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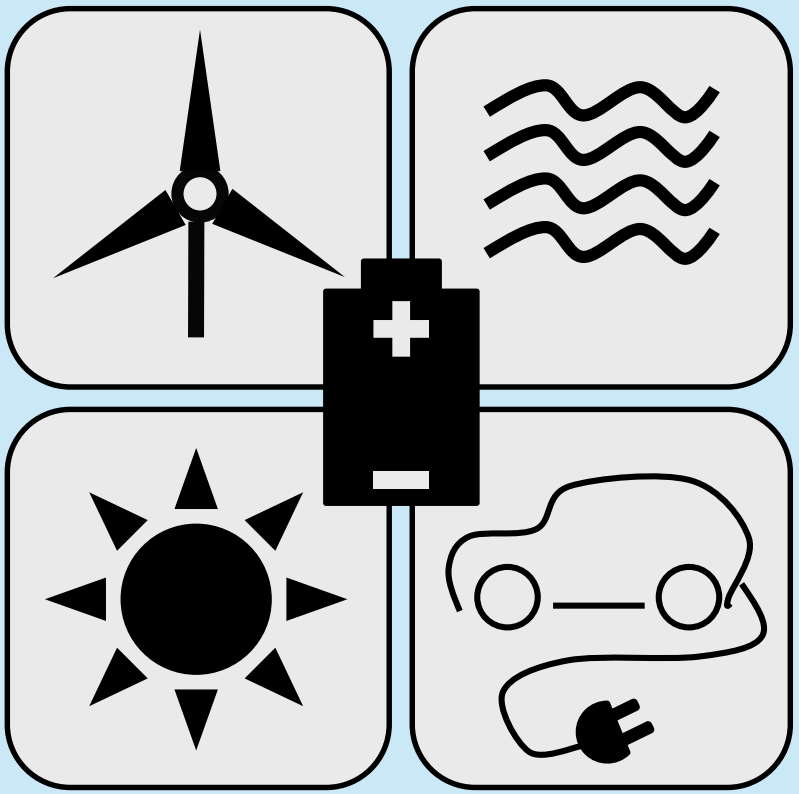

Analysis of the role of energy storages in Germany with TIMES PanEU – methodology and results

ETSAP Workshop Madrid
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IER

Outline

Outline

Introduction

Motivation:

- Political induced increase of share of renewables
- Increasingly feed in of electricity from variable renewables (wind and pv)

➔ Occurance of a strongly fluctuating negative residual load

➔ Increased need for flexibility options to balance supply and demand of electricity

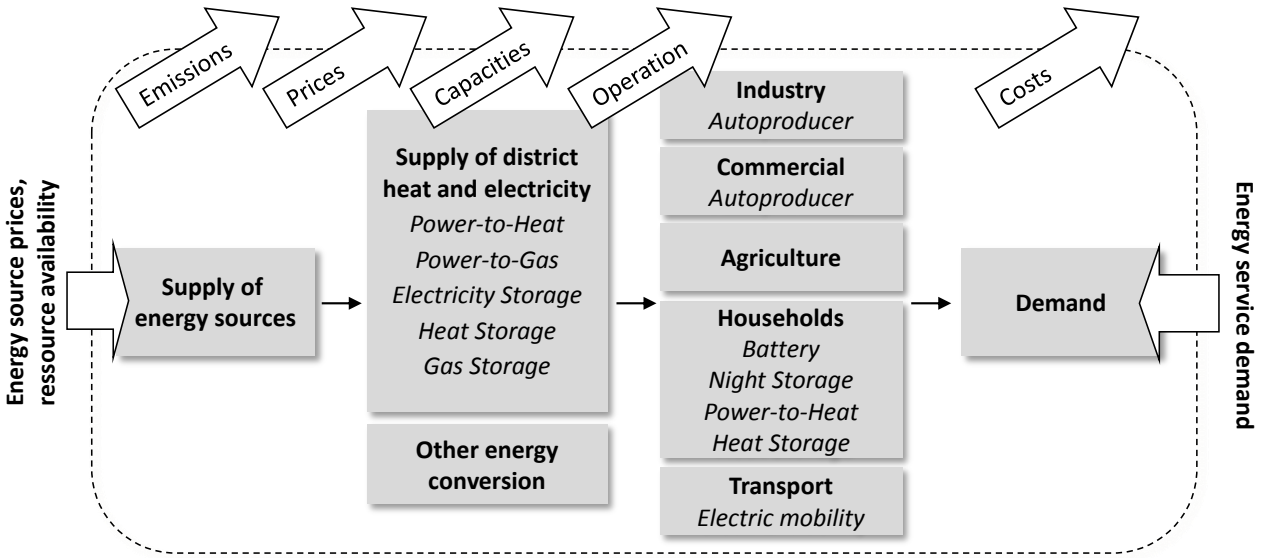
Objective:

- Methodological improvements of the energy system model TIMES PanEU regarding to the temporal resolution and the modelling of energy storages
- Determination of the optimal configuration of energy storages and power-to-x under minimizing the overall system cost
- Including ESTMAP database for storages
- Analysis of the role of electricity storages within the ESTMAP project

TIMES PanEU

Energy system model TIMES PanEU:

- Linear optimization model
- 30 regions (EU-28, NO, CH)
- Horizon: 2010 to 2050
- Whole energy system, from energy supply to energy service demand



Model improvement for modelling storages:

- Creation of methodologial extensions for modelling and analysis of energy storages
- Increase of the temporal resolution for Germany
- The high temporal resolution is based on representative, coherent and successive time segments

Research focus:
Integrated consideration of options in the sectors of electricity, heat and mobility over the optimization period taking into account sector coupling through the use of Power-to-Heat, Power-to-Gas and electric mobility

Outline

Methodology: Temporal resolution in TIMES PanEU

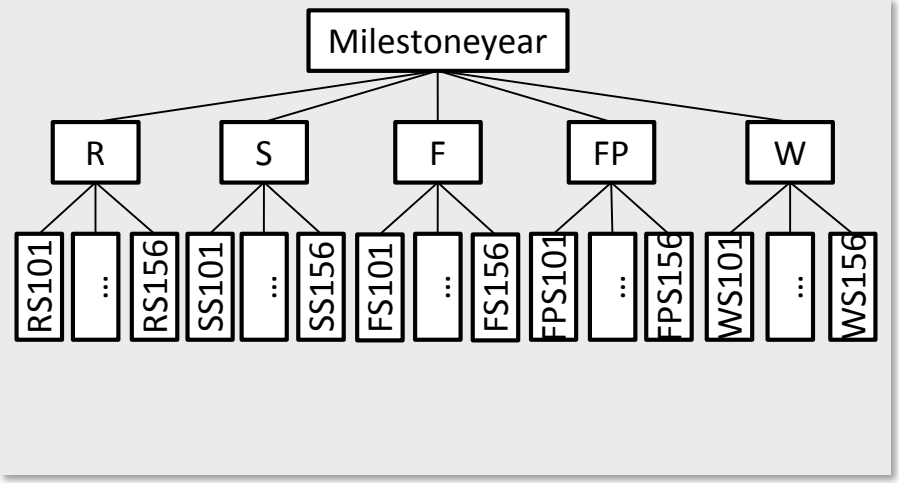
Increase of the temporal resolution for Germany

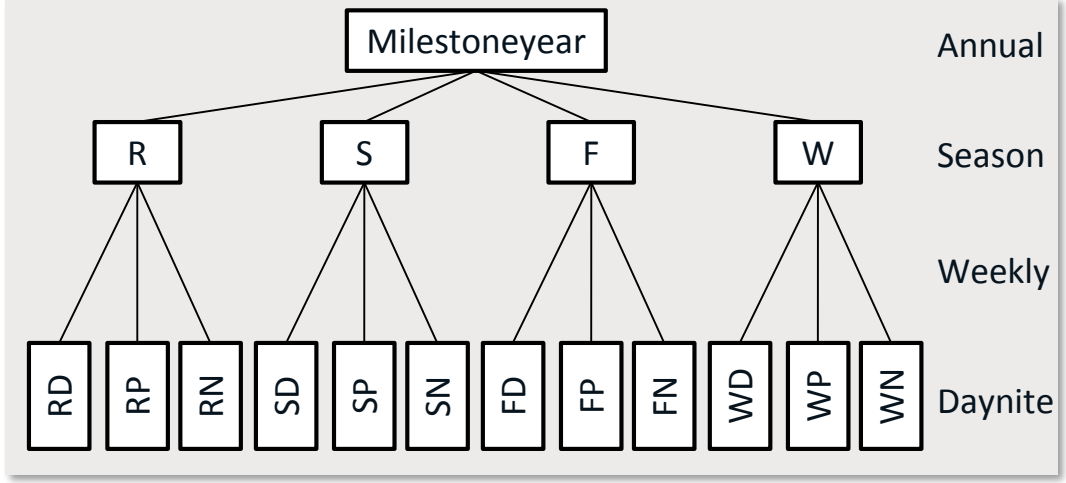
Germany:

- 280 time segments:
  - One typical week per season with three-hourly-resolution (224 time segments)
  - One additional week for representing high feed of variable renewable energies (56 time segments)
- Representative, coherent times segments

TIMES PanEU

- 12 time segments per year (one typical day per season with three time steps)
- No coherent temporal resolution

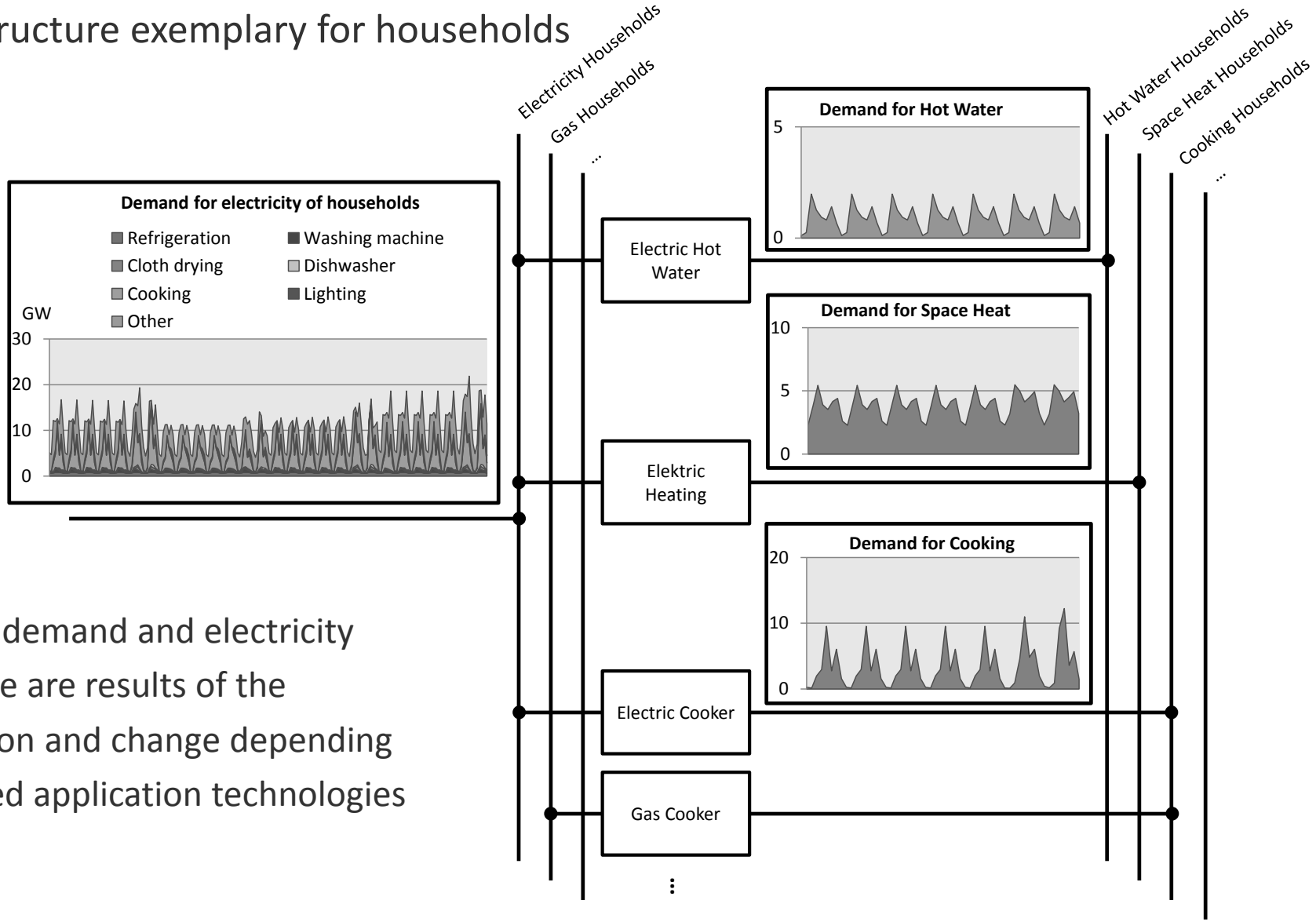




➔ Coupling of timeslice trees for modelling trade
➔ Integral optimization over all regions and modelling periods

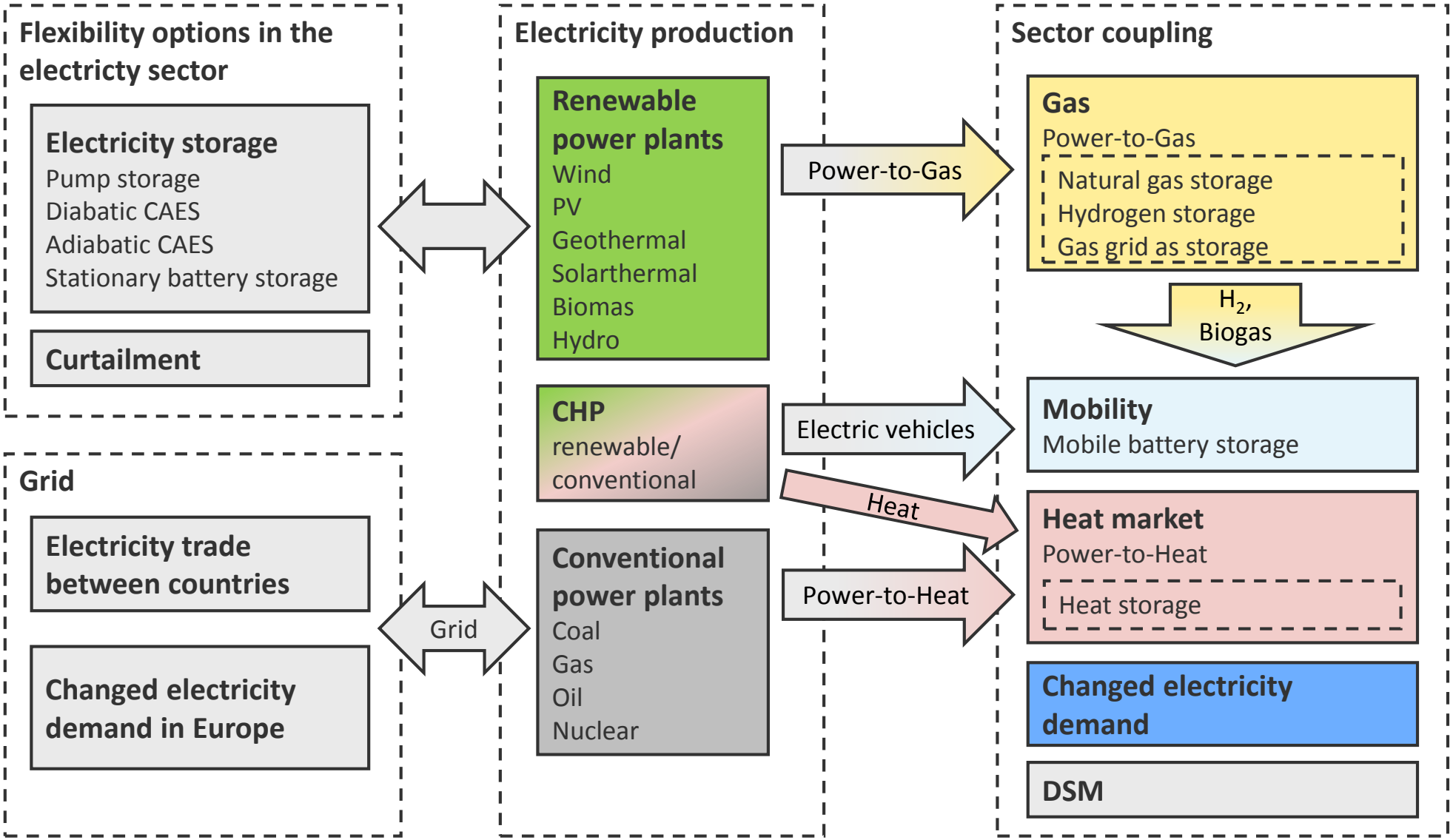
Methodology: Temporal resolution in TIMES PanEU

Demand structure exemplary for households



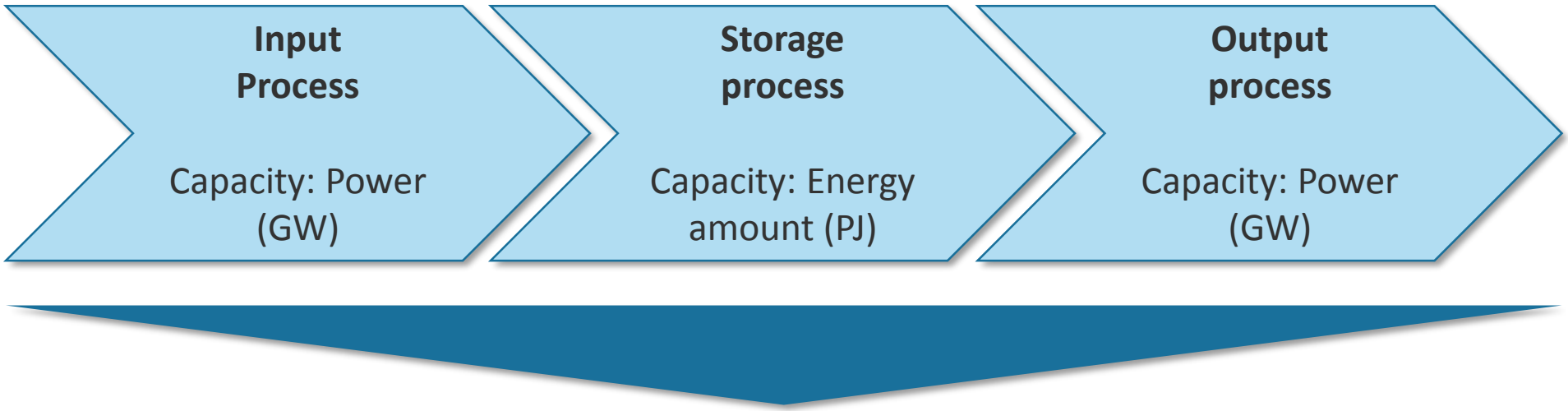
➔ Electricity demand and electricity load profile are results of the optimization and change depending on the used application technologies

Methodology: Flexibility options in TIMES PanEU



Methodology: Modelling of energy storages in TIMES PanEU

Modelling of storages as a sequence of three processes



➔ Storage content and storage power are endogenous optimziation results

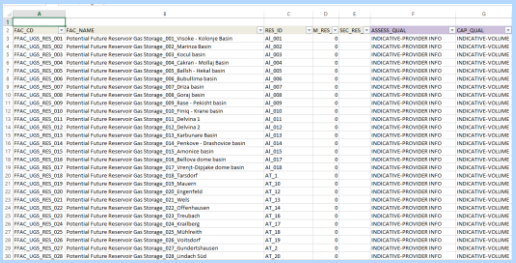
Interface ESTMAP storage database – TIMES PanEU/TIMES regional models

Database and GIS mapping

Technical/economical characterization

Potentials

EXCEL database analysis input deck



Creation of Pivot Tables in EXCEL

	Spaltenbeschriftungen		
	Compressed Air Energy Storage	Compressed Air Energy Storage	Compressed Air Energy Storage
	gas	gas	gas
	SALT_CAVERN	SALT_CAVERN	SALT_CAVERN
Zeilenbeschriftungen	Summe von MAX_CAP_IN	Summe von MAX_CAP_OUT	Mittelwert von VOM_COST_OUT
AL			
AT			
BA	50	110	
BG	100	220	
CY			
CZ			
DE			
DK	600	1320	
FI			

Integration of data in TIMES

Attribute	Year	AT	BE	BG	CH	CY	CZ	DK	EE	ES	FI	FR
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	11111.11111	11111.11111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.11
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	753.1155405	750	753.44219	750	752.87097	753.25152	750	750	750	753.99286	752.598
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	753.1155405	750	753.44219	750	752.87097	753.25152	750	750	750	753.99286	752.598
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	11111.11111	11111.11111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.11
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	753.1155405	750	753.44219	750	752.87097	753.25152	750	750	750	753.99286	752.598
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	753.1155405	750	753.44219	750	752.87097	753.25152	750	750	750	753.99286	752.598
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	11111.11111	11111.11111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.11
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	328.095	325	325	325	325	328.01667	325	325	325	325	326.4441
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	328.095	325	325	325	325	328.01667	325	325	325	325	326.4441
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	11111.11111	11111.11111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.111	11111.11
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	328.095	325	325	325	325	328.01667	325	325	325	325	326.4441
INVCOST	2015,2020,2025,2030,2035,2040,2045,2050	328.095	325	325	325	325	328.01667	325	325	325	325	326.4441
INVCOST	2015	11388.88889	11388.88889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.88
INVCOST	2020,2025	11388.88889	11388.88889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.88
INVCOST	2030,2035	11388.88889	11388.88889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.889	11388.88
INVCOST	2040,2045	12222.22222	12222.22222	12222.222	12222.222	12222.222	12222.222	12222.222	12222.222	12222.222	12222.222	12222.22

Interface TIMES regional models – PowerFys

- Capacities of power and CHP plants
- Electricity and heat production of power and CHP plants
- Fuel input in power and CHP plants
- Emissions
- Electricity trade (capacities and amounts)
- Capacities of electrcity storages
- Electrcity demand by sector

Outline

Scenario analysis from the ESTMAP project

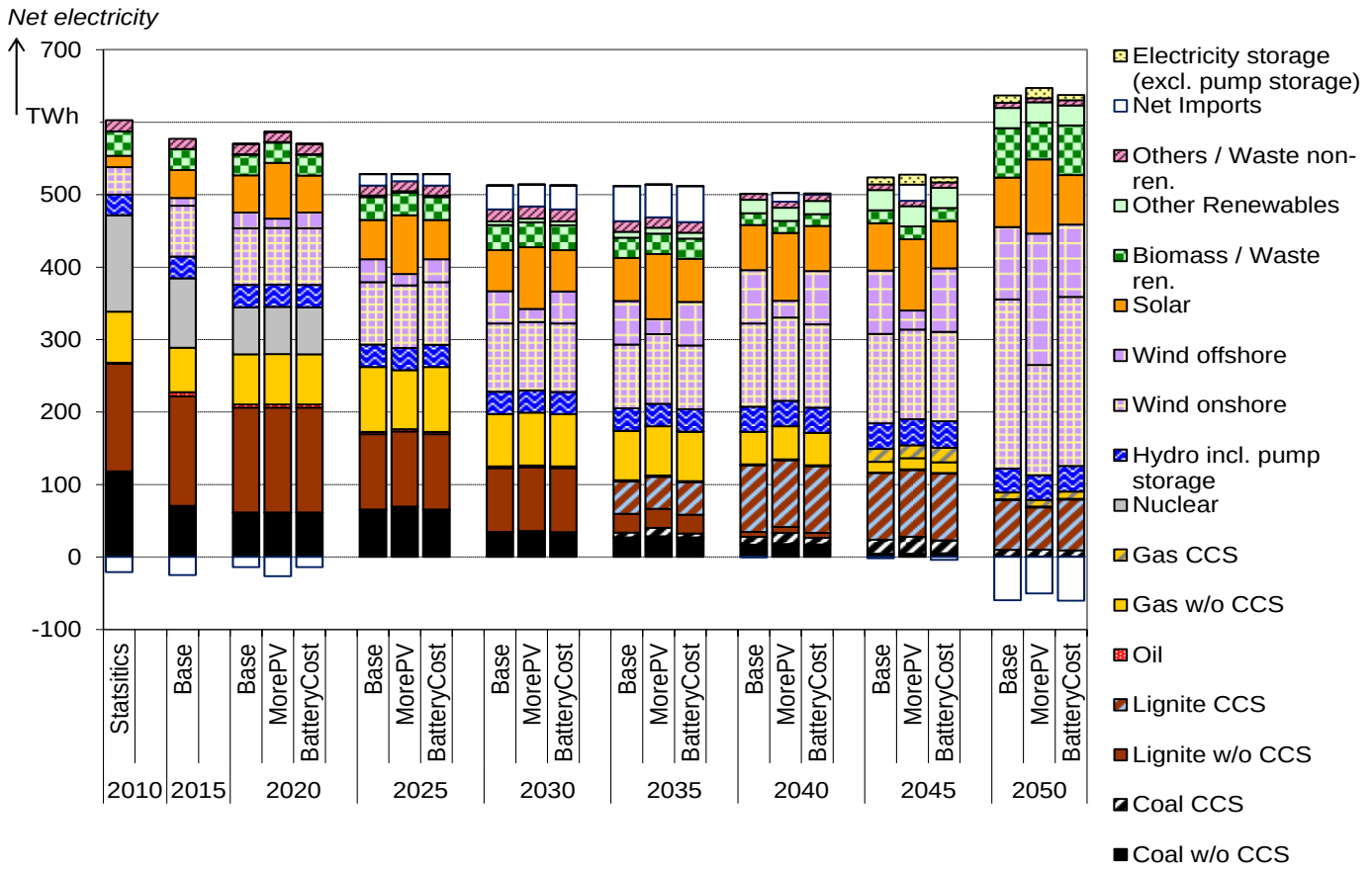
Scenario definition

Scenario assumptions	2030			2050		
	Base	MorePV	Battery Cost	Base	MorePV	Battery Cost
GHG reduction in the EU (vs. 1990)	40 %			90 %		
Renewables at electricity consumption in the EU	30 %			80 %		
Renewables at gross final energy consumption in the EU	27 %			75 %		
PV Capacity in Europe	120 GW	180 GW	120 GW	364 GW	546 GW	364 GW
PV Capacity in Germany	58 GW	87 GW	58 GW	70 GW	105 GW	70 GW

Scenario analysis from the ESTMAP project

Electricity production by energy carrier in Germany

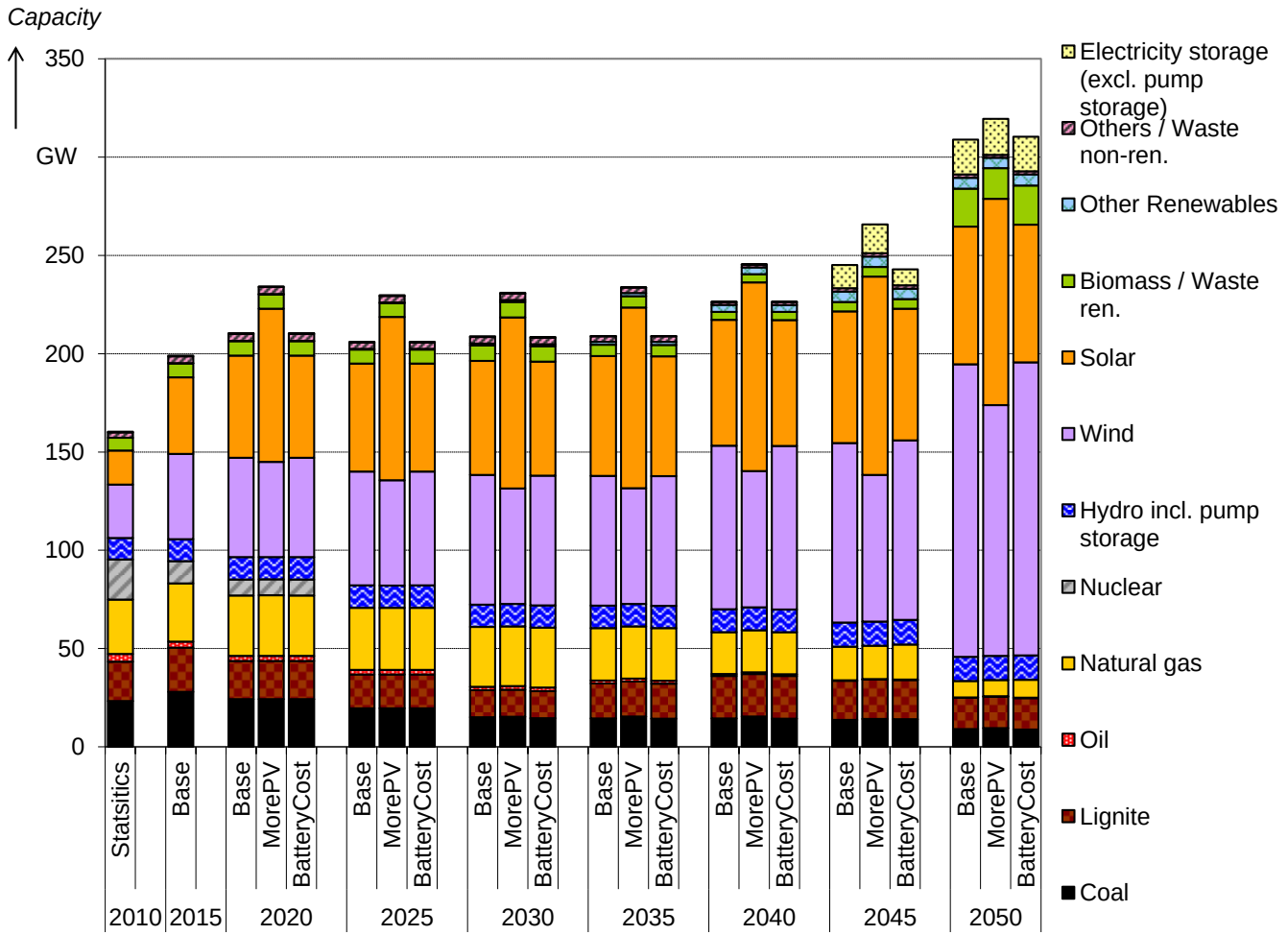
- Electrification of the energy system until the year 2050 (achieve GHG emission targets)
- Electrification enables integration of variable renewable energies
- Other energy carriers can be substituted
- With nuclear phase-out in the year 2025 wind turbines are increasingly used to achieve the share of renewables
- From the year 2035 additional lignite CCS power plants enter the market (reduction of GHG emissions)



Scenario analysis from the ESTMAP project

Capacities in Germany

- Increase of the capacities is higher than the increase of the overall electricity production
- Lower full load hours of pv and wind plants

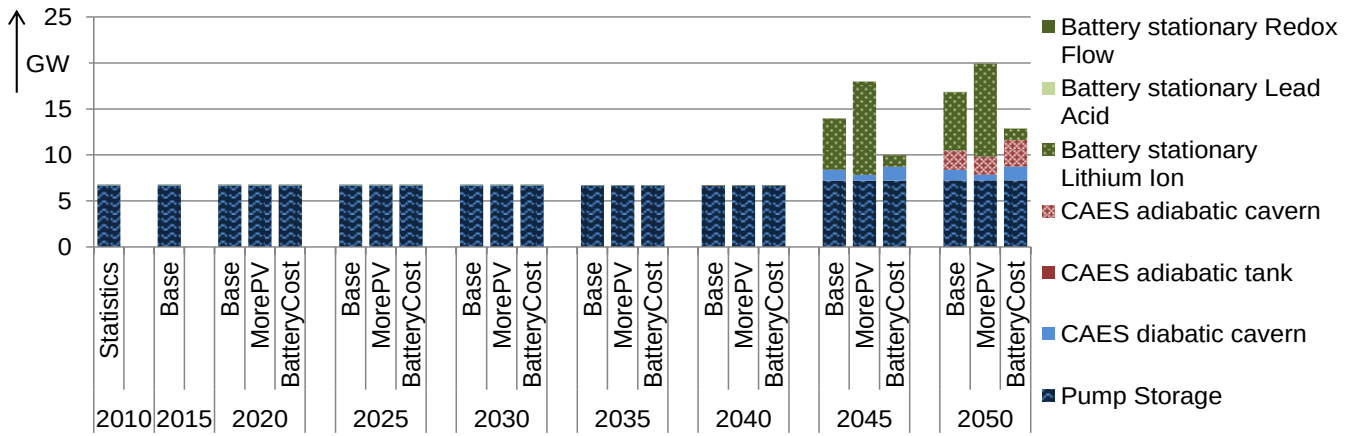


Scenario analysis from the ESTMAP project

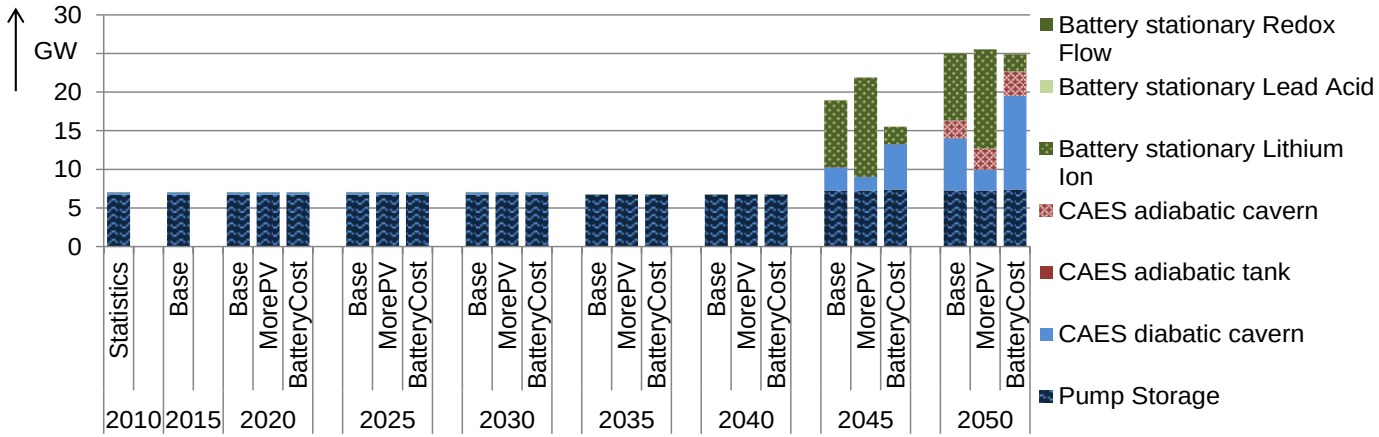
Electricity storages in Germany

- The increased fluctuating supply of electricity from wind and pv systems leads to a higher flexibility need in the whole energy system
- Therefore new electricity storages (especially stationary lithium ion batteries in combination with pv) are built from the year 2045 onwards in Germany

Storage input capacity

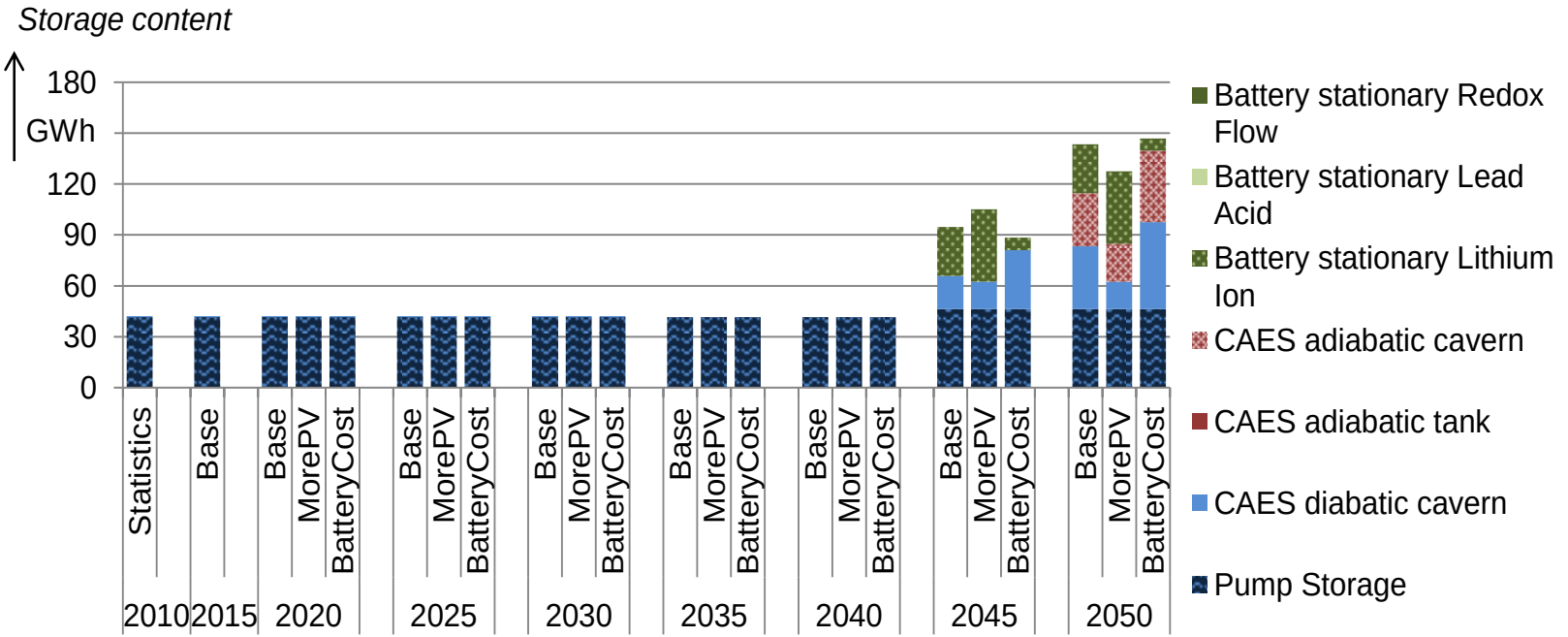


Storage output capacity



Scenario analysis from the ESTMAP project

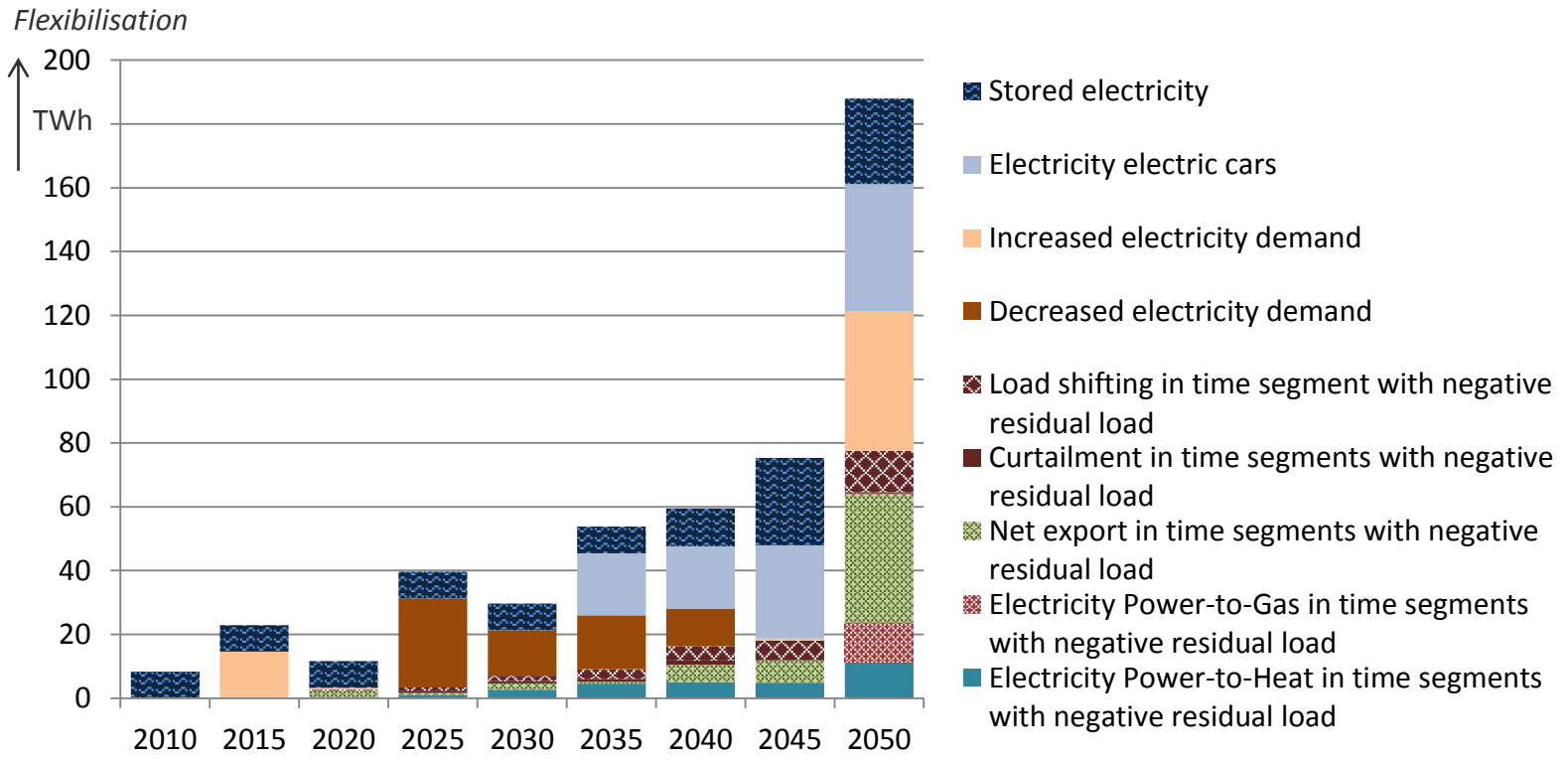
Electricity storages in Germany



It can be seen, that the ratio of storage content and power is lower for the battery storage than for the pump storage. This is due to the lower content-specific investment costs with higher power-specific investments of pumped storage.

Scenario analysis from the ESTMAP project

Flexibilisation of electricity in Germany for the MorePV scenario



- In order to achieve a high share of renewables in electricity consumption in Germany, less curtailment is used in 2050
- The amount of electricity which is not curtailed is instead stored in electricity storage or used by Power-to-Heat or Power-to-Gas installations (sector coupling)

Outline

Conclusions and outlook

Conclusions:

- Comparing the results for Germany to the ones from the TIMES PanEU model it can be seen, that a big part of new energy storages in Europe are built in Germany.
- This results are not only attributable to the amount of potential storage sites from the ESTMAP database, but also due to the model design with a higher temporal resolution only of the German region.
- With a lower temporal resolution the storage need in the energy system is generally underestimated. The high flexibility need, which results from peaks and valleys of PV and wind production, cannot be mapped adequately in a model with a temporal resolution of only a few typical days.
- New storages after 2040, other flexibility options are important model components

Outlook:

- Outcomes of energy system analysis depend on storage technology parameters, such as cost projections, so that a sensitivity analysis could be useful
- Higher temporal resolution for other countries – model handling

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Thank you!

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