IEA Energy Conservation through Energy Storage Programme

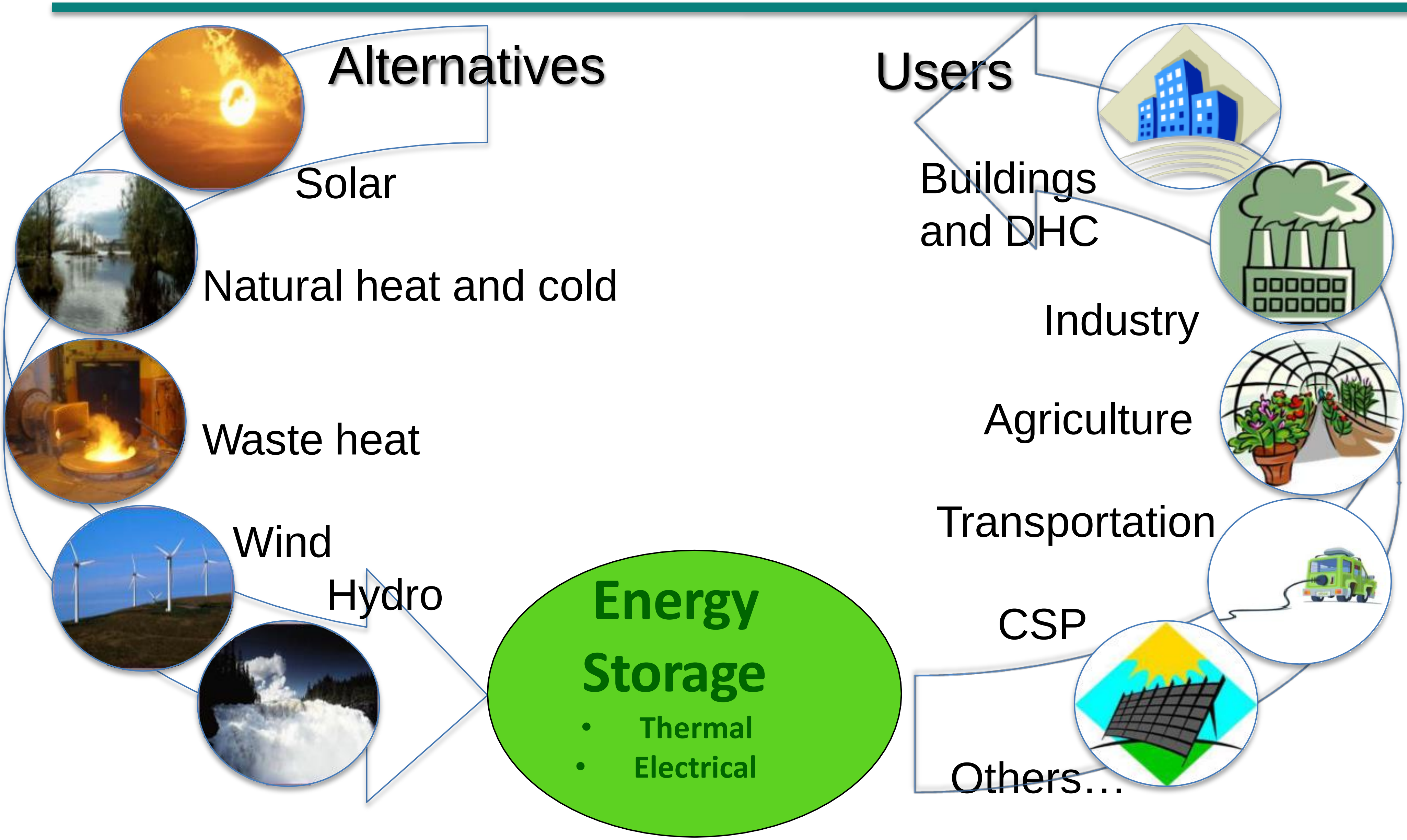
ECES

- since 1978
- Thermal or Electrical Energy Storage Technologies
- Mission

  "To facilitate an integral research, development, implementation and integration of energy storage technologies to optimize energy efficiency in any kind of energy system and to enable the increasing use of renewable energy instead of fossil fuels."
- 18 Participating Countries
- Chair: Halime Paksoy, Cukurova University, Turkey

www.iea-eces.org

Energy Storage
Matching Supply and Demand



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Participating Countries

ECES

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Federal Ministry
of Economics
and Technology

IEA Committee on Energy Research and Technology
EXPERTS' GROUP ON R&D PRIORITY-SETTING AND EVALUATION
The Role of Storage in Energy System Flexibility
Berlin (Germany), 22nd October 2014

»Future Electric Energy Storage Demand«
- Results from the IEA eces26 project

Dr. Christian Doetsch (OA eces26)

Fraunhofer UMSICHT

Supported by:

Federal Ministry
of Economics
and Technology

on the basis of a decision
by the German Bundestag

IEA eces26

iea Energy Technology Network

ECES

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General approach

What is the aim of a project called
„Future electric energy storage demand“ ?

The most expected answer is:

„In 20xx (year) the energy storage demand for yy (country) is about zz GW“

General approach

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„Future electric energy storage demand“ ?

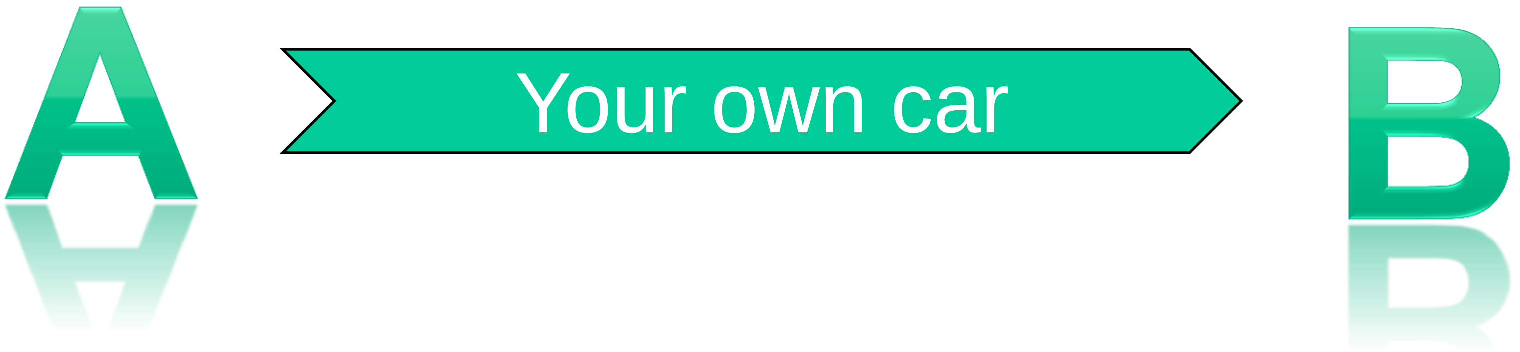
The most expected answer is:

„In 20xx (year) the energy storage demand for yy (country) is about zz GW“

But this is wrong !

Example: Travelling

If you want to go from A to B you can derive a demand of using your car for (e.g.) 2 hrs for this way….



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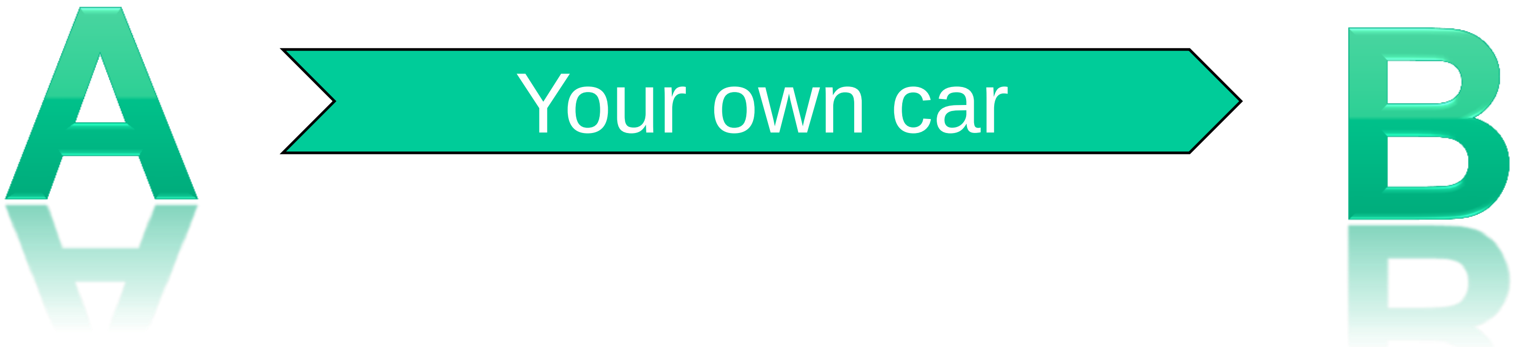

But this is not the general demand.
This is only ONE technical solution.
And it is only valid for a single special case

The real demand is to **<u>travel</u>** from A to B (incl. distance, time, comfort etc.).

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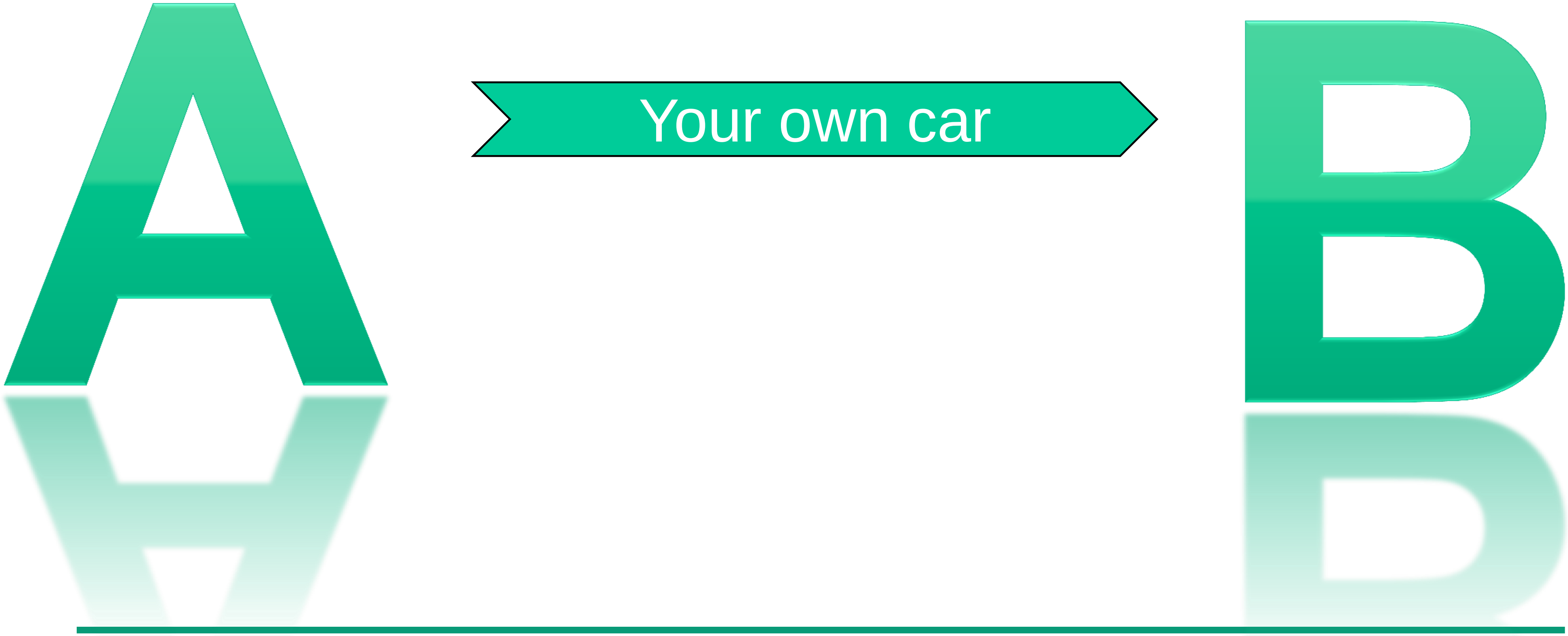
Example: Travelling

And there are more opportunities then only one ….



Example: Travelling

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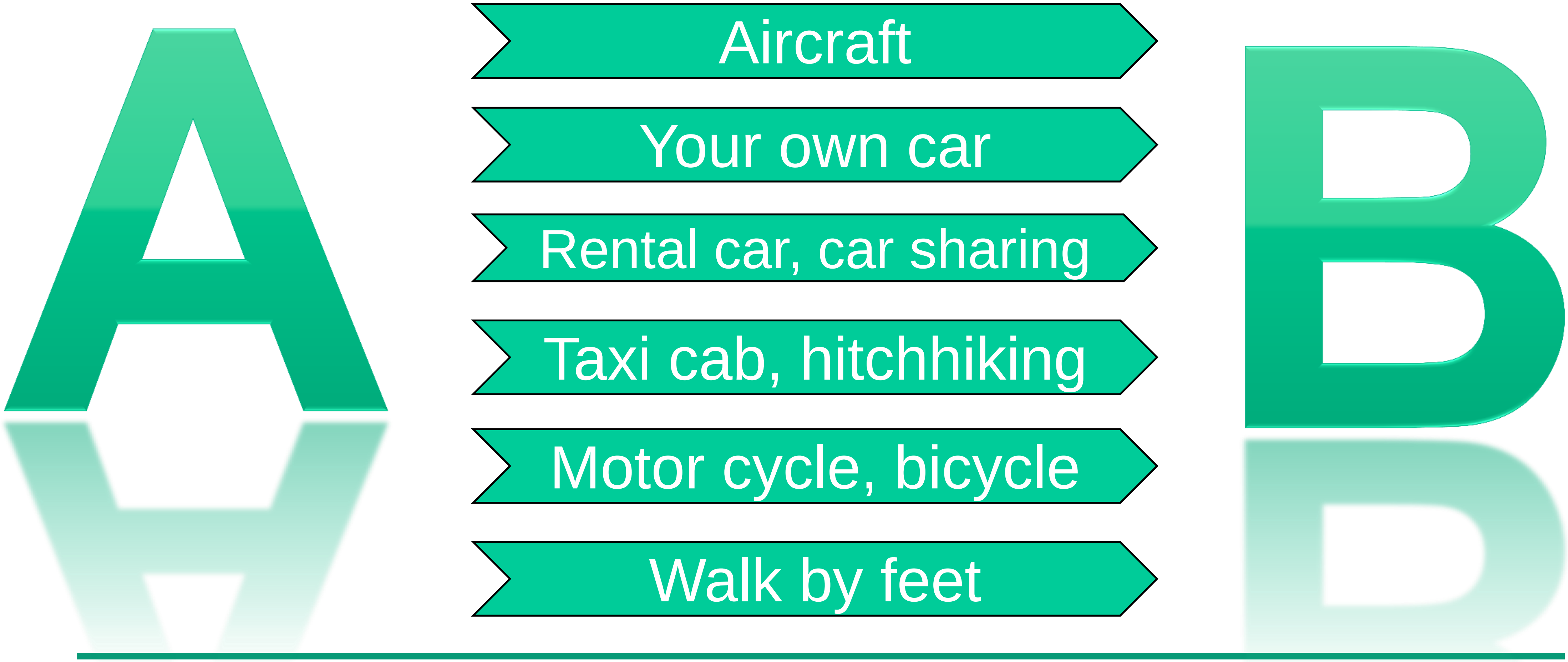

Example: Travelling

And there more opportunities then only one ….

Decision will be made by

- (technical) **feasibility** **e.g. time to travel**
- **economics** **e.g. reasonable cost**
- (legal) **framework** **e.g. what is allowed by your company**

Aircraft

Your own car

Rental car, car sharing

Taxi cab, hitchhiking

Motor cycle, bicycle

Walk by feet

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1st Conclusion
Technical Storage Demand

- **There is NO (technical) electric energy storage DEMAND!**
  (but mobile application)

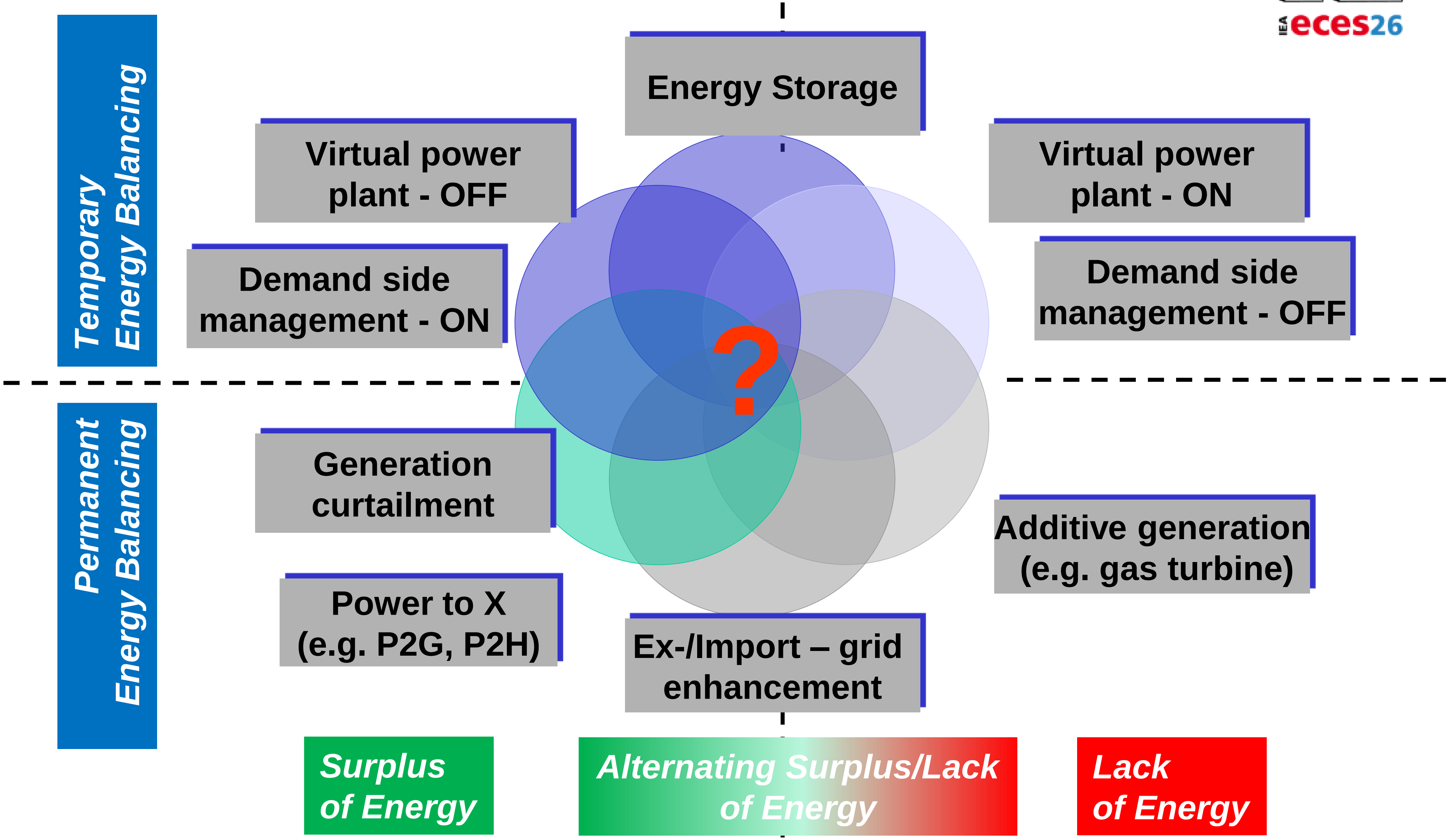
- **There is only an electric energy BALANCING demand which opens a real MARKET for different balancing technologies**
  (storage, DSM, curtailment etc.) **which compete which each other.**

- **This market is mainly influenced by technical feasibility, economics, and legal framework**

- **Energy storages will be part of the solution – the share will depend on economic figures and climate aims.**

- **Watch the business case !**

Energy Balancing Options vs. Energy Storage



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Energy Balancing Options: Pros and Cons

Pros	Option	Cons
Highly flexible, multiple services, usage of unused energy	Energy Storage	Mostly high CAPEX
Inexpensive if existing power plant could be "virtualized"	Virtual power plant	Additional thermal storage needed, limited potential due to heat demand
Probably inexpensive	Demand side management	Additional thermal storage needed, limited potential due to heat demand
Easy and cheap to realize	Generation curtailment	Wasting energy, probably higher CO_2-emissions
Permanent balancing option, inexpensive (P2H), easy to manage	Power to X (e.g. P2G, P2H)	Expensive (P2G), need for high ramping rates, less operating hours
Highly flexible, multiple services/ applications	Additive generation (e.g. gas turbine)	Additive CO_2 production; less operating hours -> business case?
Highly flexible	Ex-/Import – grid enhancement	NIMBY; probably only exporting balancing problems

2nd Conclusion:
"How should energy balancing demand be compensated?"

- Cheap solutions (curtailment, additive generation) are less efficient (CO2 emissions) and only reasonable for short periods.
- Inexpensive solutions (DSM, VPP) are reasonable, but ofte not easy to realize and have a limited potential
- "Leaving" the electric market (power to x) is reasonable for a permanent surplus but not for balancing short term imbalances
- Export/Import is limited due to NIMBY, transformer capacity and willingness of neighbor countries to solve German balancing problems.
- Energy storage is the only, nearly unlimited potential with less NIMBY effect, but CAPEX are too high => cost degression is needed

3rd Conclusion:
"How should energy balancing demand be compensated?"

To get an overall efficient, environmental friendly and economic solution on an energy balancing market there must be….

- **a fair access to the market for all technical solutions and stakeholders**
- **a transparent market with public accessible price systems**
- **market rules which enables business cases for the best fitting solutions**

And probably individual subsidies for new, promising technologies to reach maturity and to come to the market

ECES 26 »Future Electric Energy Balancing/ Storage Demand«

Preface

The main objective of this task is to develop a method or approach to calculate the **regional energy balancing demand** and to derive **regional storage demand** rasterizing the area and taking into account that there are competitive technical solutions.

Additionally there are two important aspects. On the one hand an overview about the different technical and **economical and legal framework requirements** in the different countries.

Case Studies: Running projects, planned projects and future projects of stationary energy storage systems.

And on the other hand **typical operation modes for energy storages** and derived from this typical charge/discharge curves, needed for future standardizations.

ECES 26 »Future Electric Energy Balancing/ Storage Demand«

WP 0	**Project organization (Operating agent)**	Project Leader Dr. Christian Doetsch Fraunhofer UMSICHT
WP 1	**Technical and economic framework requirements for electric energy storage systems**	Leader work package 1 Dr. Bert Droste-Franke European Academy
WP 2	**Calculation Method to determine spatial demand for electric energy balancing/storage systems**	Leader work package 2 Dr. Yvonne Scholz DLR - GERMANY
WP 3	**Technical Storage Issue: Application of electric energy storage**	Leader work package 3 Dr. Grietus Mulder VITO, Belgium
WP 4	**Requirements for test procedures**	Leader work package 4 Dr. Marion Perrin INES-CEA - France

WP 2

Calculation Method to determine spatial demand for electric energy balancing/storage systems

Some basic conditions/assumptions

- the model bases on Germany as reference
- the model includes different balancing technologies
- the model takes into account that there are positive and negative balancing demands

Why is Germany a good case study ?

- Need of energy balancing devices
- In Germany most problems will occur at first

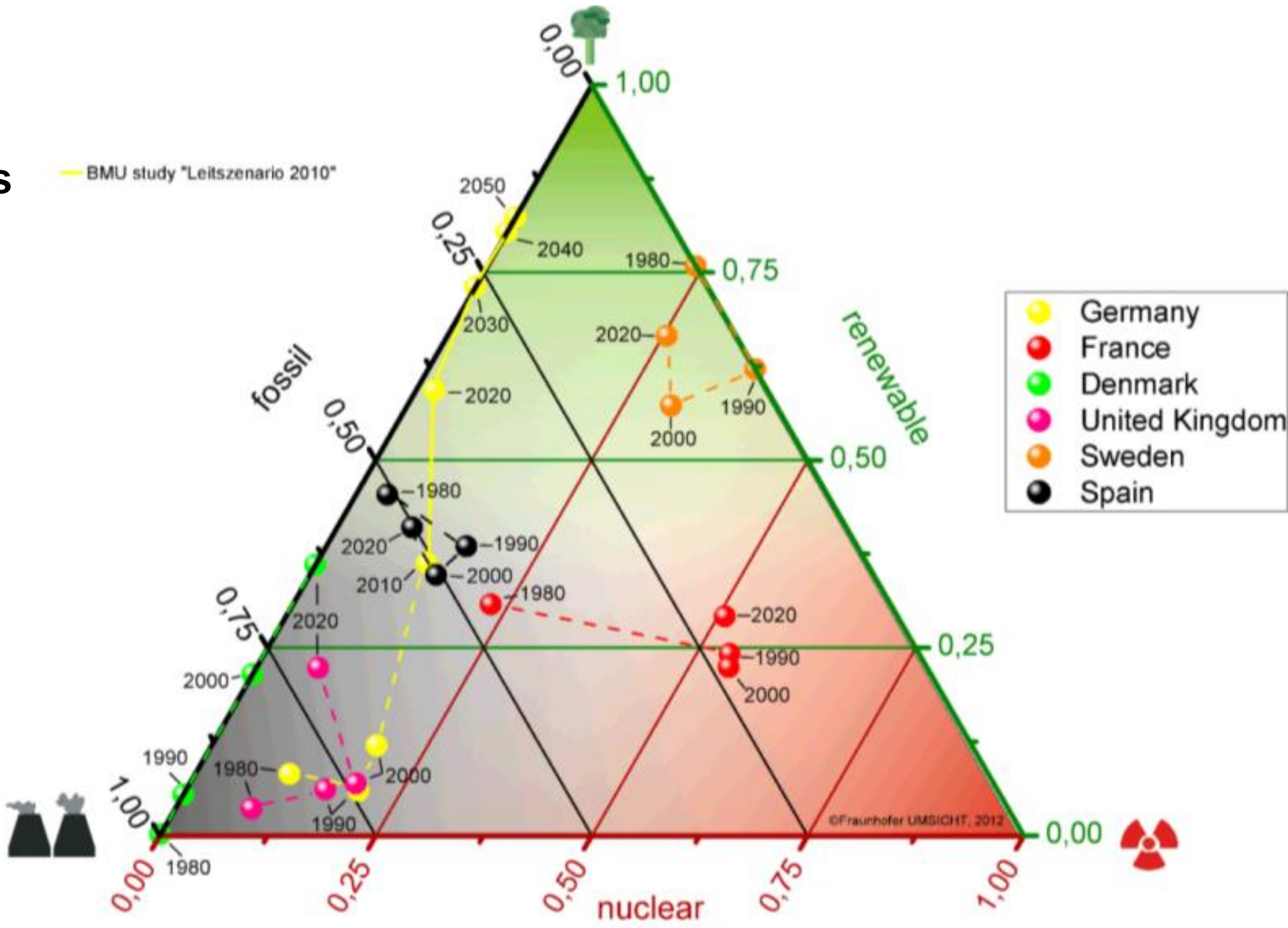

Fig.: Installed electricity generation power in different European countries

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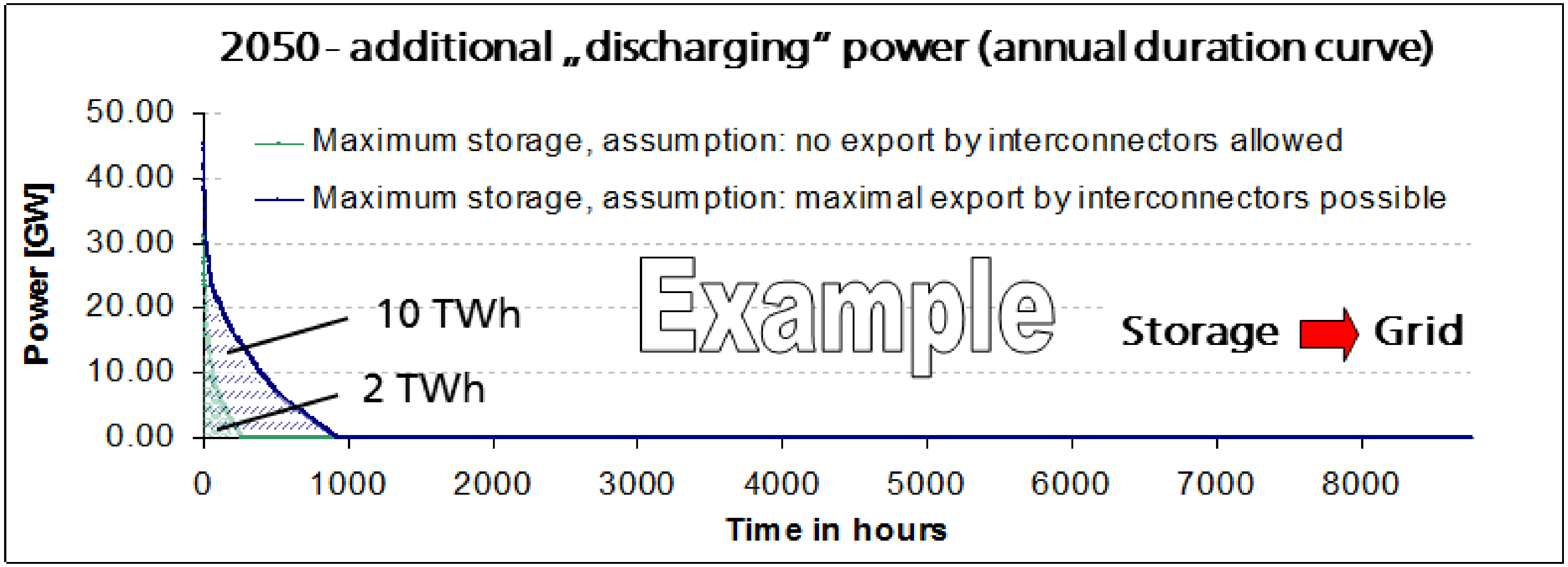
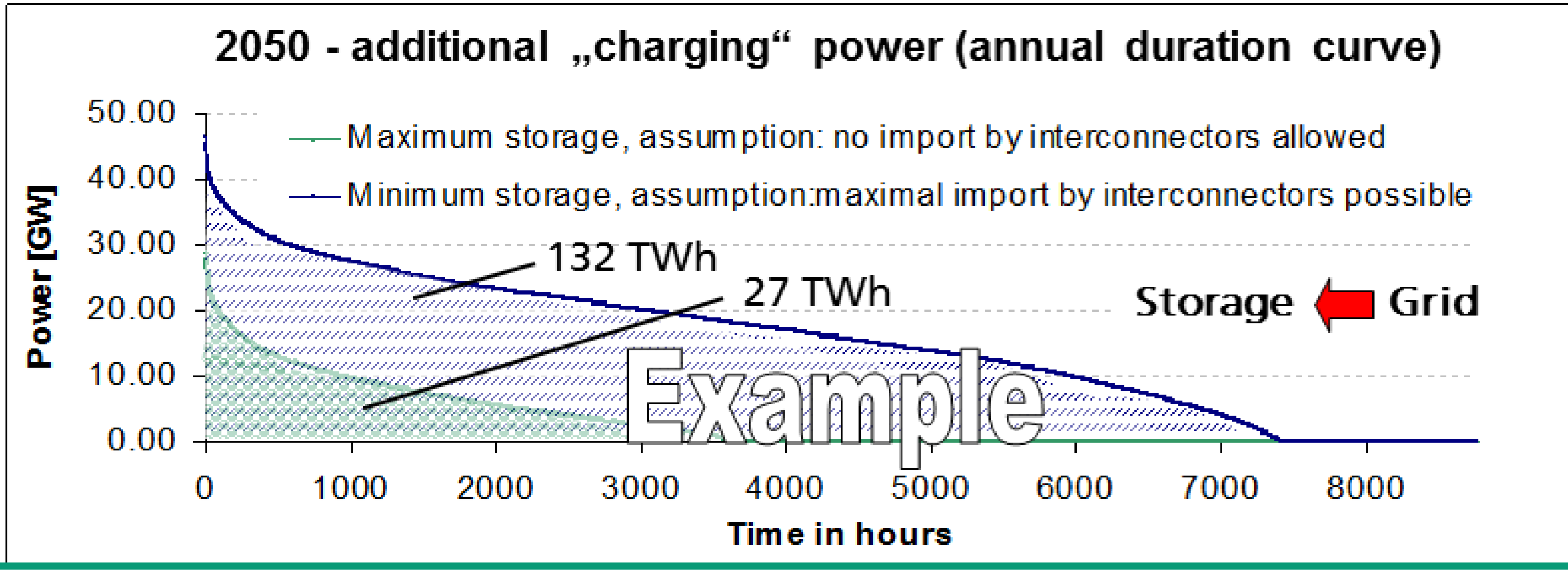
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy





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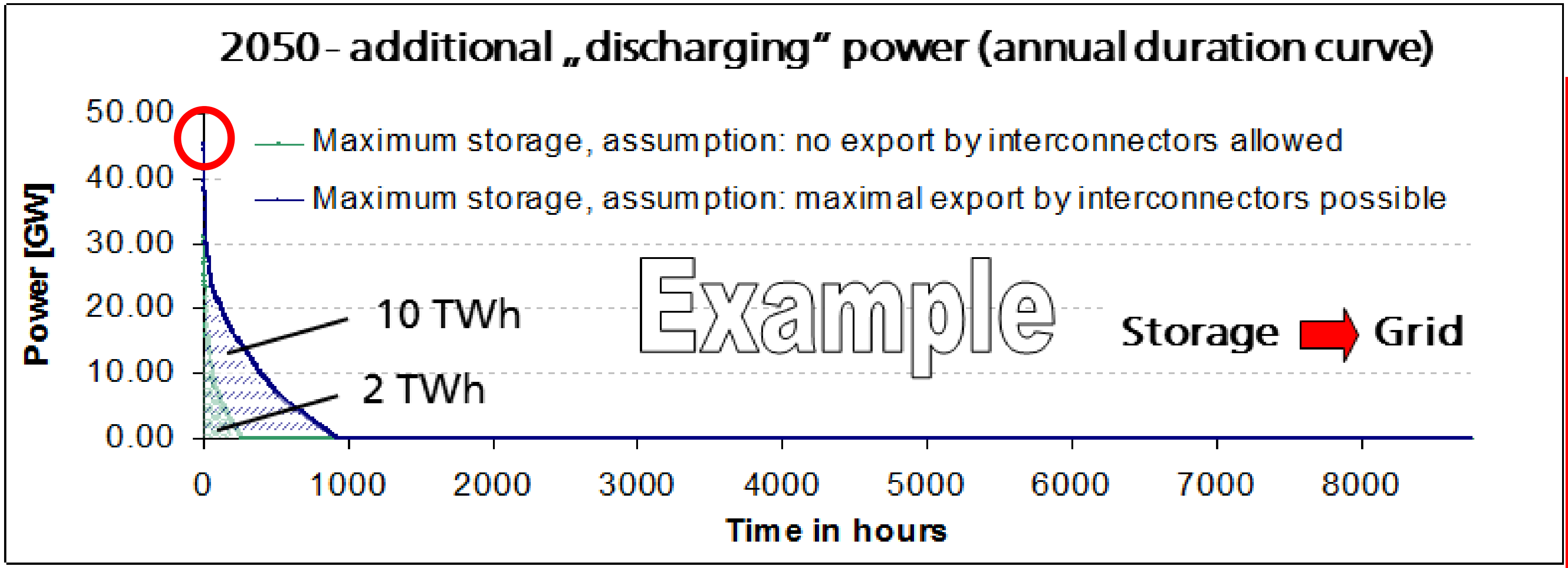
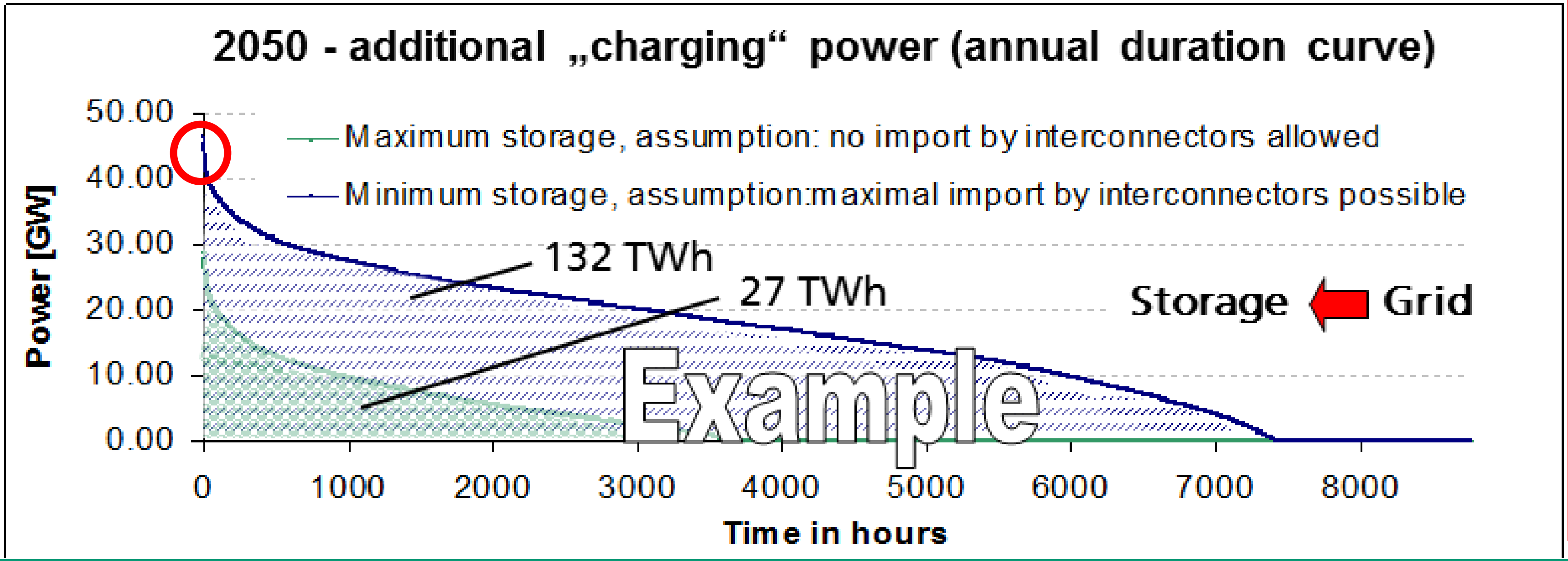
Grid Balancing Demand Analysis: Power vs. Yearly Stored Energy





Example:

Grid Balancing Demand 2050

Discharging: 2-10 TWh

Charging: 27-132 TWh

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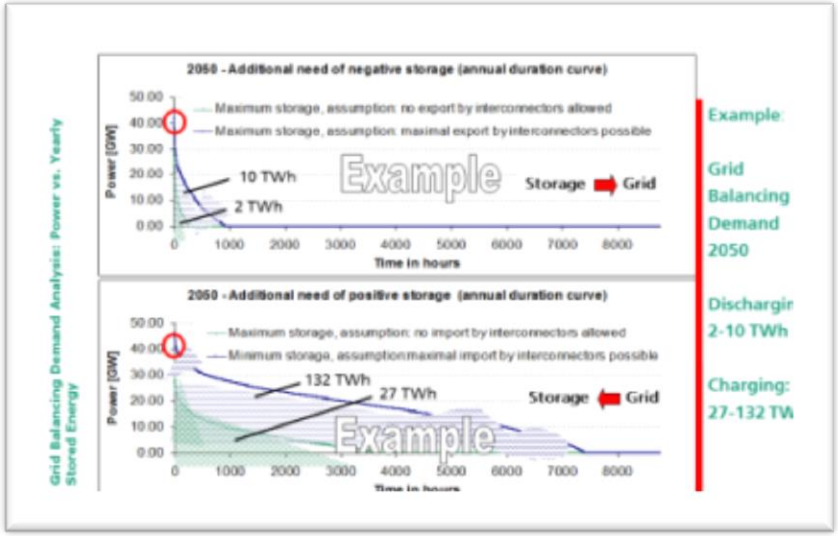
Key Figures of Energy Balancing Demand

- **There is disparity between positive and negative balancing demand**
  - positive balancing demand: lack of electric energy (e.g. discharging storage or DSM)
  - negative balancing demand: surplus of electric energy (e.g. charging storage or power2heat)



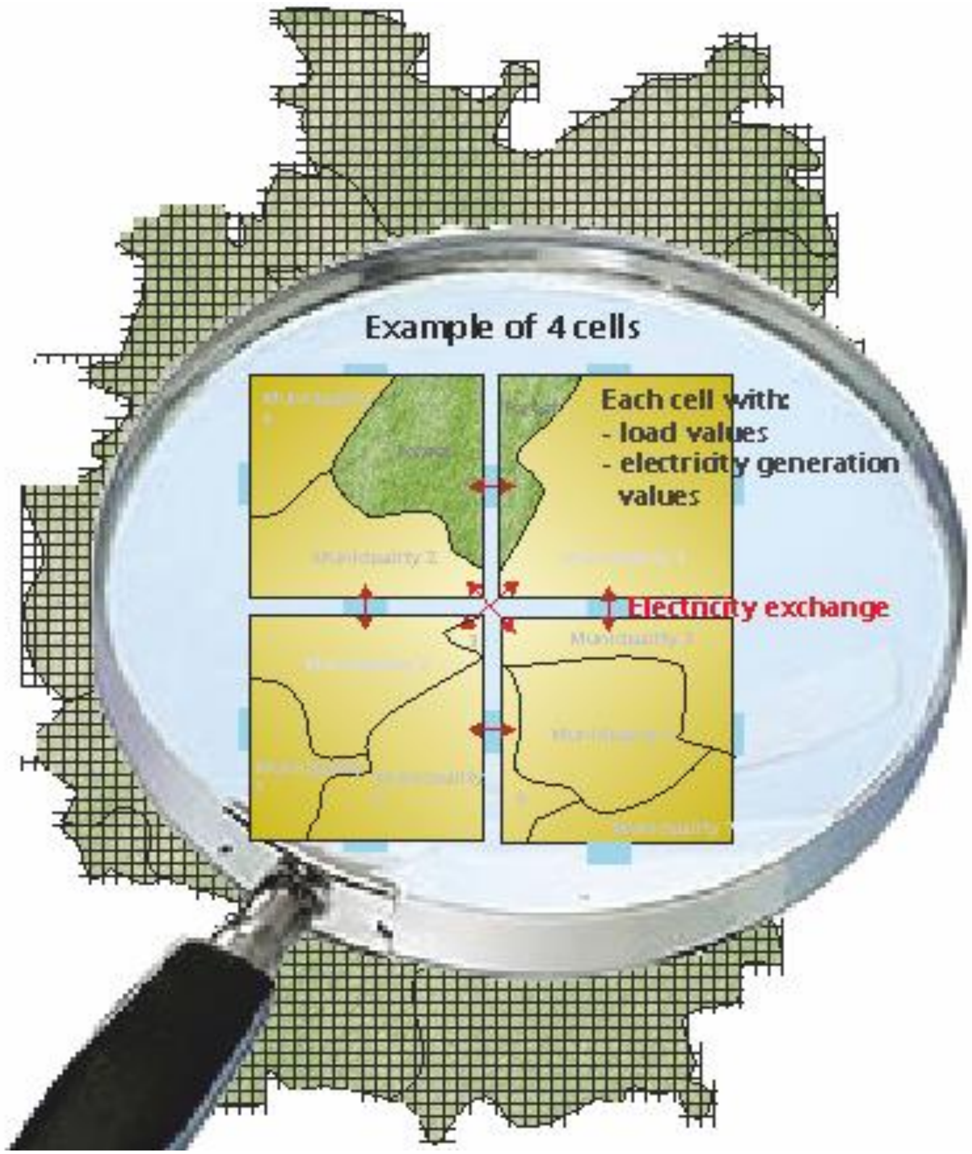
- **The annual amount of energy balancing demand is calculated in TWh/a**
  - this figures shows if there is a total annual surplus or lack of electric energy
  - from these figures the potential market for energy storage devices could be derived (the minimum of both figures, because storage devices must be balanced!)

- **The needed capacities (MWh) of storage devices are the result of a hourly based simulation**

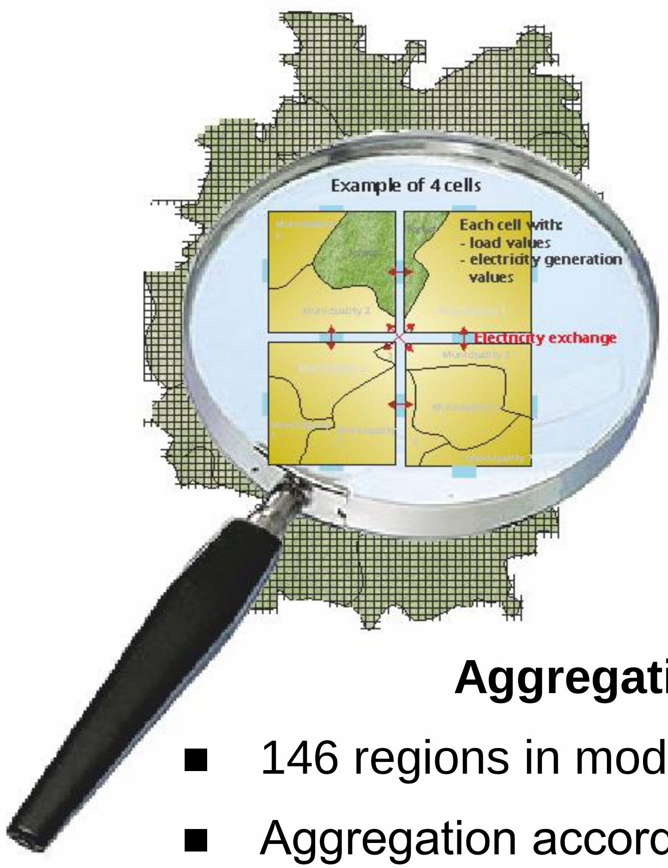
Allocation of Germany into 6 953 cells

GIS Raster

- raster maps 0.083° x 0.083°
  approx. 9 x 6 km
- 6.953 cells
- N-S length: 886 km
  W-E width: 636 km
  area: 357 121 km²
- “perfect grid” in each cell



Aggregation of 9536 cells to 146 Energy regions in Germany



Aggregation

- 146 regions in model
- Aggregation according to “density” of local inhabitants and urban characteristics
- First assumption “perfect grid” in each region but not between

areas for balancing demand analysis (own illustration)

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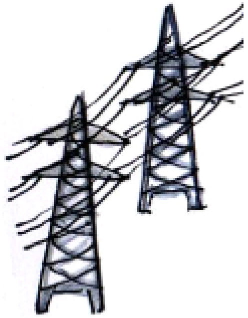
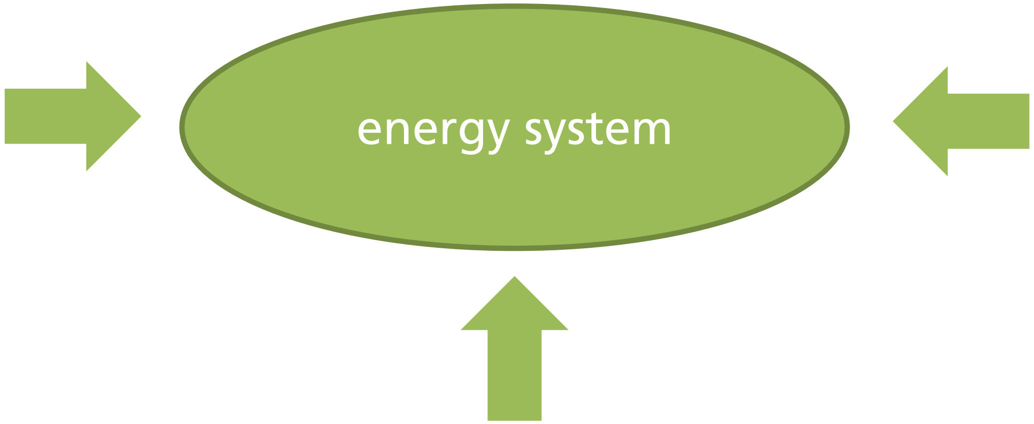
Modeling

grid

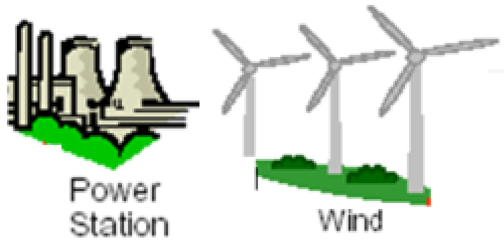




parameters

- degree of intermeshing
- electric circuit length
- load density
- transmission capacity
- switching system

supply



parameters

- installed capacity
  - fluctuating RE
  - projectable EE
  - conventional power stations
- generated electricity

demand

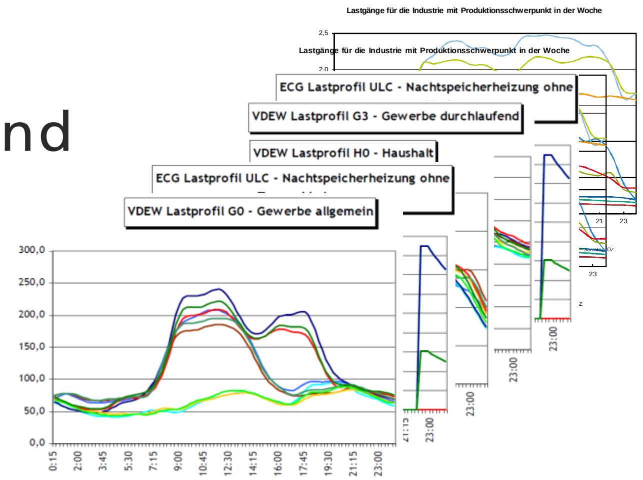
parameters

- load profile
- number
- 9 types of consumer (households, agri-culture, commerce/trade/services, industry)

Input Data

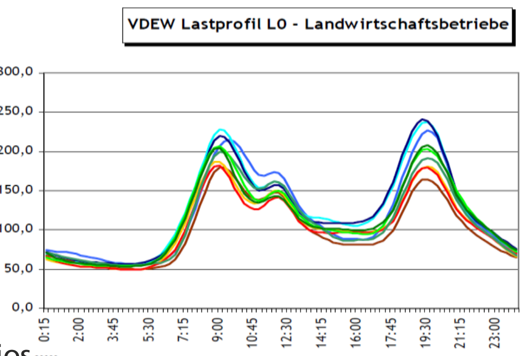
Demand

Zelle	Anzahl Haushalte m. Nachtspeicher	Anzahl Haushalte o. Nachtspeicher	…
1			
2			
3			
…	…	…	…

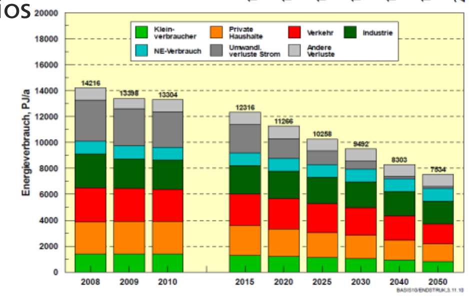


Hourly resolution of load curve subdivided in 9 consumer loads and local mapping of consumer

Szenarios



Definition of szenarios based on “Leitstudie 2010”



Electricity Generation

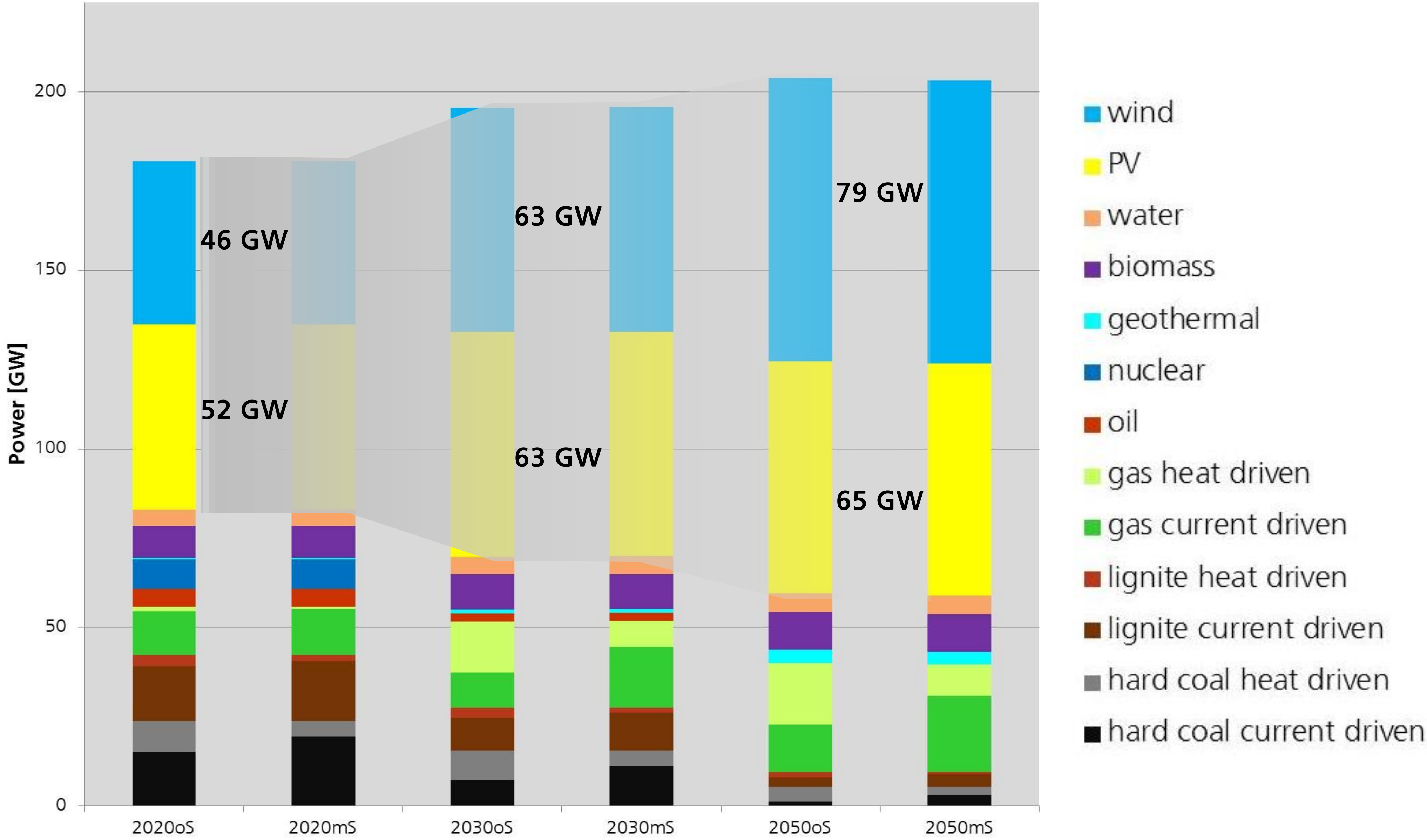
Reihen-folge	Kraftwerks-typ	Leistung	Nutzungs-grad	Baujahr
…	…	…	…	…

Generator database local resolution

MELENA

Local*and hourly energy balancing demand (*per cell and per region)

Scenarios



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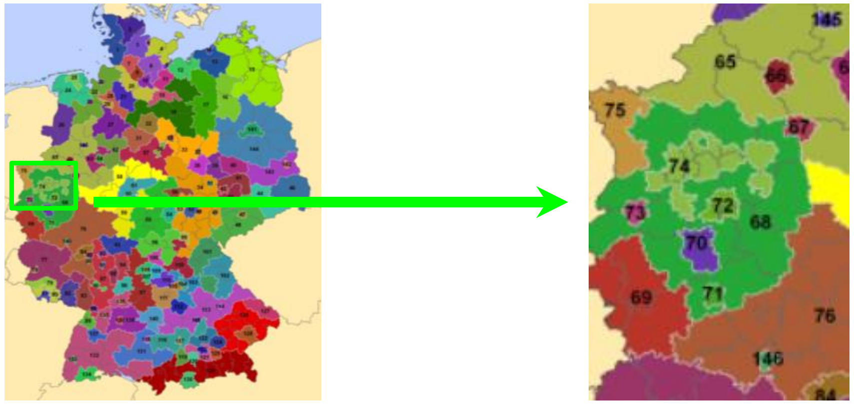
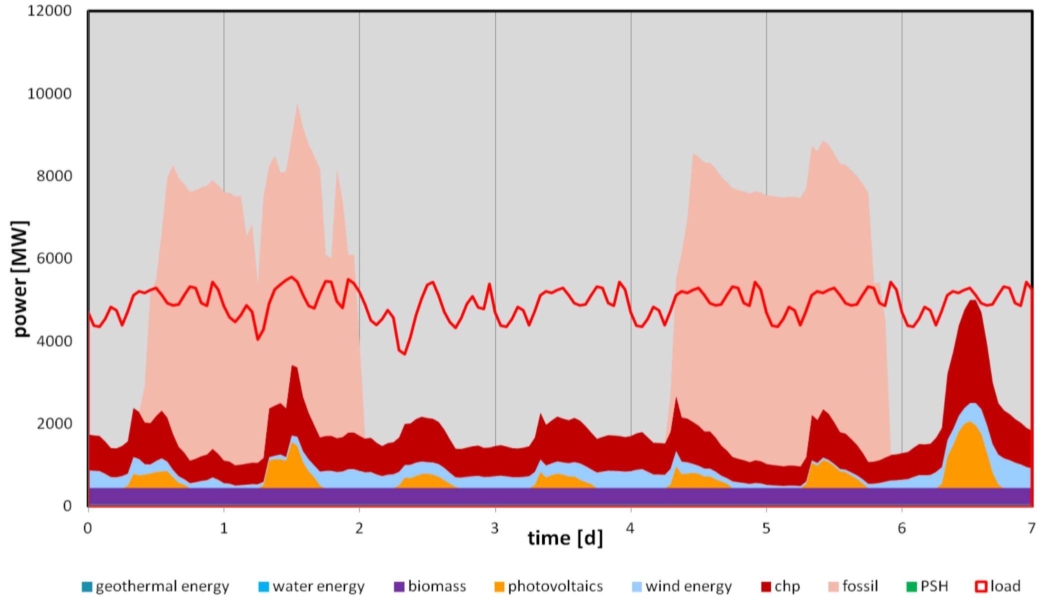
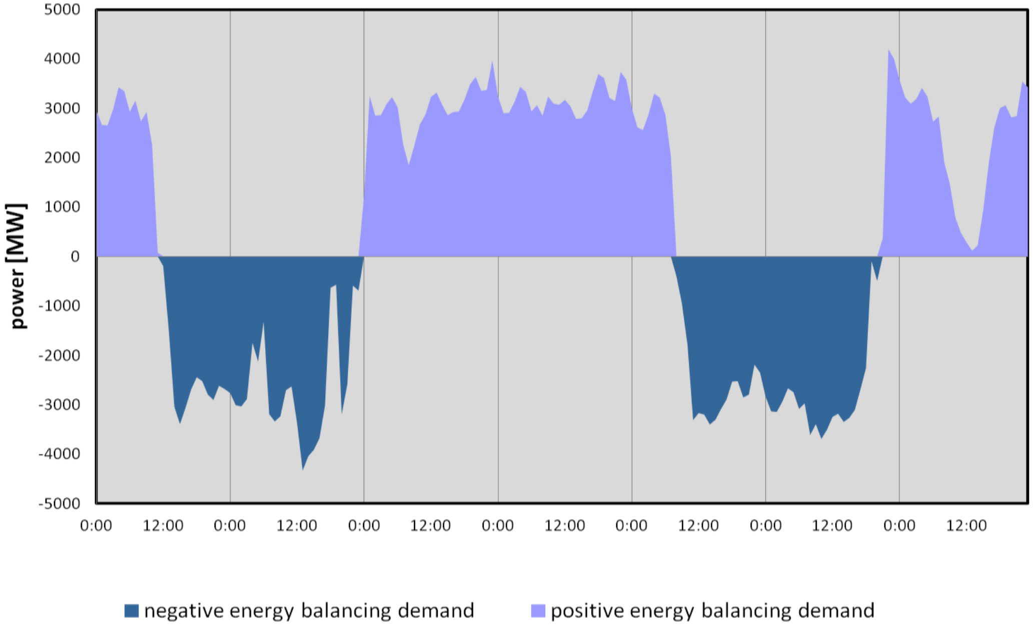
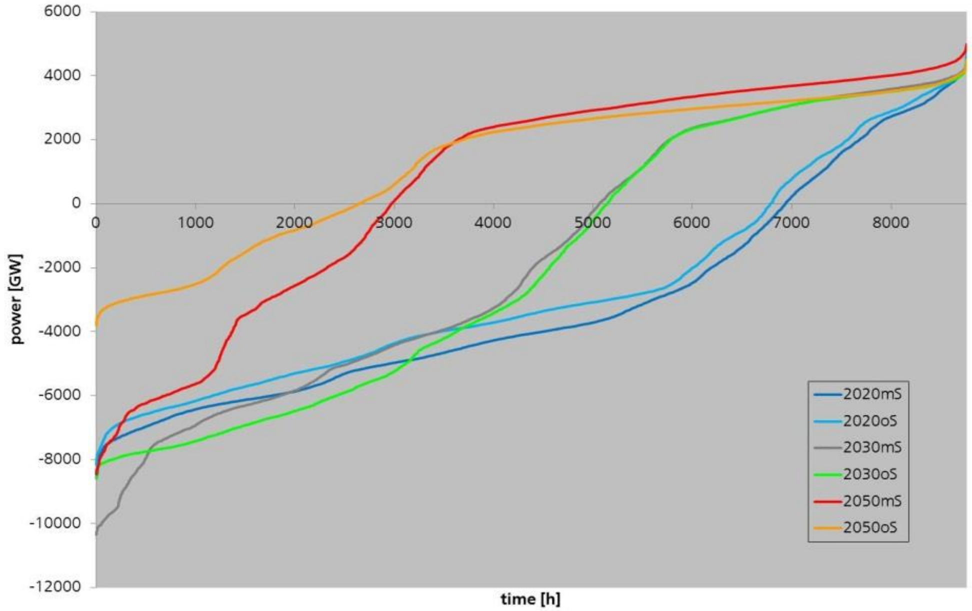
Detailed Example: Scenario 2050 for energy region 68

- Haltern, Xanten, Lüdenscheid, Grevenbroich, etc.









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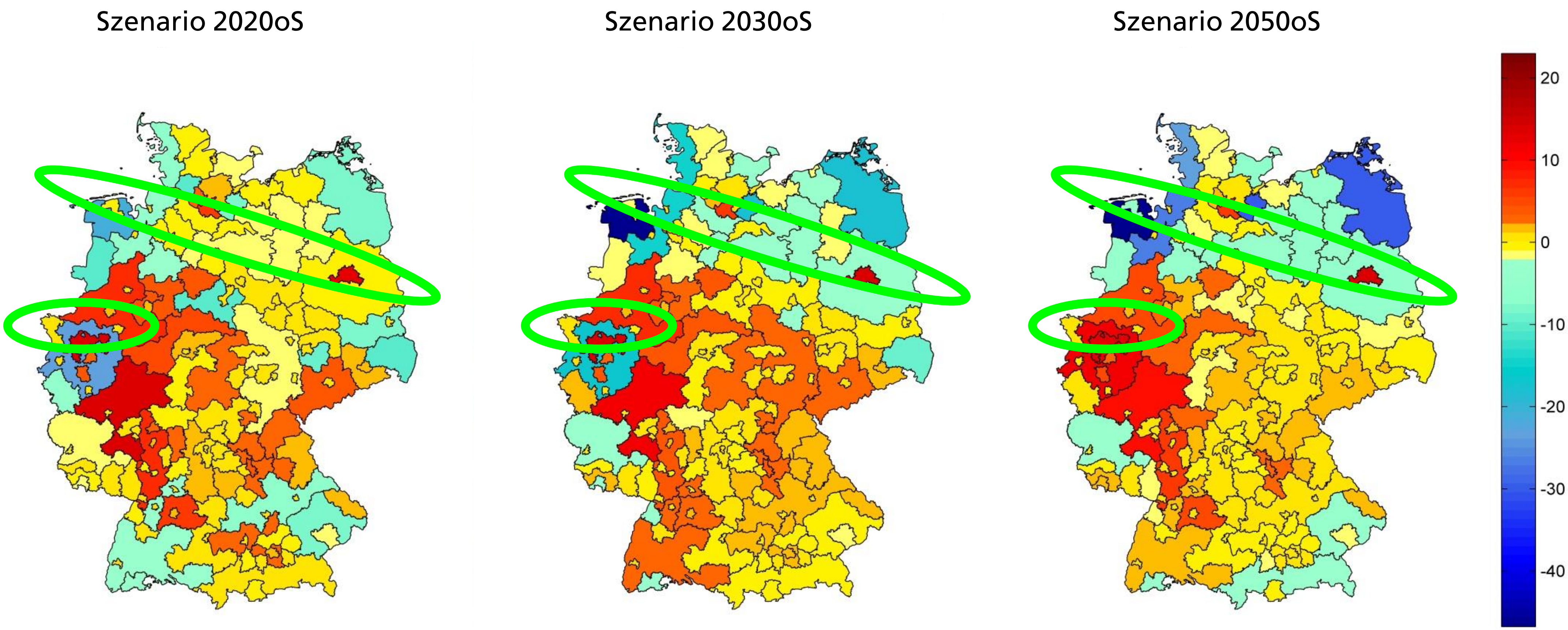
Total Annual Regional Energy Balancing Demand [TWh/a]

(with infinity storage capacity in the regions !)
(without interconnections between the regions !)



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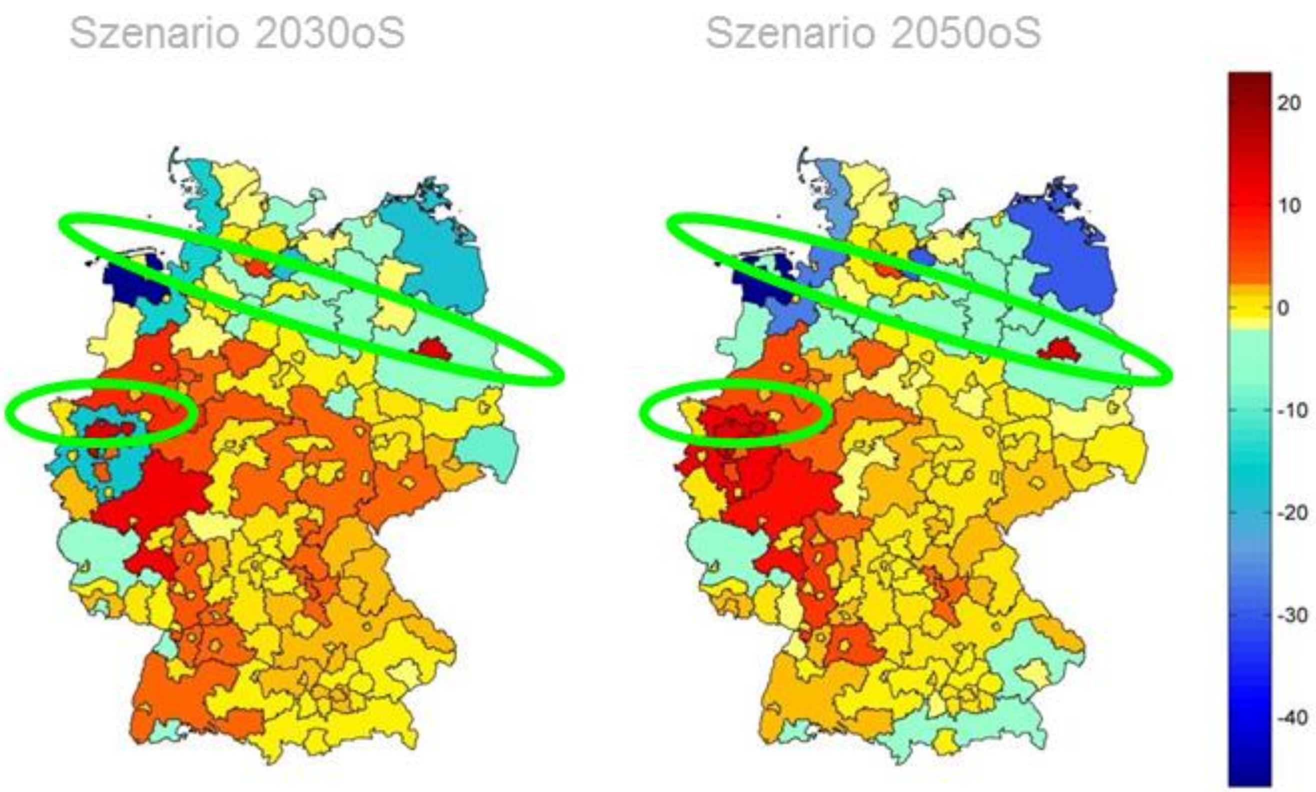
Results

- Based on "Leitstudie 2010"
- Extreme scenario: - No grid between 146 regions
  - unlimited storage capacities



- Permanent (over the year) surplus of electric energy in the north (new lines needed)
- Lack of energy in big cities (power plant are often around)
- Model very sensitive to operation of fossil power plants (putting out of order or building a new fossil power plant)

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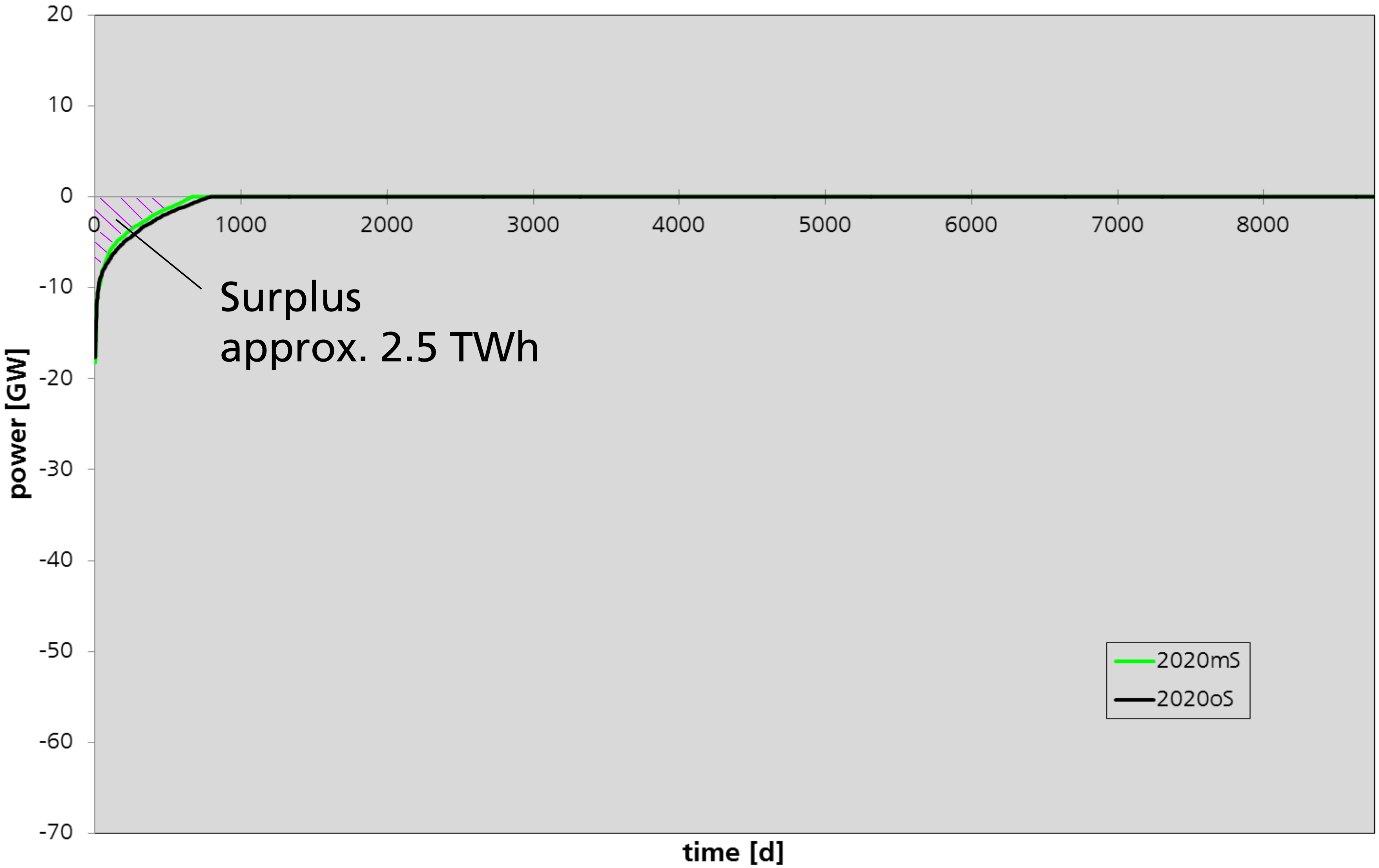
Sorted annual curve of the Energy Balancing Demand in Germany (perfect grid, no ex-/import assumed)



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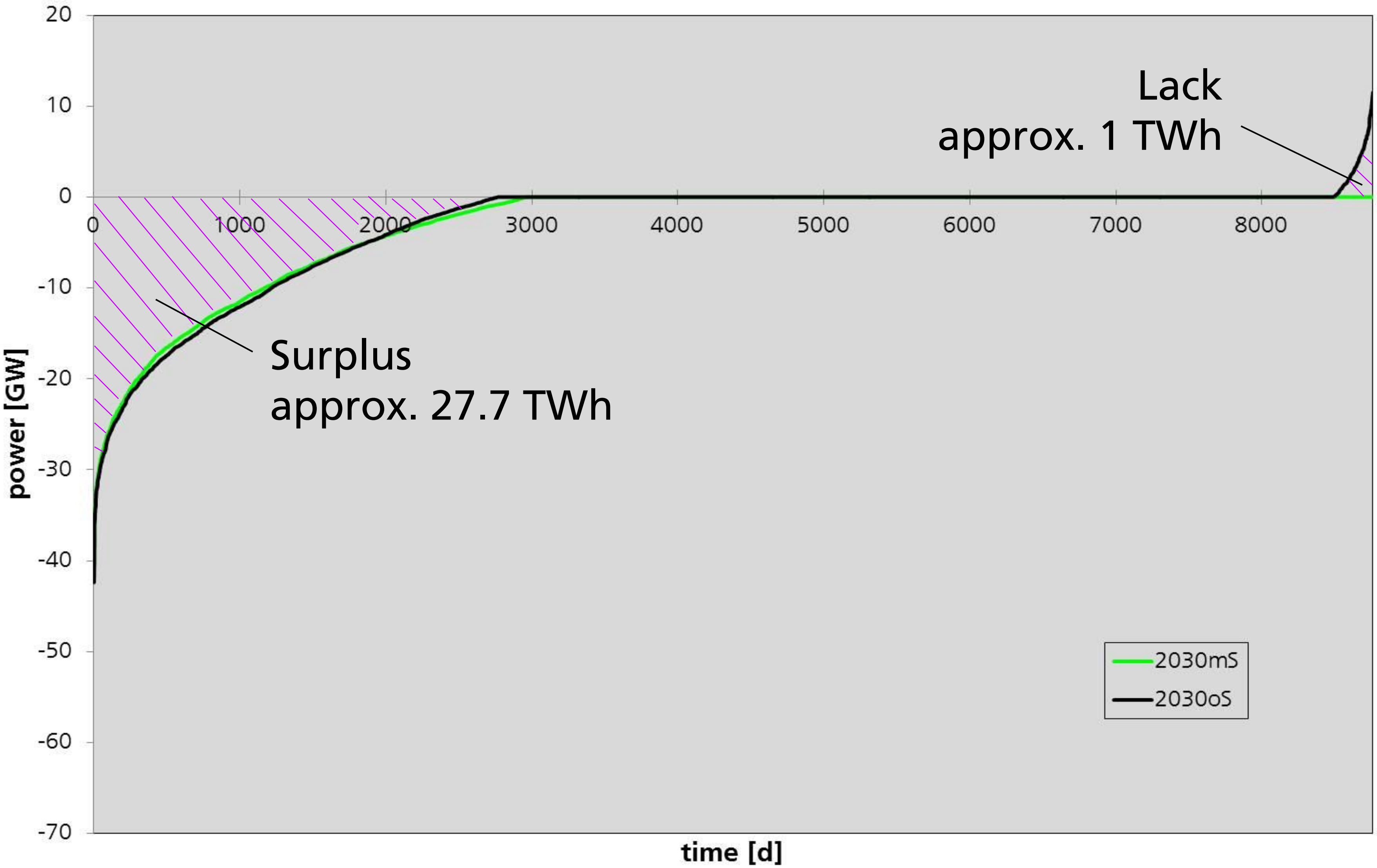

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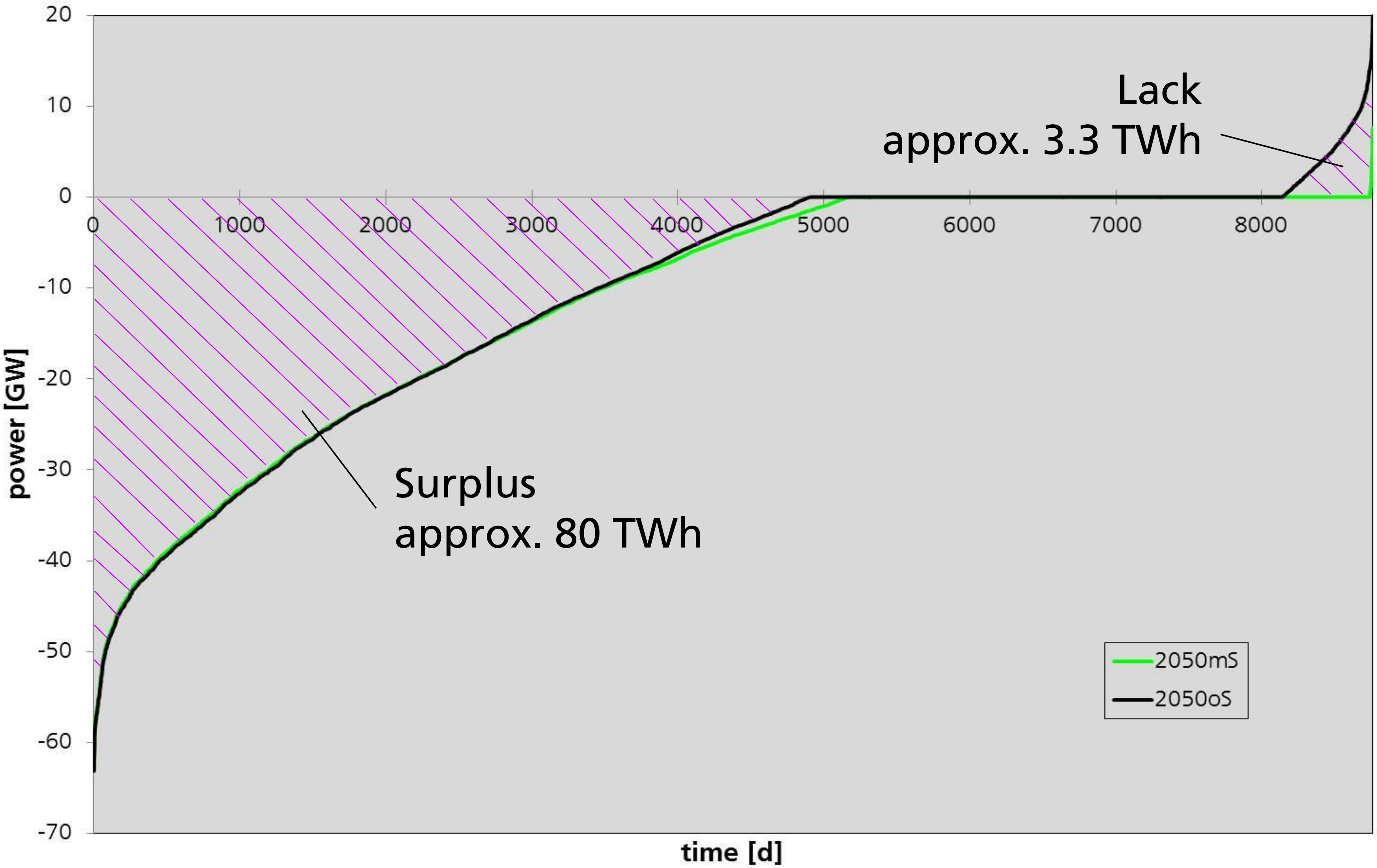
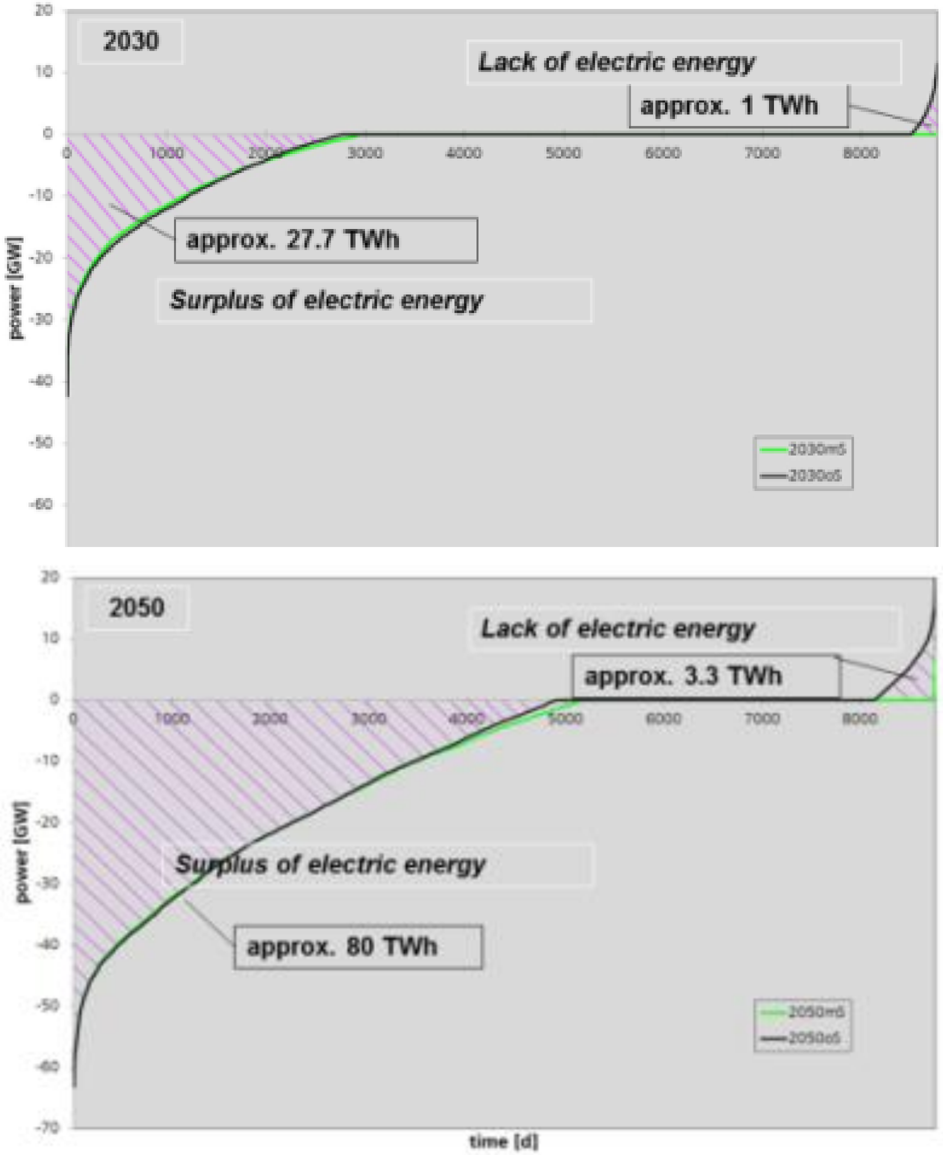


Energy System Modelling –
Example: Future overall Electric Balancing Demand (Germany)



- Assumptions
  - Perfect grid, no interaction with neighbors
  - Germany in total, without P2Gas, P2Heat etc.
- Results
  - In 2020 nearly no balancing demand
  - In 2030 a storage »market« for 1.0 TWh/a
  - In 2050 a storage »market« for 3.3 TWh/a
  - Surplus of energy 25 times higher than lack of energy

➔ Energy utilization for high short generation peaks are needed

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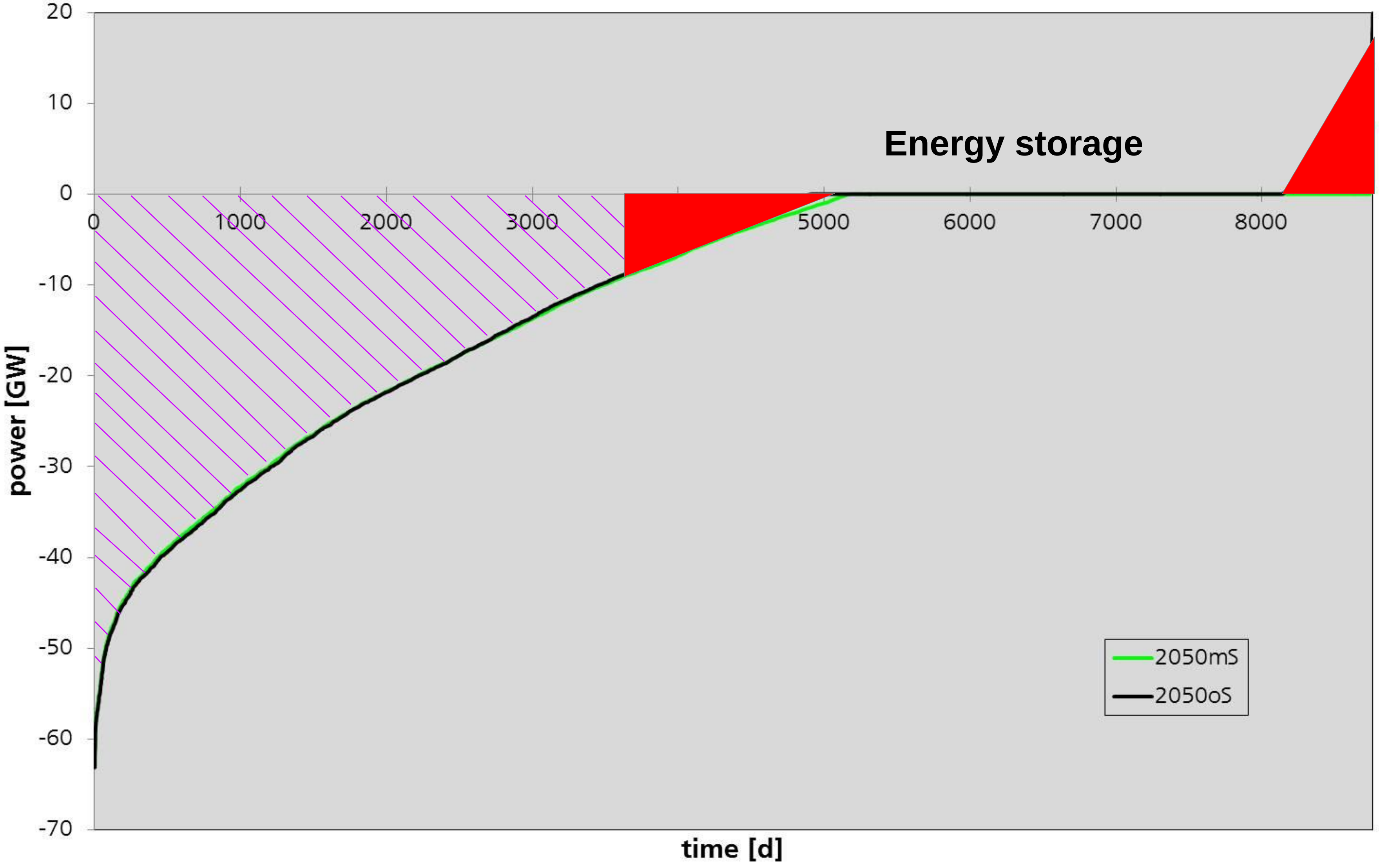
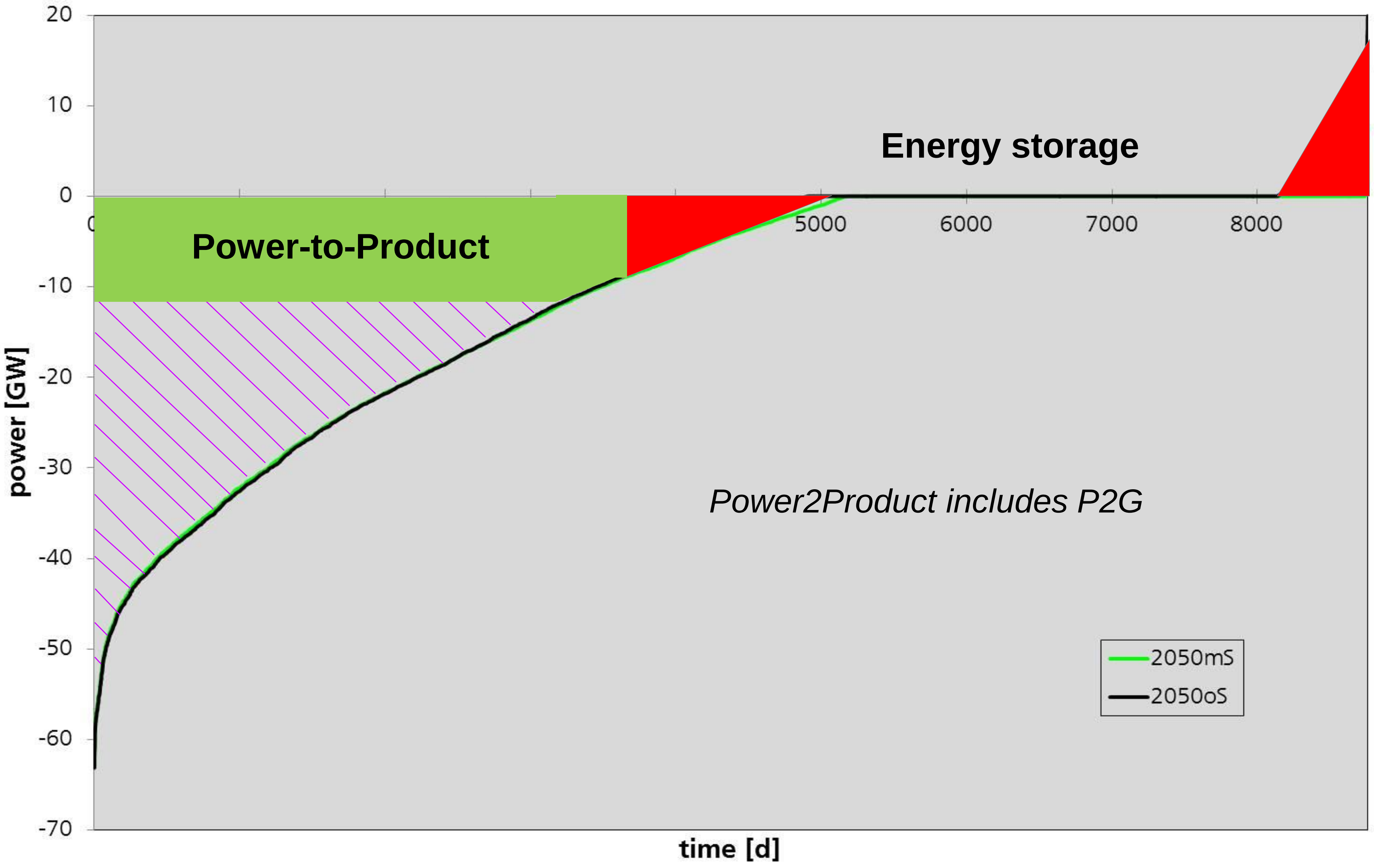
Energy System Modelling

Energy Storage / Power2Product / Power2Heat



Energy System Modelling
Energy Storage / Power2Product / Power2Heat



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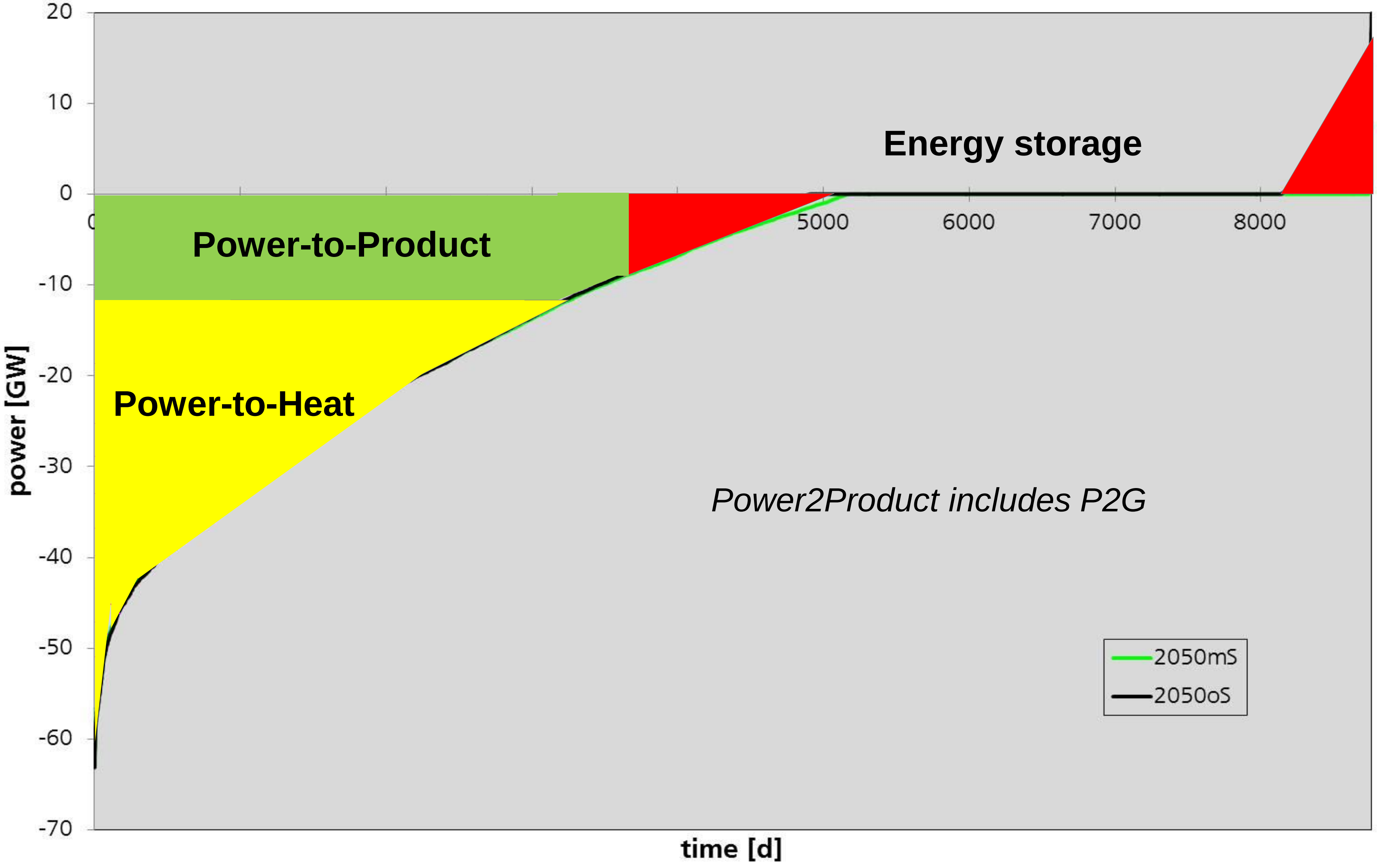

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