Economics of Energy Storage

The Role of Storage in Energy System Flexibility

Prof. Dr. Dominik Möst, Berlin, October 2014
Storage applications – its the competition what matters ...

- Energy arbitrage
- Ancillary services
- Avoidance of renewable curtailment
- Generation, transmission & distribution grid deferral
- End user application
  - Managing energy costs and RE-feed-in (also P2H)
- Emergency application
- Electric Mobility
Agenda for today …
How to determine the economic need of additional storage power plants?

1. From a system perspective
   • Which technologies are required in the future? (also depends on the assumptions made)
   • What need for energy storages, especially electricity storage exists?
     ⇒ Use of energy system models or bottom-up electricity market model!

2. From a market based view
   • Is the power plant economic at todays market prices?
   • What is my expectation about future market prices?
   • How will the market look like and where are which incentives?
     ⇒ Expectation about price developments and use a model optimizing the plant dispatch at exogenous prices!
Simple peak load model

But where can a storage plant be sorted in?

- Is a storage plant investment cheaper than a gas turbine?
  - No!
- Is a storage plant operation cheaper than a gas turbine?
  - Yes!

- Storage power plant makes arbitrage between low base-load and high peak load prices
- What will change in the future?
What is the residual load curve and how do renewable sources affect the residual load curve?

Residual load = Demand – Renewable feed-in
... has to be satisfied by flexible (in general conventional capacities)

How will residual load change in 2020 / 2030 due to RES-E?

- Peak: nearly no change
- Off-peak: increasing amount of hours with surplus energy
System perspective
Adaptation of „optimal“ capacity?

### Necessary generation portfolio – what will change?
- Reduction of base-load and mid-load
- Increase of peak-load
- Increase of storage power plants

### What to do with the surplus?
- **Store**
  - Decreases variable production costs (as surplus will probably be „cheap“)
- **Export**
- **Demand Side Management (Smart Market)**
- **Curtail surplus**
The integration of renewable energy sources (RES) significantly influences the residual load:

- Number of hours with negative residual load rises
- Surplus of RES feed-in increase
- Level of maximal negative residual load grows

What to do with the surplus?

- Store, export or curtail?
Electricity system model **ELTRAMOD** to analyse the interdependence between storage need, grid extension and renewable curtailment

### Model purpose
- Fundamental system analysis
- Integration of renewable energy sources (RES) in the European electricity market
- Flow calculation based on Net Transfer Capacity (NTC)
- Trade-off between grid and storage extensions
- Optimal dispatch of power plant capacity

### Main characteristics
- Bottom-up electricity market model
- Temporal resolution of 8760 hours
- Calculation of the cost-minimal generation dispatch and investments in additional transmission lines and storage facilities
- Country specific times series of wind and PV feed-in
Removing the feed-in obligation and its impact on grid and storage extension

- Also for keeping up obligation feed-in a RES surplus supply will occur
- The shifting to curtailment schemes has got a low impact no integrated RES generation
  => However: significant difference for grid and storage extensions settings

Central statement:
- From the economic point of view it is not optimal to integrate every available unit of RES.
- RES should be demanded for system stability and further market integration.
  => Mid term perspective: grid extension and stronger market integration, then storage…
Impact of RES-E share and CO₂-prices

Share of RES-E generation
- Mid-term (<40%): Nearly no change in storage demand
- Long-term (>60%): Increase of storage demand, but still moderate
- Long-long-term (>85-90%): Significant increase of storage demand!

Cost of CO₂
- Low CO₂-price (<15 €/t): Good for storage power plant (cheap base-load)
- High CO₂-prices (>40 €/t): Amount of storage at 50% RES-E at about todays storage level

=> Storage need is quite sensitive to RES-E share and CO₂ costs, but unfortunately in a contradictory way!
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### Central electricity storage options
- Arbitrage
  - Decreasing price differences (< 60 €/MWh)
- Ancillary services
  - Offer capacity

### Decentral storage options / End user applications
- Manage energy costs (= arbitrage)
- In Germany:
  Arbitrage possible between approx. 200 €/MWh and 300 €/MWh
  - Use for own consumption and save 30 Cent/kWh vs. feed-in (10 Cent/kWh) => 200 €/MWh
  - or even loose it => 300 €/MWh

### Decentral storage options have about 5 times higher incentives
- but strongly dependent on regulation (grid fees, feed-in tariff, market rules, …)
- Decentral option: strong drivers will lead to market uptake …
- Central option: how will energy prices differences develop?
Development of electricity prices and price gap between peak and off-peak prices

Price duration curve 2002-2009

- Durchschnittspreis 1000-teuersten h
- Durchschnittspreis 1300-günstigsten h
- Standardabweichung

Zeit [h]

Strompreise [€/MWh]

Durchschnittspreis
1000-teuersten h
Durchschnittspreis
1300-günstigsten h
Standardabweichung

[Graph showing the development of electricity prices and price gap between peak and off-peak prices from 2002 to 2009.]

TU Dresden, Chair of Energy Economics, Prof. Dr. Möst
System perspective
Adaptation of „optimal“ capacity?

Load duration curve
Higher amount of peaker, but up to now no price signal (=overcapacities)

Capacity phase-out

Surplus for free?

Costs
[€/MW]

P inst, 1
P inst, 2
P inst, 3

Time [h]

Technology 1
Technology 2
Technology 3

C_var1*t1
C_var2*t2
C_var3*t3

Cfix1
Cfix2
Cfix3

Cfix1

8760 h

Extension of renewables
• merit-order effect of renewables
  • Pressure on prices, but „correct“ price signal
  • market not in equilibrium state and overcapacities are not earning sufficient money

⇒ phase-out of base and mid load

⇒ Policy interventions and introduction of capacity markets?
Transition to renewables:
The merit-order effect of renewables (long-term effect)
(without introduction of capacity markets)

In a long-term view, the merit order effect of RES will change the price duration curve and with it the generation portfolio.
* Base-peak-spread will increase in the mid to long-term*
Conclusion

- Storage demand is in the short-/mid-term (often) overestimated, while effort for necessary grid extension is underestimated

- Storage demand depends on RES-E share, but also on other developments, such as CO$_2$-price (unfortunately in contradiction)

- In the long-term: storage demand will increase, especially with RES-E shares > 60%

- From load orientation towards RES-E orientation: market prices under pressure (and this will be the case in the next years)

- Role of Europe vs. national strategies?
»Wissen schafft Brücken.«