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# TOWARDS A RENEWABLE ENERGY ECONOMY

## FRAUNHOFER INSTITUTE FOR SOLAR ENERGY SYSTEMS ISE

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IRENA Electricity Storage Workshop

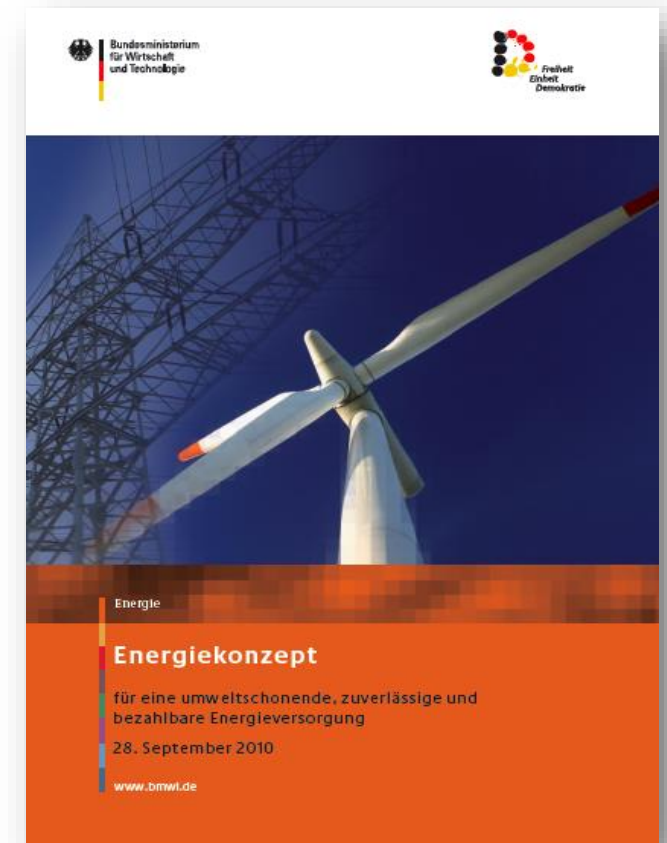
Akasaka Station TKP Conference Centre  
Nov. 7<sup>th</sup>, 2014, Tokyo, Japan

Fraunhofer Institut for Solar Energy Systems  
ISE, Freiburg, Germany

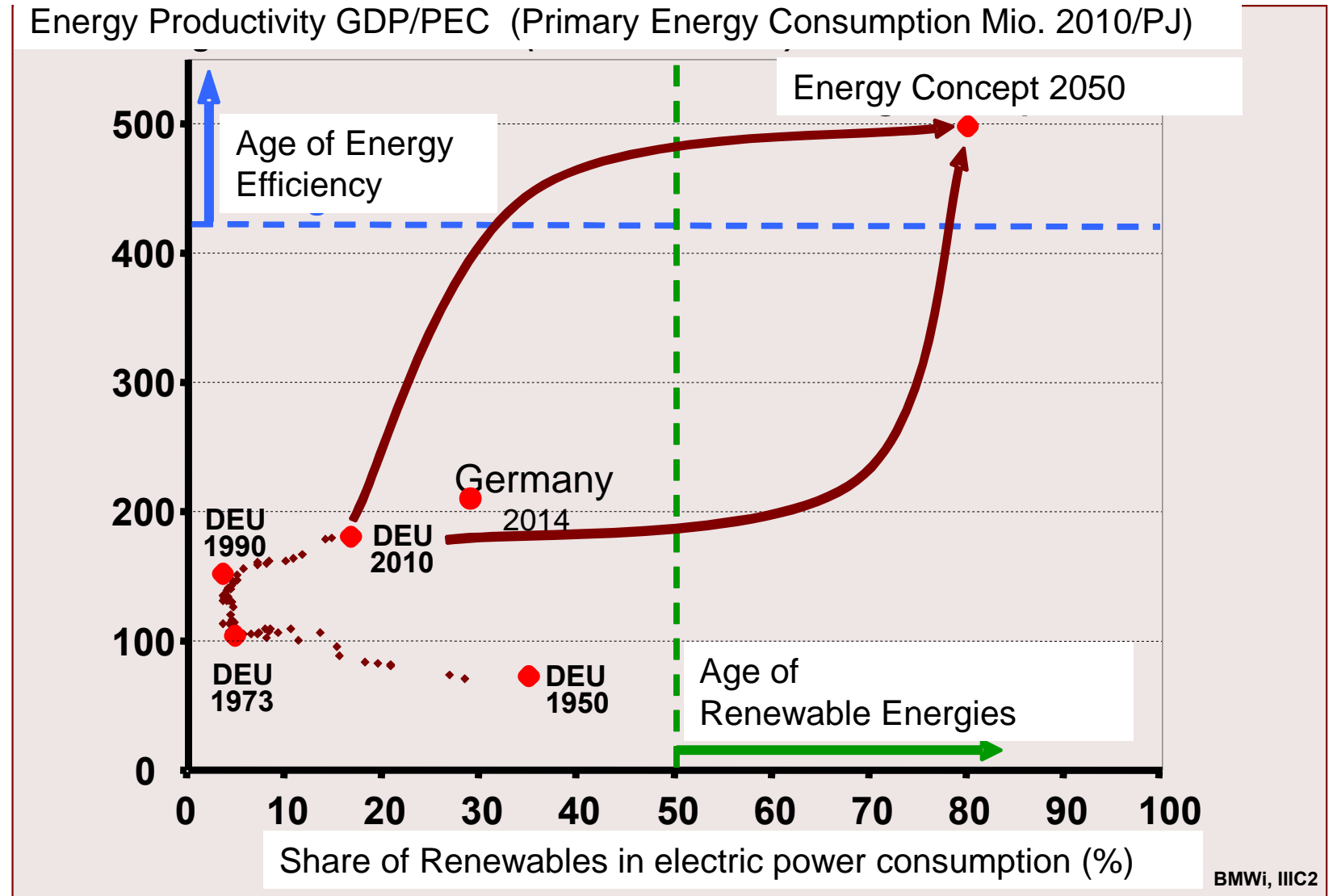
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# The Energy Concept of the German Government

Targetes for the year	2020	2050
Reduction green house gases	- 40%	- 80/95%
Share of renewables on the electricity consumption	35%	> 80%
Reduction primary energy consumption	- 20%	- 50%

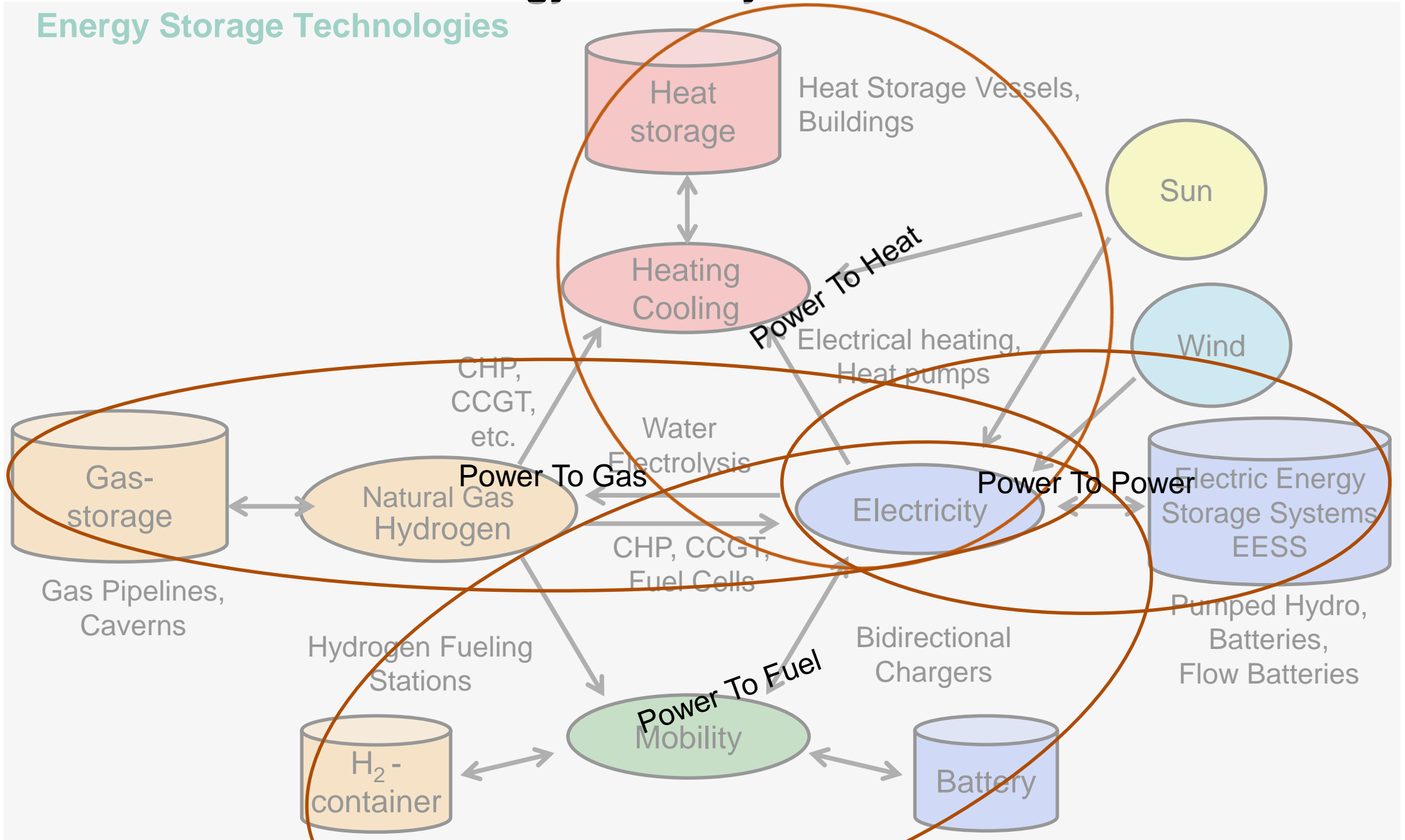


# Development of Energy Efficiency and Renewable Energy in Germany



# Transition to a Solar Energy Economy

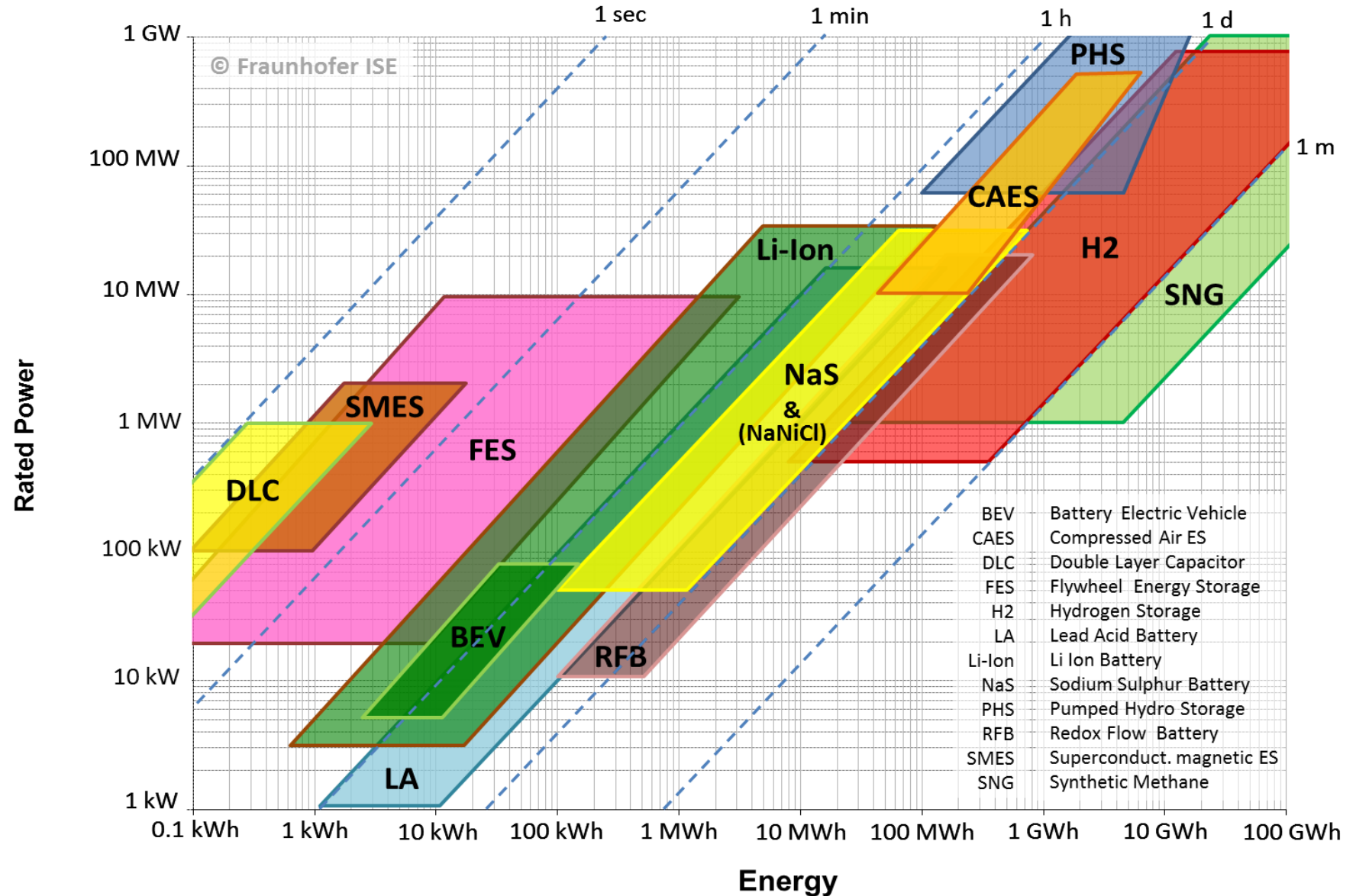
## Energy Storage Technologies



# Energy Storage Technologies

## Storage principles:

- Electromagnetic
- Electrochemical
- Mechanical
- Chemical



# Local Hydrogen Storage in gas tube fields

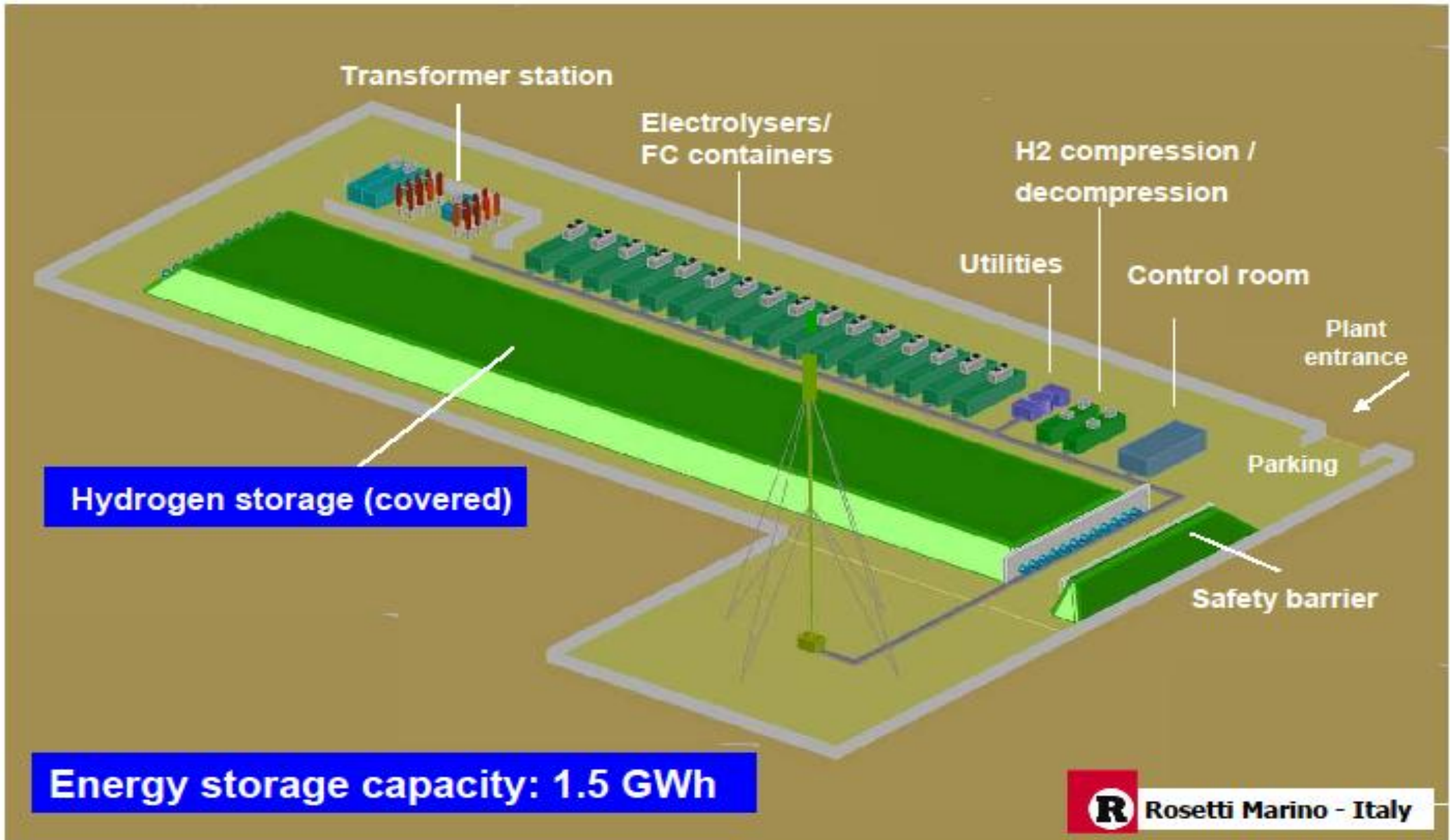
Zürich, Switzerland, 24 tubes of 250m length (1.5m), 70 bar, 714.000 Nm<sup>3</sup> Natural Gas  
1.5 GWh Storage Capacity when filled with Hydrogen



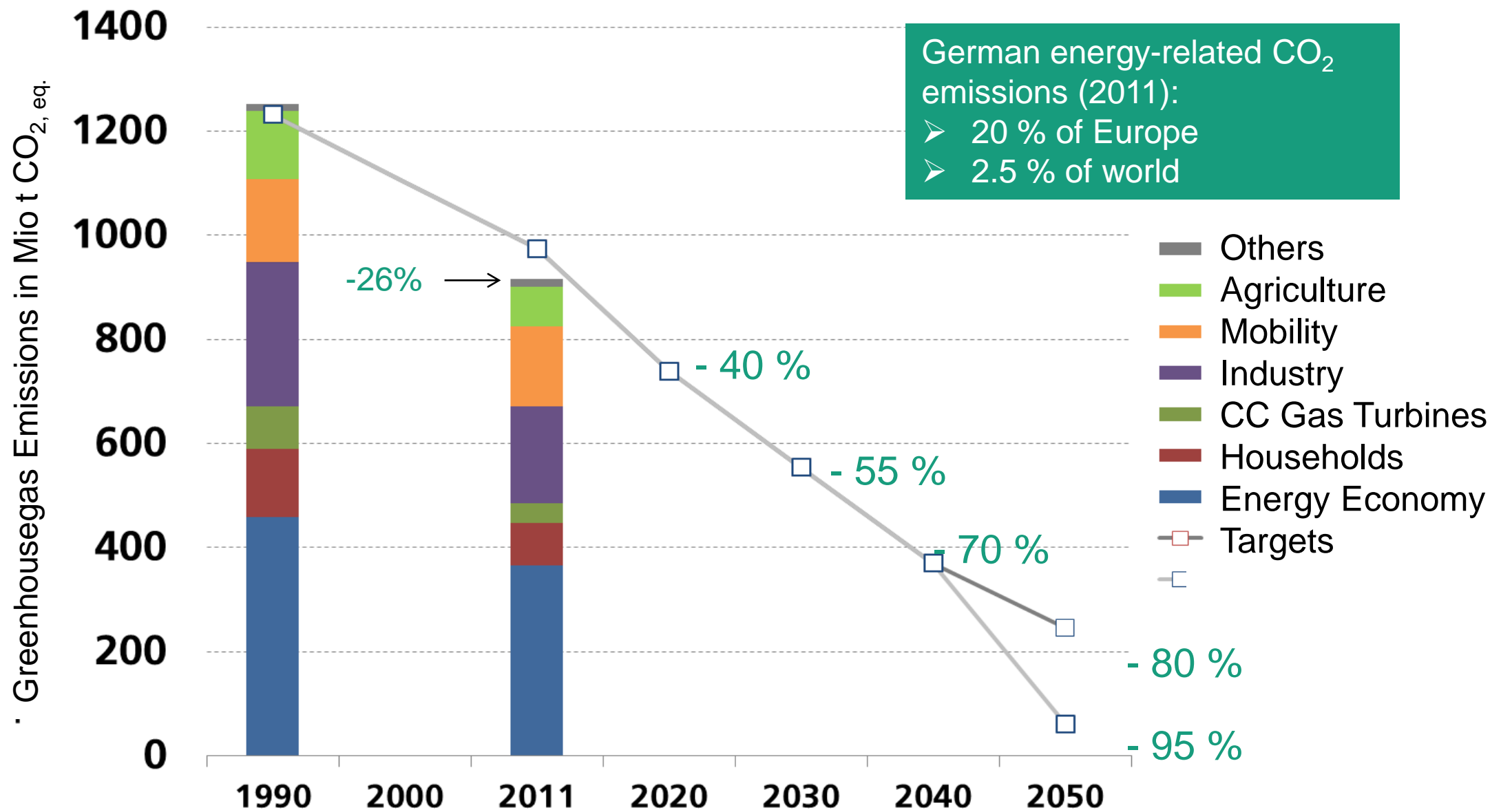
Source: Rosetti Marino - Italy

# Local Hydrogen Storage in gas tube fields covered with PV

## Renewable Energy Peakshaving Facility with Hydrogen Storage



# Reduction of Greenhouse Gas Emissions until 2050

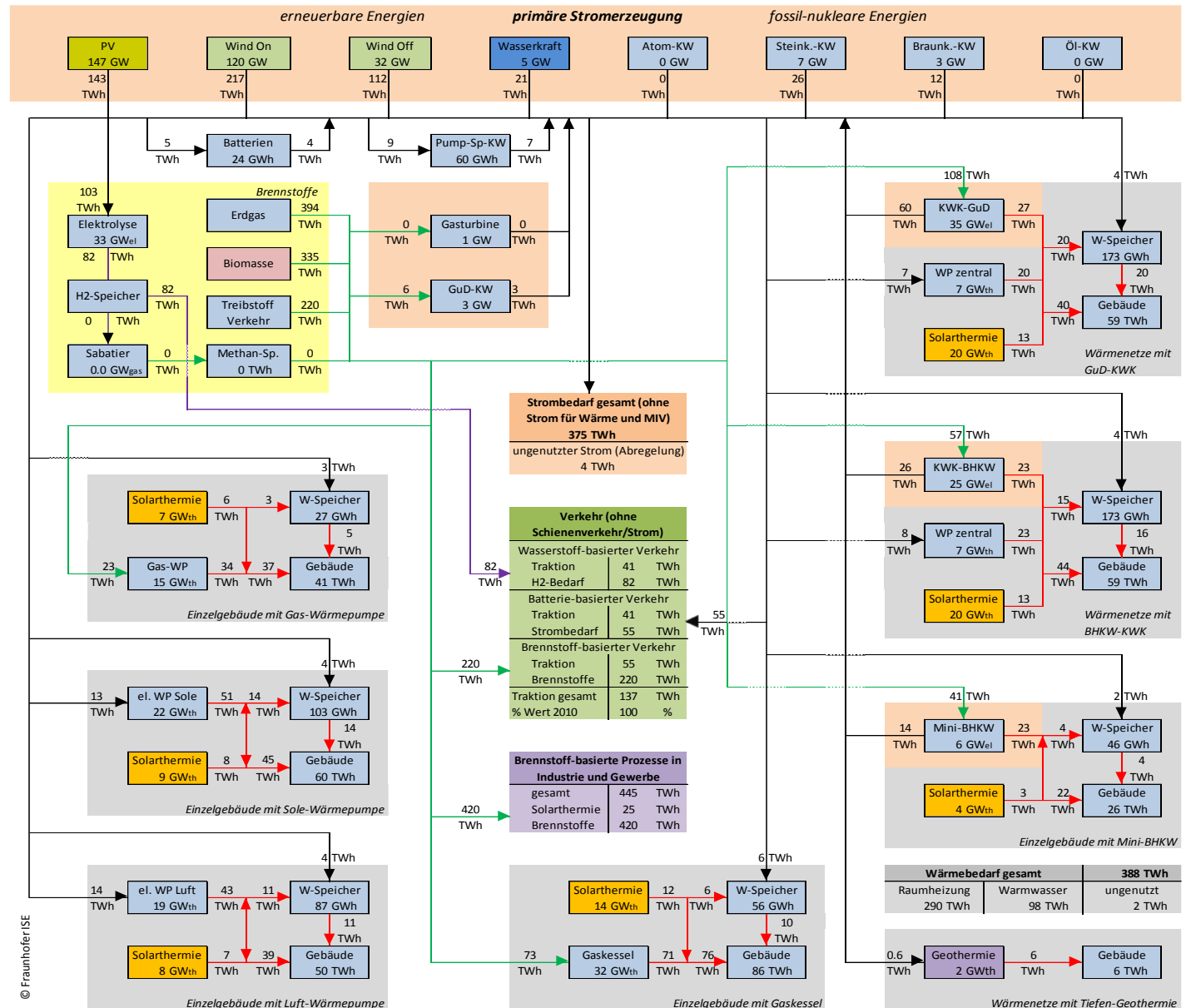




# Optimization of Germany's future energy system based on hourly modeling

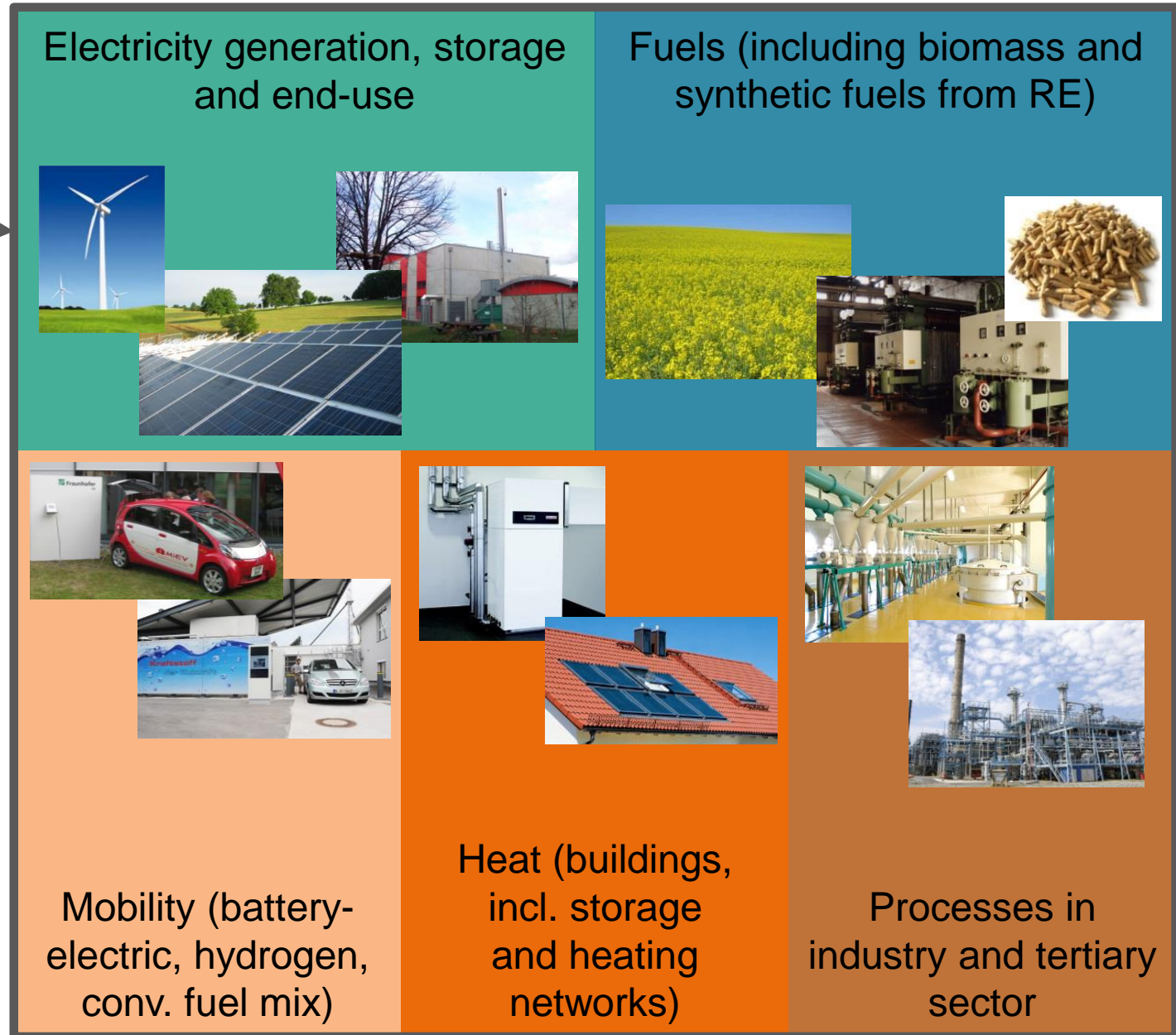
## REMod-D Renewable Energy Model – Deutschland

- Space heating demand 40% of today's value (reduced by energy retrofit of building stock)
- Cost optimized system for a reduction of energy-related CO<sub>2</sub> emissions by 80 % (compared to Kyoto reference value)



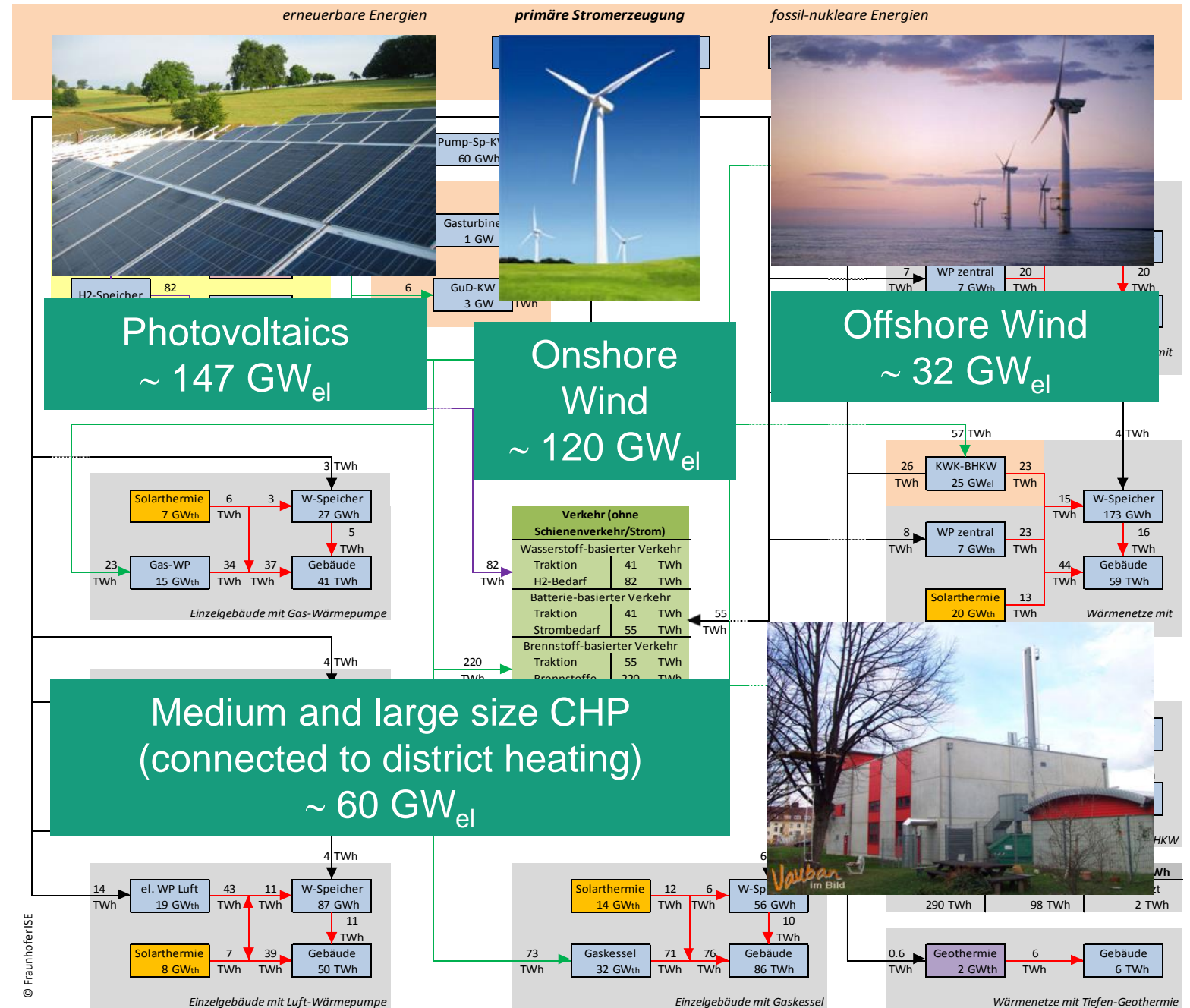
# Optimization of Germany's future energy system based on hourly modeling

Comprehensive analysis of the overall system



**REMod-D**  
Renewable  
Energy Model –  
Deutschland

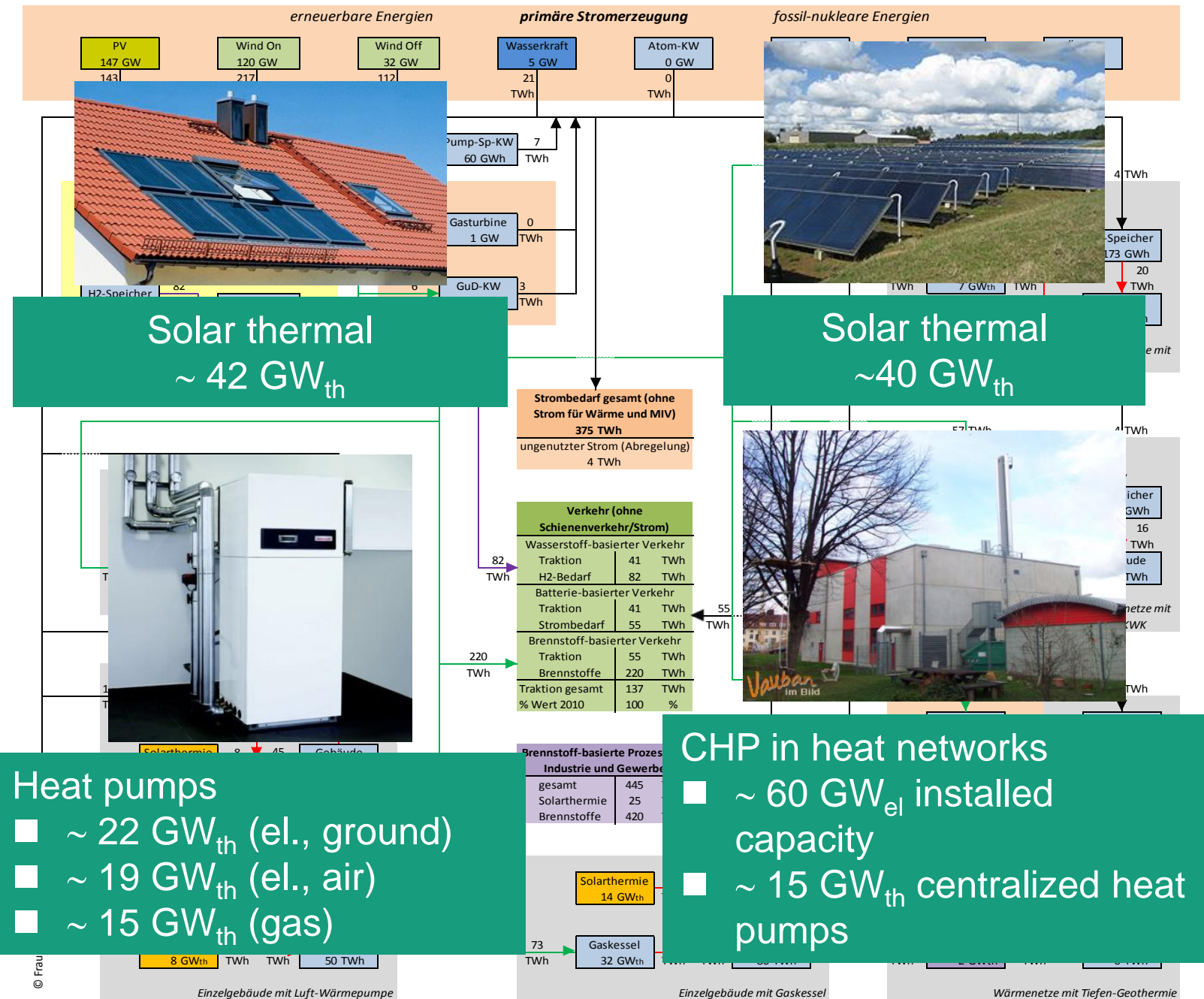
# Electricity generation



# Heat

## decentralized

## centralized



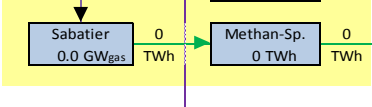
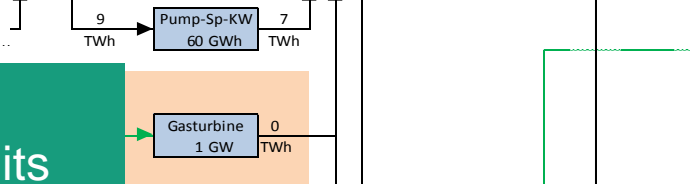
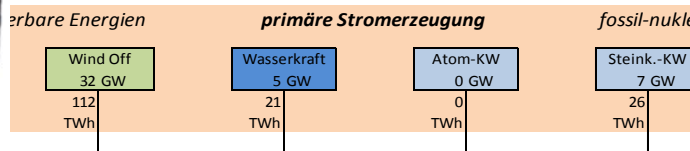
# Storage



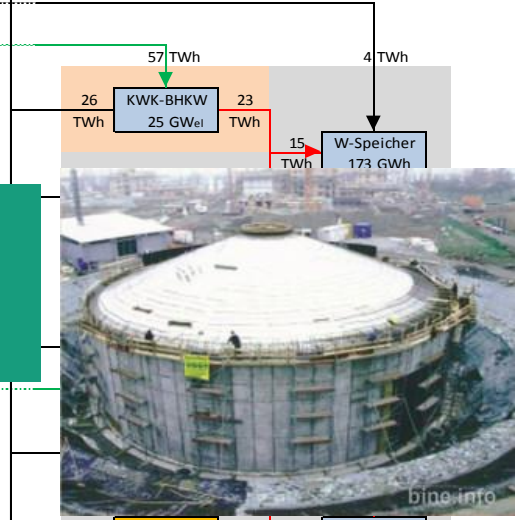
Stationary batteries  
Total ~24 GWh (e.g. 8 Mio units with 3 kWh each)



Pumped storage power plants  
42 units with a total of 60 GWh



Electrolysers with total capacity of 33 GW<sub>el</sub> (needed for mobility)



Heat buffers in buildings  
Total ~320 GWh (e.g. 7 Mio units with 800 Litres each)

Brennstoffe	220	TWh
Traktion gesamt	137	TWh
% Wert 2010	100	%

Brennstoff-basierte Prozesse in Industrie und Gewerbe	
gesamt	445 TWh
Solarthermie	
Brennstoffe	



Large scale heat storage in district heating systems  
Total ~350 GWh (e.g. 150 units with 50.000 m<sup>3</sup> each)

Einzelgebäude mit Luft-Wärmepumpe

Einzelgebäude mit Gaskessel

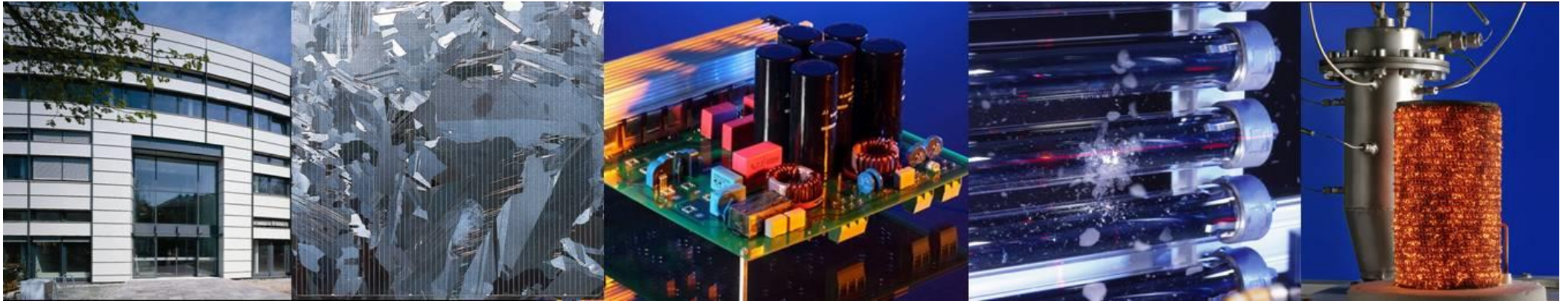
Wärmenetze mit Tiefen-Geothermie

# Summary

- Reduction of energy-related CO<sub>2</sub> emissions by 80 % and above are possible
- Lower cost for the energy system on the mid to long term
- Fluctuating renewable energies (wind, solar PV) will become the backbone of electricity generation and will dominate the overall system
- Flexibilization of residual electricity production and electricity use in all end-use sectors (mobility, heating) is needed
- Investments needed for components and systems in all energy conversion and end-use sectors  
→ Many groups of investors including citizens
- Solutions on the local and regional district level will play a dominant role for decentralized systems
- Results can be transferred to other industrialized regions or countries



# Thank you for your attention



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