Business Cases für Speicher und regulatorische Hemmnisse

Dr. Rainer Saliger, Technology & Innovation, Energy Management Division
Siemens AG, Erlangen

June 08, 2015, Clearingstelle EEG, Berlin
Contribution of renewables to electricity supply in Germany

Gas- und Stromverbrauch 1. bis 3. Quartal 2014:

**Strom- und Gasverbrauch rückläufig**

Erdgasverbrauch sank um 18 Prozent / Erneuerbare Energien decken zu 28 Prozent den Stromverbrauch Deutschlands

Source: https://www.bdew.de/internet.nsf/id/20141023-pi-strom-und-gasverbrauch-ruecklaeufig-de
Ambitious German RE targets require highly flexible back-up systems

80% German electricity load coverage from Renewables
(Net Power Generation and load, red line, in GW)

10% German electricity load coverage from Renewables
(Net Power Generation and load, red line, in GW)
Role of energy storage for German Energiewende

Contribution of Renewables to electricity consumption of Germany

- Fill the gaps in residual load
- Deal with Renewable Excess electricity
- Increase Absorption capability of the grids

1. Storage not an issue
2. Increase Absorption capability of the grids
3. 3 phases of RE integration challenges where storage can help

Contribution of Renewables to electricity consumption of Germany

Source: Siemens AG

GW (Wind+Solar) ~3 x Peak load

GW (Wind+Solar) ~3 x Peak load
Uneven build out of renewables create integration challenges on a regional level

Wind power build-out mainly in the North

Solar power build-out mainly in the South

Ambitious renewable energy plans need additional flexibilities

Even with planned grid extensions Germany will not become a „copperplate“

Share of Renewable generation (energy yield)
In regions *

* Source: AGEE-Stat, LAK, extrapolated
Energy storage is one of 4 major flexibility options to cope with increased volatile renewable build out.

- **Energy storage**
  - e.g. Grid stability and system efficiency; time shift of "excess electricity"

- **Flexible and efficient power generation**
  - e.g. cost-efficient use of conventional power supply and backup capacity

- **Grid extension**

- **Demand Side Management / Automation Digitalization**
  - e.g. Flexibilise Demand with Smart tariffs

- **Cross-regional electricity transfer and integration of distributed generation**
Bottom up analysis of storage market - 
Storage used for very different purposes

Application

- **Energy reserve (D)**
  - Segmentation (use-cases)
  - Days Weeks

- **Time shift (C)**
  - Hours

- **Firming (B)**
  - Minutes

- **Power system stability (A)**
  - Seconds

**Days**

- **Con-/ Prosumer (4)**
  - 1 kW

- **Generation buffer (2)**
  - 100 kW

- **Decentralized fleet (2a)**
  - Volatile plants (PV / Wind On)
  - 1 MW

- **Volatile plants (2b)**
  - On-Grid + grid expansion deferral
  - 10 MW

- **Conventional power plants (2c)**
  - 100 MW

- **Central fleet (2d)**
  - Remote areas / off-grid
  - 1000 MW

**Hours**

- **Grid stability (3)**
  - 1 kW

- **Distribution grid (3a)**
  - 100 kW

- **Transmission grid (3b)**
  - 1 MW

**Minutes**

- **Residential/ commercial self supply**
- **Industrial peak shaving**

**Seconds**

- **Con-/ Prosumer (3)**
  - On-Grid + grid expansion deferral

- **Generation buffer (2)**
  - Remote areas / off-grid

- **Decentralized fleet (2a)**
  - Integration and grid services

- **Volatile plants (2b)**
  - Avoid curtailment

- **Conventional power plants (2c)**
  - Increase flexibility/ load optimization

- **Central fleet (2d)**
  - Energy arbitrage (Time Shift)

**Source:** Siemens AG
Different technologies available for various use-cases – not all developed to full maturity

1) Compressed Air Energy Storage
Source: Siemens
Electricity Storage attractive today in use-cases with high power prices or grid quality issues

Application

- **D** Energy reserve
- **C** Time shift
- **B** Firming
- **A** Power system stability

Storage Attractivity
- Tendency
- Potential

Electricity Reserve
- Electricity reserve
- Cover low wind or sun periods

Application

- **Decentralized fleet**
- **Power system stability**
- **Firming**
- **Time shift**

Electricity Reserve

- volatile plants (PV / Wind On)
- Conventional power plants
- central fleet
- Energy Arbitrage (Time Shift)

Energy Reserve

Cover low wind or sun periods

Tendency

Power

1 kW 100 kW 1 MW 10 MW 100 MW 1000 MW

Minutes

Hours

Days Weeks

1 2 3 4

Con-/Prosumer

Generation buffer

Grid

Transmission grid

Distribution grid

Remote areas and Off-Grid

On-Grid + grid expansion deferral

Industrial peak shifts

Ensure power system stability

Avoid Curtailment

Integration and grid services

Decreasing storage costs

Power system stability

Integration and grid services

Ensure power system stability

Avoid Curtailment

Time shift

Tendency

Power

1 kW 100 kW 1 MW 10 MW 100 MW 1000 MW

Minutes

Hours

Days Weeks

1 2 3 4

Con-/Prosumer

Generation buffer

Grid

Transmission grid

Distribution grid

Remote areas and Off-Grid

On-Grid + grid expansion deferral

Industrial peak shifts

Ensure power system stability

Avoid Curtailment

Integration and grid services

Decreasing storage costs

Power system stability

Integration and grid services

Ensure power system stability

Avoid Curtailment

Time shift

Tendency

Power

1 kW 100 kW 1 MW 10 MW 100 MW 1000 MW

Minutes

Hours

Days Weeks

1 2 3 4

Con-/Prosumer

Generation buffer

Grid

Transmission grid

Distribution grid

Remote areas and Off-Grid

On-Grid + grid expansion deferral

Industrial peak shifts

Ensure power system stability

Avoid Curtailment

Integration and grid services

Decreasing storage costs

Power system stability

Integration and grid services

Ensure power system stability

Avoid Curtailment

Time shift

Tendency

Power
Combination of various revenue streams are needed to make storage a viable business case – regulation may not hamper multiple use cases

Volatile Power Plants – Onshore Wind

Description and expected geographic focus
- Onshore wind-plants
- Main motivation:
  - Offer ancillary services (primary operating reserve)
  - Increase wind yield (e.g. ramp rate control)
  - Avoid/Reduce forecasting error and increase yield in direct marketing
  - Reduce curtailment losses

Typical installation (used for illustrative business case)
- Storage is co-located with 10 MW wind-park, 3000 full load hours.
- Storage: Li-Ion Battery System
- Power: 2 MW
- Capacity: 1 MWh

Main drivers of business case: assumptions
- Market value
  - Primary reserve 2014 | 2020: 3,000 | 2,500 €/MW/week
  - Bids accepted: 60% | 50%
  - 2% increased yield of wind turbines due to storage
  - Avoided balancing energy of 2€ | 3€/MWh (direct market.)
  - Curtailment losses 2% | 5%, 20% not compensated

Illustrative business case
- Typical installation (used for illustrative business case)
  - Storage is co-located with 10 MW wind-park, 3000 full load hours.
  - Storage: Li-Ion Battery System
  - Power: 2 MW
  - Capacity: 1 MWh

Market value
- Primary reserve 2014 | 2020: 3,000 | 2,500 €/MW/week
  - Bids accepted: 60% | 50%
  - 2% increased yield of wind turbines due to storage
  - Avoided balancing energy of 2€ | 3€/MWh (direct market.)
  - Curtailment losses 2% | 5%, 20% not compensated

Annualized costs and revenues (€ ’000)

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX</td>
<td>209</td>
<td>175</td>
</tr>
<tr>
<td>OPEX</td>
<td>28</td>
<td>48</td>
</tr>
<tr>
<td>Costs</td>
<td>28</td>
<td>45</td>
</tr>
<tr>
<td>Revenues</td>
<td>134</td>
<td>162</td>
</tr>
<tr>
<td>Costs</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Revenues</td>
<td>94</td>
<td>65</td>
</tr>
</tbody>
</table>

Volatile Power Plants – Onshore Wind

Typical installation (used for illustrative business case)
- Storage is co-located with 10 MW wind-park, 3000 full load hours.
- Storage: Li-Ion Battery System
- Power: 2 MW
- Capacity: 1 MWh

Main drivers of business case: assumptions
- Market value
  - Primary reserve 2014 | 2020: 3,000 | 2,500 €/MW/week
  - Bids accepted: 60% | 50%
  - 2% increased yield of wind turbines due to storage
  - Avoided balancing energy of 2€ | 3€/MWh (direct market.)
  - Curtailment losses 2% | 5%, 20% not compensated

Illustrative business case
- Typical installation (used for illustrative business case)
  - Storage is co-located with 10 MW wind-park, 3000 full load hours.
  - Storage: Li-Ion Battery System
  - Power: 2 MW
  - Capacity: 1 MWh

Market value
- Primary reserve 2014 | 2020: 3,000 | 2,500 €/MW/week
  - Bids accepted: 60% | 50%
  - 2% increased yield of wind turbines due to storage
  - Avoided balancing energy of 2€ | 3€/MWh (direct market.)
  - Curtailment losses 2% | 5%, 20% not compensated

Annualized costs and revenues (€ ’000)

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPEX</td>
<td>209</td>
<td>175</td>
</tr>
<tr>
<td>OPEX</td>
<td>28</td>
<td>48</td>
</tr>
<tr>
<td>Costs</td>
<td>28</td>
<td>45</td>
</tr>
<tr>
<td>Revenues</td>
<td>134</td>
<td>162</td>
</tr>
<tr>
<td>Costs</td>
<td>24</td>
<td>48</td>
</tr>
<tr>
<td>Revenues</td>
<td>94</td>
<td>65</td>
</tr>
</tbody>
</table>
## Key regulatory topics in relation to storage

<table>
<thead>
<tr>
<th>Regulatory topic</th>
<th>Impact on storage business case</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Definition of Storage → Is it generator or consumer</td>
<td>- Impact on grid fees to be paid by storage</td>
</tr>
<tr>
<td>- Who is allowed to own / operate storage systems?</td>
<td>- Could DSOs/TSOs make use of benefit in combination with other market based benefits?</td>
</tr>
<tr>
<td>- Is storage acknowledged as an asset of the grid?</td>
<td>- Could be substitute to traditional grid enforcement if guaranteed ROI is give in regulated market</td>
</tr>
</tbody>
</table>
| - Storage Subsidies / Surcharges for self consumed electricity  
- Participation of behind the meter storage systems in energy markets | - Effects business case for behind the meter storage  
- Allows combination of use cases                                                                                                                                                                                                   |
| - Qualification conditions for balancing markets  
- Are system services (e.g. speed and accuracy of system reaction) valued by market design? | - In a system consisting up to 100% of inverter connected generation system dynamics change, there is currently no market mechanism in D                                                                                                                                 |
| - Smoothing / Balancing Requirements for PV and Wind farms and Grid codes | - Encourages RE operators to contribute to power system stability                                                                                                                                                              |
By comparing Top down storage demand with Bottom Up Business case analysis need for regulatory action can be derived

1. Top-Down Demand side approach: based upon mismatch between volatile supply and demand

   - Load in hourly values (GW)
   - Wind / PV generation (GW) for xx% RE share
   - Must run conventional PP (GW)
   - Non fluctuating renewables (GW)
   - Pumped Hydro storage
   - Export
   - RE excess Energy (GW)
   - Residual load (GW)

   If > 0
   - Demand for Storage in GW/GWh for xx% RE share

   If < 0

   no relation to economics

2. Bottom-up Market approach: based upon profitable business cases

   - Storage use cases
     - a
     - b
     - c
     - ...
   - Is storage profitable in use cases a, b, ... and in country xyz?

   What is the adaption rate of profitable use case for various countries (%)

   Annual market for storage (GW/a)

   Cumulative installations in GW/GWh in year xyz

   no relation to share of renewables

   In case of large mismatch need for regulatory action!
Vielen Dank!