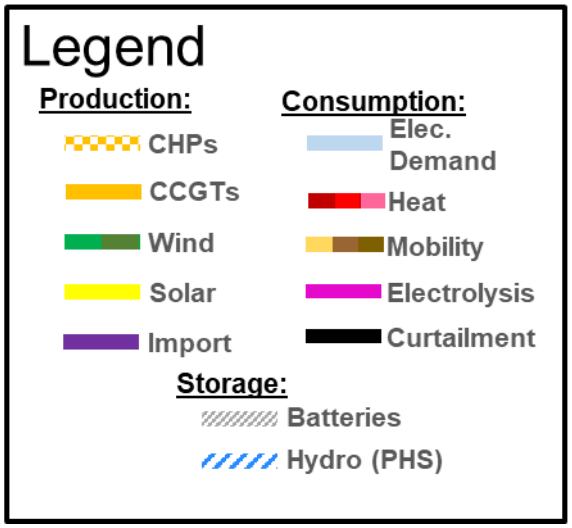
➔ Pillars:

5. Without synthetic fuels



Less biomass used
No electrolysis ✕

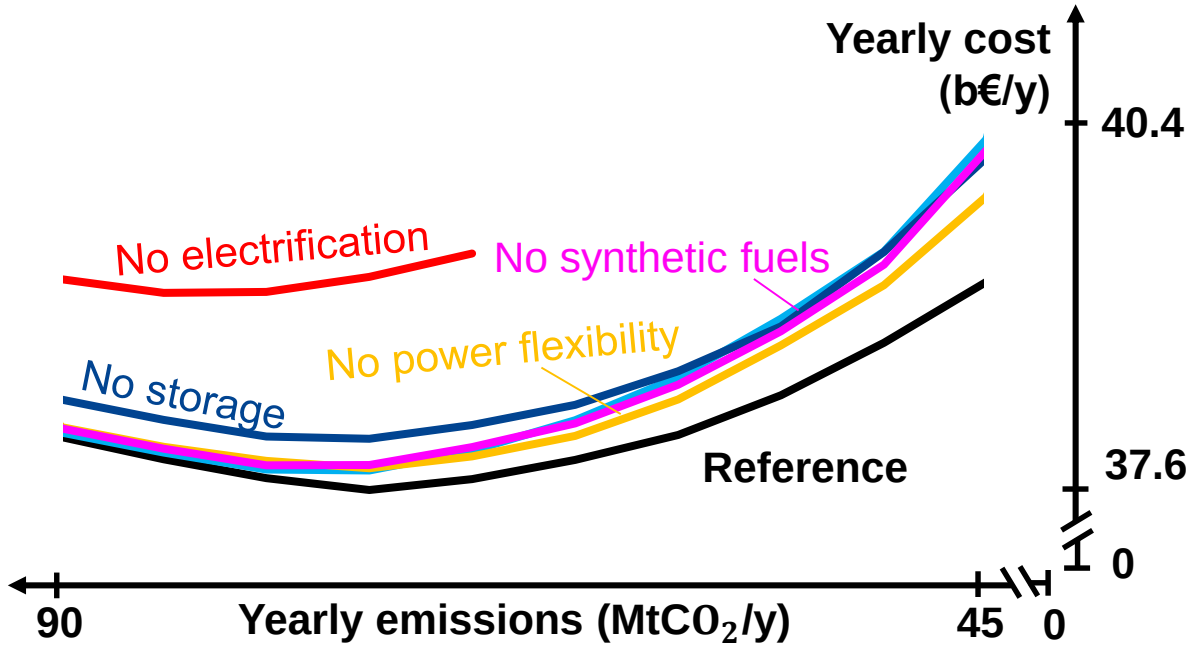
=> More gas used
=> More efficient measures to avoid curtailment and losses



Conclusion

➔ Pillars:

- There is no '*Silver bullet*'. Instead a mix is necessary to decarbonate the system.
- Electrification is mandatory to integrate massive share of PV and wind



THANKS YOU

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