„Integrating renewable energies - estimating needs for flexibility, competition of technologies and the impact of grid extensions“

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Frieder Borggrefe, Yvonne Scholz, Thomas Pregger
German Aerospace Centre (DLR), Institute of Technical Thermodynamics

DLR

Structure

1. Introduction: The DLR System Analysis Group
2. REMix: Load balancing and flexibility options
3. Load balancing with high shares of renewable energies, BMWi 2014
4. Results: Technology assesment
5. Critical discussion of modelling approaches

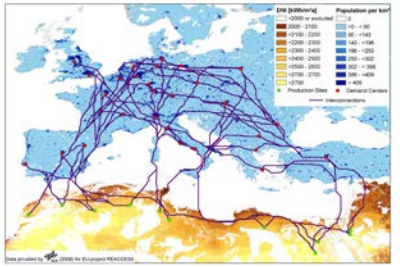
1. Introduction

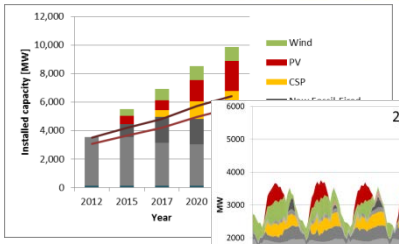
DLR - Who we are

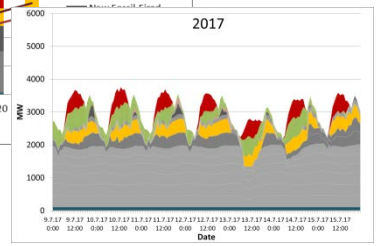
Research Areas

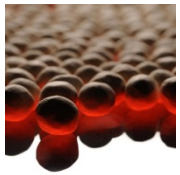
- Aeronautics
- Space Research and Technology
- Transport
- Energy
- Space Administration
- Project Management Agency

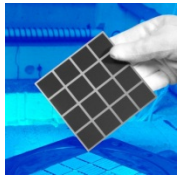
- Solar Research
- Wind Energy Research
- Systems Analysis
- Thermal & Chemical Storage
- High & low Temp. Fuel Cells
- Combustion & Gas Turbine Technologies

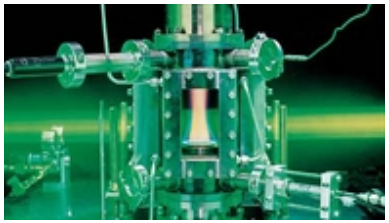






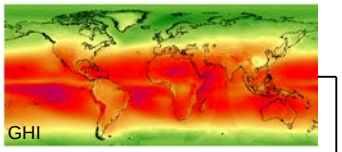


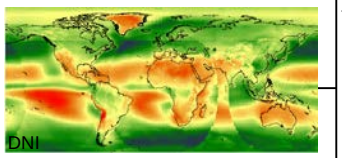


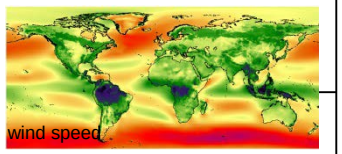


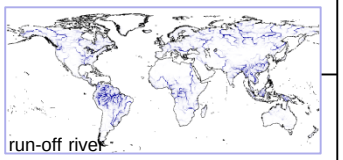
2. Energy systems model REMix:
validation of power supply, load balancing and flexibility demand

Installed capacities and power generation profiles from renewables









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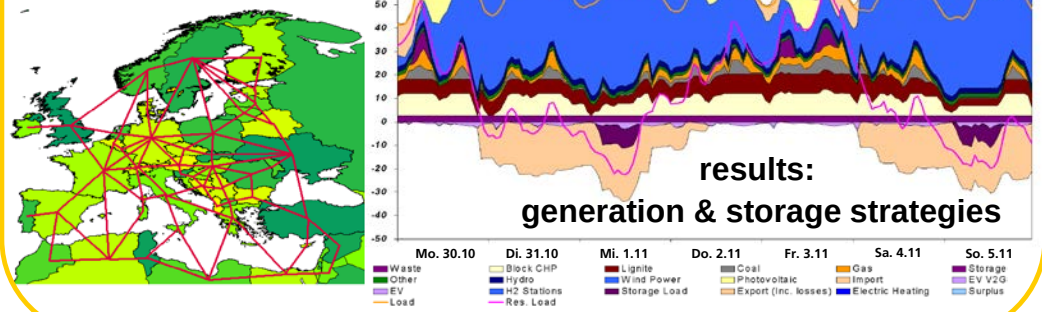
HVDC lines
long-range power exchange and imports

Transmission grid
based on current European AC grid

Scenario analysis with model REMix
cost minimised supply in temporal & spatial resolution

model



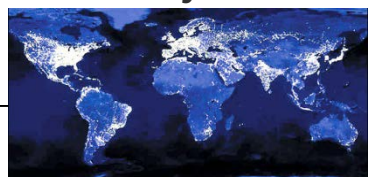
results:
generation & storage strategies

Conventional generation
nuclear, coal, gas power plants

Storages
pumped hydro
compressed air
hydrogen

Demand side management
industry & households, increases system efficiency

Electricity demand

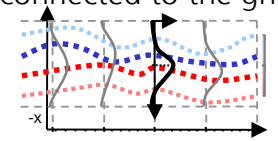


Heat demand

Flexible operation of CHP with:
- heat storages
- peak boiler & electric heaters

Electric vehicles (EV)

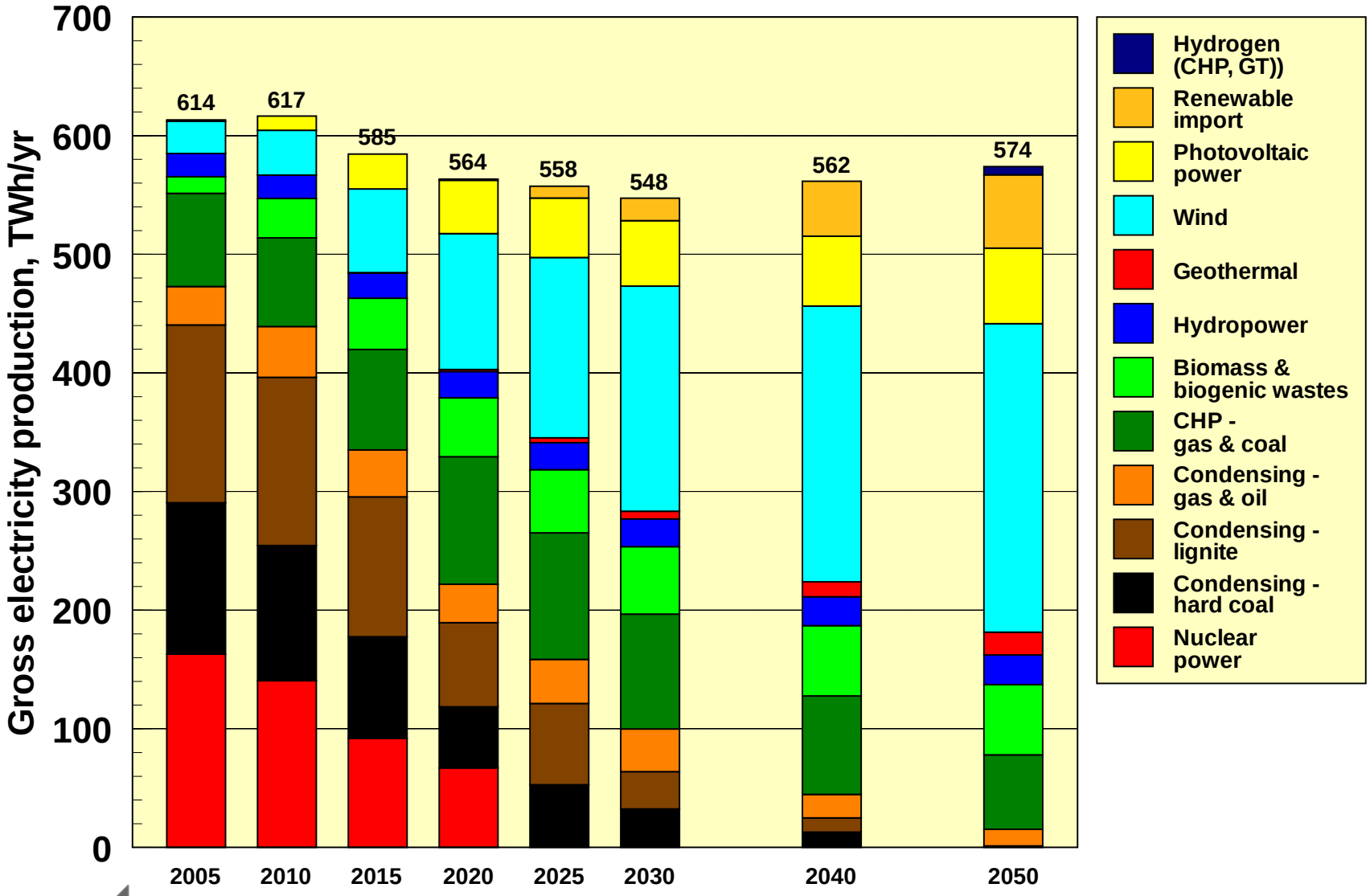
BEV/hybrids: charging strategies, hourly battery capacities of the fleet connected to the grid



FCEV: flexible on-site H_2 generation

source: DLR-TT

Results: Structure of gross electricity generation in Scenario A



3. Potential for load balancing to integrate large shares of REN-E

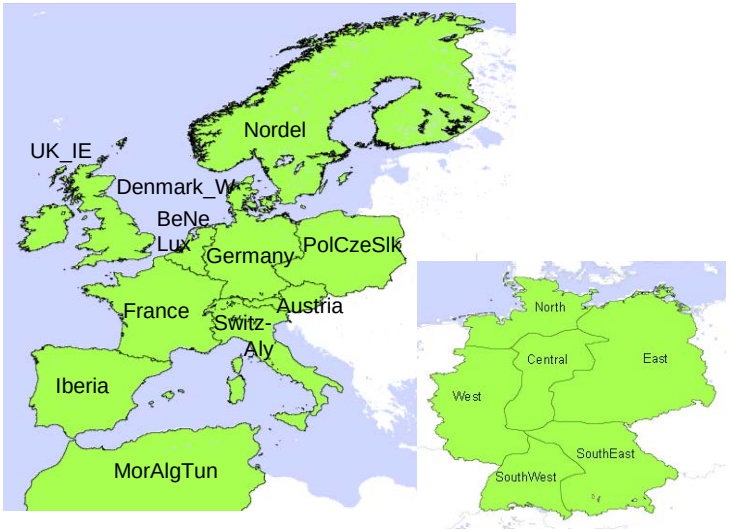
Investigated Scenarios

Reference Scenario	Scenario „H2“	Scenario „Import“
No solar import, regional REN-E	No solar import, reg.	Solar CSP import
Cons. grid 2020	No grid ext 2050	Opt. grid 2050
Cons. grid 2030	Opt. grid 2050	
No grid ext 2050		
Opt. grid 2050		

- How will flexible technologies be used and to what extend competition might arise between these technologies?
- What characteristics define an efficient electricity mix for the integration of large shares of renewables?

REMix OptiMo

Linear energy systems modelling



Configuration

Investments: yes

Configuration: LP (Linear programming)

Time slices: 1 Year, 8760 days

Regions: 16

Model variables:

- Generation-, transport and storage- capacities
- Electricity generation
- Transport and storage
- Heat generation and storage
- Excess capacity

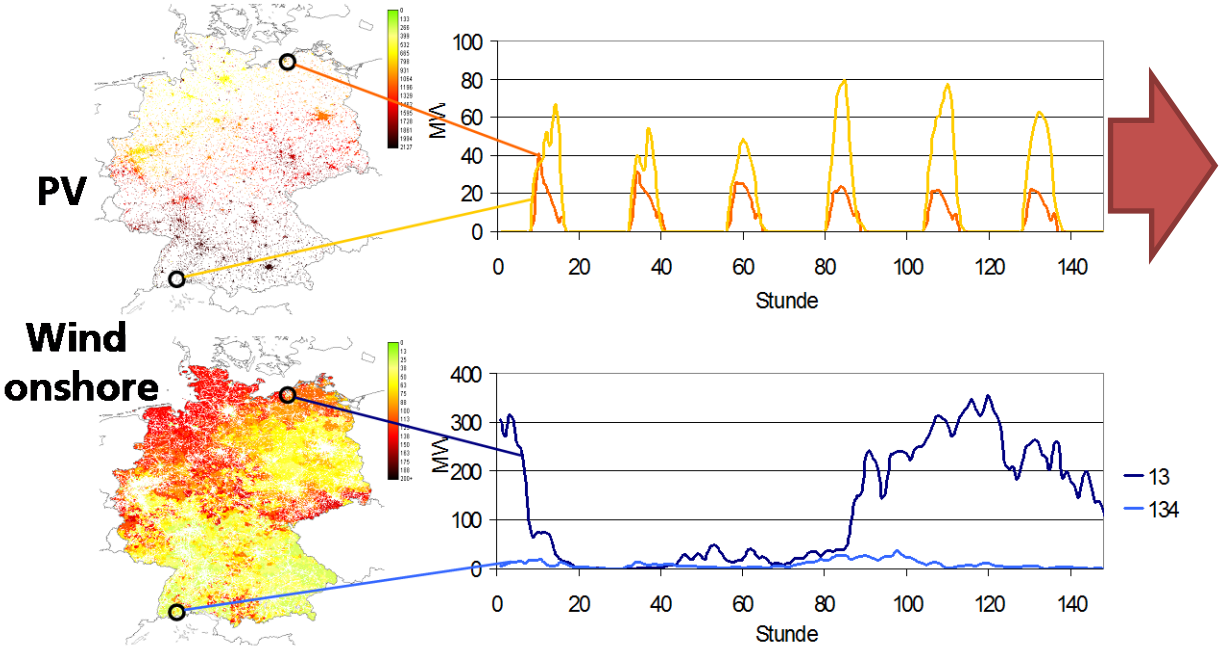
Technologies

	Electricity	Heat
CHP	20	23
Conventionals	40	
DSM	30	
Storages	5	
Renewables	4	
CSP	2	
Electric vehicles	1	
Total	**102**	**23**

Time steps	
All hours of one year	8760h

REMix: Data

Feed-in from fluctuating renewables



o	Reference scenario: No additional flexibility options
+	Flexible CHP based on thermal storage, conventional and electric peak load boiler
++	Additional load management options Heat pumps Electric vehicles - flexible charging
+++	Additional construction of electricity storages (e.g. CAES)

Identification of flexiblity from heat demand

- GIS-based method with 1 x 1 km² area pixel
- Upper bound for district heating grids

Demand per capita

Density of heat suppy

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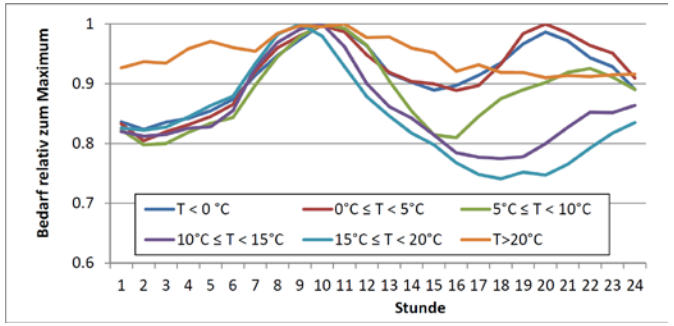
District heating

- 23 technologies
- Potential district heating areas
- Annual demand
- Heat density
- Costs



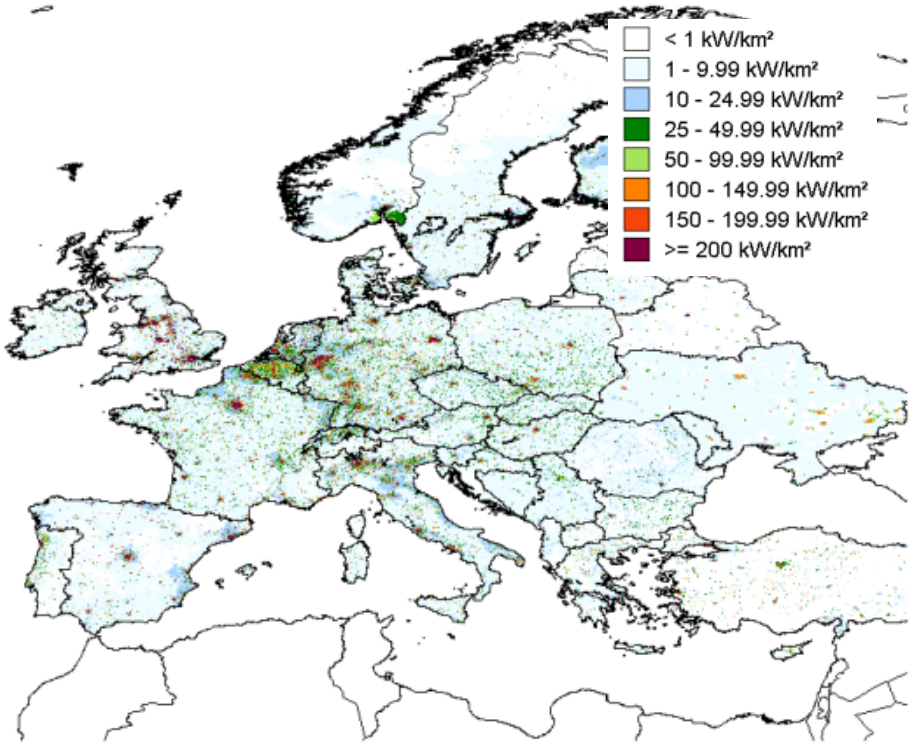
DLR

REMix: Data

Identification of flexible load

30 different endusers with the ability for load shifting and load shedding

Theoretic potential for DSM in 2010



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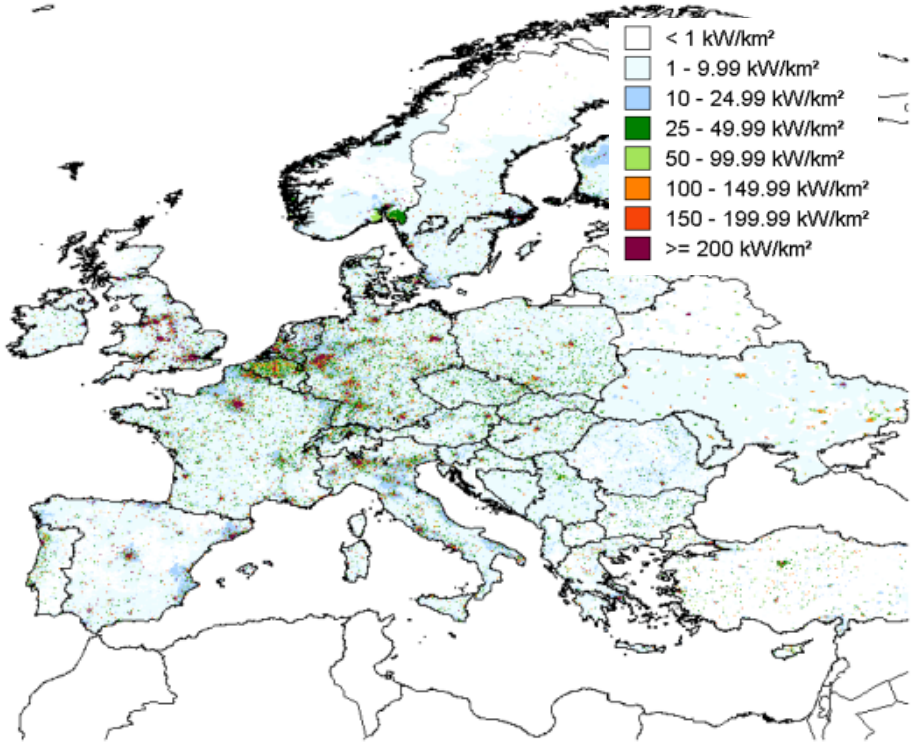

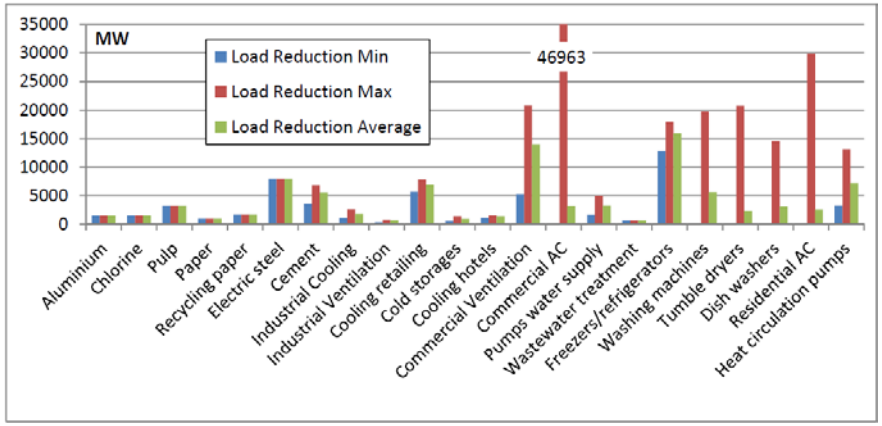

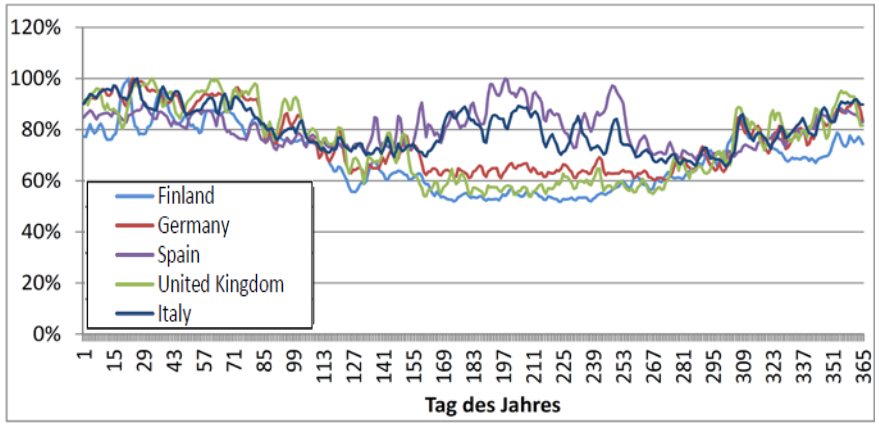

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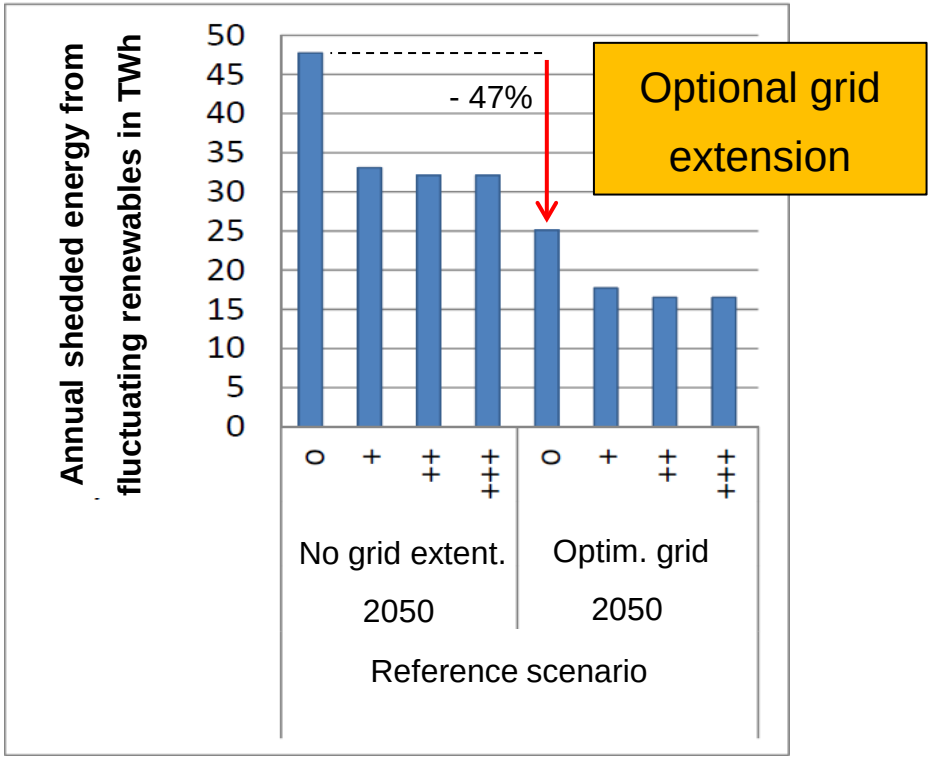
4. Results:

Indicator 1 - annual shedded energy



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Importance of the grid: Model endogenous grid extension significantly reduces demand for storage

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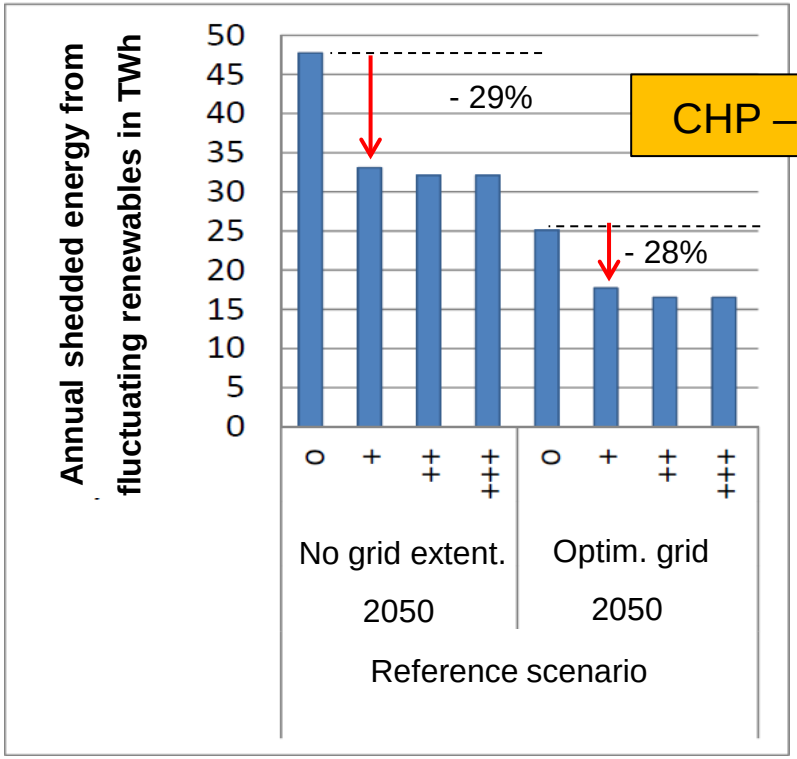

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Runner up: CHP – plants can significantly reduce load shedding

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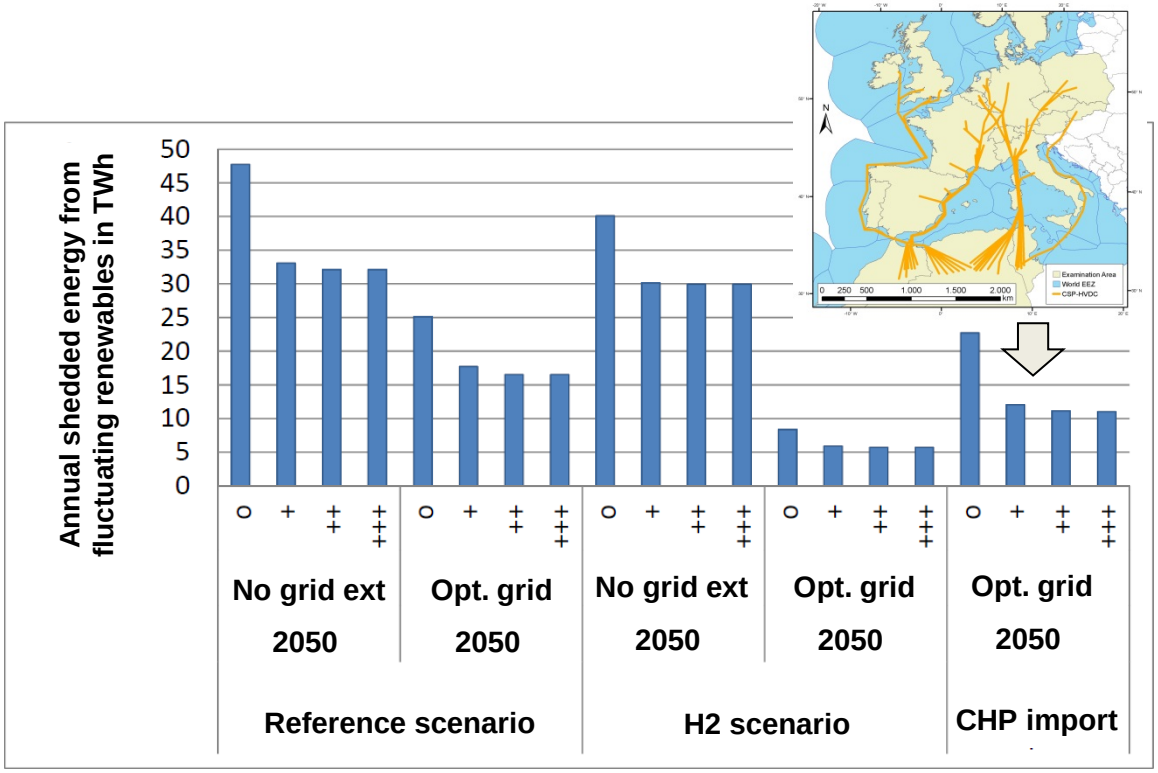

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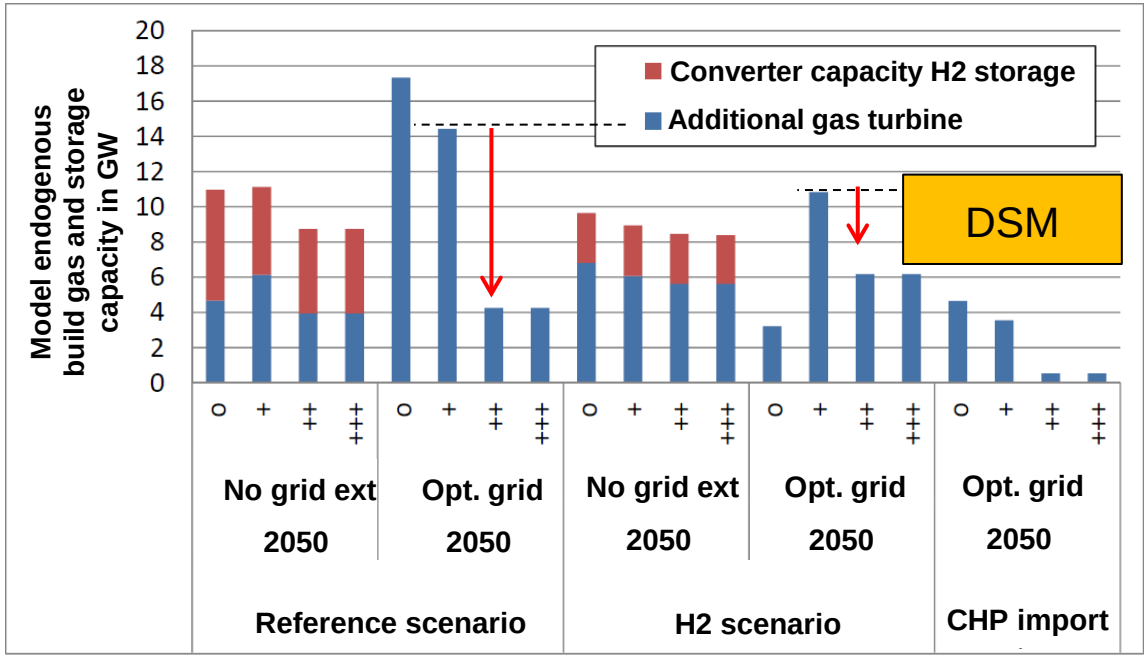
4. Results:

Indicator 2 – model endogenous build of gas turbines and H2 storage



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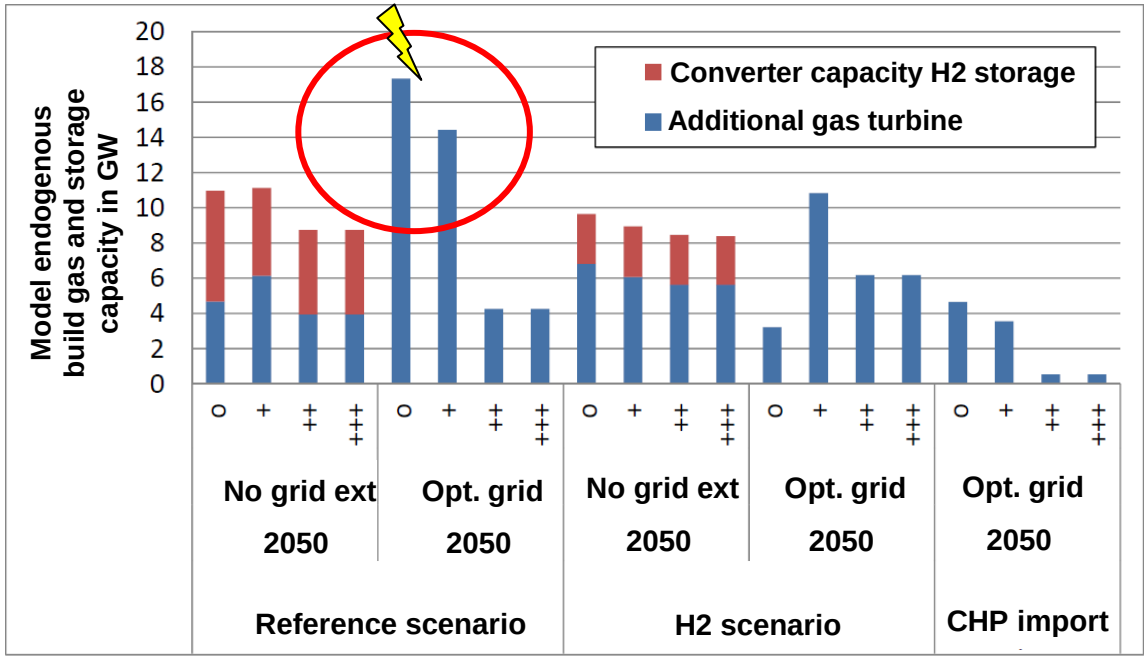

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4. Results

Overview

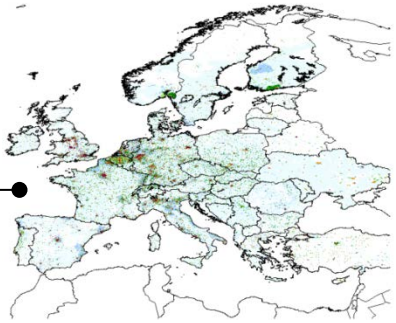
Indicator 1 RE shedding	Indicator 2 Capacity
Grid CHP	Grid DSM
Grid DSM CHP	
CAES	

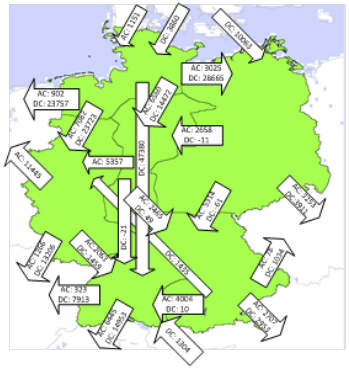
- Importance of the grid: Model endogenous grid extension significantly reduces demand for storage
- CHP plants can contribute significant flexibility
- DSM will be used to cover peak hours. Will be valuable only in combination with grid extensions
- CHP and DSM complement each other well
- By using CSP imports demand for storages can be significantly reduced.
- Long term storages will only become available if other flexibility options are not used.

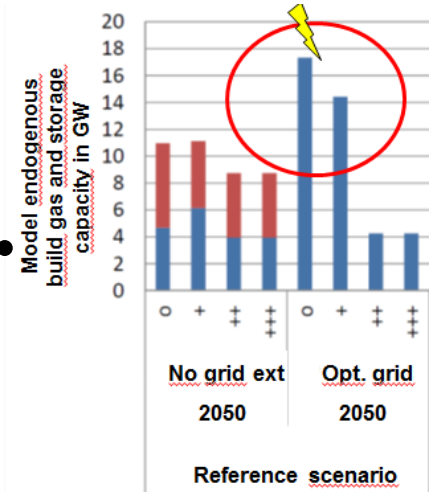
4. Results

Critical discussion

- How to use the full potential of the data?
- Regional aggregation: under-estimating demand for flexibility?
- Indicators for renewable integration must be precise
- Cost based evaluation of scenarios necessary
- How to make a strong sensitivity analysis?
- Beyond steady state: Investment path







Recommendations

1. Understand your indicators
2. Get your costs right
3. Understand the sensitivity of your key parameters
4. Don’t underestimate the grid …

… but it is only half the cure

5. Don’t spend to much time on CAES-modelling …

… it is better spend in modelling the heat sector

Recommendations

1. Understand your indicators
2. Get your costs right
3. Understand the sensitivity of your key parameters
4. Don’t underestimate the grid …

… but it is only half the cure

Take your time and understand what is important for the quality of your model results

Thank You!

References

- **BMWI/BMU 2010**: Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung. (in German) Ministries of Commerce and Environment for the Federal government; Berlin, September 2010
- **DLR/IWES/IfNE 2012:** Long term scenarios and strategies for the deployment of renewable energies in Germany under the consideration of European and global developments. Final report in commission of the German Federal Ministry for the Environment (in German), March 2012
- **DLR 2014:** Potential and constraints of load balancing by energy storage, demand side management, and flexible CHP with high shares of renewable electricity generation (in German) funded by the German Federal Ministry of Economic Affairs and Energy, June 2014
- **SCHOLZ, Y. 2012:** Renewable energy based electricity supply at low costs - Development of the REMix model and application for Europe; Dissertation, University of Stuttgart, 2012