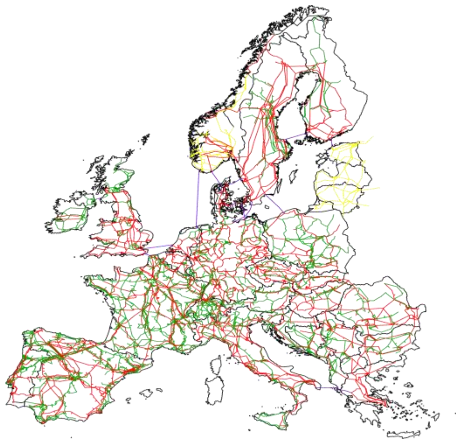
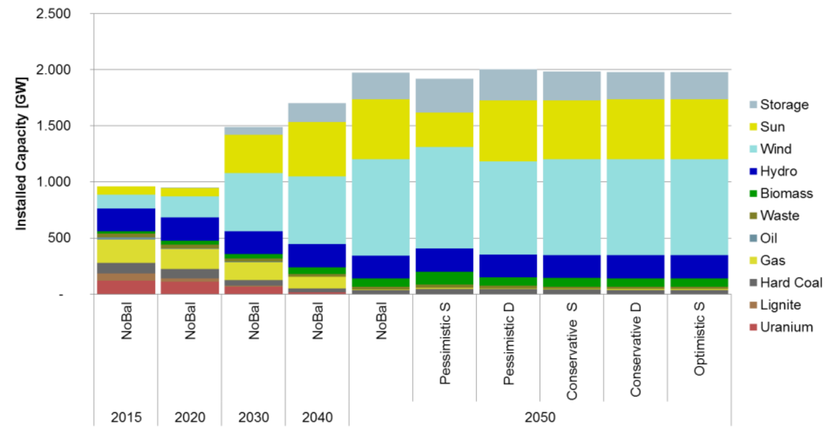
Strommarkttreffen - *Regelenergie*

02.09.2016, Berlin, Reiner Lemoine Institut





Influence of balancing reserves on the electricity infrastructure in Europe until 2050

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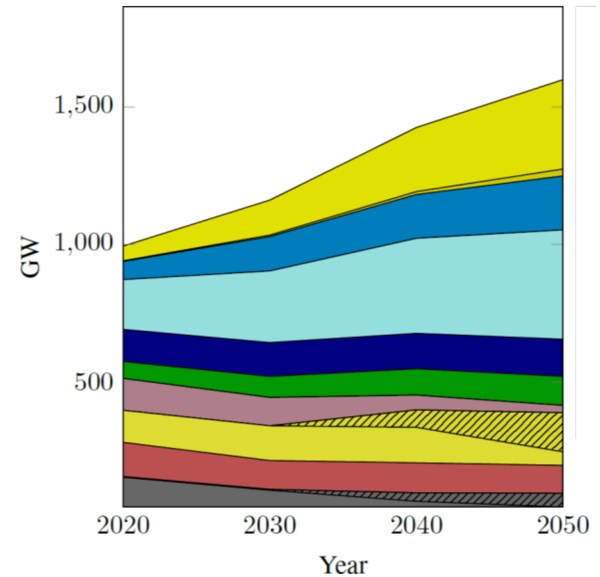
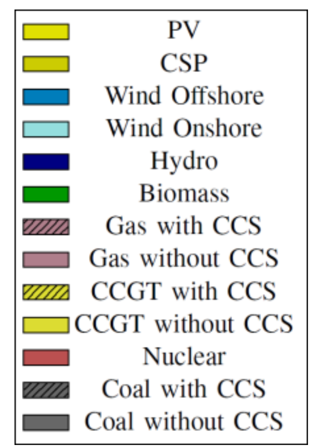
Agenda

1. **Introduction**
2. **Model**
3. **Application**
4. **Results**

Introduction

- **EU wide target of up to 80-95 % CO_2 emission reduction until 2050 that requires far-reaching transformation of the electricity generation infrastructure**
- **Possible pathways for the generation infrastructure have been subject of many analyses (PRIMES, LIMES, DIMENSION, etc.)**
- **Very few studies on the implications of balancing reserves**
  - Pineda et al., 2016; Stiphout et al., 2014
  - Predict a need for a large conventional base load





Source. Own depiction based on EC (2012): Roadmap 2050 - Diversified supply technologies

- **Very high shares of fluctuating RES will induce an increased demand for balancing reserves in the long term**
- **These reserves must be provided by either (non-)dispatchable generation technologies or storages that therefore have to reduce their possible production**
- **These interdependencies must be included when deciding upon the optimal level of fluctuating RES expansion**
- **Question: What are the influences of balancing reserves on the optimal electricity infrastructure investments?**

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Model: Dynelmod

Scope: Europe (EU 28)

Objective: System cost minimization

- Variable and fixed generation
- Investment into generation, storage and grid

Investments: ten-year steps

- 2015, 2020, 2030, 2040, 2050

Plant dispatch: hourly resolution

- Variable set of calculated hours (1-8760) for full investment options (including scaling)
- Post-Calculation with reduced investment options for 8760 hours

Boundary condition examples

- Decommissioning of existing plants
- Electricity demand development per country
- CO_2-Budget over time
- Market coupling method: NTC or Flow-Based

Model: Dynelmod

Balancing Demand:

- Historical demand for all countries as basis
- Additional demand for each additional MW of fluctuating RES

Balancing Reservation:

- Technology sharp reservation of capacities (no difference to block sharp if no integer constraints)
- Reduced production flexibility during reservation
  - Maximum production output
  - Minimum run constraints
  - Minimum storage level
- Reduction of transmission capacity for exchanges

Solution Method:

- Formulated in GAMS as a linear program
- Solved with GUROBI/BARRIER

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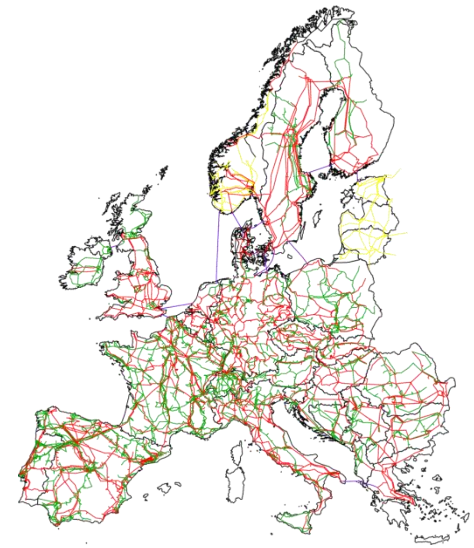
Application

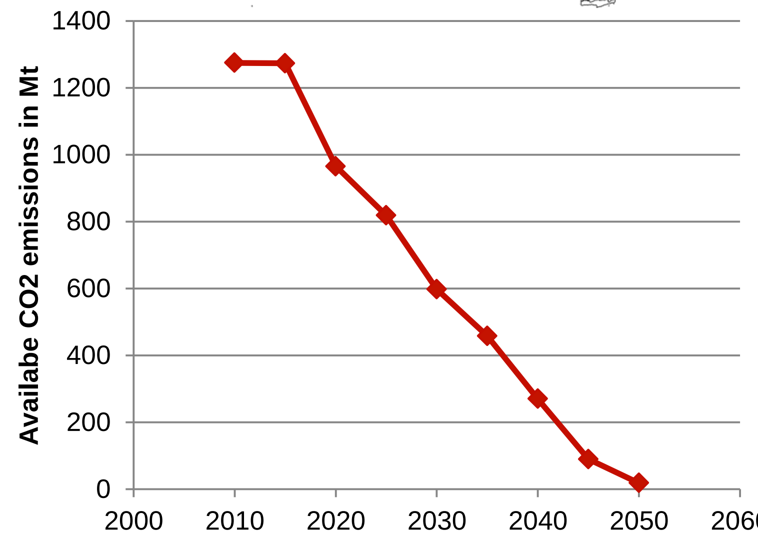
Application to a European Data Set:

- Originally plant-block and line-sharp data accuracy for all EU-28 countries, as well as Norway, Switzerland and the Balkan countries
- Hourly RES feed-in and load for 2012
- Investment cost based on Schröder et al. (2013), Pape et al. (2014) and Zerrahn and Schill (2015)



Aggregation to a country resolution

- One node per country
- Distances between geographical centers are used for transmission expansion cost calculation



Other boundary conditions regarding the long-term development of **prices, load,** and **CO_2 emission path** are based on **EC's "Energy Roadmap 2050 Impact Assessment and Scenario Analysis"** scenario **"Diversified supply technologies"**

Application 2

- **Technical and market developments are uncertain which influences the system costs of balancing provision**
- **Three scenarios summarize these possible developments :**

Scenario	*Pessimistic*	*Conservative*	*Optimistic*
Reserve dimensioning	**static/dynamic**	**static/dynamic**	**static/dynamic**
Additional demand from RES	10%	6%	3%
RES participation	5%	20%	50%
Balancing exchanges	5%	20%	50%
Storage commitment	24h	4h	1h
New exogenous nuclear plants	No	No	No

- **Each factor/assumption has a different impact**
- **The influence of each factor is therefore assessed against the *Pessimistic Scenario* in a further sensitivity analysis (not presented)**

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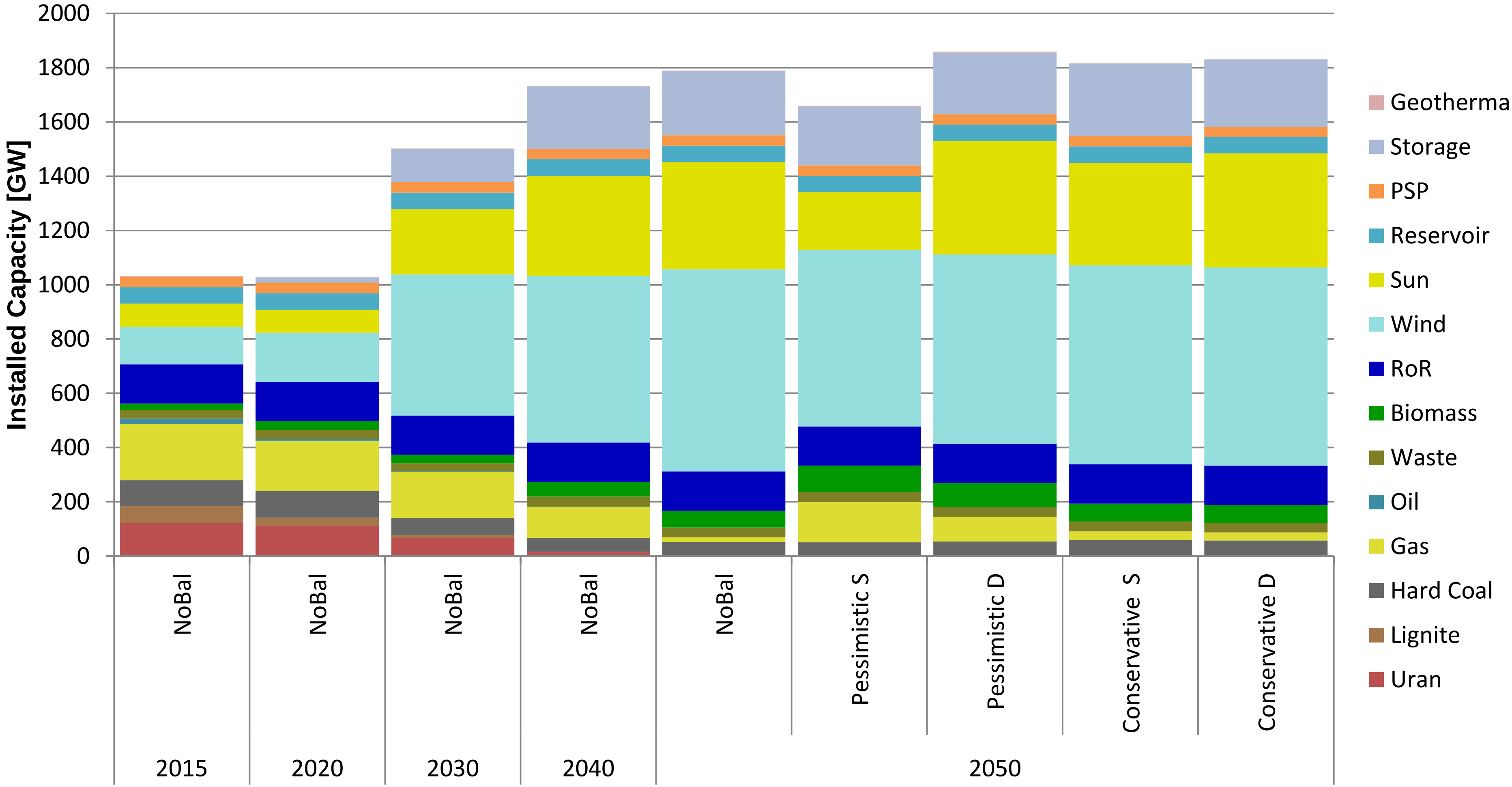
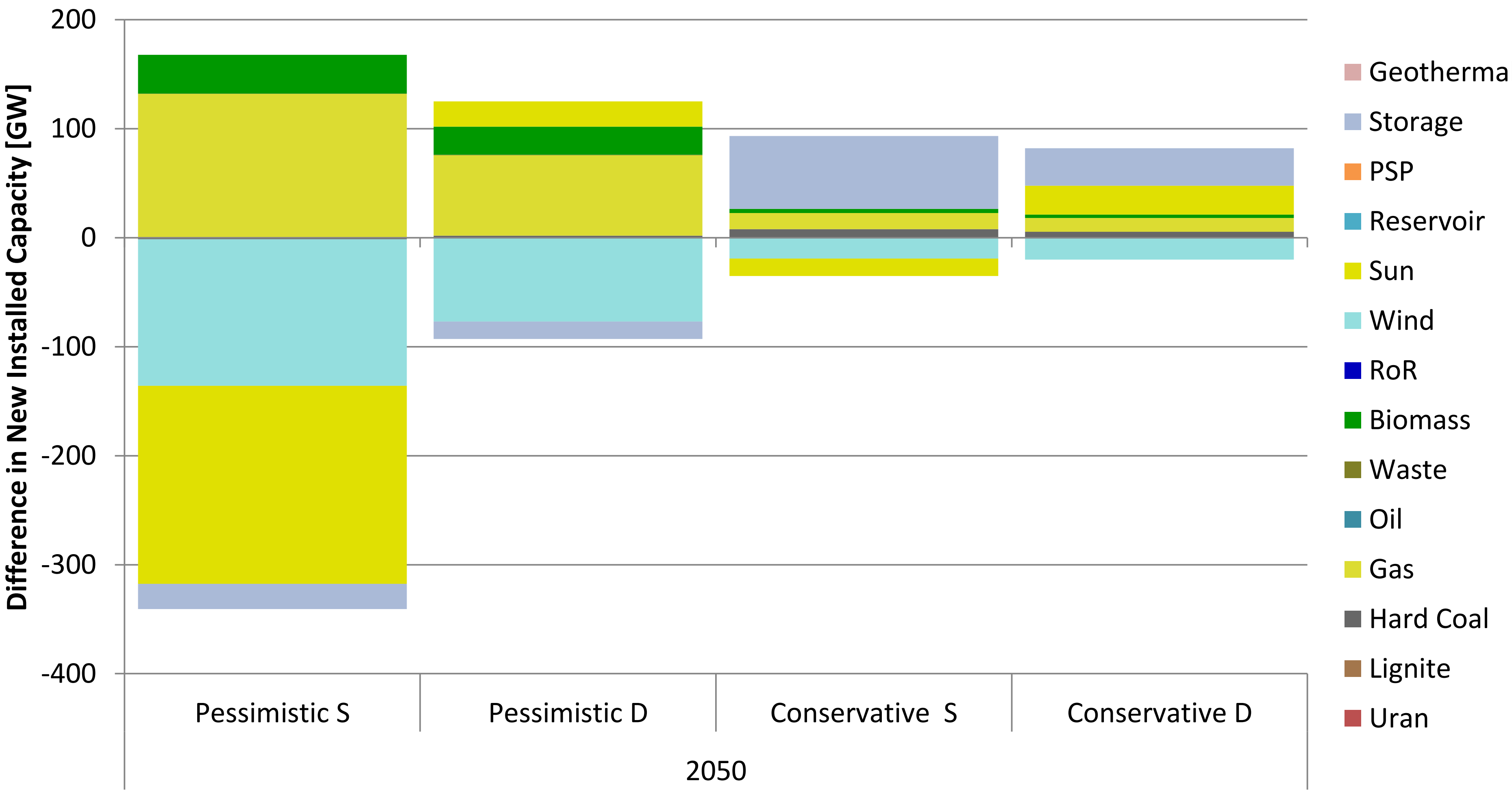
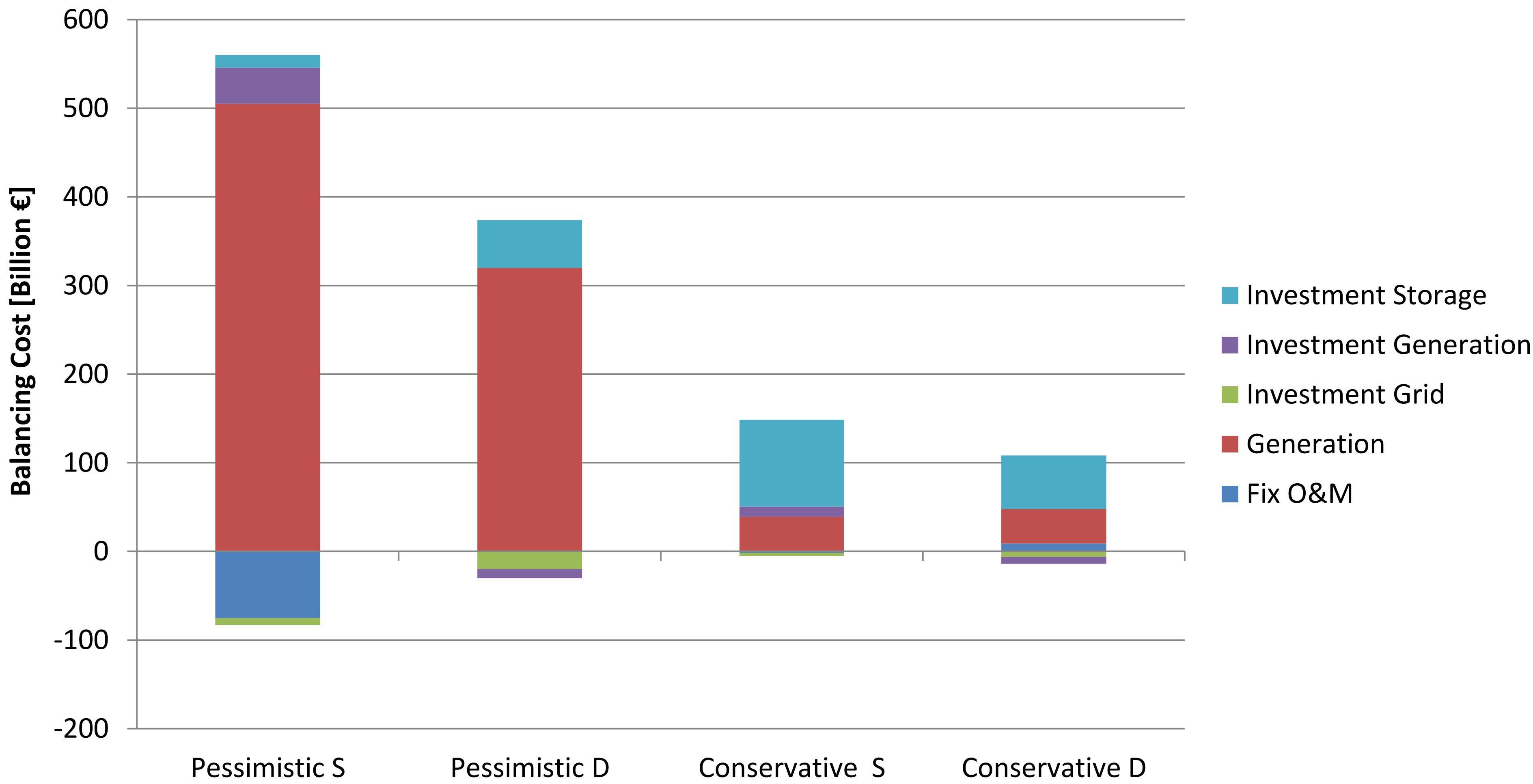
Results: Installed capacity



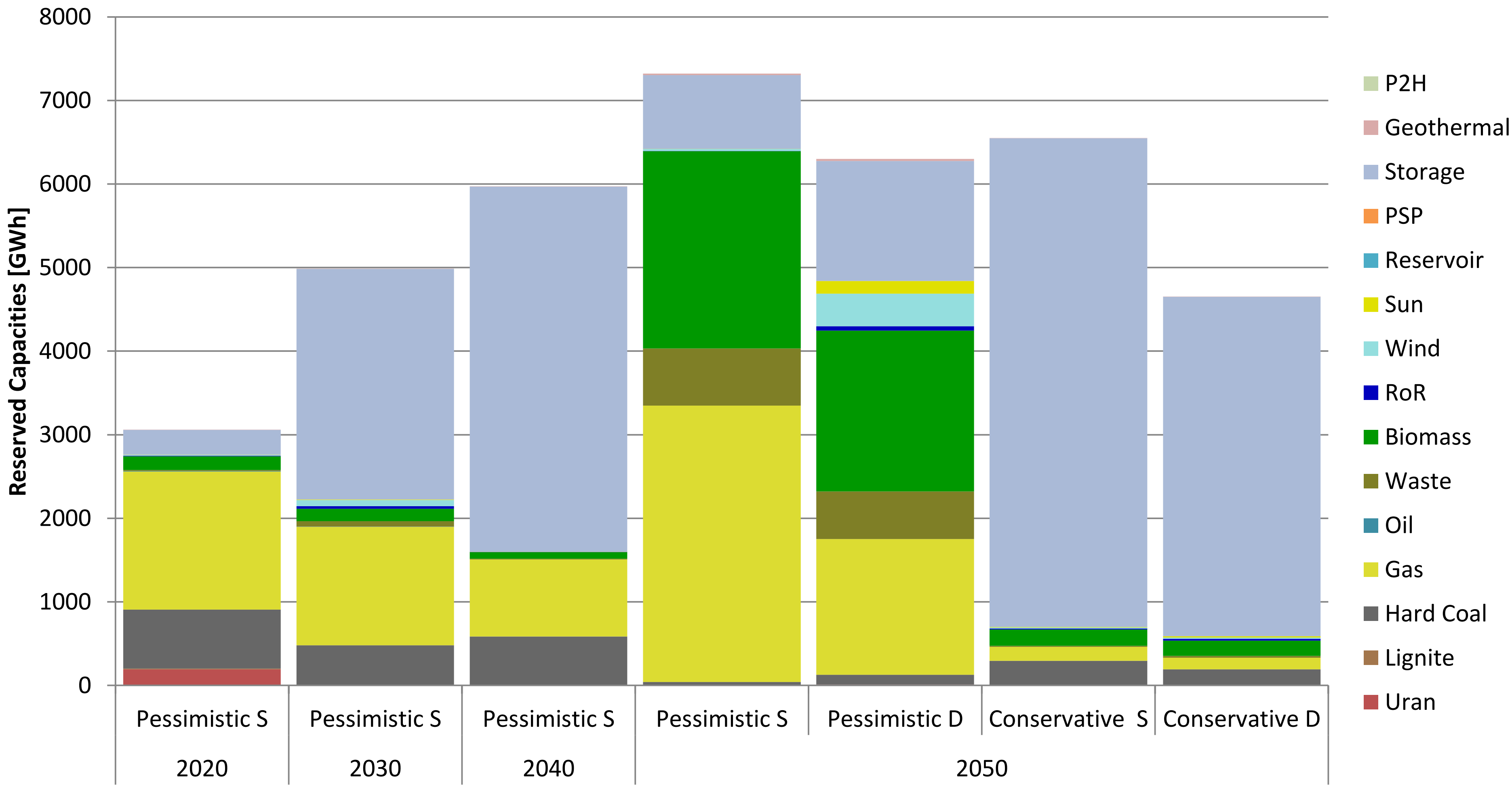
Results: Difference in New Installed Capacity



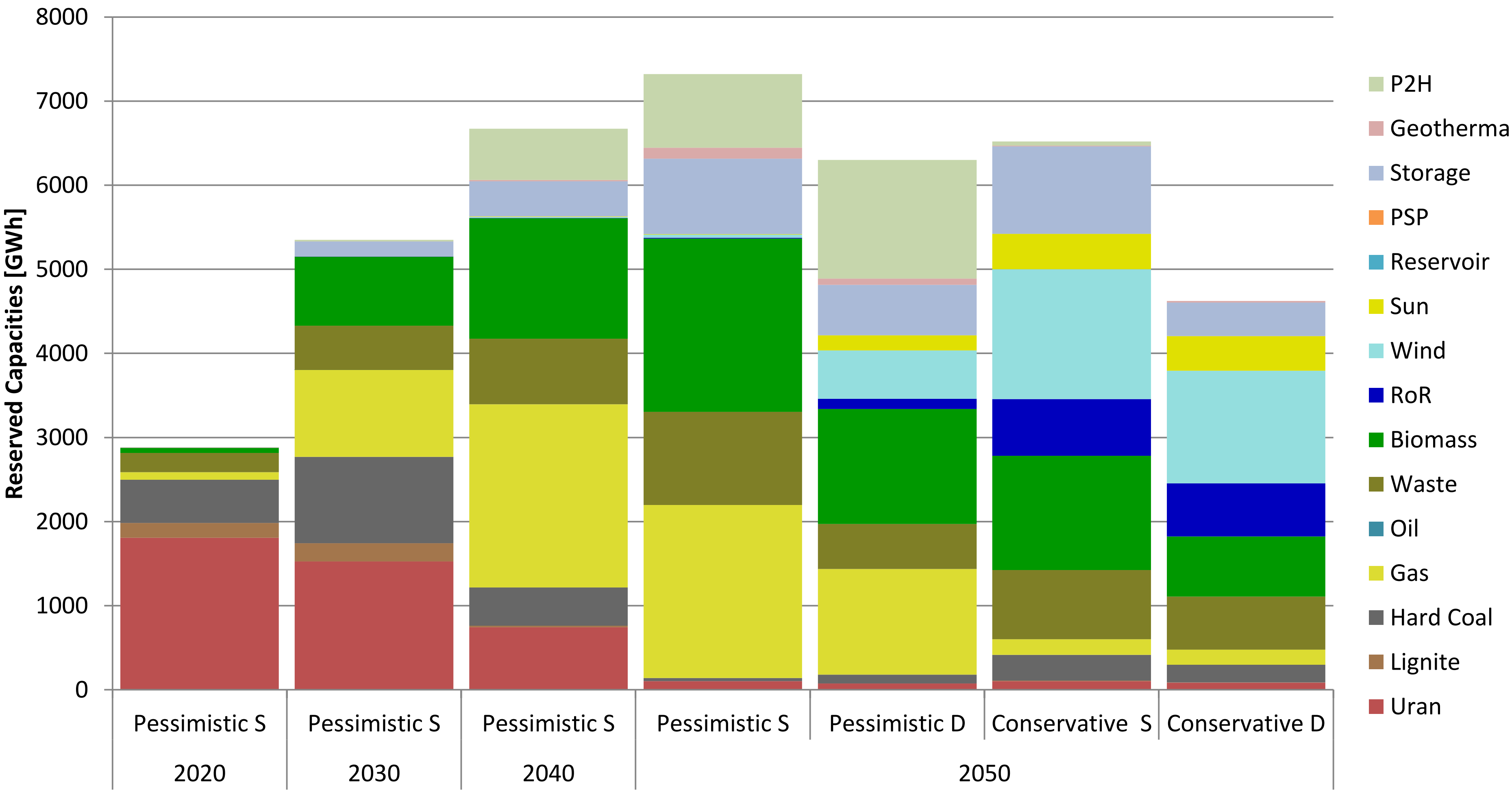
Results: Balancing Cost



Result: Positive Reserves



Result: Negative Reserves



Conclusion & Outlook

- Balancing reserves only have a large impact on the optimal long term electricity infrastructure when pessimistic assumptions regarding technology and market development are made

- The effect is already reduced with conservative assumptions regarding the provision of balancing reserves (underestimation due to aggregate model type)

- (Battery) Storage is playing a major role for future positive balancing reserves

- Dynamic reserve sizing can lower the cost and the influence of balancing reserves dramatically

- Determination of additional balancing demand from renewables is still too complicated in a long term model due to non-liniarities and therefore sensitives are a better option

- Reserve provision from transport and heat sector is still unclear

Questions for you!

- **How realistic is an 80 % share of storages for the provision of positive reserves?**
- **What is a realistic time horizon for storage capacity withholding for the provision of reserves?**
- **Is it realistic that those storages can recharge in that time period if the market is very short during long term shortage?**

- **Would the provision by reducing fluctuating RES be cheaper?**
  - Li-Ion: 35 € per kW and 188€ per kWh in 2050
  - PV: 230 € per kW and FLH 1752
  - For 1 kW of (positive) reserves we need four times storage capacity and five times PV capacity
  - Result: 787 € / kW for Li-Ion vs 1150 € / kW for PV
  - This neglects:
    - Positive side effects of storages
    - Non-spinning OCGT can not provide FCR and aFRR
    - No cost for reserve provision during curtailment of RES

Literature

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Thank You for Your Attention!

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