
# Integrating Energy Storage into the German Electricity Market


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## Introduction

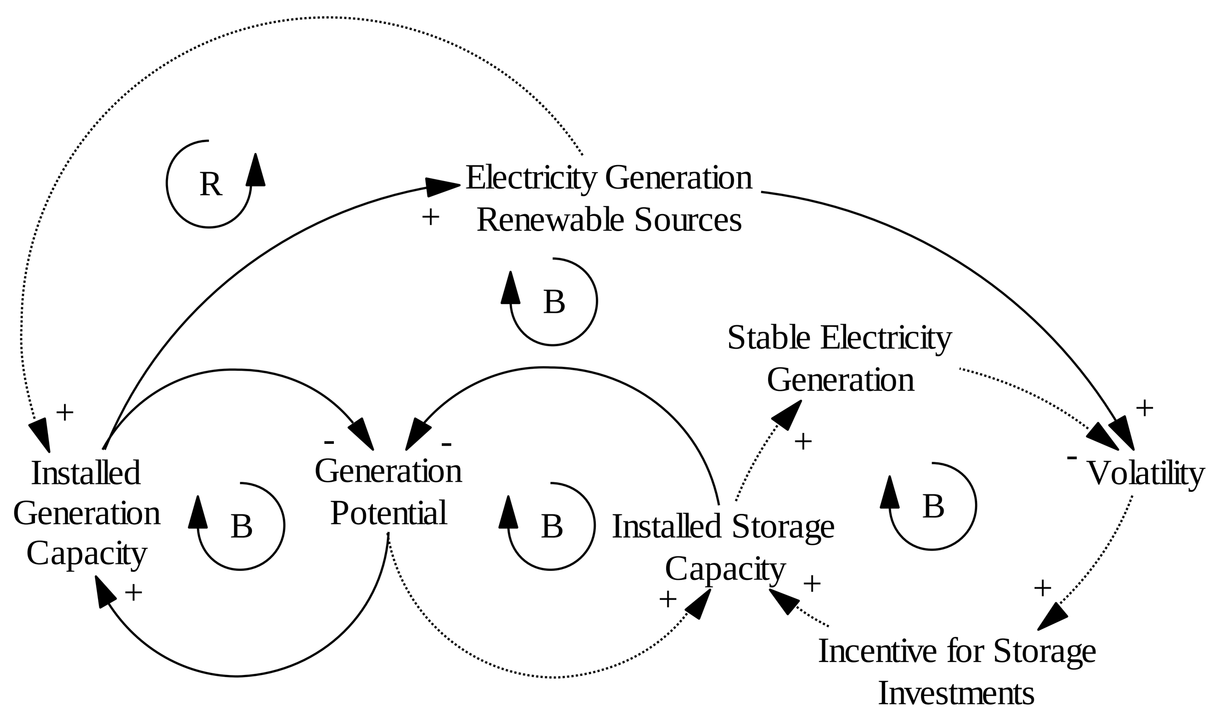
After fatal disaster of Fukushima in March 2011, the German government decided on the abandonment of nuclear power until 2019. This abandonment represents a huge challenge for the German energy policy taken into account that nuclear power was considered one of the foundations of stable and cheap energy production (Haunss et al. 2013). A consequence of the abandonment is the deconstruction of installed production capacity and an appropriate replacement. This replacement will most likely happen through investments in renewable energy technology due to the strong focus on renewable energy of the German government since at least 2000, when the Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG) was passed (Lipp 2007). Another indicator for the diffusion of renewable energies is the recent amendment of the EEG in 2014. It states that the renewable share of produced electricity should at least be increased to a level of 80% by 2050 (EEG 2014, §1 No. 3).

These changes in the German energy market represent a disruption of the incumbent structures and are likely to be related to high investments because of the locked-in infrastructures of incumbent technologies, longer delays because of changes in legislature due to new technologies and resistance by incumbent companies (Jacobsson und Johnson 2000). Further, the stronger focus of the energy policy on sustainability affects the security of supply and economic feasibility. Having a large share of renewable energy generation might bear some risks to economies. The oscillation resulting from the volatile energy generation challenges a stable and reliable energy supply which is crucial for an economy with its different industries and companies. Renewable energy cannot be dispatched from the grid. The power system therefore needs to balance generation excess supply and shortages. This challenge has led to an ongoing discussion about the security of supply in renewable energy generation scenarios. One of the insights from this discussion is that storage technologies play a key role regarding stable energy supply (e.g. Schill 2014).

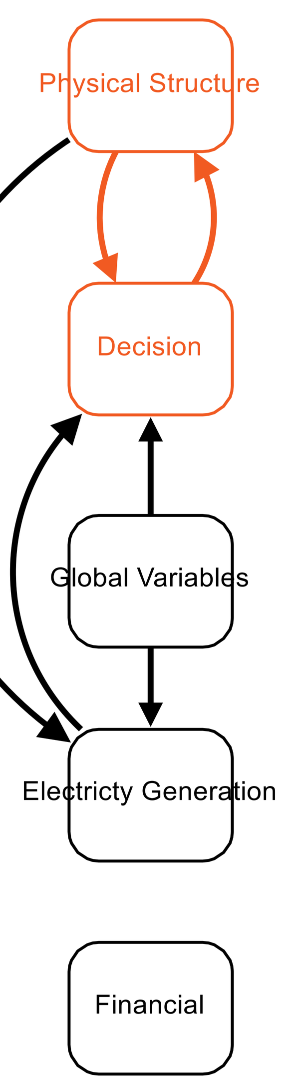
The paper has three goals:

- Understanding why the investments in energy storage technology is very low at that point
- Assessing the capabilities of energy storage technologies in the German electricity market.
- Identifying the key factors for the investment decisions into energy storage technologies.

## Hypothesis




## Sectors of the model




- Generation capacity & storage capacity
- Installed capacity, capacity under construction, capacity in approval process
- Planned shut downs of nuclear power plants

- Generation Potential, increased by planned shut downs and increasing expected demand
- Installed capacity, capacity under construction, capacity in approval process
- Planned shut downs of nuclear power plants
- Currently decisions based only on payback time

- Data is inconsistent
- Unit calculations needed
- Standard values, i.e. MW <> GW, Kelvin constant, hours per day etc.

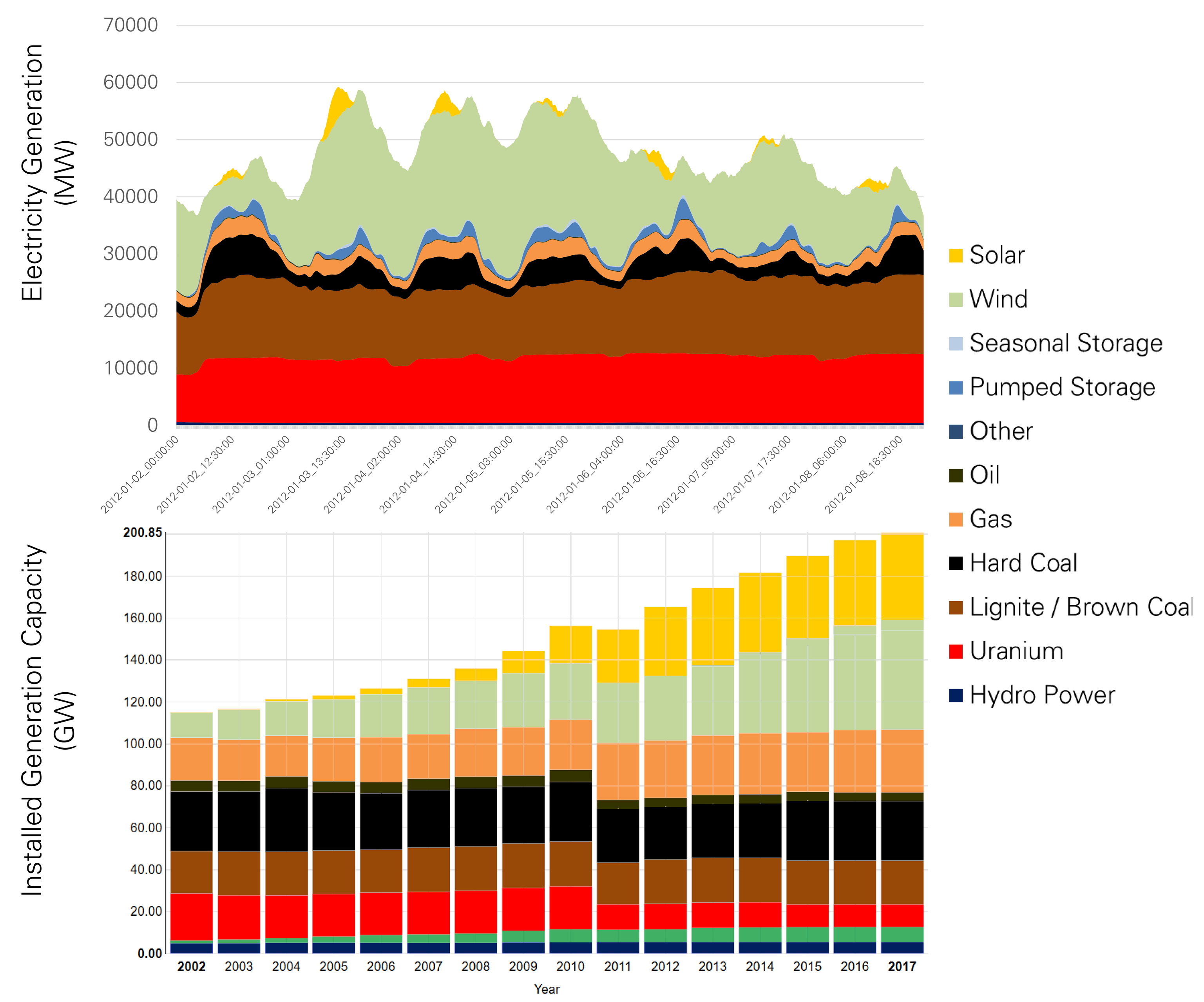
- Electricity generation by energy carrier, volatile generation based on real world data (solar, wind, flow)
- Base load coverage by inflexible energy carriers
- Priority of renewable energy before conventional
- Conventional energy by efficiency, capacity factor, demand coverage

- Currently under construction
- Price and price expectations
- NPV, IRR, payback period
- Investment cost

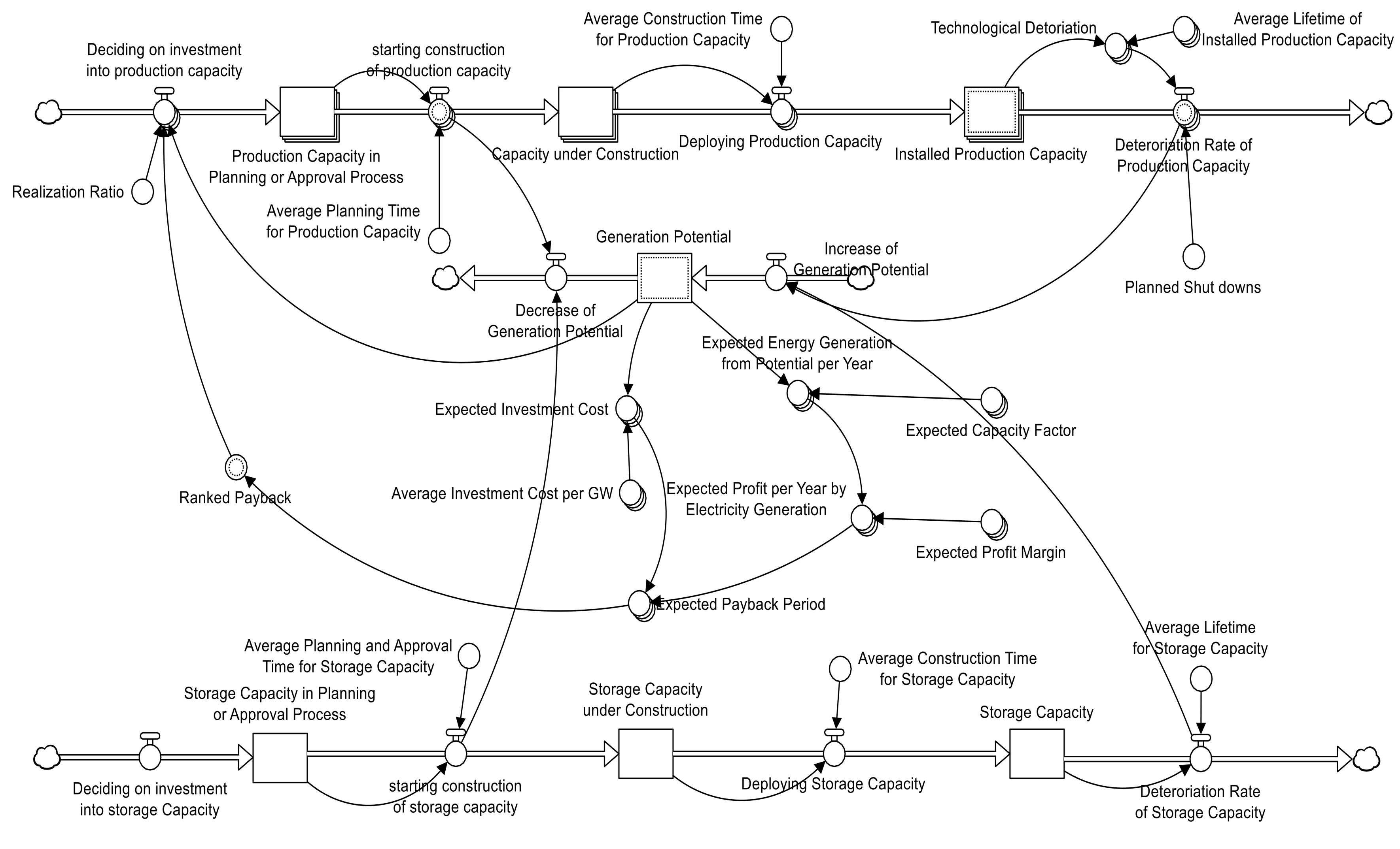
## Model Boundary Chart

| | Item | Reasoning |
|---|---|---|
| Endogenous | • Investment decision based on shut downs and expected demand<br>• Divide between investments in generation and storage capacity | • Germany has only little experience in investment into storage capacities (only pumped hydro and future investments unlikely), future investments likely to be in renewables and swing producers<br>• Investments in storage capacity cannibalizes generation capacity, focus on effect of storage onto electricity generation |
| Exogenous | • Prices<br>• Demand<br>• Weather condition (solar energy, wind speed, flow velocity of rivers) | • Different markets (intra-day, day-ahead, futures, derivatives), political and psychological effects not focused on<br>• Research and forecasts on demand can be used, focus on supply side<br>• Climate has huge delay times, forecasts and detailed data exists, focus only on German market, time horizon too small |
| Excluded | • Europe<br>• Vehicle market<br>• Energy efficiency<br>• Price elasticity of demand | • Countries have different focus (France: nuclear, Slovenia: geothermal)<br>• Vehicle market might have big impact but politically driven, buyer behavior too specific, is covered with demand as exogenous data<br>• Energy efficiency not in focus<br>• Prices for consumption quite stable, price and demand dynamics are complex topic on its own |

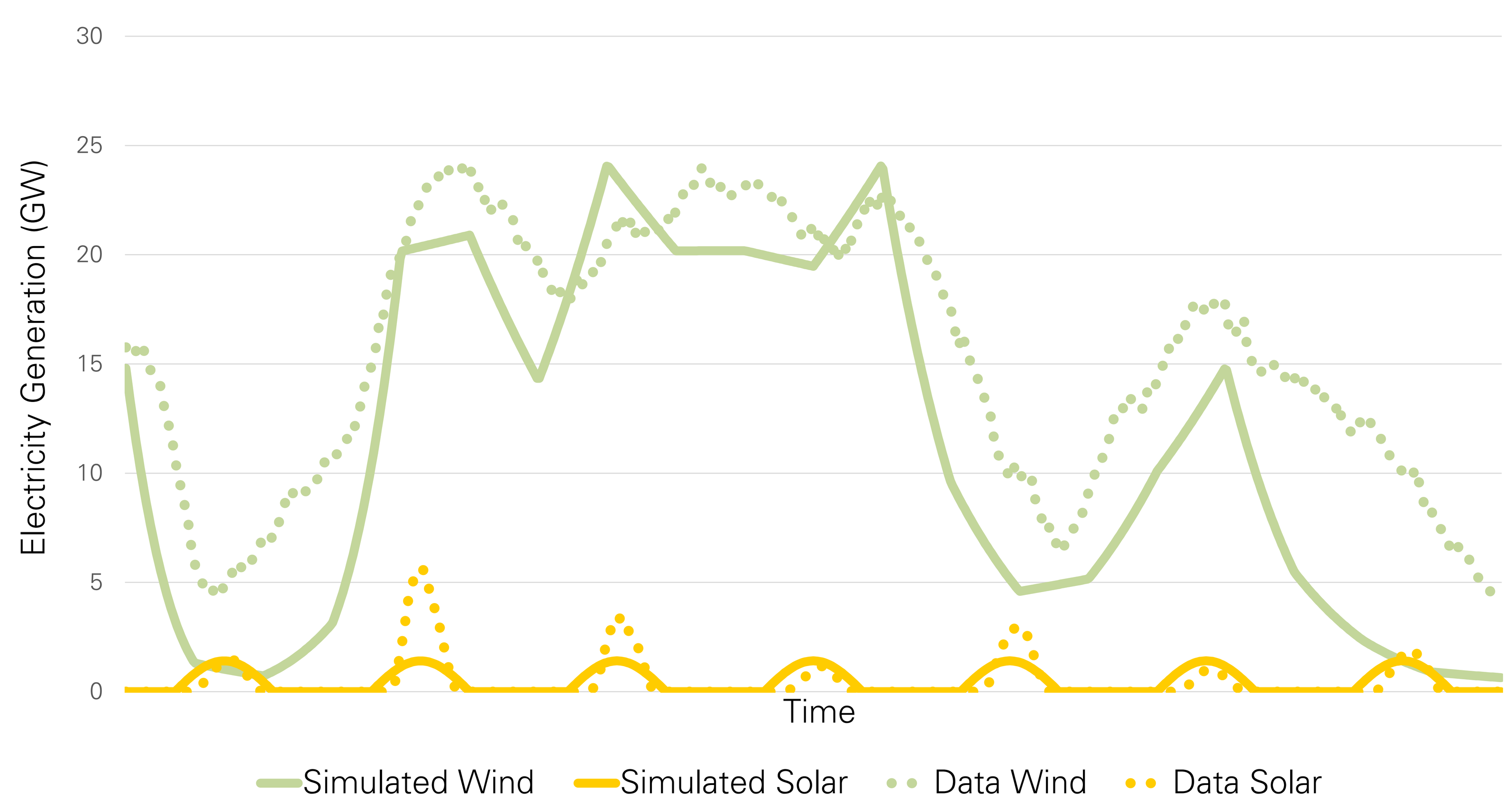
## Two reference modes




## Model




## Simulation

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