Hydraulic Hydro Storage System

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Water is pumped into a subsurface cavity, using cheap electrical power. The water is lifted by hydraulic forces. The storage is discharged when the energy price is high, using a power converter.
Hydraulic Hydro Storage System

Physical Properties

- Mass: \( r^3 \)
- Maximum height: \( r \)
- Storage capacity:
  \[ E = 2 \pi g \rho \times r^4 \]
- Surface area: \( r^2 \)
- Cost per kWh capacity: \( 1/r^2 \)
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Construction

1. tunnel
2. tunnel
base tunnel, water intake

construction road

mine shaft

2r
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base plate Separation

mined space

side view

Energy Storage Forum Europe 2012 Rome
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base plate separation

2. tunnel

excavated material

cutted rock

rock

exca-vator

top view!
base plate separation

- base plate separated
- cylinder is mounted on a ballast bed

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side view
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Drilling

drilling guide holes for the wire saw
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Diamond wire sawing

1. tunnel

cut surface

drilling holes

traction

rock

Diamond wire saw

side view
Due to rock mechanics, it is necessary to cut a V-shaped trench.
trench will get smaller due to rock pressure

every surface is sealed using geomembrane
Sealing and Securing

- Metal
- Sealing ring
- Rock securing
- Sealing to keep rock dry
- Floating piston
- Cylinder capacity filled with water
Hydraulic Hydro Storage System

Sealing O-ring

rock mass

steel cover

steel

pin joint with sensor

water pressure

seal

podest

piston
Hydraulic Hydro Storage System

Setup: multi O-ring sealing

rock

pressure: 10 Bar per O-ring

podest

piston
There should be systems that stop a leakage by physical means.

Safety

1. Backup sealing ring
2. Backup sealing ring

Self-inflating in case of water contact

Blocking in case of high flow

Floating piston

Cylinder capacity filled with water
## Hydraulic Hydro Storage System

### Investment for r=500 m HHS

<table>
<thead>
<tr>
<th>Component</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>tunnel</td>
<td>10.000 €/m</td>
<td>73 Mio. €</td>
</tr>
<tr>
<td>drilling</td>
<td>500 €/m</td>
<td>157 Mio. €</td>
</tr>
<tr>
<td>wire saw</td>
<td>10 €/m²</td>
<td>63 Mio. €</td>
</tr>
<tr>
<td>overburden</td>
<td>20 €/m³</td>
<td>126 Mio. €</td>
</tr>
<tr>
<td>base separation</td>
<td>1.000 €/m²</td>
<td>785 Mio. €</td>
</tr>
<tr>
<td>seal (stainless steel)</td>
<td>200 €/m²</td>
<td>157 Mio. €</td>
</tr>
<tr>
<td>seal geomembrane</td>
<td>100 €/m²</td>
<td>393 Mio. €</td>
</tr>
<tr>
<td>O-ring</td>
<td>10.000 €/m</td>
<td>31 Mio. €</td>
</tr>
<tr>
<td><strong>Summe</strong></td>
<td></td>
<td><strong>1.785 Mio. €</strong></td>
</tr>
</tbody>
</table>
# Hydraulic Hydro Storage System

## Technical and Financial Data*  

<table>
<thead>
<tr>
<th>Radius [m]</th>
<th>62,5</th>
<th>125</th>
<th>250</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>storage capacity [GWh]</td>
<td>0,5</td>
<td>7</td>
<td>100</td>
<td>1600</td>
</tr>
<tr>
<td>pressure [Bar]</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Investment² [Mio. €]</td>
<td>40</td>
<td>112</td>
<td>400</td>
<td>1800</td>
</tr>
<tr>
<td>Investment per kWh [€]</td>
<td>80</td>
<td>16</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>value of one loaded system 100€/MWh [Mio.€]</td>
<td>0,05</td>
<td>0,800</td>
<td>12</td>
<td>200</td>
</tr>
<tr>
<td>ROI [# of cycles]</td>
<td>800</td>
<td>140</td>
<td>33</td>
<td>9</td>
</tr>
</tbody>
</table>

*figures rounded

²invest does not include pumping system
Hydraulic Hydro Storage System

Advantage

✓ **storage capacity** beyond 1000 GWh visible
✓ **efficiency**: 80% known value
✓ no resource problem
✓ no mountains necessary
✓ no environmental problems
✓ only small **footprint** (up to 2 MWh/m²)
✓ less water consumption than PHS (~1/4)
✓ known **technologies**
✓ **price** drops with $1/r^2$
Thank you!

www.Hydraulic-Hydro-Storage.com
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