Extension of Pumped Storage Plant Waldeck 2 in Northern Hesse / Germany

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Agenda

Introduction

Existing facilities

Overview of the planned extension Waldeck 2+

Location of the new cavern Waldeck 2+

Machine concept and design capacity of the new plant

Cavern concept

Use of existing upper and lower basins

Project status and outlook
Introduction

- PSP were originally designed for providing peak-load and to profit from daily spreads
- Now PSP were increasingly used for the provision of system services
- Enormous construction of wind and solar powerplants are a result of the incentivizing renewal energy act (EEG) in Germany
- Storage of energy and a provision of high capacities on short notice is important to secure the power system and electricity supply

E.ON reviews the option to extend pumped storage power plant Waldeck 2

Examples from operation Waldeck 2, engine no. 5
When planning the Waldeck 2 scheme in the 1960s, a future extension of the plant had already been considered and the basins were designed accordingly.
Overview of the planned extension Waldeck 2+

Existing cavern Waldeck 2

Headrace-tunnel

Tailrace-tunnel

Planned cavern Waldeck 2+
Geological Investigations

- **Existing cavern and tunnels**
- **Planned cavern and tunnels**
- **Exploration tunnel**
- **Geological main fault**
- **Rubblestone/Sandstone**
- **Exploration boreholes (depth up to 360 m)**

**Cross section**
- Access tunnel and exploration tunnel
- Cross section

**Dimensions**
- 30 m
- 65 m
Geological Investigations

Investigations confirmed the geologists’ assumptions
Machine concept and design capacity of the new plant

- Investigation of numerous layout and design options
- Parameters considered in detail
  - Design capacities between 200 MW and 400 MW
  - One- and two-machine concepts
  - Different design discharges (with or without extension of the basins)
  - Different types of machines:
    - pump-turbines with synchronous generator (without speed control)
    - pump-turbines with asynchronous generator (with speed control)
    - ternary machine sets (3-machine sets)

- Comprehensive studies of economic viability and technical feasibility

**Optimal solution for Waldeck 2+:**
Reversible, variable speed pump-turbine with a rated power of 300 MW

By combining the two existing ternary machine sets with the new variable speed pump-turbine the total system can be used much more flexible.
Machine concept and design capacity of the new plant

<table>
<thead>
<tr>
<th></th>
<th>Waldeck 2 (existing facility)</th>
<th>Waldeck 2+ (planned facility)</th>
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<tbody>
<tr>
<td><strong>Pressure head</strong></td>
<td>330 m</td>
<td>330 m</td>
</tr>
<tr>
<td><strong>Design capacity</strong></td>
<td>2 × 240 MW = 480 MW</td>
<td>300 MW</td>
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<tr>
<td><strong>Machine type</strong></td>
<td>2 ternary machine sets</td>
<td>Reversible pump-turbine with</td>
</tr>
<tr>
<td></td>
<td>consisting of turbine,</td>
<td>asynchronous generator</td>
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<tr>
<td></td>
<td>motor generator and pump</td>
<td>(pumping capacity variable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>between 200 and 300 MW)</td>
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<tr>
<td><strong>rpm</strong></td>
<td>375 min⁻¹</td>
<td>333 min⁻¹</td>
</tr>
<tr>
<td><strong>Design discharge Q_{Turb}</strong></td>
<td>2 × 80 m³/s</td>
<td>105 m³/s</td>
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<tr>
<td><strong>Grid connection</strong></td>
<td>380 kV</td>
<td>380 kV</td>
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Cavern concept

- Machine and transformer are housed in the cavern powerhouse
- Excavation volume of cavern could be considerably reduced from 89,000 m³ down to 55,000 m³ → dimensions now L/W/H = 68.00/27.00/48.45 m
Use of existing upper and lower basins

**Upper basin**

- Extension of water volume for 450,000 m³ (extension by 11 %)
- Maximum water level will be increased for 1.50 m
- Raising of the crest for 0.50 m
- Wave protection with steel parts on the crest

**Lower basin**

- Maximum water level is increased by 0.10 m, minimum water level is simultaneously reduced by 0.10 m
Project status and outlook

• The current German energy market does not provide sufficient investment security for the planned extension

→ E.ON has postponed the investment decision for the main project

However:

The increase of the upper basin’s dam will start as a first sub measure in May 2014

„Peak-Shaving“ due to feed-in of subsidized renewable energies reduce profitability of PSP dramatically

At present there is no market for system stabilization

Source: Godde + Engels (2013)