MACREDES – Modelling a resilient decentralized energy system

EDGaR – Energy Delta Gas Research, the Netherlands

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Background of the project

- EDGaR project, 2010 – 2014, see http://www.edgar-program.com/

- Abbreviation of:

MApping the Contextual conditions of Resilient Decentralized Energy Systems

- Multi-disciplinary research with the University of Groningen, the Hanze University of Applied Science and DNV GL (on behalf of Gasunie)
- Role of DNV GL and Hanze: WP1 (Technical aspects)

- Essence:
  - **What is the regional energy potential of a region? (project focus on Northern Netherlands)**
  - **What is a realistic transition to a Resilient Decentralized Energy System?**

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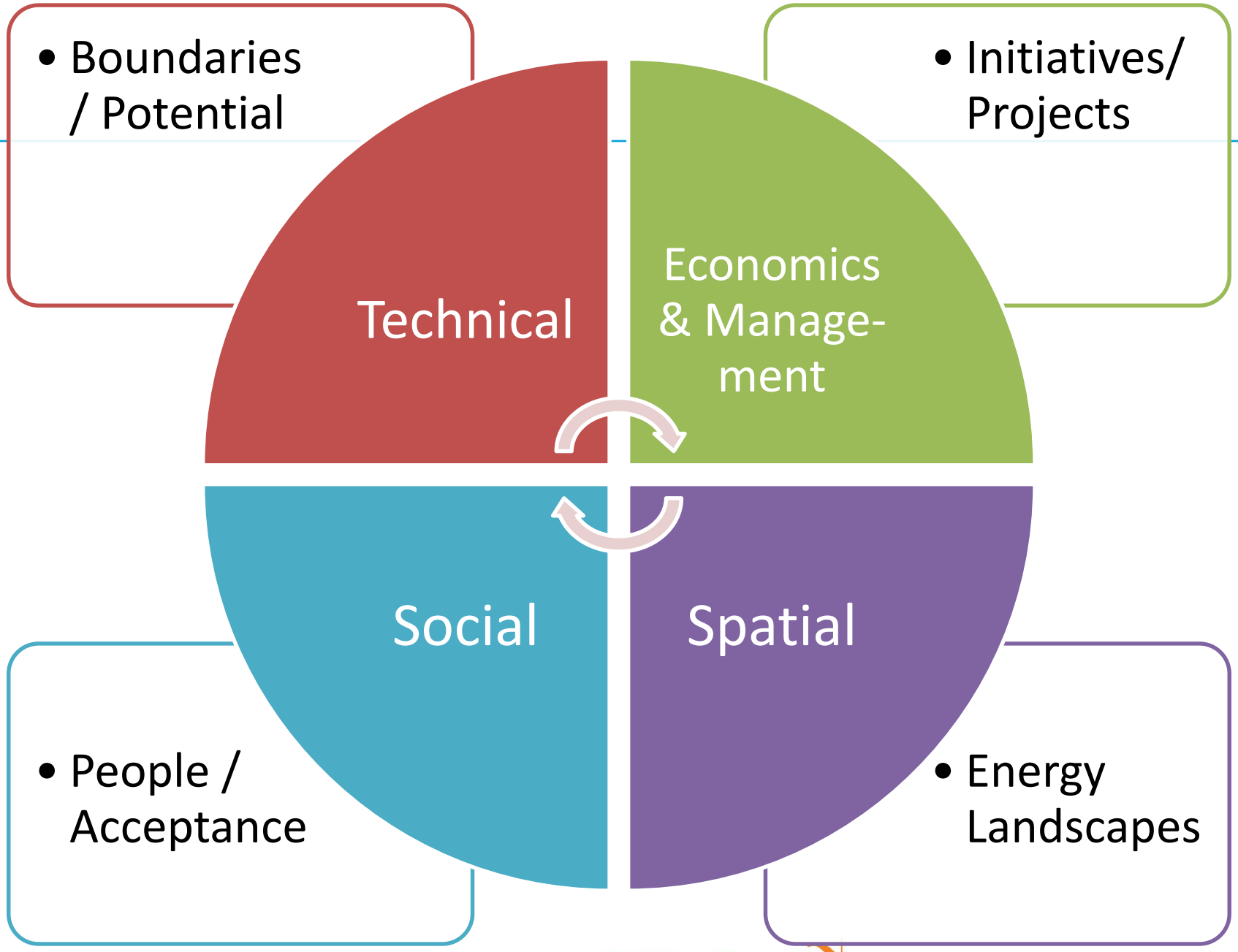

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Aim and approach of the research

- Aim: Determining technical conditions of a resilient decentralized energy system

- Approach:
  - Modeling (Matlab and Excel)
  - Finding an optimal solution, combining energy supply, demand, storage and conversion
  - Showing the technical implications of energy policies

Energy balancing model

Value of the model: enabling estimations of the viability of solutions

Provide insight to policy makers

Question: can the energy demand (E, H, G) be met on hourly basis, in a specific area from decentralized and partly non-adjustable supply?

➔Generating sufficient energy

➔Balancing temporary surpluses and shortages using storage

➔If necessary, convert energy from one source to another

Supply, storage and conversion are varied in size and number until the energy demand is met at all times

➔ Focus on Northern Netherlands, but model is applicable to many regions

Focus region Northern Netherlands

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Input of the model

- Energy demand $E_e(t)$, $E_h(t)$ en $E_g(t)$ (electricity, heat and gas)
- Numbers and sizes of
  - energy sources
  - storage capacities
  - conversion capacities
- Solar and wind profiles (hourly basis)

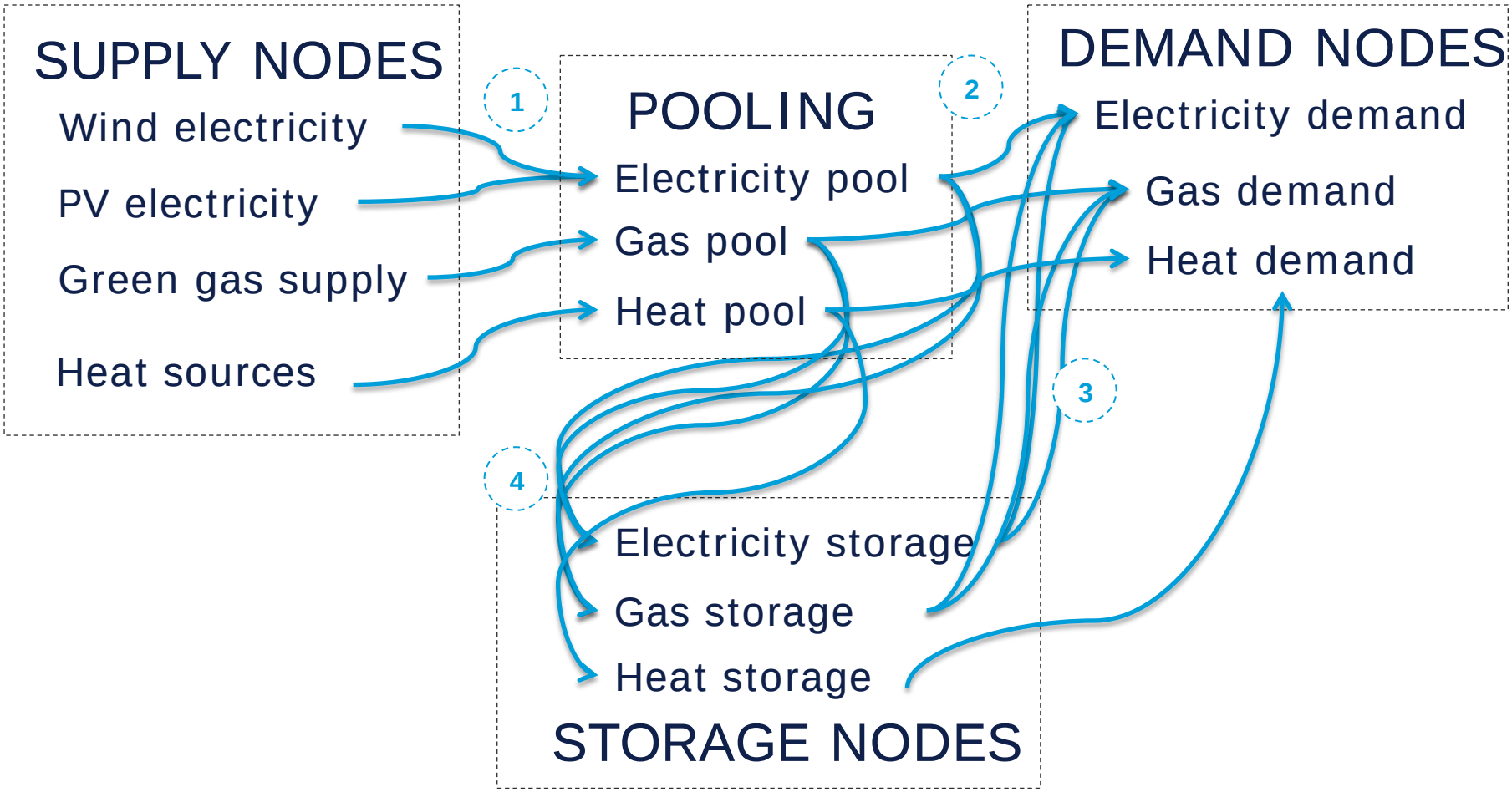
Output of the model

1. The energy delivered as a function of time (constraints: demand is met at all times, over the simulation period there is supply and demand equilibrium)
2. Surface area required for the energy system
3. Costs

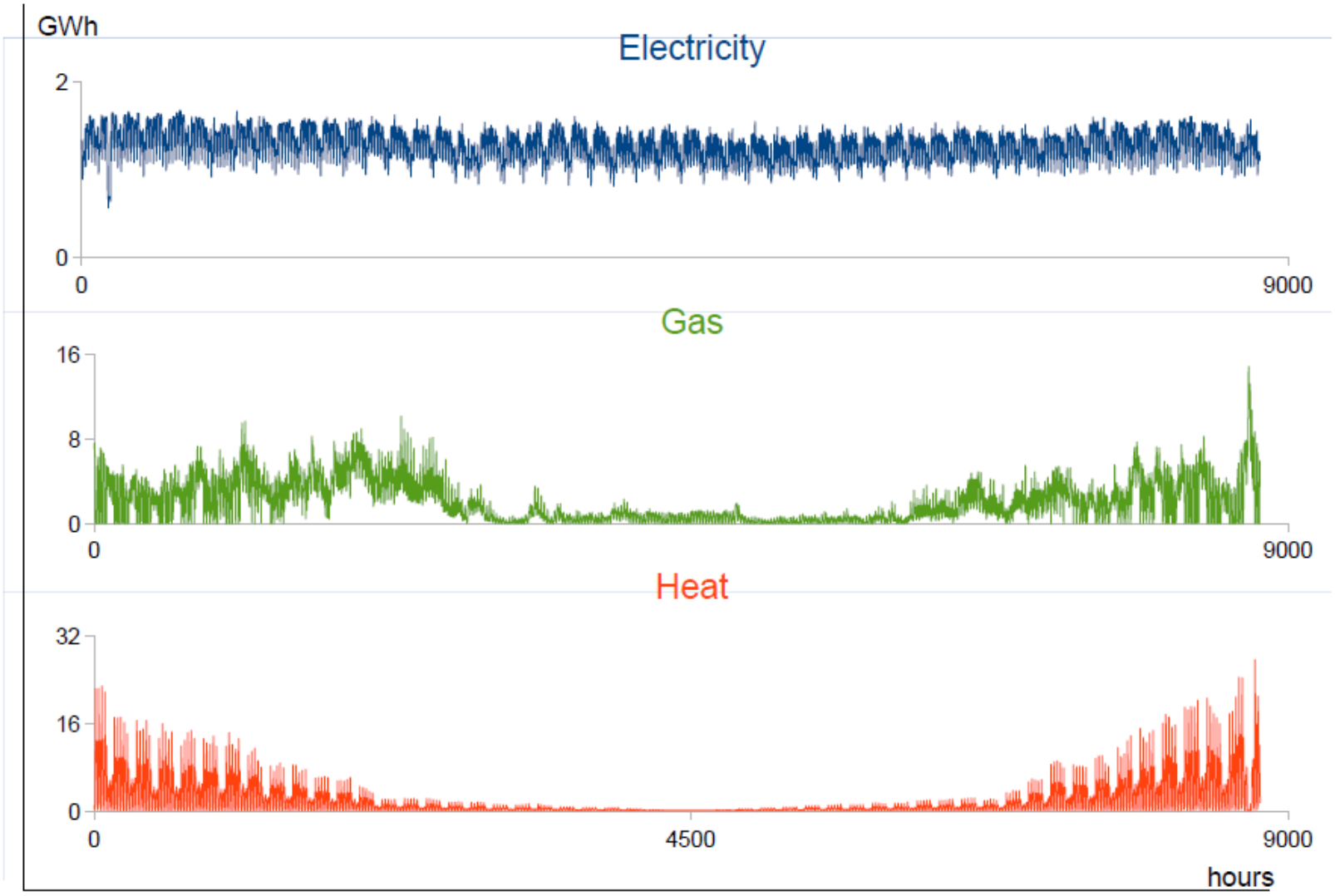
These results are used for further analysis (e.g. compatibility with other constraints (societal, legal, economical, etc.)

Basic algorithm of Macredes model

For every hour, this algorithm is executed:



Some profiles: energy demand electricity, gas and heat



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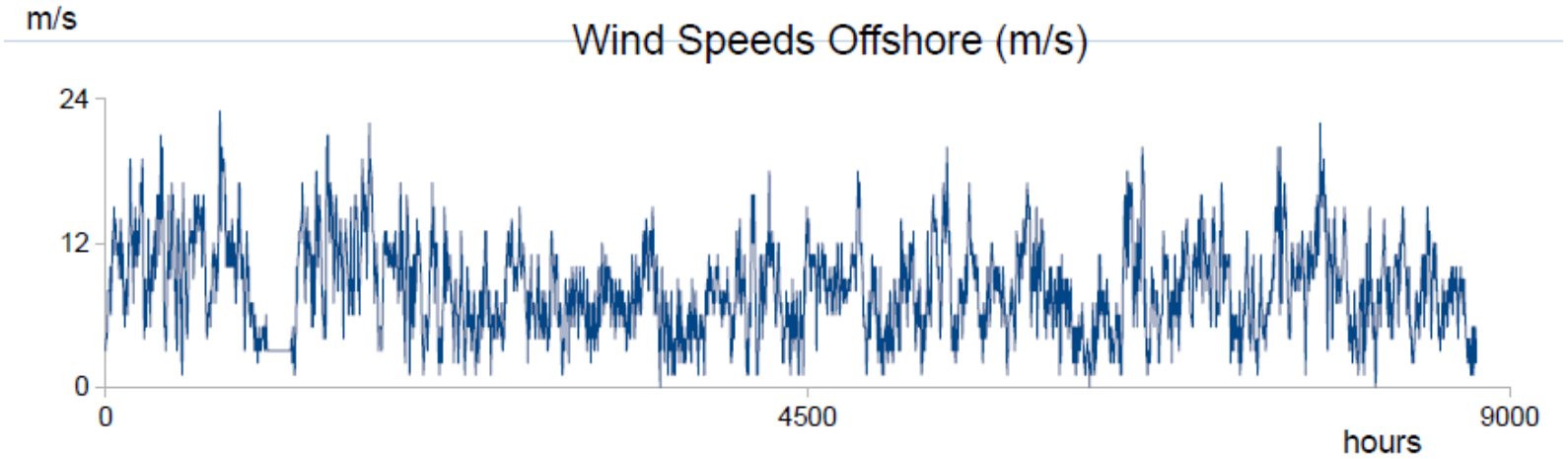
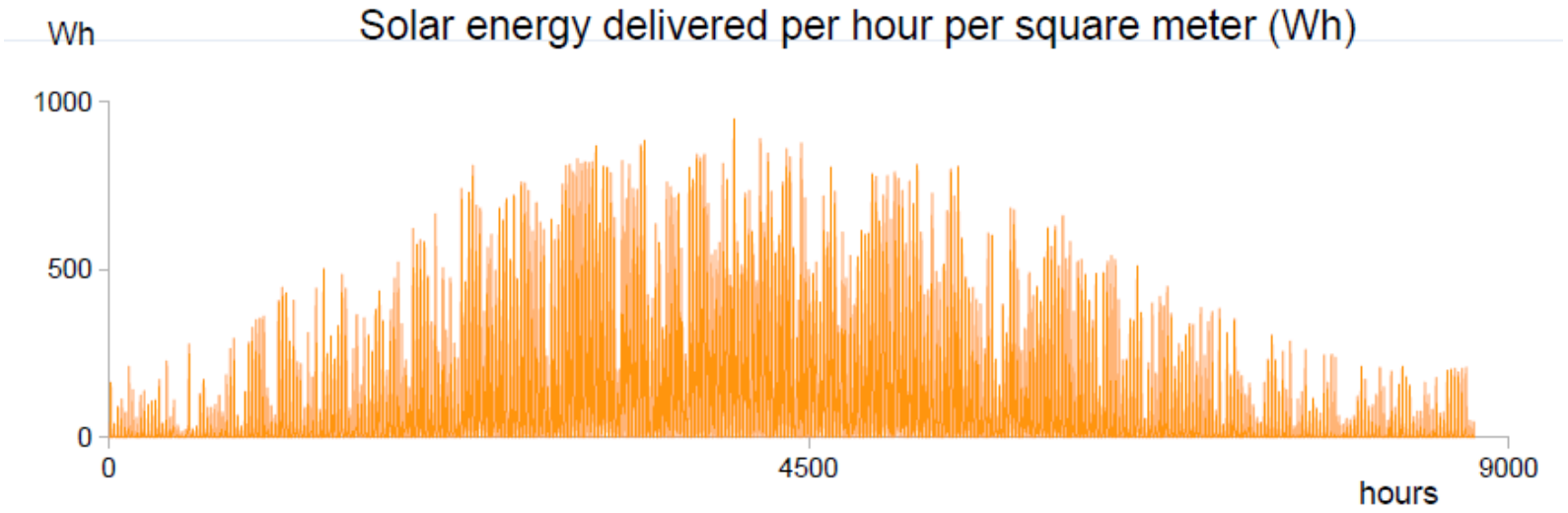
Some profiles: wind and solar energy





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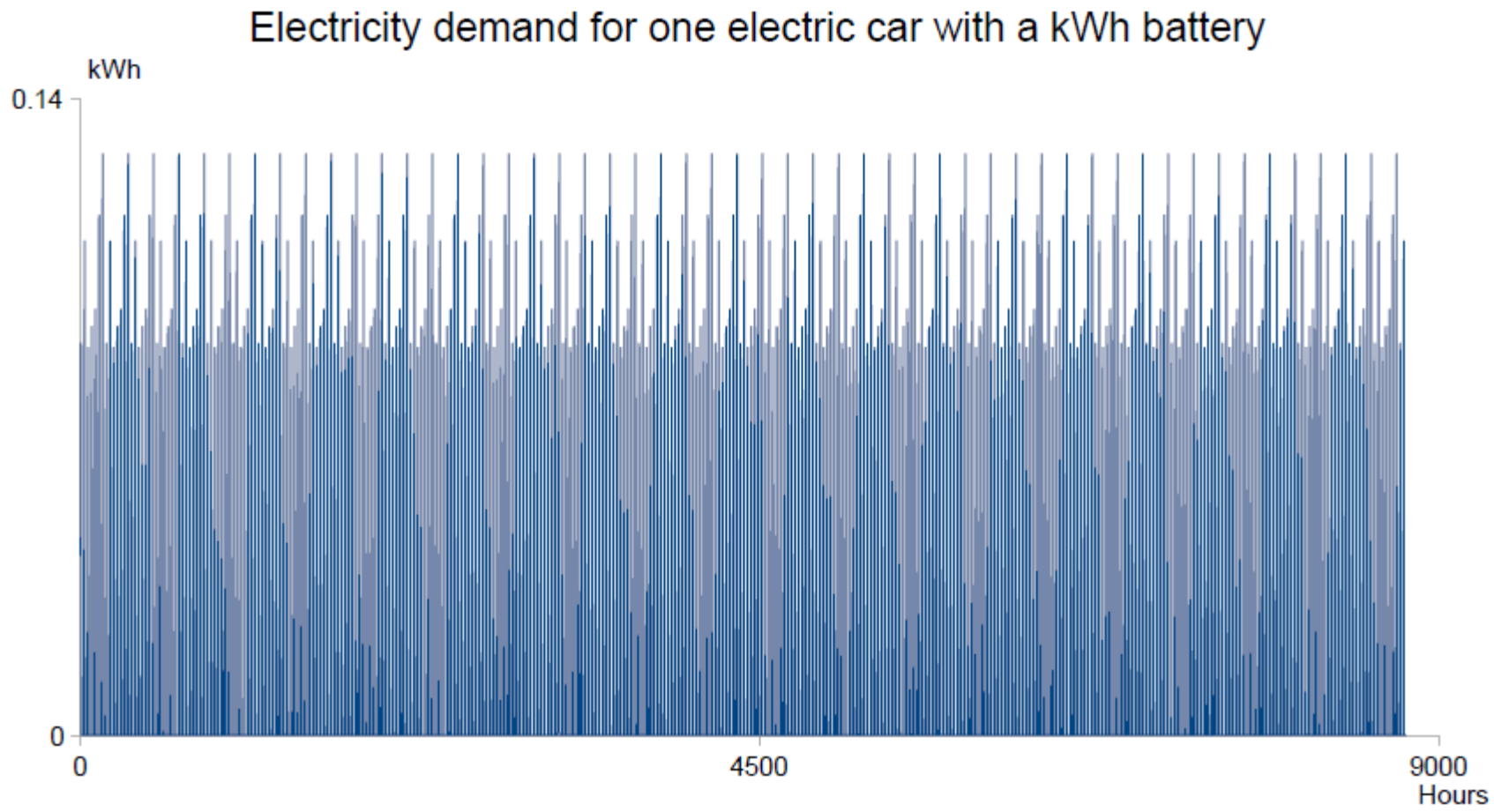
Some profiles: electric car



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Results on simplified scenarios – only PV production

- Stored energy as a function of time

- Constraint: storage may never be empty
- Regular demand pattern, PV production pattern
- Storage very often full

Results on simplified scenarios – only PV production

- Production capacity vs. required electric storage

- Extensive series of model runs
- Regular demand pattern, PV only energy source
- Clear tradeoff between generation capacity and storage capacity

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Results on simplified scenarios – only wind onshore

- Regular demand pattern, wind onshore production pattern
- 3 MW turbines
- Storage never full in this case

Results on simplified scenarios – only wind turbines onshore

- Production capacity vs. required electric storage

- Extensive series of model runs
- Regular demand pattern, PV only energy source
- Clear trade-off between generation capacity and storage capacity

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Results on simplified scenarios – only wind offshore

- Regular demand pattern, wind offshore production pattern
- 7,5 MW turbines
- Storage often full in this case

Results on simplified scenarios – only wind turbines offshore

- Production capacity vs. required electric storage

- Extensive series of model runs
- Regular demand pattern, offshore wind only energy source
- Sharp bend in the curve

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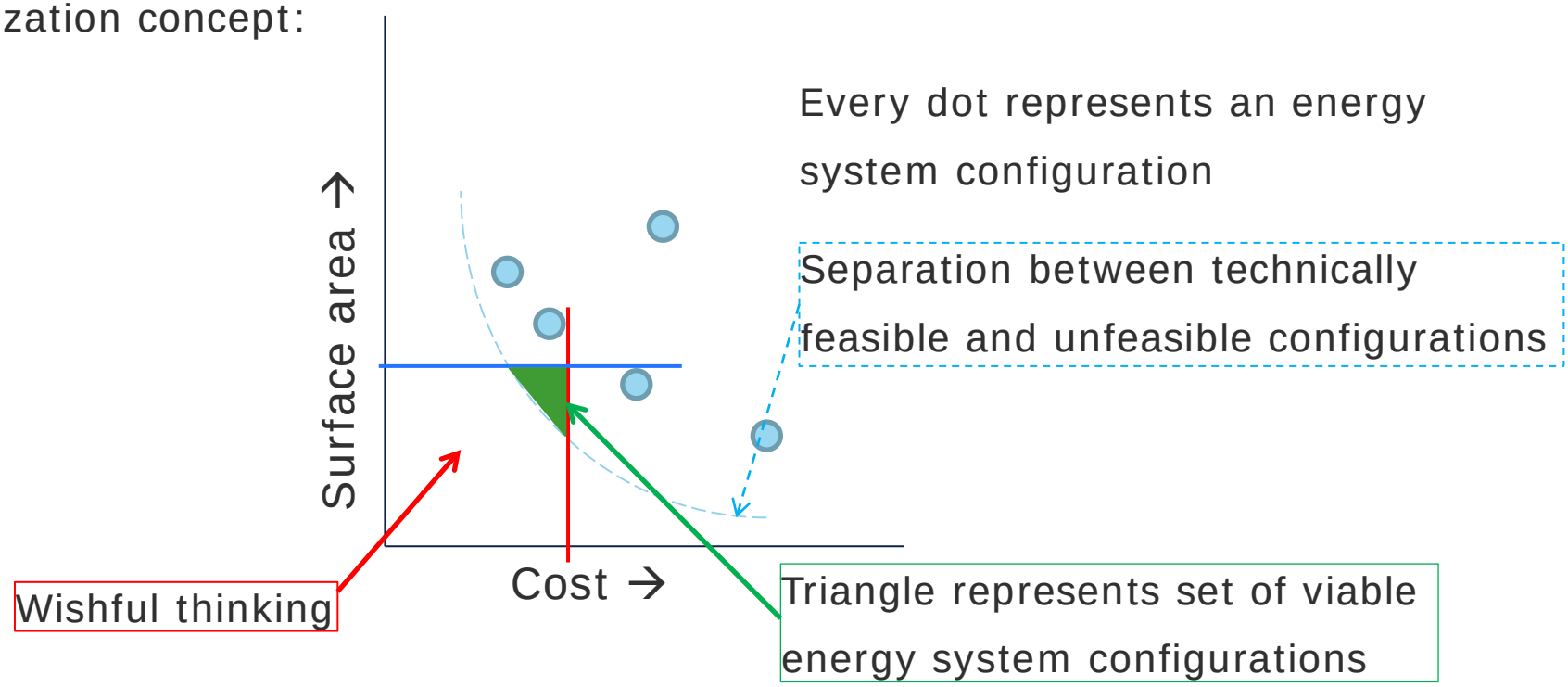
What can we use this for?

- Calculate energy system scenarios
- Show consequences of choices (e.g. target of x % power from renewable sources)
- Support integral thinking on the energy transition
- Visualization concept:



Conclusion and outlook

- Macredes model built to be able to:
  - Calculate technical feasibility of energy transition targets
  - Show relationship between required surface area and cost
  - Help determine optimal energy system layout

- The model will be used for complex energy systems
  - Multiple (renewable) energy sources
  - Multiple storage technologies (with charging, decharging capacities)
  - Multiple energy conversion options (with ramp-up and ramp-down constraints)
  - Exchange with ‘foreign’ energy systems

- Put simply: can you reach your transition targets? Which technologies do you need?

Macredes scenario results: quick and rough calculations

- Calculation resulted in technically possible coverage of most energy demand
- Costs not calculated, but – based on technical specifications – expected to be very high
- Not enough biomass for transport fuels:
  - (Solution: more electrical vehicles – but prob capacity)
- Conclusion:

1. Conversion and temporal balancing essential tem (Note: Embedded CO_2 not even considered)
2. Renewable energy system incompatible with

Source: infobae.com

- Solution?
  - Energy efficiency measures
  - Revolution in electricity storage
  - Demand shifting schemes
  - More radical: reduction in energy consumption and wealth?

Thank you. Questions?

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