Provision of District Heating by Energie Baden-Württemberg (EnBW) - State of Green & DBDH Tour
EnBW T-BDF
Dr. Andreas Arlt
19. November 2014
Portrait of EnBW
One of the largest energy companies in Germany and Europe

Business segments:
Sales, Grids, Renewable Energies, Generation and Trading

Annual revenue 2013: more than €20 billion
Customers: some 5.5 million
Employees: some 20,000
Shareholder structure
as of 31 December 2013\textsuperscript{1}

<table>
<thead>
<tr>
<th>Shareholder</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEW Energie-Beteiligungs GmbH</td>
<td>46.75%</td>
</tr>
<tr>
<td>NECKARPRI-Beteiligungsgesellschaft mbH\textsuperscript{*}</td>
<td>46.75%</td>
</tr>
<tr>
<td>Badische Energieaktionärs-Vereinigung</td>
<td>2.45%</td>
</tr>
<tr>
<td>Gemeindeelektrizitätsverband Schwarzwald-Donau</td>
<td>0.87%</td>
</tr>
<tr>
<td>Landeselektrizitätsverband Württemberg</td>
<td>0.11%</td>
</tr>
<tr>
<td>Neckar-Elektrizitätsverband</td>
<td>0.63%</td>
</tr>
<tr>
<td>Free float</td>
<td>0.37%</td>
</tr>
<tr>
<td>EnBW</td>
<td>2.08%</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Difference to 100% in case of figures restated.
### Breakdown of the EnBW Group’s generation portfolio and electrical output in MW

<table>
<thead>
<tr>
<th>EnBW Group(^1)</th>
<th>Electrical output(^2) in MW (as of 31/12)</th>
<th>2013</th>
<th>2012(^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable energies</td>
<td></td>
<td>2,642</td>
<td>2,527</td>
</tr>
<tr>
<td>Thermal power plants(^3)</td>
<td></td>
<td>11,160</td>
<td>10,873</td>
</tr>
<tr>
<td><strong>Installed capacity of EnBW Group (without standby reserve)</strong></td>
<td></td>
<td>13,802</td>
<td>13,400</td>
</tr>
</tbody>
</table>

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1. Generation portfolio includes long-term procurement agreements and generation from partly owned power stations.
2. Capacity values irrespective of marketing channel, for storage: generation capacity
3. Including pumped storage power stations that do not use the natural flow of water.
The German Energiewende will lead to a structural shift in the sources of income along the value chain.

### Generation & trading
- Operating times and margins for conventional power plants falling sharply
- Simultaneously: Power plants indispensable from the perspective of security of supply
- Exit from nuclear energy

### Renewable energies
- Continued significant expansion with lower specific costs
- Trend towards own generation ("energy autonomy")
- Technological leaps; first solutions combining storage

### Grids
- Critical element for system stability of the Energiewende
- Significant investment in expansion of the transmission grid
- Expansion of intelligent distribution grid

### Sales
- Development of pure commodity business (electricity/gas) through to services & solutions related to the subject of energy

**Growth areas:**
- Smart worlds of energy
- Local generation
- Energy efficiency
- E-mobility

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"energy autonomy"
## EnBW 2020 Strategy

### Sustainable
- Key player in the German “Energiewende”
- Creation of future energy systems
- Sustainable, safe energy supply
- CO₂ efficient energy generation
- Energy efficiency

### Robust
- Fully integrated provider in Germany across whole value chain
- High proportion of regulated business (grids, renewables)
- System competence for energy (holistic)
- Highest level of efficiency and op. Excellence
- Stable shareholder structure

### Customer proximity
- “Customer proximity” (understanding, orientation, solutions)
- Energy-related services and products
- Actively committed to customers & partners,
  Offers for project participation
- Innovation capability and management
- Strong market portfolio

### Regional positioned
- Quality and ingenuity from Baden-Württemberg
- Part of the regional network BW – citizens, companies, local authorities, politics
- Focus on dialogue, participation and partnerships
- Outside of the BW region in DE, AT, CH and Turkey
2014 will be a year of implementation

**Engine room of the Energiewende**

**Offshore wind power**
- Commissioning of first plant: EnBW Baltic 2

**Onshore wind power**
- Doubling project pipeline to 1,000 MW
- Doubling wind farms in operation to 360 MW
- Expansion of wind farm business in Turkey

**Conventional power generation**
- Full commissioning of RDK 8 (CHP-Plant)

**Transmission grid**
- Preparation of Südlink project by grid subsidiary TransnetBW
2014 will be a year of implementation

**Customer proximity**

*Private and industrial customers*
- Smart home platform: broad-based market launch
- E-mobility: Expansion to 1,000 charging points
- Expansion of energy contracting business

*Local authorities*
- Further expansion of local authority partnerships
- Regional expansion of broadband technology

**Innovation**
- Systematisation of innovation management
- Foundation of the Innovation Campus
Our locations in Baden-Württemberg and Germany

- Onshore and offshore wind farm
- Offshore wind farm at planning or construction stage
- Photovoltaic power plant
- Conventional power plant with EnBW participation, purchase and supply contracts
- Nuclear power plants
- Hydro-electric power plant
- Hydro-electric power plant with EnBW participation, purchase and supply contracts
- Biomass plant

1 Operations were shut down on 11 May 2005 in line with the consensus on nuclear power.
Business Radius outside Baden-Württemberg

1 Direct and indirect shares
2 Assigning of the participating interests to EnBW’s own Contractual Trust Arrangement (CTA) at the end of the financial year 2013
District Heating Provision of EnBW
District Heating at EnBW | Plant Sites

EnBW is one of the leading district heating companies in Germany (about 4 TWh heat production in 2013)

**HEILBRONN**

Integrated District Heating System

Production: 526 GWh
Thermal Power: 550 MW

**KARLSRUHE**

Piping System owner: Stadtwerke Karlsruhe

Production: 466 GWh
Thermal Power: 220 MW

**ULM**

Integrated District Heating System

Production: 543 GWh
Thermal Power: 442 MW

**ROSTOCK**

Piping System owner: Stadtwerke Rostock

Production: 403 GWh
Thermal Power: 300 MW

**STUTTGART**

Integrated District Heating System

Production: 1.835 GWh
Thermal Power: 966 MW

1) Production and Power 100%, EnBW share: 50%

All Information from Annual Balance Sheet 2013
EnBW Business Segment District Heating

**Heat Purchase from power-controlled plants depends on electricity market**

Complete District Heating Supply with Heat Production, Piping Network and Customers

**EnBW Business Segment District Heating**

**City Implication**

<table>
<thead>
<tr>
<th>City</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heilbronn</td>
<td>Responsibility: Whole value-added chain / Result</td>
</tr>
<tr>
<td>Ulm (FUG)</td>
<td>Heat Purchase: Compensation based on marginal return of electricity</td>
</tr>
</tbody>
</table>
District Heating System of Stuttgart and its vicinity

With a length of 270 km and a purchase of 1.700 GWh, the so-called “Mittlere Neckarschiene” (MNS) is EnBW’s most important District Heating System.

Key data

- Length: 270 km
- Sub-Systems: 9
  - therefrom 4 with different static pressures
- Thermal Power: 966 MW
- Production: 1.700 GWh
- No. of contracts: ca. 8,000
- CHP-Share: > 90%
- System limited to inner-city region due to geographical altitude of max. 300 a.s.l.
Our actual position
Highly Efficient Cogeneration of Heat and Power

CHP is eco-friendly:
CHP Share of heat production within the MNS-system exceeds 90%.

Reduction of Fuel Consumption:
Compared to a separate production of heat and power, CHP reduces the fuel consumption by approximately 40%.

District Heating = Renewables:
In Germany, heat purchased from highly efficient CHP plants is treated equally to heat from renewables (CHP-law, EEG, EEWärmeGesetz)
Our actual position
Positive Environmental Impact within the MNS-Region due to CHP and Efficient Technology

**Protection of Inner-City Low Emission Zones:**
due to the application of district heating within the region

**CO₂ Reduction:**
The use of district heating reduces the CO₂-emissions by approx. 150,000 t p.a. within the MNS-region

**Air Pollution Prevention:**
Highly efficient flue gas treatment ensures clean air, e.g. with regard to fine dust
Provision of about 25,000 households, 1,300 companies and 300 public buildings

Approx. 3/4 of the total heat demand within the MNS-region are allotted to the city of Stuttgart.
Completed Projects During the Last Years
Continuous Development and Optimization in the Past:
CHP Share of Heat Production Doubled since the 1990s

- **Production**: Implementation of Two Backpressure Turbines
- **Piping System**: Capacity Increase Mittlere Neckarschiene
- **Sales and Distribution**: New Connections (Development Area S21)
- **Production**: Implementation of the Heat Plant Marienstraße
- **Piping System**: Capacity Increase North/West

Continuous Optimization of the whole value-added chain consisting of Production, Distribution and Customer Service

<table>
<thead>
<tr>
<th>Techn. Werke Stuttgart</th>
<th>EnBW</th>
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<tbody>
<tr>
<td>1995</td>
<td></td>
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<tr>
<td>2014</td>
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CHP Share of Heat Production

- About 40%
- About 90%
Further Development of District Heating
Ongoing and Future Activities

**Heat Demand Study**
as a basis for heat supply planning

**Roll-out of District Heating**
Expansion to areas closed to existing system (e.g. S21-area)

**Construction of Heat Storage Facility**
Realized Heat storage in Ulm (140 MWh)
Heat storage in Stuttgart in planning

**CHP-unit**
Assessment of gas-based CHP-units for further development of district heating system
Further Development of District Heating
Combination of Secondary Systems with the Primary District Heating System

- Secondary systems are connected to the primary system at the return flows due to temperature levels.
- Secondary systems can be heated using e.g. an innovative heat pump technology.
- Heat from environment and civilization, e.g. “waste heat” can be used as a heat resource.
- Expansion of primary system possible by economically efficient means.
The Future of District Heating
Components of a District Heating System in the 2050s

- Excess Electricity
- Power to Heat
- Heat Storage
- Low-ex-Sub-Systems
- Geothermal Energy
- Chilling with Heat
- Smart Heat Supply
- Gas Fired CHP
- Biomass and CHP

**Heat Demand**
- Indirect electricity storage
- Stabilization of Electrical Grid

**Flexibility**
- Stabilization of Heating Network

**SMART THERMAL ENERGY**
- Highly Efficient CHP
- Gas and Steam Combined Power Plants
- Flexibility
- Implementation of Natural and Bio Gas

**Low Temperature Environmental Energy**
- UW

**Energy Sources**
- Natural Gas
- Biomass and CHP
- Waste Removal (50% Biogenic Fraction)
- Ligneous Biomass

**Future Trends**
- Stabilization of Electrical Grid
- Flexibility
Economical and Political Environment for District Heating Systems in Germany – a view aspects
Objectives of the German energy transition „Energiewende“
› Allow the phase-out of nuclear power generation in Germany
› Reduce dependency on coal, petroleum and gas
› Foster economic growth and create jobs
› Contribute to the reduction of greenhouse gases

Policy areas of action for the energy transition
› Renewable energies – EEG
› Reform of the European Emissions Trade System
› Electricity market design
› Energy efficiency as “second pillar” of the energy transition
› Strategy for reduction of building energy demand by refurbishment
› New high voltage lines for transport of electricity from north to south

Information from: http://www.bmwi.de/DE/Themen/Energie/Energiewende/gesamtstrategie.html (translated)
Development of Renewable Electricity Generation Capacity in Germany

Historical data

Forecast
- Mid-term prognosis of the system operators, www.eeg-kwk.net

Policy driven success story
Fossil fuels remain the most important source for heat supply in the German market.

Source of data
Forecast: Mid-term prognosis of the system operators, www.eeg-kwk.net
Distribution of Electricity Production Sites in Germany

- Energy demand is mainly located in the Western and Southern Part of Germany
- Wind Production sites are located in the North of Germany
- Need for new high-voltage transportation lines from North to South and East to West
A Policy Driven Growth: Renewables Play a Key Role in Electricity Generation

Before the implementation of the Renewable Energy law, only 5% of the gross generation originated from renewable energies.

With a share of 22.6% (2012) in total gross generation, renewables play the second largest role in electricity generation after lignite.

Source of Data: AG Energiebilanzen
Energy Prices for the German Market

Development of energy prices relevant for the German market

→ After the price boom in 2007/2008 electricity prices are continuously declining (under 40 €/MWh).

Source of data
European Energy Exchange (www.eex.com), ICE (www.theice.com), APX power exchange (www.apxgroup.com)

Energy Transition from the Perspective of a Utility · Sept. 16 2014 · Clemens Cremer · 20140910_Draft_Presentation_SEPA_Meeting.pptx
Profitability of Conventional Generation Capacity

- Electricity generation from gas is out of the money
- Coal plants can generate minor margins.
- No/Low margins of gas and coal plants reflect the high supply of renewables making large parts of the fossil capacity obsolete in many hours of the year.

Source of data
European Energy Exchange (www.eex.com), ICE (www.theice.com), APX power exchange (www.apxgroup.com)
Influence of Renewable Energies on Price Profiles

- Solar PV feed-in depends highly on weather patterns.
- Comparison of two weekdays of subsequent weeks show the effects:
  - Low Solar PV feed-in yields high prices in the morning with a dip in the afternoon.
  - In the evening we observe a price peak induced by power demand especially for lighting and domestic use.
  - At days with high total feed-in of Solar PV, a short price peak emerges at early morning before the power production from solar shows its effects. A comparable peak emerges after Solar PV ceases production.
- Solar PV strongly influences power plant dispatch.

Source of data:
European Energy Exchange (www.eex.com); grid operators’ data on renewables
Renewable energies at low (zero) marginal costs change the dispatch of the conventional fleet.

Gas fired generation is hardly used; coal plants run often but generate low margins, lignite has to reduce production in periods of lower demand.
Situation of CHP-Plants in the German Market

➢ CHP-Plans face a difficult economic situation in the German electricity market (e.g. negative clean spark spreads).

➢ However, some elements of the regulatory framework support the technology

   ➢ **CHP-Law ("KWKG")**
     Goal: Increase of share of electricity generated in CHP-units
     Mechanism: Subsidizes the co-generation of heat and power (installed power, full load hours), the installation (grid) of district heating and heat storage facilities
     Power from CHP-plants benefits from a priority feed-in regulation (KWKG §4)

   ➢ **Renewable Energy Law ("EEG")**
     Goal: Leverage the installation of renewable capacity
     Mechanism: Guarantee feed-in tariffs for a period of 20 yrs.

   **Renewable Heat Legislation ("EEWärmeG", "EWärmeG")**
     Goal: Leverage the use of renewable energies for domestic heat supply
     Mechanism: Building take appropriate “means” upon heating modernization
     Specific aspect: District heating is own option to fulfill the heat legislation

   ➢ **Energy Law ("EnWG")**
     Goal: Set the Framework for the Energy Market
     Requirements: Safe, economic, consumer-friendly, efficient, environmentally sound, pipe-based provision of heat, increasingly based on renewable energies
General Framework

- Heat market plays a key role for success in German energy transition (49% of primary energy demand)
- Competition on heat market
- Reduction of heat demand due to higher efficiency
- Declining revenues from power generation
- Industrial “own-consumer plants” for reduced EEG-allocation

Challenges

- Increase of flexibility
- Maintenance of eco-performance (Share of CHP, low PE-demand, etc.)
- Integration of renewables in the heat market (power to heat, power to gas, etc.)
- Integration of CHP in the electricity market
CHP-based Power Generation and Renewables – complementary partners for future power supply e.g. solar power

Feed-in of solar power is low during cold hours

Source: Prognos
CHP-based Power Generation and Renewables – complementary partners for future power supply e.g. wind power

Feed-in of wind power is low during cold hours

Feed-in of wind power is high during moderate hours

Source: Prognos
Need for an Increasing Flexibility of the total electricity system

- Increasing importance of storage facilities and flexible CHP-plants

Quelle: AGFW
Integration of CHP-Generation in the electricity market of the future (Simulation)

Basis: German market situation in 2000
Blue line: CHP-power generation
Red line: Total grid load
Black line: Average grid load
Integration of CHP-Generation in the electricity market of the future (Simulation)[2]

- Roll-out of renewables
- Increase of fluctuation of residual load
- High demand of storage facilities
- Average residual load equals to double CHP-capacity
- Renewables and CHP can create a viable symbiosis

Basis: German market situation in 2034

Blue line: CHP-power generation
Red line: Residual load (demand minus renewable production)
Black line: Average grid load
Thank you for your attention.