Hydropower: View from the Industry
Daniel Fischlin
CEO
## Key data of KWO

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>318 full-time jobs</td>
</tr>
<tr>
<td>therefrom apprentices</td>
<td>23</td>
</tr>
<tr>
<td>Annual production</td>
<td>2'130 GWh (2016)</td>
</tr>
<tr>
<td>Annual inflow</td>
<td>800 Mio. m³</td>
</tr>
<tr>
<td>Annual turnover</td>
<td>CHF 140 Mio.</td>
</tr>
<tr>
<td>Storage capacity</td>
<td>195 Mio. m³</td>
</tr>
<tr>
<td></td>
<td>8 storage lakes</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>1'317 MW</td>
</tr>
<tr>
<td>Power plants</td>
<td>10</td>
</tr>
<tr>
<td>Catchment area</td>
<td>420 km²</td>
</tr>
</tbody>
</table>
Shareholders of KWO

- BKW Energie AG, \(\frac{1}{2}\)
- Energie Wasser Bern, \(\frac{1}{6}\)
- Industrielle Werke Basel, \(\frac{1}{6}\)
- Stadt Zürich, \(\frac{1}{6}\)
Thoughts on the future development

Questions to be reflected

- How the power plant park will develop in the surrounding countries?
- Which storage technology will prevail and in what time frame?
- Will the "energy only" market continue to exist?
- What influence will the abandonment of nuclear energy 2022 in Germany have on the prices?
- Are the empty storage lakes during the winters 2015 and 2016 an indication of a long-term trend?
Production costs of all joint ventures

Unter der Schmerzgrenze

Entwicklung der Großhandelspreise in Deutschland

40 €/MWh
35
30
25
20
15

Historische 1-Jahres-Absicherungs-Preise
Forward-Preise für 2017/2020

Quelle: Thomson Reuters, Independent Credit View

Drohende Millionenverluste

Prognostizierte jährliche Defizite der Schweizer Wasserkraftwerke

1458 Mio. Fr.

Abschreibungen
358
Finanzierungskosten
173
Abgaben (Wasserzinsen, Steuern)
486
Reine operative Kosten
441
Erzeugungskosten

603
120
735

Stromverkauf zu Marktpreisen
Geplante Subventionen
Defizit

Quelle: Independent Credit View, UREK-N

Quelle: NZZ am Sonntag, 22.05.2016
Developments in the European electricity market

• **Decommissioning of generation capacities** in Europe and Switzerland:
  - nuclear power phase-out 2022 in Germany (-10.8 GW inst. capacity; total 20.9 GW)
  - deactivation NPP Mühleberg in Switzerland (-373 MW inst. capacity)?
  - deactivation NPP Beznau 1 in Switzerland (-365 MW inst. capacity)?

• **More expected breakdowns** of aging NPP`s in France

• **Delay in the construction** of the HVDC transmission line from the north to the south in Germany
  → Excessive production in the north cannot be transmitted to the southern part of Germany

• **Winter period**: Increasing demand for power output and storage capacity
  → The gap caused by energy from wind and solar sources can be closed by hydro production, primarily by storage power plants

**Prepared for the future:**
KWO is able to supply the demand thanks to the expansion projects:

- New storage lake Trift, new power plant Trift
- Enlargement of Lake Grimsel
- New Pump Storage Plant Grimsel 1E
Situation in Germany January 2017

Stromerzeugung und Stromverbrauch
Das Agorameter im Januar 2017

Swissgrid: Internat. Redispacht
Swissgrid: Internat. Redispacht im Notfall
Impacts on grid stability

December 2016
- Power production in CH is not sufficient. Duty cycle of imports: 94%
  - 18 frequency deviations +/- 100 mHz
  - 22 French NPP`s out of order
- Risk of cascading outages in certain regions
- The international warning system RAAS has been placed on amber alert 10 times.
- International redispaches: in emergency operations the TSO`s help each other across borders to stabilise the power grid

Januar 2017
- Power production in CH is not sufficient. Duty cycle of imports: 98%
  - 28 frequency deviations +/- 100 mHz
  - 6 French NPP`s out of order
- Warning system 20x on amber alert and 1x on red alert (close to a blackout)
- Redispatch Swissgrid for the European power grid only in absolute emergency, because the reserves in the storage lakes were too low.
  ➔ KWO empty the lake Oberaar to support the power grid
KWO`s contribution to grid stability
January 2017

Result: Lake Oberaar was empty!
Annual production in Switzerland

2015

2016

Quelle: BFE Elektrizitätsstatistik 2015

Quelle: BFE Elektrizitätsstatistik 2016
Production cycles renewable sources

Quelle: BFE und Meteotest, Jahre 2008-2011
Two scenarios 2035 without NPP`s

Scenario environmental alliance

Scenario BFE energy strategy

**Forecast electricity generation**
- storage hydropower
- run-of-the-river hydropower
- photovoltaics
- wind
- biomass
- thermal power plants

**Forecast demand**
- consumption
- deficit

→ Both scenarios forecast a lack of power
Installed capacity in Germany
Forecasted capacity in Germany

Quelle: Fraunhofer ISE, 2016
Development of the power plant park in Germany

Quelle: Fraunhofer ISE, 2016
Electricity market and pricing

**present time**

- Base for today's electricity price: **marginal costs**
- Market distortion energy from wind and sun
  - variable costs decrease to zero
  - subsidised by the state
- Conventional power plants are *"gap fillers"*
- Loss-making power plants:
  - operating hours
  - uncovered costs
- Power plants **free of charge** in stand-by mode
  - only sold energy is paid

**future**

- Another pricing model?
- Provision of capacities will be compensated?
- Electrical energy more favourably priced, on the other hand rising grid costs?
- Producers can charge higher prices during peak loads?

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**Der strompreisdämpfende Effekt der Erneuerbaren Energien (Merit-Order-Effekt) senkt den Börsenstrompreis**

[Diagram showing the effect of renewable energy on electricity prices.]

- Netze
- Europäischer Verbund
- Speicher
- Lastmanagement
- KWK

Quelle: AEE
Quelle: BEE/Greenpeace energy/IZES
Grid inertia due to rotating masses

Questions to be reflected

- What is the influence on grid stability by decreasing inertia masses?
- What is the time frame for "electronic inertia" to achieve industrial maturity?
Model of the Central European power grid

- Rotating shaft, which turns at a rate of 50 rotations per second
- All producers and consumers coupled by a shaft
- Producers accelerate, consumers decelerate the shaft
- Production ≠ consumption → speed change

UCTE as model: shaft with $r = 1m$, $l = 2$ km

$n = 3000$ u/min
Offers of ancillary services

Kraftwerksausfall  Primärregelung  Sekundärregelung  Tertiärregelung

ancillary services

instantaneous reserve: inertia masses limiting f-deviation
Influence on grid stability by inertia masses

02.04.2003 - AKW Paluel (F)

Failure of one 1.2 GW power plant unit
Frequency deviation $\Delta f = -50 \text{ mHz}$
Half inertia masses $\rightarrow \Delta f = -100 \text{ mHz}$

The decrease of inertia masses leads to an increased risk of dangerous frequency drops.

Grids with less inertia masses react more sensitively to frequency oscillations
KWO`s current projects

Aspects to be reflected

- The increase in photovoltaic capacity causes an over-availability of energy in summer.
- KWO is only able to store 25% of the annual inflow (April-October) and therefore can be transferred to the winter period.
- KWO in function as a "run-of-river power station" does not produce enough revenue during the summer period.
- Sufficient pump-storage capacity in Switzerland for the coming years

=> Safeguarding the future of KWO by means of expanding the storage capacity
Retreat of the Trift glacier
Trift Dam
Storage project Trift – Gadmen valley

Key data of the project
- Storage volume: 85 Mio. m³/ 215 GWh
- Annual inflows: 154 Mio. m³/a
- Additional energy production: 145 GWh/a
- Installed capacity: 80 MW
- Nominal discharge: 21 m³/s
- Investment costs: 387 mio.CHF

Quelle: KWO
Storage project Grimsel – Aare valley

KWO’s complaint approved by the federal supreme court of Switzerland on April 05, 2017
Storage project Grimsel – Aare valley

Substantial increase of storage energy throughout Switzerland with take out a low environmental impact

Göscheneralp:
- height: 155 m
- lake's surface: 1.32 km²
- dam volume: 9.3 Mio m³
- energy content: 221 GWh

Limmern:
- height: 146 m
- lake's surface: 1.36 km²
- dam volume: 0.6 Mio m³
- energy content: 258 GWh

Oberaar:
- height: 104 m
- lake's surface: 1.46 km²
- dam volume: 0.45 Mio m³
- energy content: 243 GWh

Increase lake Grimsel:
- additional height: 23 m (present height: 114 m)
- additional lake's surface: 0.8 km²
- additional dam volume: 0.5 Mio m³
- additional energy content: 240 GWh
- present energy content: 270 GWh

Quelle: KWO
New construction of Spitallamm Dam (lake Grimsel) as of 2019

Key data:

- Height ca. 115 m (without increase)
- Volume of concrete ca. 160’000 – 205’000 m³
- Construction time ca. 5 – 6 years

Licensing procedure:
- Building consent with environmental compatibility test
New construction of Spitallamm Dam as of 2019

Submission of the building application
May 2017
New construction of Spitallamm Dam as of 2019

Quelle: KWO
View of the new dam
Thank you very much for your interest

HYDROPOWER has good prospects for the future

…and KWO takes on the role of take out the most important player