An Overview on Geothermal Potential of Romania

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OVERVIEW ON PRESENTATION:

- Geothermal Energy: Romania in Eastern Europe
- Evolution of Geothermal Research
- Assessment of Romania’s Geothermal Potential

Geothermal Systems in Romania:

- **Hydro-Geothermal Systems – Direct Use**
- **Shallow Geothermal Anomalies - Heat Pump concept**

- Environmental, Legislative and Economic issues
- Concluding Remarks
Mapping Geothermal Potential of Eastern Europe

Temperature at 2 km depth

From Atlas of Geothermal Res. in Europe
DIRECT USE OF GEOTHERMAL ENERGY IN EASTERN EUROPE
(in MWt)

Total Eastern Europe (except Russia): 1860 MWt
Total Europe: 6507 MWt

Romania: 150 MWt
RESEARCH EVOLUTION FOR GEOTHERMAL RESOURCES

FOCUS
- PAST: Interest for geothermal exploration “New Frontiers”
- PRESENT: Economic concern (utilization of geothermal energy), Technologic concern
- FUTURE: Economic concern, Social concern, Environmental impact

ACTIVITIES
- Geothermal mapping
- Geothermal resources inventory
- Systematic surveys
- Geothermal modeling
- Interpretation & syntheses
- Integrated studies
- Policy and regulations
- Specific market applications

PROGRAM MATURATION
Romania’s Assessment of Geothermal Potential

The vertical axis is the degree of economic feasibility.

The horizontal axis is the degree of geological assurance.

<table>
<thead>
<tr>
<th>Depth</th>
<th>Economic Feasibility</th>
<th>Geological Assurance</th>
</tr>
</thead>
<tbody>
<tr>
<td>About 3 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>About 5 km</td>
<td></td>
<td></td>
</tr>
<tr>
<td>About 10 km</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Resource: That part of resources which can be extracted economically and legally at present
- Reserve: Energy which could be extracted economically and legally in the near future

Table:

<table>
<thead>
<tr>
<th>Enthalpy</th>
<th>Source 1</th>
<th>Source 2</th>
<th>Source 3</th>
<th>Source 4</th>
<th>Source 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low enthalpy</td>
<td>&lt;90</td>
<td>&lt;125</td>
<td>&lt;100</td>
<td>&lt;150</td>
<td>&lt;190</td>
</tr>
<tr>
<td>Intermediate</td>
<td>90-150</td>
<td>125-225</td>
<td>100-200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>High enthalpy</td>
<td>&gt;150</td>
<td>&gt;225</td>
<td>&gt;200</td>
<td>&gt;150</td>
<td>&gt;190</td>
</tr>
</tbody>
</table>

Source:
- (b) Hochstein (1990).
- (c) Benderitter and Corny (1990).
- (e) Axelsson and Gunnaugsson (2000)
Location of main Hydro-Geothermal Areas in Romania

LEGENDA

- **Arii cu ape subterane geotermale utilizate pentru incalzire** (Temperatura la emergenta 60-120 C)
- **Sonde adanci in care s-au efectuat determinari de temperatura**
Intermediate temperature fields – Applicable for Direct Use

- **Temperature 60 - 110 °C**
- **At 1 – 3 km depth**
- **Mostly found in sedimentary basins and fracture zones around Romania**
- **Used for space heating, heat pumps, balneology, green houses, fish farming etc.**
- **Exploited by 88 geothermal wells (53 active)**

*Thermal spring 41 °C; Felix-Oradea, Romania.*
<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>U/M</th>
<th>Oradea System</th>
<th>Bors System</th>
<th>Western Plain System</th>
<th>Olt Valley System</th>
<th>North Bucharest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Reservoir</td>
<td></td>
<td>Fissured Carbonate</td>
<td>Fissured Carbonate</td>
<td>Sandstone</td>
<td>Grit stone</td>
<td>Carbonate</td>
</tr>
<tr>
<td>Surface</td>
<td>Km²</td>
<td>75</td>
<td>12</td>
<td>2500</td>
<td>18</td>
<td>300</td>
</tr>
<tr>
<td>Depth</td>
<td>Km</td>
<td>2.2-3.2</td>
<td>2.4-2.8</td>
<td>0.8-2.1</td>
<td>2.1-2.4</td>
<td>1.9-2.6</td>
</tr>
<tr>
<td>Drilled Wells (total)</td>
<td></td>
<td>14</td>
<td>6</td>
<td>88</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>Active Wells</td>
<td>No.</td>
<td>12</td>
<td>5</td>
<td>37</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Well Head Temperature °C</td>
<td></td>
<td>80-110</td>
<td>120</td>
<td>60-90</td>
<td>90-95</td>
<td>60-80</td>
</tr>
<tr>
<td>Temperature Gradient °C/km</td>
<td></td>
<td>35-43</td>
<td>45-50</td>
<td>38-50</td>
<td>45-48</td>
<td>28-34</td>
</tr>
<tr>
<td>Total Dissolved Salts g/l</td>
<td></td>
<td>0.8-1.4</td>
<td>12.0-14.0</td>
<td>2.0-7.0</td>
<td>13.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Annuel Savings toe</td>
<td></td>
<td>9700</td>
<td>3200</td>
<td>18500</td>
<td>2600</td>
<td>1900</td>
</tr>
<tr>
<td>Total installed power (with existing wells) MWt</td>
<td></td>
<td>58</td>
<td>25</td>
<td>210</td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td>Exploitable Reserve (for 20 year) MW/d</td>
<td></td>
<td>570</td>
<td>110</td>
<td>4700</td>
<td>190</td>
<td>310</td>
</tr>
</tbody>
</table>
SUMMARY OF GEOTHERMAL DIRECT HEAT USE IN ROMANIA

Total thermal installed capacity in MWt: 150
Direct use in TJ/year: 2,841.0
Direct use in GWh/year: 789.2
Capacity factor: 0.52-0.62

- district heating 57.2%
- greenhouse heating 28.3%
- industrial process heat 14.1%
- fish farming 3.1%
- bathing & swimming 42.4%
The most favorable locations in Romania for application of Geothermal Heat Pump concept (temperature > 20°C at approx. 20 m depth)
PROBABLE POSITION OF COOLING MAGMATIC SYSTEMS FROM BAIA MARE REGION

- Sapanta Caldera
- Pietroasele Stratovolcano
- Muntele Mic Strato-volcano
- Ilba-Nistru Structure
- Piscuiatul Strato-volcano
- Ulmoasa Laccolith
- Ignis Strato-volcano
- Gutin Cupola
- Mogosa Strato-volcano

Age (M.Y.)

Structure Volume (Km3)

LITTLE GEOTHERMAL POTENTIAL

POSSIBLE GEOTHERMAL POTENTIAL

Theoretical cooling models

PROBABLE POSITION OF COOLING MAGMATIC SYSTEMS FROM BAIA MARE REGION

• Cube 300 C
• Slab 300 C
SUBSURFACE TEMPERATURE GRADIENT DISTRIBUTION MAP
(at 40m depth)
Toplita Area (Volcanic Arch of East Carpathians)

LEGEND
Temperature Gradient [°C/100m]

Scale: 10 km
Temperature at 3000m depth in Romania

Key:
Red = areas with temperature exceeding 140 C at 3000m depth
Location of HDR Tulcea Geothermal Project
HDR Tulcea Geothermal Project

GEOLOGICAL MAP

GEOLOGICAL MAP
Tulcea area
GEOLOGICAL CROSS-SECTION

Geological Cross Section through North Dobrogea

- Quaternary
- Jurassic
- Triassic
- Upper Palaeozoic (granitoides)
- Proterozoic
- Mesozoic magmatic rocks (basalts)

0m 4000m 8km

Frecatei Telita
Exploration Permit GarlaSomova Danube
Romania/Ukraine Border
HDR Tulcea Geothermal Project

INTEGRATED GEOTHERMAL MODEL:

Geological Log

Geothermal Parameters

Temperature vs. depth calculated into two hypotheses:

- Linear temperature gradient
- \( T(z) = F(\text{heat flow, heat conductivity, heat generation}) \)
HEAT FLOW MAP OF DOBROUDJA (Romania)
**IMPACT OF GEOTHERMAL ENERGY UTILIZATION ON THE ENVIRONMENT**

*(from an European Commission Study – JRC-Ispra, 2004)*

**Keys:**  L = low;  M = medium;  H = high

<table>
<thead>
<tr>
<th>Impact</th>
<th>Probability of occurring</th>
<th>Severity of consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air quality pollution</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Surface water pollution</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Underground pollution</td>
<td>L</td>
<td>M</td>
</tr>
<tr>
<td>Land subsidence</td>
<td>L</td>
<td>L to M</td>
</tr>
<tr>
<td>High noise levels</td>
<td>H</td>
<td>L to M</td>
</tr>
<tr>
<td>Well blow-outs</td>
<td>L</td>
<td>L to M</td>
</tr>
<tr>
<td>Conflicts with cultural and archaeological features</td>
<td>L to M</td>
<td>M to H</td>
</tr>
<tr>
<td>Social-economic problems</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>Chemical or thermal pollution</td>
<td>L</td>
<td>M to H</td>
</tr>
<tr>
<td>Solid waste disposal</td>
<td>M</td>
<td>M to H</td>
</tr>
</tbody>
</table>
General Principles:

- The mineral resources (including Geothermal Energy) make the exclusive object of public ownership and belong to the Romanian State;

- The right to conduct exploration operations and mining activities (including harnessing of Geothermal Energy) is provided by concession agreements, concluded with the National Agency for Mineral Resources (NAMR) and approved by Governmental Decision;

- The concession agreements are tax – royalty type;

- The provisions of the exploration agreement and of the production license remain valid for their entire duration on the terms on which were concluded, excepting the case that legal provisions favorable to the title holder are adopted;
KEY STRATEGIES FOR DEVELOPMENT OF GEOTHERMAL RESOURCES IN ROMANIA

- Explore for the most appropriate subsurface conditions for geothermal production.

- Drill into this formation by as cheap and effective methods as possible.

- Develop efficient methods for use of geothermal heat for direct use and/or electricity production.

- Secure the environmentally friendly use of geothermal energy, in particular concerning protection of underground drinking water resources, emissions, etc.

- Regulate competing uses and securing sustainable use of geothermal energy. It is apparent that the present lack of specific regulation for geothermal energy exploitation is inhibiting the effective use of this underutilized resource.

- Grant investors certain right to use geothermal energy in a given area and to a given extent, as the basis for business plans.
Thank You !