Renewably powered self-sufficient industrial sites - a cost analysis

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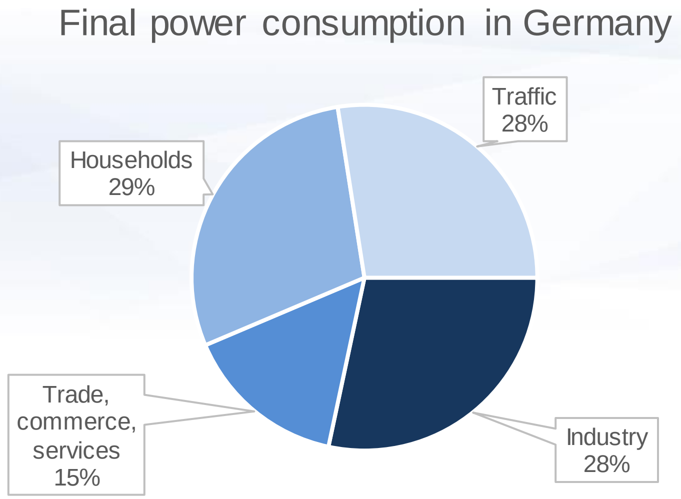
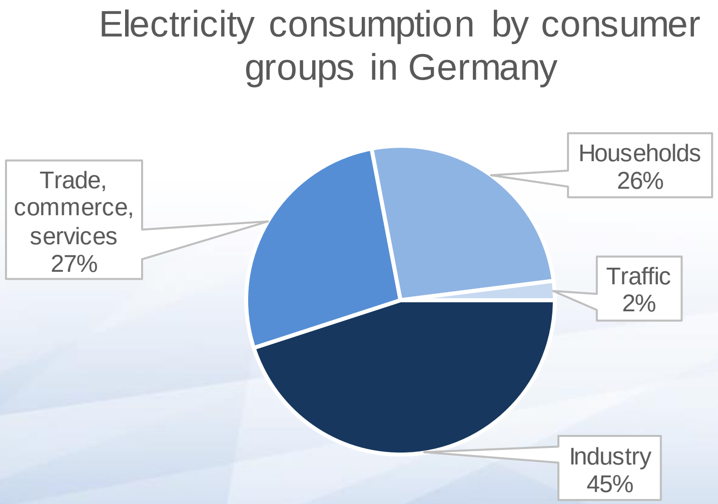
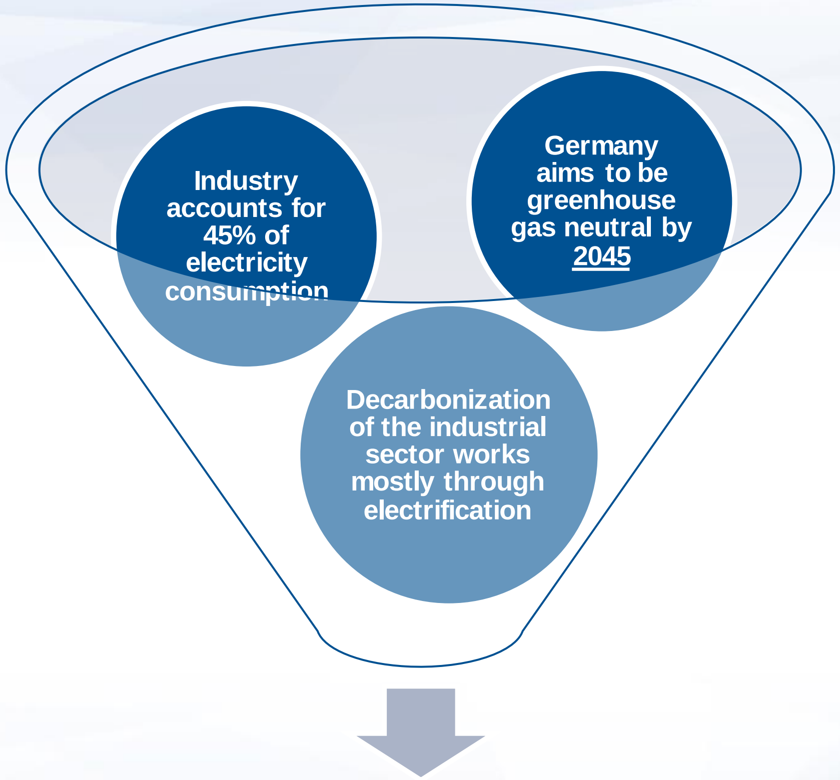
The Issue



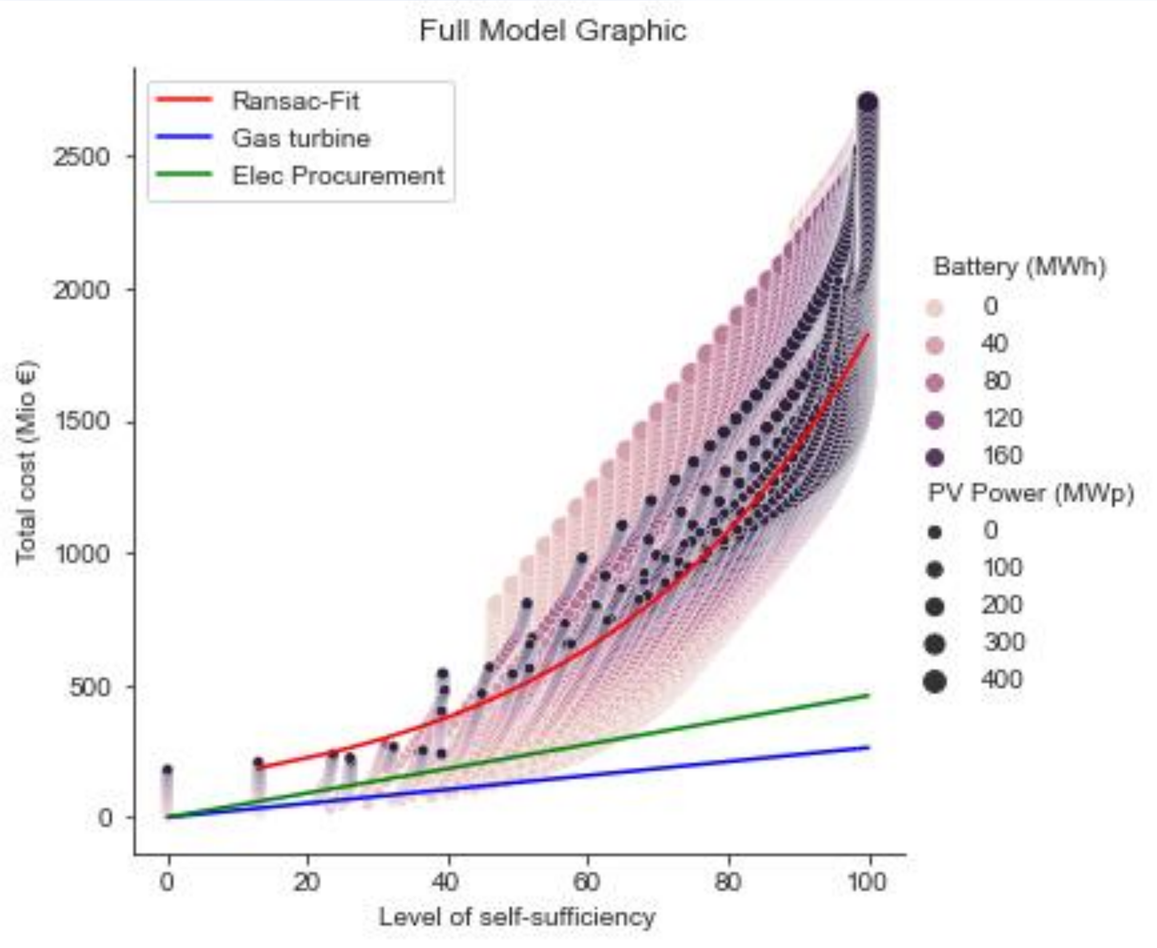




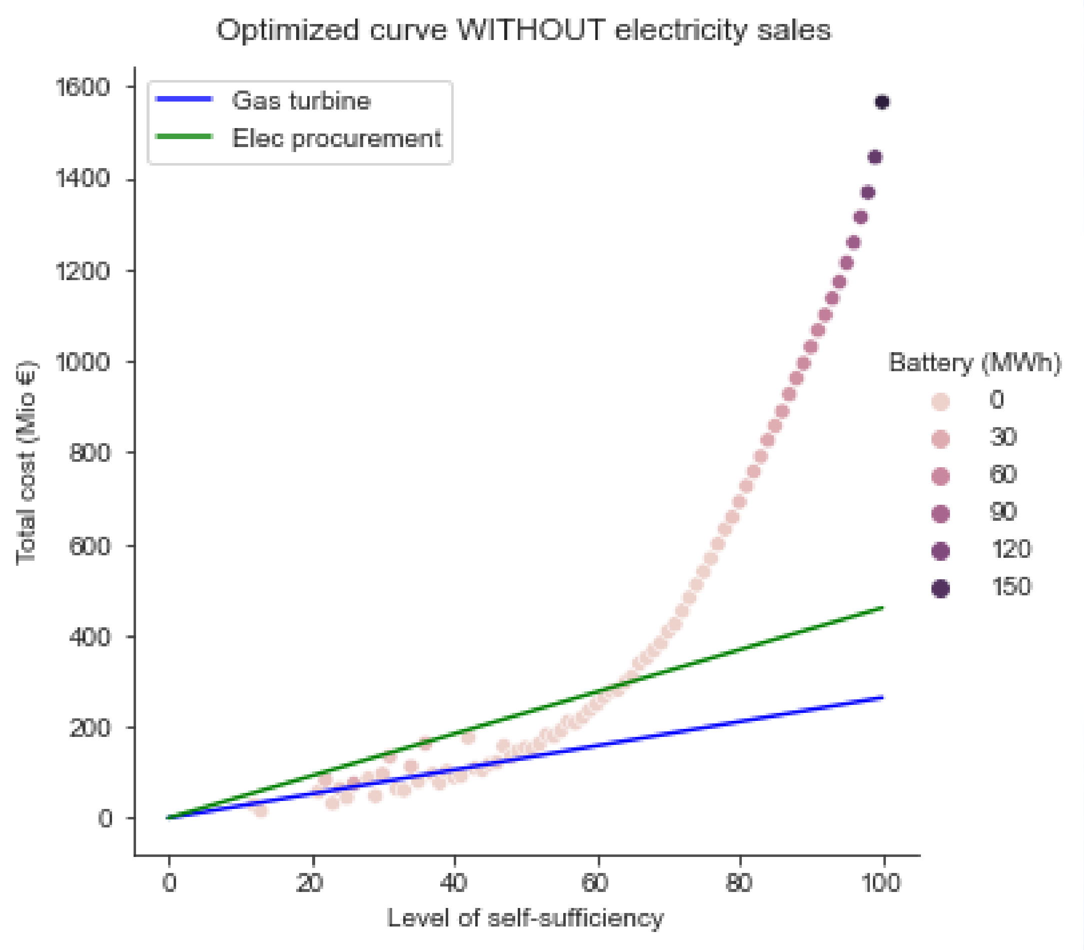
Industrial sites need to generate non-fossil based electricity

Method

- **Building of a cost-model that compares energy generation options**
  - Photovoltaics (PV)
  - Wind turbines
  - Batteries
  - Gas turbines
- **It calculates the most cost efficient combination of the options above**
- **Key input parameters:**
  - Global radiation and wind speeds for a given location
  - PV cost: 1.31 €/Wp (Capex) + 0.01 €/(Wp*a) (Opex)
  - Wind turbine cost: 1.62 €/W (Capex) + 0.05 €/(W*a) (Opex)
  - Battery cost: 500.5 €/kWh (Capex)
  - Gas turbine cost: 950 €/W (Capex) + 20 €/(W*a)
  - Market price for electricity: 0.21 €/kWh



Results (1)
LCOE & Cheapest option to power an industrial site

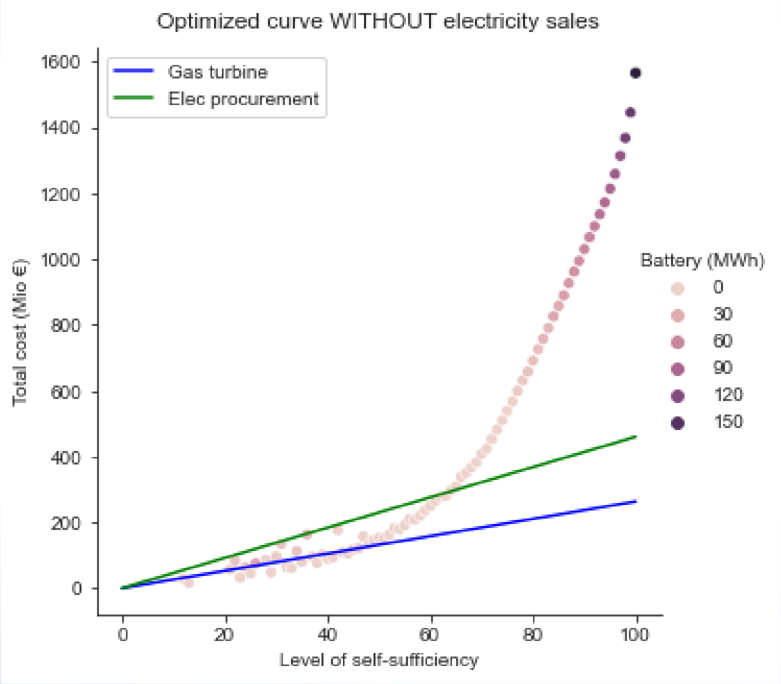


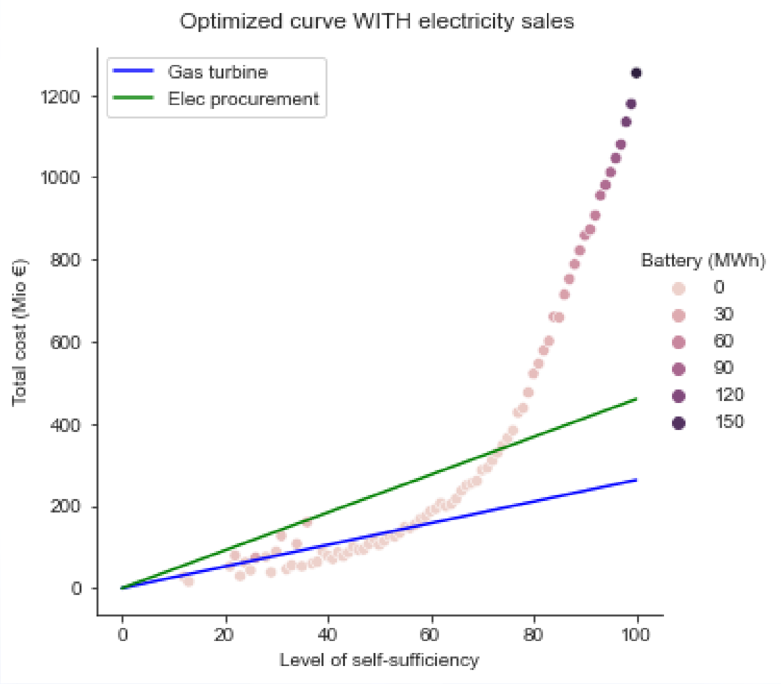
- **Results of the model for Frankfurt (LCOE):**
  - PV: 5,6 ct / kWh
  - Wind turbine: 10,1 ct / kWh
  - Gas turbine: 12,0 ct / kWh
- **But: Under today's circumstances gas turbines are the cheapest option to power a self-sufficient site**
  - Electricity is generated when needed
  - No overcompensation for dark windless days
  - No need for energy storages like batteries

Self-sufficiency	Cost Gas turbine (Mio. €)	Cost Renewables (Mio. €)	PV (MWp)	Wind (MW)	Battery (MWh)
35%	92.18	80.17	49.91	0	0
55%	144.85	191.45	29.95	50	0
75%	197.52	538.89	49.91	160	0

Results (2)
The effect of energy sales

- **Obviously there is a huge effect if the sales of unused electricity is added to the model (0.04 €/kWh)**
  - The highest self-sufficiency rate where only PV, Wind turbines and batteries are the cheapest option rises from 45% to 54%
  - High levels of self-sufficiency rates become a lot cheaper

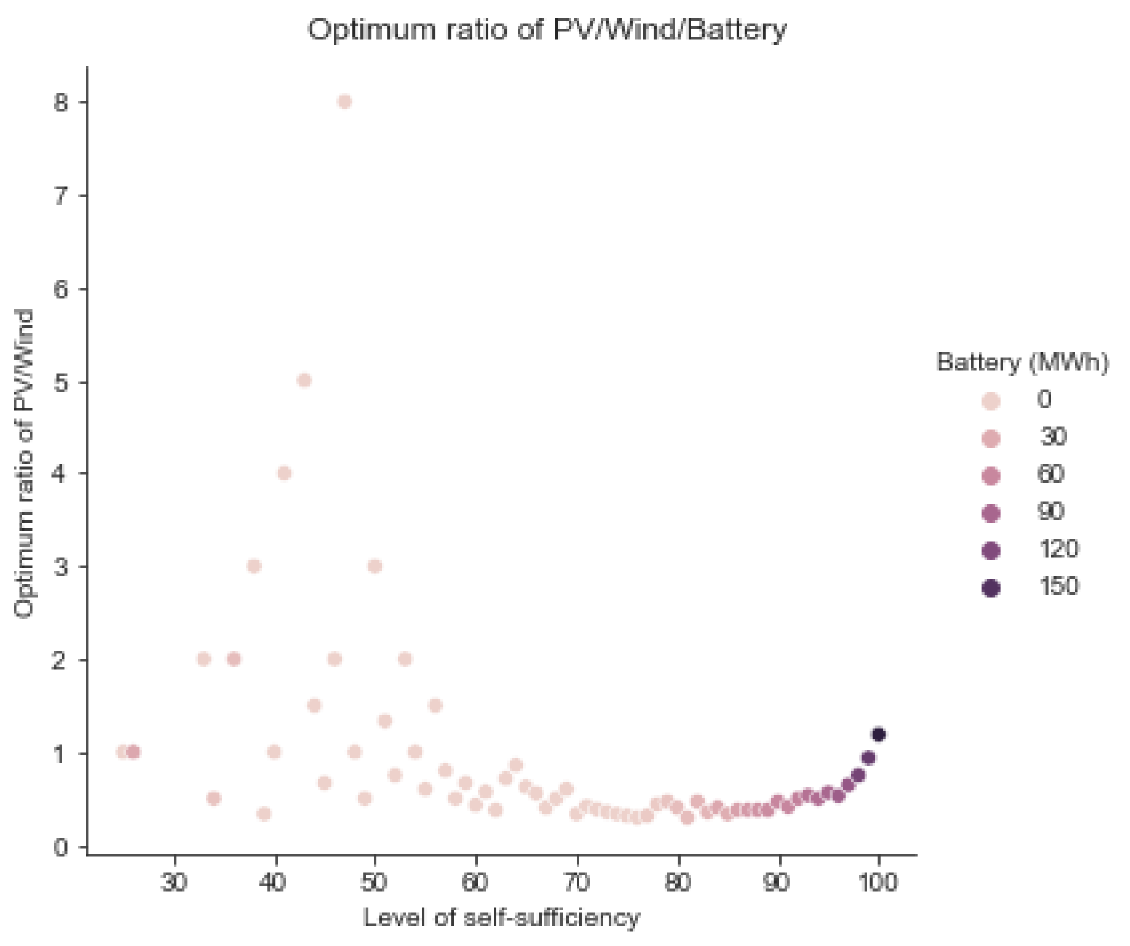




- **But: In a fully decarbonized electricity system every power company tries to buy / sell energy at the same time**
- **So: Can a company expect any willingness to pay for electricity when local renewables produce high amounts of energy?**

Results (3)
Cost efficient combination of PV/ Wind turbines and Batteries

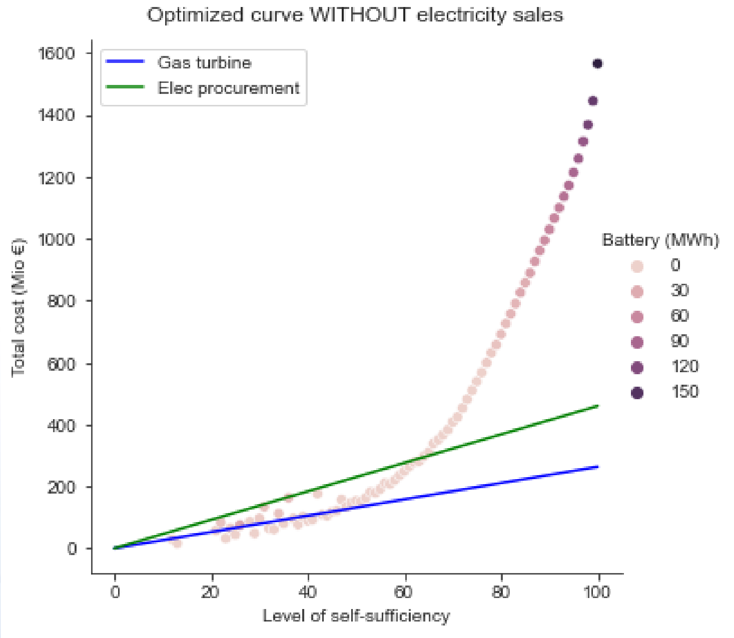
- **The most cost efficient combination of PV/ Wind turbines and Batteries is depending on the targeted level of self-sufficiency**
  - For low self-sufficiency rates high proportions of PV and no Batteries are the most cost efficient option
    - Low LCOE, but very unstable electricity generation
  - With increasing self-sufficiency rates the share of Wind turbines increases in the generator mix
    - Higher LCOE than PV, but more stable electricity generation
  - Only for very high self-sufficiency rates (> 75%) it is favorable to use Batteries
    - No electricity generation and high costs, but higher self-sufficiency rates can be reached



Results (4)
Reusing BEV Batteries

- **Recycling vehicle batteries is frequently mentioned as a way to use batteries more sustainably**
  - *Changes in the model:*

1. $\frac{\textbf{Capex Battery}}{\textbf{2}}$, Capacity of Battery = 80%
2. $\frac{\textbf{Capex Battery}}{\textbf{3}}$, Capacity of Battery = 80%



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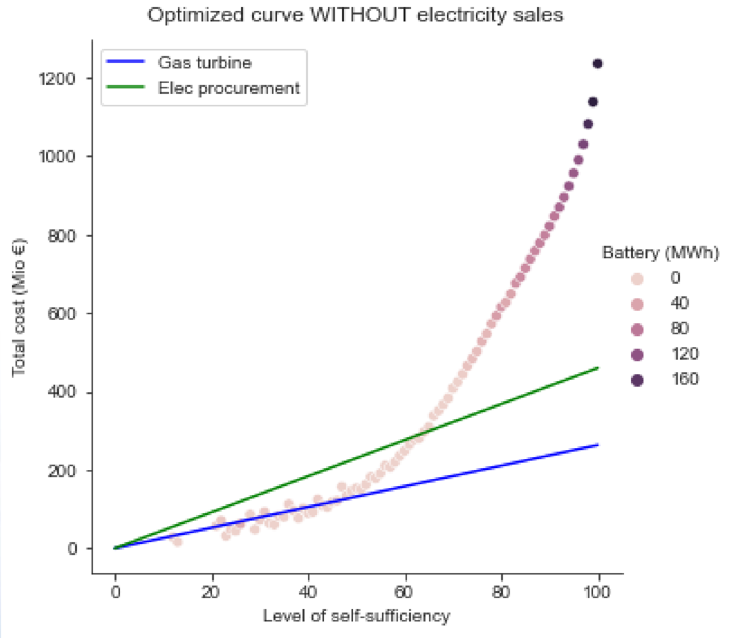

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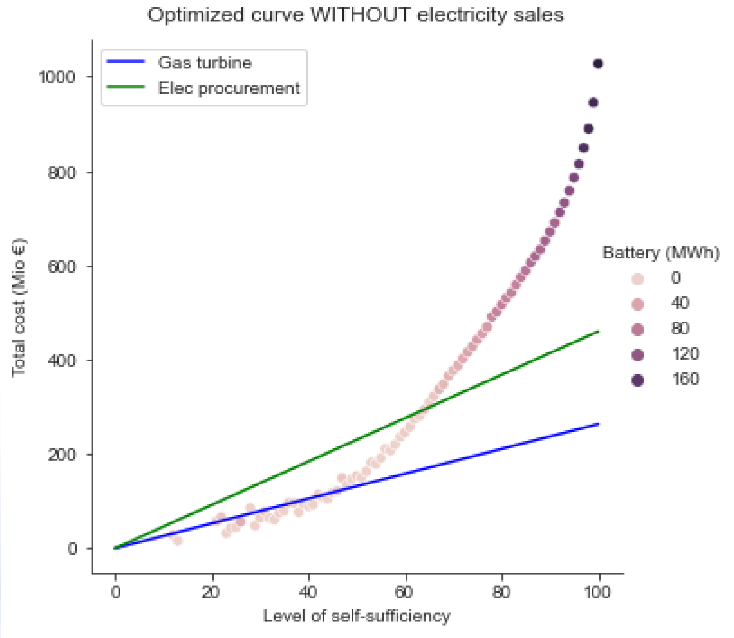

Limitations of the model

- The model does not include variable energy consumption profiles (for now)
- The industrial heat sector is not included (for now)
- Market prices for gas and electricity have a high impact on the cost comparison but forecasts are prone to failure
- Renewable energy sources consume large areas. The current model neglects land consumption.

Discussion

Thank you for your attention.

Questions?

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