STEAG Large Scale Battery System - 90 MW Experience and Learnings
Steag GmbH: Portfolio overview

- Steag GmbH is fully owned by a consortium of German municipalities
- 80 Years *young* company based in Essen
- Fossil power: 12 coal-fired and 1 refinery power plants
- Renewable & distributed generating units: more than 200
- References from projects in more than 60 countries

**Key Figures for FY 2015**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Germany</th>
<th>Outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>~ 6,000</td>
<td>3900</td>
<td>2100</td>
</tr>
<tr>
<td>Sales</td>
<td>€ 3.6 billion</td>
<td></td>
<td></td>
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<tr>
<td>EBITDA</td>
<td>€ 400 million</td>
<td></td>
<td></td>
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<tr>
<td>Capital expenditure</td>
<td>€ 220 million</td>
<td></td>
<td></td>
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<tr>
<td>Installed Capacity</td>
<td>10,200 MW</td>
<td>8200 MW</td>
<td>2000 MW</td>
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</table>
Steag GmbH – Milestones in Power plant development

1937
Foundation of Steag

1996
Leuna (Germany)
162 MW Refinery

1998
Illmenau (Germany)
5 MW Refinery (1)

2000
Köln-Godorf (Germany)
211 MW Refinery

2002
Karlstädt (Germany)
1 MW Biogas (1)

2006
Ridham Dock (UK)
25 MW Biomass

2009
Leuna (Germany)
1,320 MW
Hard coal

2010
1999
Termopaipa (Colombia)
165 MW
Hard coal

2003
Iskenderum (Turkey)
1,320 MW
Hard coal

2006
Mindanao (Philippines)
232 MW
Hard coal

2012
Walsum 10 (Germany)
790 MW
Hard coal

1999
2003
2006
2009
2013

about 8,000 MW commissioned in the Rhine-Ruhr and Saar regions
STEAG holds a strong position in the renewable energy market

- **Sites of Steag New Energies GmbH**
- **Subsidiaries**

### Steag Projects

#### Wind
- 306 MW total in Germany, Romania, France and Turkey

#### Solar
- 50 MW CSP plant at Arenales, Spain
- Two pilot plants in India

### Installed capacity

<table>
<thead>
<tr>
<th>Plants</th>
<th>Total Capacity</th>
</tr>
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<tbody>
<tr>
<td>223</td>
<td>1,271 MW el</td>
</tr>
<tr>
<td>100</td>
<td>905 MW th</td>
</tr>
</tbody>
</table>

#### Biomass
- since 2002
- #3 in Germany

<table>
<thead>
<tr>
<th>Installed capacity</th>
<th>Plants</th>
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<tbody>
<tr>
<td>MW_el</td>
<td>MW_th</td>
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<tr>
<td>66</td>
<td>154</td>
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</table>

#### Biogas
- since 2007
- First own biogas plant commissioned

<table>
<thead>
<tr>
<th>Installed capacity</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW_el</td>
<td>MW_th</td>
</tr>
<tr>
<td>177</td>
<td>139</td>
</tr>
</tbody>
</table>

#### Mine gas
- since 1908
- #1 in Germany

<table>
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<th>Installed capacity</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>108</td>
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</table>

#### Geothermal
- since 1994
- #1 in Germany

<table>
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<th>Installed capacity</th>
<th>Plants</th>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>100</td>
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</tbody>
</table>

#### Contracting
- since 1961
- #2 in Germany

<table>
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<th>Installed capacity</th>
<th>Plants</th>
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</thead>
<tbody>
<tr>
<td>77</td>
<td>905</td>
</tr>
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</table>
Need for alternate systems for Primary Frequency Control

- The share of energy from renewable sources in Germany is likely to increase from current ~30% to 55 - 60 percent by the year 2035.

- This increases fluctuations in the grid – since the production of solar or wind power is uneven and cannot be precisely forecast.

- Such fluctuations have to be compensated for immediately, so a system is required which automatically responds to the frequency change.

- Such a system is often referred to as Primary Frequency Control.

- Primary frequency control power has up to now been predominantly supplied by conventional power plants.

- Photovoltaic systems and wind turbines are unable to do so since no spare capacity is there.

- Since the share of conventional energy is reducing, there is a need to look for alternate systems to provide Primary Frequency Control power.
For providing primary control power, the conventional plants have to generate a certain minimum load at all times, and burn coal, oil or gas.

In the case of large-scale batteries, this is not necessary.

The batteries are able to store electricity from the grid or feed electricity into the grid in a matter of seconds, compensating for the fluctuations.
STEAG secures the energy transition by an investment of 100 million Euros in 6 X 15 MW large-scale battery systems.
Sites of installation

Walsum

Lünen

Fenne

Herne

Weiher

Bexbach
Key facts regarding each installation

• 15 MW installed power for primary frequency control

• 10 battery storage units each in a container including:
  • Auxiliary units such as heating, air conditioning, on-site power and 400V AC auxiliary supply
  • 4-Quadrant-Power Converters with network filter (Bi-directional AC/DC power converting system)

• 1 container housing the electronic control unit with superior control & communication technology for
  • Operation and monitoring
  • Protection and control

• Hierarchic protection and surveillance system

• Connection to grid at 10kV

• Capacity to provide primary frequency control reserve for 30 minutes according to the requirements of the TSO
Key facts regarding each installation
Views from different sites
Views from different sites
Battery systems are a fundamental element of the energy transition, as a safeguard for system stability and security. They are able to contribute to the various system services like:

• Maintenance of frequency stability
• Maintenance of voltage to ensure that the stability and the nominal system voltage do not exceed defined limit values by supplying reactive power and short-circuit power as necessary.
• In the event of a large-scale power failure, batteries can help to build up and control an electrical grid and based on this grid you can start a gasturbine etc. Black start capability.
• At present, only the supply of control power for frequency stability is put out to tender
Allowable frequency band is 50 Hz ± 200 mHz. In case of deviation, the Primary, Secondary and the Tertiary control power is deployed one after the other to stabilize the system.

Primary control power is activated fully automatically, triggered by the deviation of the actual frequency from the nominal frequency.

In the interconnected control zones of the European grid, primary control power is deployed as per their respective shares of electricity production.

The secondary control power replaces the primary after 5 minutes (if required) to preserve the primary capacity for new frequency upsets.

The secondary control power is supplied by Pumped storage units, Large gas and coal plants, Biogas, Biomass etc.

To ensure that the secondary control range and power is kept available, it is replaced by minute reserve power if the frequency deviation persists.

Minute reserve (tertiary control) power is a scheduled product that is manually or automatically requested by the TSO and is fully activated within 15 minutes from the moment the request was issued.
The market exists since 2001. Internet platform (www.regelleistung.net) exists since ~2007 for the three different types of control energy.

Since 2012 Germany’s neighboring countries have (partly) joined the platform.

Currently ~ ±1300 MW (primary control power) is tendered for coupled markets of Germany, France, Austria, Switzerland, Belgium and the Netherlands. Denmark is due to join in the near future.

Performance period - Monday 0:00 hrs to Sunday 23:59 hrs

The capacity must be available for 15 (conventional plants) and 30 (battery system) minutes on either side

The minimum lot size is ±1 MW, and a 100 % availability must be ensured.

TSOs sort the bids in ascending order and award the contracts until the demand is covered.

This is remunerated by payment of a capacity price and the energy actually flowing in and out of the battery system is not paid separately.
Simulations of the operation of battery systems during past major disturbances in the European interconnected grid show that the primary control power for at least 30 minutes would have been necessary for system stability.

This figure is to be discovered for India.