GEOTHERMAL SPA
An attempt to connect social, economic, and environmental solutions for Samosir region in North Sumatra, Indonesia
HEAT UNDERGROUND = CONVERTED TO ELECTRICITY
ADVANTAGES OF GEOTHERMAL ENERGY

SUPPLY
ABBUNDANT SUPPLY

LAND USE
LOW AMOUNT OF LAND REQUIRED

POLLUTION
REDUCE EMISSIONS IN THE ATMOSPHERE

RELIABILITY
24 HOURS AVAILABLE

COST
NO FUEL COST
LOW MAINTENANCE
<table>
<thead>
<tr>
<th>Technology</th>
<th>Increase in energy production, 1997–2001 (percent per year)</th>
<th>Operating capacity, end 2001</th>
<th>Capacity factor (percent)</th>
<th>Energy production, 2001</th>
<th>Turnkey investment costs (2001 USS per kilowatt)</th>
<th>Current energy cost</th>
<th>Potential future energy cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>~ 2.5</td>
<td>~ 40 GWe</td>
<td>25–80</td>
<td>~ 170 TWh (e)</td>
<td>500–6000</td>
<td>3–12 c/kWh</td>
<td>4–10 c/kWh</td>
</tr>
<tr>
<td>Heat</td>
<td>~ 2</td>
<td>~ 210 GWh</td>
<td>25–80</td>
<td>~ 730 TWh (th)</td>
<td>170–1000</td>
<td>1–6 c/kWh</td>
<td>1–5 c/kWh</td>
</tr>
<tr>
<td>Wind electricity</td>
<td>~ 30</td>
<td>23 GWe</td>
<td>20–40</td>
<td>43 TWh (e)</td>
<td>850–1700</td>
<td>4–8 c/kWh</td>
<td>3–10 c/kWh</td>
</tr>
<tr>
<td>Solar photovoltaic electricity</td>
<td>~ 30</td>
<td>1.1 GWe</td>
<td>6–20</td>
<td>1 TWh (e)</td>
<td>5000–18000</td>
<td>25–160 c/kWh</td>
<td>5 or 6–25 c/kWh</td>
</tr>
<tr>
<td>Solar thermal electricity</td>
<td>~ 2</td>
<td>0.4 GWe</td>
<td>20–35</td>
<td>0.9 TWh (e)</td>
<td>2500–6000</td>
<td>12–34 c/kWh</td>
<td>4–20 c/kWh</td>
</tr>
<tr>
<td>Low-temperature solar heat</td>
<td>~ 10</td>
<td>57 GWh (95 million m²)</td>
<td>8–20</td>
<td>57 TWh (th)</td>
<td>300–1700</td>
<td>2–25 c/kWh</td>
<td>2–10 c/kWh</td>
</tr>
<tr>
<td>Hydro energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>~ 2</td>
<td>690 GWe</td>
<td>35–60</td>
<td>2600 TWh (e)</td>
<td>1000–3500</td>
<td>2–10 c/kWh</td>
<td>2–10 c/kWh</td>
</tr>
<tr>
<td>Small</td>
<td>~ 3</td>
<td>25 GWe</td>
<td>20–90</td>
<td>100 TWh (e)</td>
<td>700–8000</td>
<td>2–12 c/kWh</td>
<td>2–10 c/kWh</td>
</tr>
<tr>
<td>Geothermal energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>~ 3</td>
<td>8 GWe</td>
<td>45–90</td>
<td>53 TWh (e)</td>
<td>800–3000</td>
<td>2–10 c/kWh</td>
<td>1 or 2–8 c/kWh</td>
</tr>
<tr>
<td>Heat</td>
<td>~ 10</td>
<td>11 GWh</td>
<td>20–70</td>
<td>55 TWh (th)</td>
<td>200–2000</td>
<td>0.5–5 c/kWh</td>
<td>0.5–5 c/kWh</td>
</tr>
<tr>
<td>Marine energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tidal</td>
<td>0</td>
<td>0.3 GWe</td>
<td>20–30</td>
<td>0.6 TWh (e)</td>
<td>1700–2500</td>
<td>8–15 c/kWh</td>
<td>8–15 c/kWh</td>
</tr>
<tr>
<td>Wave</td>
<td>–</td>
<td>exp. phase</td>
<td>20–35</td>
<td>0</td>
<td>2000–5000</td>
<td>10–30 c/kWh</td>
<td>5–10 c/kWh</td>
</tr>
<tr>
<td>Tidal stream/Current</td>
<td>–</td>
<td>exp. phase</td>
<td>25–40</td>
<td>0</td>
<td>2000–5000</td>
<td>10–25 c/kWh</td>
<td>4–10 c/kWh</td>
</tr>
<tr>
<td>OTEC</td>
<td>–</td>
<td>exp. phase</td>
<td>70–80</td>
<td>0</td>
<td>8000–20000</td>
<td>15–40 c/kWh</td>
<td>7–20 c/kWh</td>
</tr>
</tbody>
</table>
INDONESIA is located in the area “ring of fire” surrounded by volcanic mountains. Geothermal energy is a big opportunity.

NL / 2,5 KM/ 70-80 degree Celcius
IND/ 500 m / 100-120 degree Celcius
## Installed Geothermal Capacity Worldwide

Installed Geothermal capacity ~8.500 MW, Worldwide potential ~60.000 MW

<table>
<thead>
<tr>
<th>Country</th>
<th>Potential for electricity generation</th>
<th>Installed capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MW</td>
<td>TOTAL MW</td>
</tr>
<tr>
<td>South &amp; Central America</td>
<td>3.500</td>
<td>1.220</td>
</tr>
<tr>
<td>The Philippines</td>
<td>6.000</td>
<td>1.900</td>
</tr>
<tr>
<td>Africa, inclusive Kenya</td>
<td>6.500</td>
<td>60</td>
</tr>
<tr>
<td>Indonesia</td>
<td>27.000</td>
<td>790</td>
</tr>
<tr>
<td>P.R China</td>
<td>6.700</td>
<td>30</td>
</tr>
<tr>
<td>USA</td>
<td>12.000</td>
<td>2.300</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1.200</td>
<td>450</td>
</tr>
<tr>
<td>Japan</td>
<td>2.400</td>
<td>550</td>
</tr>
<tr>
<td>Europe, inclusive Iceland and Azores islands</td>
<td>2.000</td>
<td>1.050</td>
</tr>
<tr>
<td>Russia</td>
<td>1.400</td>
<td>60</td>
</tr>
</tbody>
</table>

**Source**

WORLD GEOTHERMAL ASSOCIATION
LOCATION CHOSEN: SUMATRA
13,800 MW RESOURCES FROM THE 27,000 MW

SOURCE:
Indonesian Geothermal Association
Environmental, Economic, and Social problems affecting the living quality of the inhabitants
PROBLEM STATEMENT
ENVIRONMENTAL ISSUES ARE STILL COMPETING WITH PUBLIC HEALTH AND SOCIAL ISSUES

- Lack of education and knowledge 67.4% 0-30 years (Big potential for the future)
- Lack of awareness of disposal of domestic waste 47-58% dominant source of the water pollution
- Lack of electricity 8 hours/day no electricity

PROBLEM APPROACH
STARTING WITH PROVIDING ECONOMY, SOCIAL, AND CLEAN ENVIRONMENT

- Attracting more tourist to the area to provide extra income
- Providing work fields
- Providing electricity
- Giving onsite educations
- Introducing clean energy and clean environment

GEOTHERMAL SPA?

USING ARCHITECTURE AS A TOOL ......
WHY SPA?

GEO THERMAL WATER

BALNEOLOGY

ADVANTAGES
The hot water produced by the earth contains minerals that can be used to cure a lot of diseases.

BALNEOTHERAPY
It may involve hot or cold water, massage through moving water, relaxation or stimulation. Many mineral waters at spas are rich in particular minerals (silica, sulfur, selenium, radium) which can be absorbed through the skin.

EXAMPLES
Diabetes
Rheumatism
Skin diseases
Therapy for stroke patients (depending on the minerals)
The only producing geothermal field in North Sumatra with 10 MW capacity

Producing 5,952,000 kWh in August 2009

= 8,000,000 W

Capacity factor = 80%

Target on producing 61,752,000 kWh for 2009
**EXCEL ANALYSIS**

Energy needs of The Toba Samosir Region

Classified in
- Households type,
- Public services (hospital and hotels)
- Private offices

Energy needs for the region
39,898,757,39 kWh/month

= 53,627,362,083 W

Compared to Sibayak 80% capacity factor

Capacity power plant needed 67.5 MW
### Indonesia's Geothermal Potential (MW)

<table>
<thead>
<tr>
<th>Prospect Areas</th>
<th>Installed</th>
<th>Reserves</th>
<th>Resources</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Proven</td>
<td>Possible</td>
<td></td>
</tr>
<tr>
<td>North Sumatra</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Sinabung</td>
<td>2</td>
<td>39</td>
<td>131</td>
<td>150</td>
</tr>
<tr>
<td>Sibayak</td>
<td></td>
<td>280</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>Sarulla</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Sibualbuali</td>
<td></td>
<td></td>
<td></td>
<td>600</td>
</tr>
<tr>
<td>Sorik Merapi</td>
<td></td>
<td>250</td>
<td></td>
<td>150</td>
</tr>
<tr>
<td>Pusuk Buhit</td>
<td></td>
<td></td>
<td></td>
<td>250</td>
</tr>
<tr>
<td>Simbolon</td>
<td>250</td>
<td></td>
<td></td>
<td>250</td>
</tr>
</tbody>
</table>

**Location: Pusuk Buhit**

Resources: 250 MW

Feasible for 67.5 MW needed for the region

**Source:**

Indonesian Geothermal Association
PUSUK BUHIT
THE LOCATION
PUSUK BUHIT VOLCANO
PUSUK BUKIT DEVELOPMENT PLANS

CONVERSION OF THE DEVELOPMENT PLAN FOR THE GEO THERMAL SPA PROJECT

NEW DEVELOPMENT AREAS

ENTRANCE FROM THE CITY CENTRE

PUSUK BUKIT DEVELOPMENT PLANS
THE POTENTIAL GEO THERMAL SYSTEM IN THE LOCATION
DERIVED FROM THE GEO THERMAL FLASH SYSTEM AND MODIFIED

- TURBINE
- GENERATOR
- CONDENSER
- COOLING
- WATER FROM THE LAKE
- CONDENSED WATER
- SEPARATOR
- WASTE WATER
- FILTER
- DIRECT USE
- PRODUCTION WELL
- INJECTION WELL
- THERMAL AQUIFER (GEOTHERMAL RESOURCES)
Applications of DIRECT USE GEOTHERMAL HEAT according to the World Geothermal Association

The applications are ordered according to different temperatures:

<table>
<thead>
<tr>
<th>T (Celcius)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>Digestion in paper pulp; Evaporation of highly concentrated solutions</td>
</tr>
<tr>
<td>180</td>
<td>Heavy water via hydrogen sulphide process</td>
</tr>
<tr>
<td>170</td>
<td>Drying of fish meal and timber</td>
</tr>
<tr>
<td>160</td>
<td>Alumina via Bayers process</td>
</tr>
<tr>
<td>150</td>
<td>Drying farm products; Food canning</td>
</tr>
<tr>
<td>130</td>
<td>Evaporation in sugar refining; Extraction of salts by evaporation &amp; crystallisation; Fresh water by distillation</td>
</tr>
<tr>
<td>120</td>
<td>Concentration of saline solution; Refrigeration (medium temperature)</td>
</tr>
<tr>
<td>110</td>
<td>Drying and curing of light aggregate cement slabs</td>
</tr>
<tr>
<td>100</td>
<td>Drying of Organic materials eg. seaweed, grass, vegetables, etc. Washing and drying of wool</td>
</tr>
<tr>
<td>90</td>
<td>Intense de-icing operations</td>
</tr>
<tr>
<td>80</td>
<td>Space Heating (buildings+greenhouses)</td>
</tr>
<tr>
<td>70</td>
<td>Refrigeration (lower temperature limit)</td>
</tr>
<tr>
<td>60</td>
<td>Animal husbandry and Greenhouses by combined space</td>
</tr>
<tr>
<td>50</td>
<td>Mushroom growing; Balneology; Therapeutic Hot springs</td>
</tr>
<tr>
<td>40</td>
<td>Soil Warming; Swimming pools; Biodegradation; Fermentations</td>
</tr>
<tr>
<td>30</td>
<td>Warm water for year round mining in cold climates; De-icing; Fish farming</td>
</tr>
</tbody>
</table>
THE TEMPERATURE of GEOTHERMAL WATER will vary throughout the functions.
A series of different functions going along the route. Clustering the three functions due to similar and overlapping spaces and the minimum temperature drop.
BUILDING CONCEPT
STACKINGS AND FUNCTION CONNECTIONS

SITTING BETWEEN THE STEAM
LYING DOWN WITH THE STEAM
VIEWING THE STEAM
WALKING ALONG THE STEAM
WALKING THROUGH THE STEAM
WALKING ON TOP OF THE STEAM
HEALTH SPA
WELNESS SPA
ENTRANCE
RESTAURANT
GEOTHERMAL SPA
SITUATION ON SITE 1:200 AND THE ROUTING
GEOTHERMAL SPA
WATERFLOW IN THE BUILDING
GEOTHERMAL SPA
OUTSIDE AND INSIDE

HEALTH SPA

WELLNESS SPA

RESTAURANT
GEOTHERMAL SPA

SEMI-PRIVATE/PUBLIC SPACES

HEALTH SPA

WELNESS SPA

RESTAURANT
GEO THERMAL SPA

VIEW TO THE LAKE
COLOURS
- Red Clay: The Human World
- White Chalk: The World of Good Spirit Above
- Black Charcoal: The Underworld

AXIAL LENGTH
From east to west

CENTRAL SQUARE
All the houses front doors are situated on the central square

TWO ENTRANCES
The entrances are positioned in the front and in the back facade

SPACE UNDERNEATH
The space under the tilted structure are usually use as extra spaces (storage or shaded daytime workspace)

ROOF PROPORTION
The roof proportions are usually bigger than the side facade

REpetitions
The buildings are situated next to each other creating a lot of repetitions

Stacking
Building on top of a building also occurs in some of the architecture

Layering
The balconies in the facade are layered and tiered according to functions

The Roof Structure
The ridges are extended from the middle structures

Structure Posts
The posts are thick beams without nails stacked on top of each other, the walls are usually not load bearing

Foundation (Flexible Structure)
The foundation are constructed with high poles on stone
MATERIALS
MAIN MATERIALS

INDONESIAN MAHOGANY
(TOONA SURENI)
growth 4 cm/year

BAMBOO
growth 7 cm-40 cm/day

NATURAL LOCAL STONES

CONCRETE
GEOTHERMAL SPA

SECTIONS DETAILS: Prefab woven bamboo wall

1. Prefab woven bamboo wall
2. Ikatian kawat dikencangkan setelah terpasang pada tiang
3. Balok bambu plaster
4. Kawat pengikat tiang dan balok bambu

Ujung atas kolom dilubangi dengan bor untuk kemudian diikat bersama balok dengan kawat beton, kawat, tali iujk atau tali bambu.
GEOTHERMAL SPA

SECTIONS DETAILS: Ceramic composite concrete
### Containable rainwater

<table>
<thead>
<tr>
<th>Month</th>
<th>Jan</th>
<th>Feb</th>
<th>Maart</th>
<th>Apr</th>
<th>Mei</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sept</th>
<th>Okt</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain (mm)</td>
<td>137.42</td>
<td>135.44</td>
<td>132.33</td>
<td>133.93</td>
<td>84</td>
<td>83.44</td>
<td>180.74</td>
<td>188.70</td>
<td>125.11</td>
<td>135.15</td>
<td>71.24</td>
<td>187.58</td>
</tr>
<tr>
<td>Rain days</td>
<td>9</td>
<td>5</td>
<td>16</td>
<td>15</td>
<td>15</td>
<td>7</td>
<td>11</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Days without rain</td>
<td>80</td>
<td>76</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
<td>67</td>
</tr>
</tbody>
</table>

### Water usage

<table>
<thead>
<tr>
<th>Water usage</th>
<th>No. of visitors per day</th>
<th>Toilet water (L) pp/pd</th>
<th>Mandi water (L) pp/pd</th>
<th>Total water per day(L)</th>
<th>Total water per month (L)</th>
<th>Largest amount of dry days</th>
<th>Needed water storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
<td>10</td>
<td>15</td>
<td>1500</td>
<td>465000</td>
<td>23</td>
<td>345000</td>
</tr>
</tbody>
</table>

### Water Tanks

5 water tanks with r=0.96 m and h=3 m.

- Capacity per tank: 8,681.47 L
- Total capacity in L: 43,407.36 L

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**GEOTHERMAL SPA**

**RAINWATER CAPTURATION**
GEOTHERMAL SPA
CLIMATE ADAPTING
CONCLUSION

CHANCES

ELECTRICITY

TOURISM

CLEAN ENERGY
THANK YOU

FIRST MENTOR
ANNE LOES NILLESEN

SECOND MENTOR
ARJAN VAN TIMMEREN

Royal Haskoning

BAPPEDA SAMOSIR

PERTAMINA GEO THERMAL ENERGY

INDONESIAN GEO THERMAL ASSOCIATION

UNIVERSITEITSFONDS DELFT

Question(s)?