SWEDISH-SLOVAK STRATEGIC RESEARCH

DEEP GEOTHERMAL ENERGY SYSTEM
Present System Solutions for Deep Geothermal in Petrothermal Environment

Drilling

Shaft

closed loop

Tunnel - Road

drill & hope
Comparison of the Capacity of 1 Borehole and 1 Artificial Fracture

In Petrothermal Systems of Geothermal Energy there is hot dry rock but not underground water.

1 Borehole
- Temperature: 200°C
- Diameter: 0.16 m
- Height: 200 m
- Number of heat transferring surfaces: 1
- Overall heat transferring surface: 100 m²

1 Artificial fracture
- Temperature: 200°C
- Length: 100 m
- Height: 200 m
- Number of heat transferring surfaces: 2
- Overall heat transferring surface: 40 000 m²

400 BOREHOLES = 1 ARTIFICIAL FRACTURE
The Challenges and Structure of a New Energy System

- The Shaft or Tunnel Construction for Deep Geothermal
- Controlled Geometrical Structures for Geothermal Energy Extraction
- Integration of the System with existing District heating system
- Utilisation of Geothermal Energy Potential for Electric Power Generation and Storage

Economic Advantages of the Presented System

- Calculable
- Inspectable
- Serviceable
- Modularity, the shaft and fracture variability
ACCUMULATION OF RENEWABLE ENERGY ON THE SURFACE

HIGH POWER SEASONAL STORAGE

ELECTROCHEMICAL STORAGE

UNDERGROUND TECHNICAL FACILITIES AND POWERPLANTS

LARGE SURFACE GEOTHERMAL-HEAT EXCHANGER
TRIDENT – Research Facility in Sweden

The research facility is located underground on the island Stora Höggarn located in Stockholm archipelago.
Technology Development – Energy Shaft

1\textsuperscript{st} generation

2\textsuperscript{nd} generation

3\textsuperscript{rd} generation
Technology Development and Field Tests
Technology Development – Energy Tunnel

MULTIFUNCTION ENERGY TUNNEL

TBS – Tunnel Boring System
ENERGY SHAFT AND TUNNEL Construction

Utilisation of three methods:

Block excavation method - Shaft
ZTS INMART, a.s.
VUNAR, a.s.
Slovakia
Member of ATASAC

Tunneling (TBS)
DIVIDEND INDUSTRIES AB
VUNAR, a.s.

Electric Pulse Boring (EPB)
Tomsk Polytechnic University
Russian Federation
Member of ATASAC
Swiss GeoPower
BLOCK EXCAVATION METHOD – SHAFT CONSTRUCTION
The bottom is also cut in a similar way creating 1.5m x 1.5m x 6m blocks á 36000 kg
TECHNOLOGY OF THE ELECTRO PULSE BORING (EPB)

RESEARCH AND DEVELOPMENT

Collaboration
Sweden, Slovakia, Swiss and Russia
### CHARACTERISTICS OF THE EPB

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak Power</strong></td>
<td>5 – 20 GW</td>
</tr>
<tr>
<td><strong>Pulse Duration</strong></td>
<td>100-200 ns</td>
</tr>
<tr>
<td><strong>Pulse Voltage</strong></td>
<td>500 - 2000 kV</td>
</tr>
<tr>
<td><strong>Peak Ampère</strong></td>
<td>10 kA</td>
</tr>
<tr>
<td><strong>Repeat</strong></td>
<td>10-40 Hz</td>
</tr>
</tbody>
</table>
### EXAMPLE

#### Drilling in granit rock with EPB

<table>
<thead>
<tr>
<th>Distance between electrodes</th>
<th>Excavated Per Pulse</th>
<th>Excavated Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S = 12 \text{ cm} )</td>
<td>100 cm(^3)</td>
<td>7 m(^3)</td>
</tr>
<tr>
<td>( S = 50 \text{ cm} )</td>
<td>1000 cm(^3)</td>
<td>70 m(^3)</td>
</tr>
</tbody>
</table>

#### Energy efficiency of the EPB

<table>
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<tr>
<th>Excavated energy Per Pulse</th>
<th>per m(^3)</th>
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TBS + EPB = Low Cost and Low Energy Tunneling
The Concept of Energy System based on Deep Geothermal

MULTIFUNCTION ENERGY SHAFT

„All that is necessary to open up unlimited resources of power throughout the world is to find some economic and speedy way of sinking deep shafts.“
Nikola Tesla
/Our Future Motive Power, 1931/
1931 Tesla’s dream may come true in 2022.
There are no fundamental limitations for construction of deep shaft and underground galleries if block excavation and electric pulse boring are applied.

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