Wuppertal Institute
for Climate, Environment
and Energy

MODELING THE INTEGRATION OF LARGE ENERGY STORAGE IN THE DANUBE REGION

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Perspectives of Renewable Energy in the Danube Region, 26.03.2015

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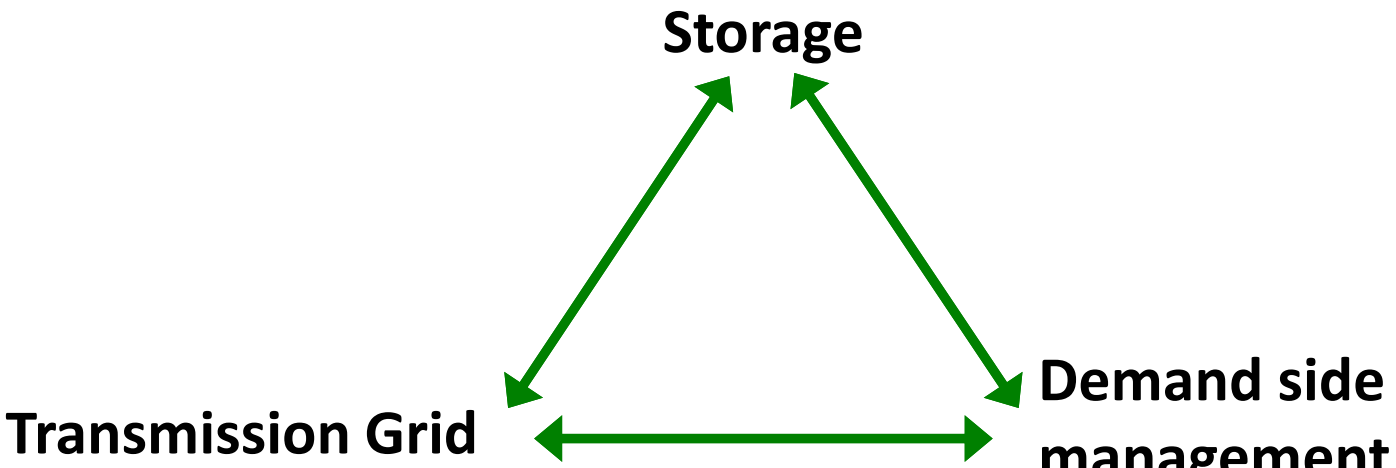
Restore 2050 project

Research project in cooperation with:
Next Energy, University of Oldenburg

Funding: BMBF (FKZ 03SF0439)

Renewable based electricity system in Europe 2050 (<= 100%)
Research focus: Interdependencies of balancing measures:



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Introduction

European electricity system model

Model database (country level, 32 countries):

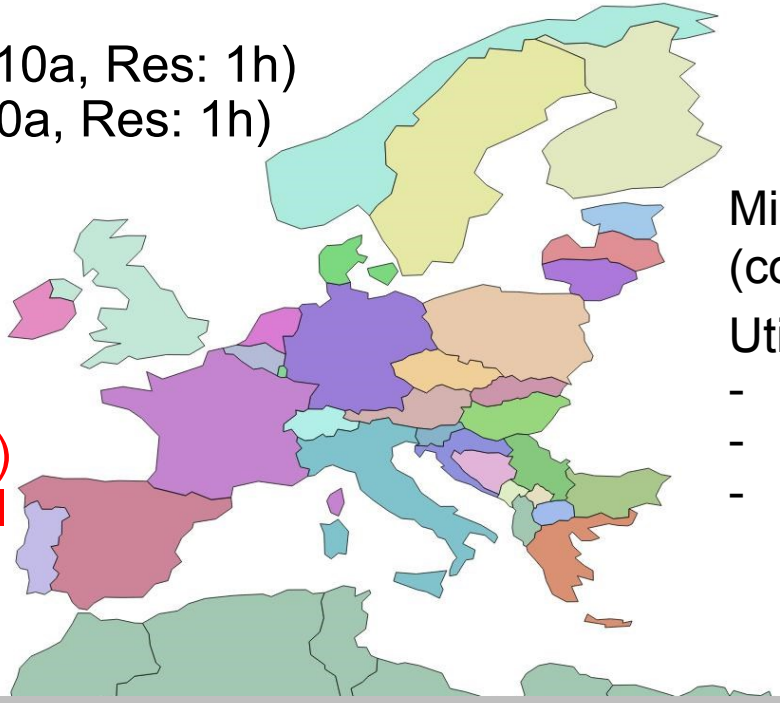
- RES capacities [1,2]
  - Wind Onshore /Offshore
  - PV
  - Biomass
  - Hydro
  - Wavepower
  - Geothermal
  - CSP
- RES infeed timelines (10a, Res: 1h)
- Sectoral loadcurves (10a, Res: 1h)

Model core:

Optimization of residual load

$$RL = P_{load}(t) - P_{RE\text{-}infeed}(t) \pm P_{bal}(t)$$

$$\min \sum_{i=1}^{m} \sum_{t} (RL_i(t))^2$$



Input parameters:

Balancing options

- Storage units
- NTC (grid connections)
- Sectoral DSM potential

Model output:

Minimized Residual load (countrylevel)

Utilization

- Storage units
- Grid connections
- Sectoral DSM

Case study:
Research questions

Looking at 2050: What happens in Danube region?

- What is the overall residual demand in the region?
- What impact has further grid extension on residual energy demand?
- How can grid extension and demand side management affect storage utilizitation?
- What happens to the energy exchange balance whithin a RES based scenario?

Case study:
Model resolution

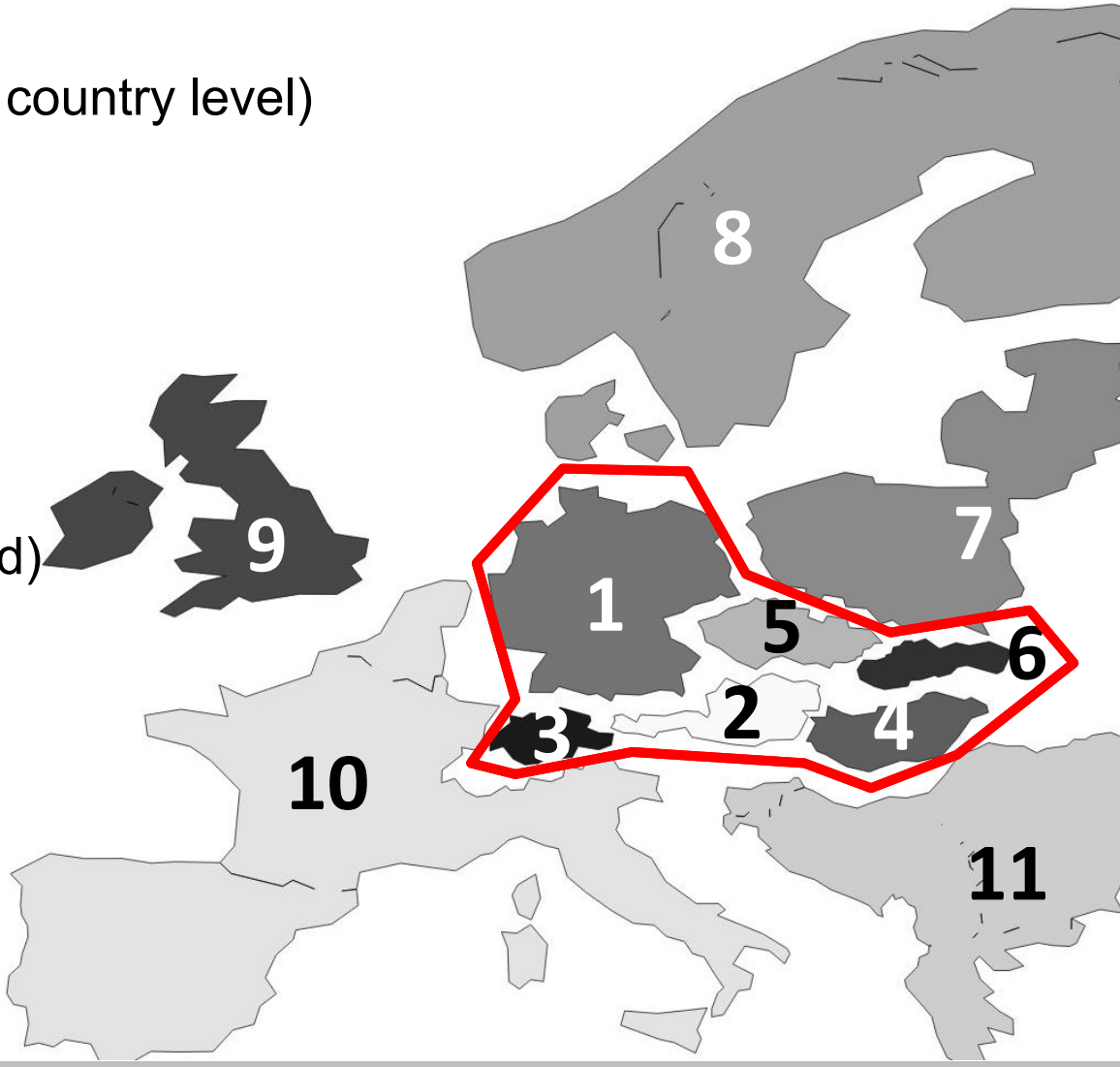
Europe in 11 regions:

Danube Countries (resolved at country level)

1. Germany
2. Austria
3. Switzerland
4. Hungary
5. Czech Republic
6. Slovakia

Remaining Europe (aggregated)

7. Baltic region
8. Scandinavia
9. UK/IE
10. Western Europe
11. Southeast Europe



Case study:
Installed RES and demand in 2050

	Wind Onshore	Wind Offshore	PV	Hydro	Biomass	Geothermal	Electricity demand
	GW	GW	GWp	GW	GW	GW	TWh
DE	54,4	50,2	69	4,8	11,5	0,2	567,8
AT	6,3	0	6,3	6,7	2,2	0,1	63,2
CH	0,9	0	8,6	11,8	0	0	54,2
HU	2,1	0	7,9	0,1	1,8	0	44,8
CZ	15,6	0	11,4	1,3	0,9	0,1	65,3
SK	1,1	0	5,4	1,9	0,5	0	29,3
Share in Europe	13%	26%	32%	20%	19%	21%	23%

Case study:
Performed model runs

3 Model runs to answer research questions:

1: Baseline 2050: Grid as in TYNDP, no DSM , PHS (as of today)

2: Increased Grid: Unlimited Grid capacity between all regions, no DSM

3: DSM: 50% of DSM potential in E-mobility
(only in Danube countries!)

	1: Baseline	2: Increased grid	3: DSM
Grid	TYNDP 2014	Perfect grid	TYNDP 2014
DSM	No DSM	No DSM	E- Mobility DSM (50%)
Storage	PHS	PHS	PHS

Results:
Residual energy demand

Results of baseline simulation (Sim1) :

	Unit	Overall System	Danube Region	AT	CH	GER	HU	CZ	SK
Electricity demand	TWh	3609	824.6	63.2	54.2	567.8	44.8	65.3	29.3
Residual demand	TWh	903.4	267.7	18.7	27.9	162.0	20.8	26.4	11.8
% of demand	%	25%	32%	30%	52%	29%	46%	40%	40%
Excess energy	TWh	276	15.7	0.5	0.7	12.6	0.3	1.5	0.2
% of demand	%	8%	2%	1%	1%	2%	1%	2%	1%
Max. residual load	GW	327.6	109.5	15.2	18.8	77.8	8.5	13.1	5.6

Effects of Grid extension (Sim 2): Spatial shift of energy

- Reduction of residual demand (Europe) of 137TWh (-15,2%)

Effect of demand side management (Sim3): Temporal shift of energy

- Reduction of RL in Europe <1% (Danube region: -1,8%)

Case study:
Impact on storage utilization

Effects of Grid extension (Sim 2): Spatial shift of energy

- Only limited effect on storage systems

Effect of demand side management (Sim3): Temporal shift of energy

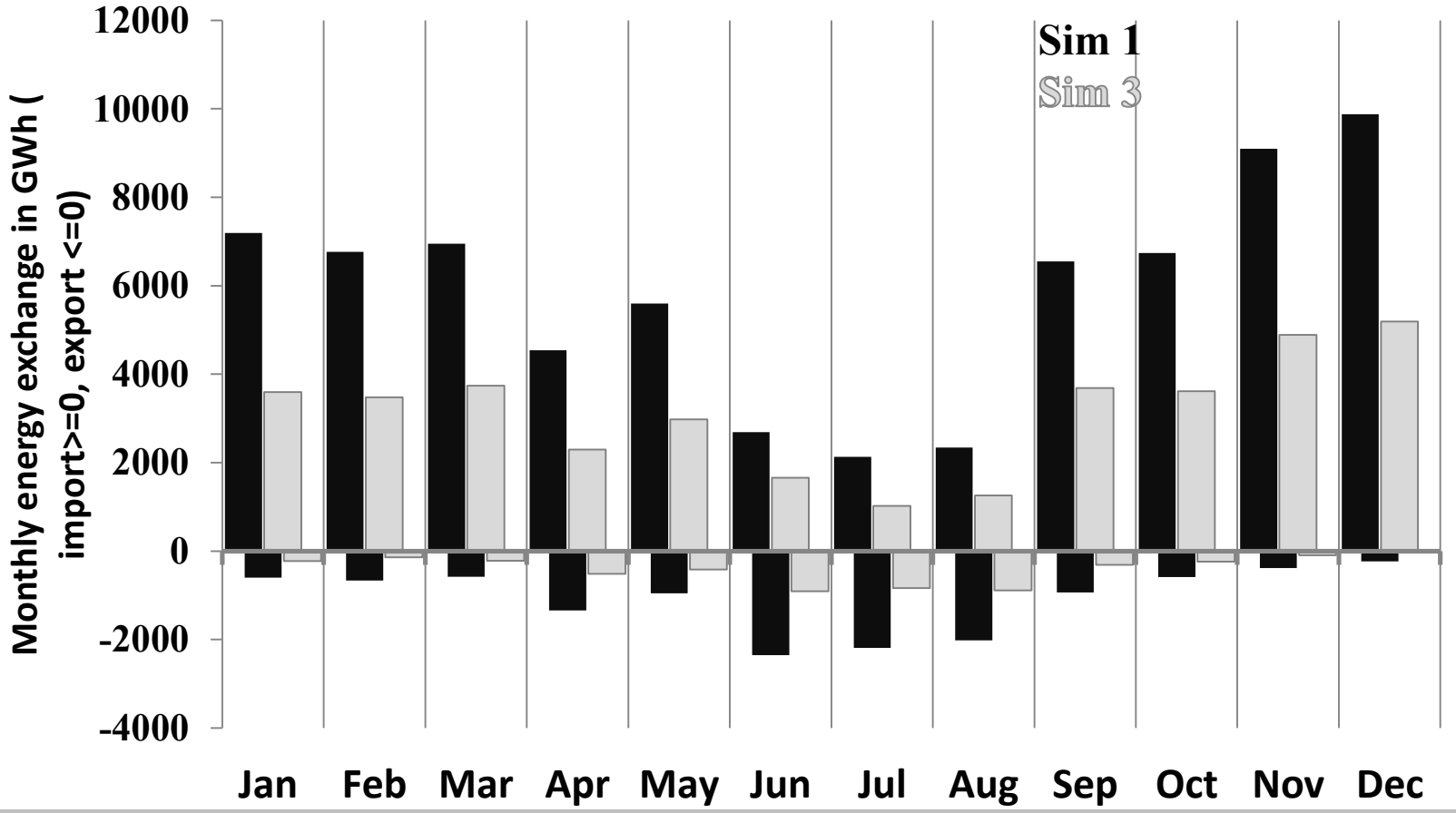
- Storage units need to act more flexible
- DSM leads to lower capacity factors of storage units

Performance indicator	AT	CH	GER	HU	CZ	SK
C/P ratio	32.9	184.5	5.8	-	10.3	4.3
equiv. load cycles (Sim 1)	48.4	9.9	287.5	-	193.3	425.0
load changes (Sim 1)	1416	1428	1415	-	1328	1445
load changes (Sim 2)	1439	1391	1539	-	1370	1651
load changes (Sim 3)	1511	1393	1554	-	1415	1516
Cap. factor c (Sim 1)	36.3%	41.6%	37.8%	-	45.4%	42.2%
Cap. factor c (Sim 2)	36.2%	41.0%	38.0%	-	42.8%	37.3%
Cap. factor c (Sim 3)	30.6%	36.6%	31.5%	-	38.5%	36.8%

Results:
Energy exchange in 2050

Today: Export: 59%, Import 41% in 2010[3]

2050: Export: 15%, Import 85%. (overall decrease of energy exchange)



Conclusions:

- Grid extension leads to residual load reduction within Europe,
- But for further reduction a temporal shift of energy is necessary.
- Grid extension has no strong effect on Storage units (with current capacity).
- Demand side management clearly competes with pumped hydro storages.
- Exchange Balance will change significantly from today.

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Thank you for your attention!!

Literature:

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[1] GP/EREC (2012): energy [r]evolution – A Sustainable EU 27 Energy Outlook

[2] Fh-ISI (2011): Tangible ways towards climate protection in the European Union (EU Long-term scenarios 2050)

[3.] Entso-E, “Statistical Yearbook 2010”, European Network of Transmission System Operators for Electricity Brussels, Belgium, 2011 (p.15)