EUROPEAN SHALLOW GEOTHERMAL DAYS

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BRUSSELS

Lasse F. Isaksen

ROTOTEC
CLEVER GEOENERGY PIONEER
AGENDA

- Rototec
- Manglerudjordet building cooperative
- Drilling technique and equipment
- Finding the solution
- Project finance

GEOENERGY COUPLED WITH DRY COOLER FOR RESIDENTIAL BUILDING COMPLEXES
ROTOTEC

We deliver geoenergy fields for ground source **heating and cooling** especially for large properties and industries, and provide consulting services for geoenergy projects.

Our services range from consulting with regards to **geoenergy solutions** to ground analysis and installation.
Rototec was founded in 2007 to challenge old-fashioned ways of doing and thinking in the industry. That marked the beginning of Rototec’s path to becoming the largest geoenergy company in Europe.

The growth of the company is based on strong organic growth as well as acquisitions.

Rototec is the market leader in large properties and the preferred partner in Norway, Sweden and Finland.
Geoenergy has an established position in a sustainable society today and in the future. By storing, and saving energy, we can save both money and environment.

<table>
<thead>
<tr>
<th>ROTOTEC IN NUMBERS</th>
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<tbody>
<tr>
<td>43 000</td>
</tr>
<tr>
<td>Energy wells drilled in</td>
</tr>
<tr>
<td>Nordic countries</td>
</tr>
<tr>
<td>50 M€</td>
</tr>
<tr>
<td>Turnover</td>
</tr>
<tr>
<td>90</td>
</tr>
<tr>
<td>People employed</td>
</tr>
<tr>
<td>47</td>
</tr>
<tr>
<td>Modern drilling units</td>
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MISSION & VISION

**OUR MISSION** is to improve energy self-sufficiency.

**OUR VISION** is to provide the best customer experience in the energy sector.
## Environmental politics in Nordic countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Goal</th>
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<tbody>
<tr>
<td><strong>Sweden</strong></td>
<td><strong>2020</strong></td>
<td>Renewables to 55% of primary energy</td>
</tr>
<tr>
<td></td>
<td><strong>2030</strong></td>
<td>Lower green house gases 40% compared to 1990</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No fossil fuels in transport sector</td>
</tr>
<tr>
<td><strong>Finland</strong></td>
<td><strong>2029</strong></td>
<td>No coal</td>
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<tr>
<td></td>
<td></td>
<td>Half the usage of imported oil</td>
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<tr>
<td></td>
<td></td>
<td>Renewables in transport sector to 40%</td>
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<tr>
<td></td>
<td></td>
<td>No oil for heating in government buildings 2025</td>
</tr>
<tr>
<td><strong>Denmark</strong></td>
<td><strong>2030</strong></td>
<td>No coal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No oil for heating</td>
</tr>
<tr>
<td></td>
<td><strong>2050</strong></td>
<td>No fossils used</td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td><strong>2020</strong></td>
<td>Heating oil ban</td>
</tr>
<tr>
<td></td>
<td><strong>2030</strong></td>
<td>Carbon neutral</td>
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</table>
MANGLERUDJORDDET BUILDING COOPERATIVE

15 buildings
518 apartments
72,000 m² plot
Built in the late 1950’s
Planned, built and owned by the municipality
Changed to cooperative owning model in 1986
Several reworks and upgrades done the last 20 years
Old heating method

Yearly energy need of 5 GWh
25% of the need for domestic hot water (DHW)
Heating and DHW heated to 70-80 degrees before distributed
DRILLING TECHNIQUE AND EQUIPMENT

Down-the-hole (DTH) drilling
139.7 x 5.0 mm permanently installed steel casing pipes into bed rock.
114.3 mm drilling in bed rock.
Comacchio MC 450 drilling units
Atlas Copco DrillAir Y35, (35 bar) compressors
12 m, 4 axel truck, for transportation of the full equipage.
High flexibility and quick mobilization.
FINDING THE SOLUTION

Original de-centralized solution:
9 independent heat pump systems to operate, control and maintain
All located in existing sub-centrals
Estimated 67 wells of 300 m. depth = 20,000 m.
4-14 bore holes in each system
Centralized solution

Fewer heat pumps and systems
Requires 81 wells of 300 m. depth = 24,300 m., due to reduced exploited rock volume, compared to the de-centralized solution
Electricity grid pricing

With full back-up heating solution the customer can choose a “low-priority / agreed disconnection” plan for their electricity to the heating central.

In periods of high electricity demand and/or service to the electricity grid, the grid owner can disconnect their supply. The bio-oil burner would then be in use.

The price for “low-priority” connection is 6,1 €/kW/year ≈ 12.100 €/year

For January month, the cost for priority connection would be 15,2 €/kW/mnd = 30.340 €

In total, the estimated savings for this, compared to a decentralised solution in which the “low-priority” connection would require a lot more equipment, is 100.000+ €/year

### Priority connection

<table>
<thead>
<tr>
<th>Month</th>
<th>€/kW/mnd</th>
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<tbody>
<tr>
<td>Jan</td>
<td>15,2</td>
</tr>
<tr>
<td>Feb</td>
<td>15,2</td>
</tr>
<tr>
<td>Mar</td>
<td>8,1</td>
</tr>
<tr>
<td>Apr</td>
<td>2,3</td>
</tr>
<tr>
<td>Mai</td>
<td>2,3</td>
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<tr>
<td>Jun</td>
<td>2,3</td>
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<td>Jul</td>
<td>2,3</td>
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<tr>
<td>Aug</td>
<td>2,3</td>
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<tr>
<td>Sep</td>
<td>2,3</td>
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<tr>
<td>Okt</td>
<td>2,3</td>
</tr>
<tr>
<td>Nov</td>
<td>8,1</td>
</tr>
<tr>
<td>Des</td>
<td>15,2</td>
</tr>
</tbody>
</table>

### Low-priority connection

<table>
<thead>
<tr>
<th></th>
<th>€/kW/year</th>
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<tbody>
<tr>
<td>Yearly</td>
<td>6,1</td>
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</table>
Show-stopper?

Two new highway tunnels planned through the property.

Distributed solution made impossible for two systems and highly affected for two systems.
Adjusted centralized solution

Tunnel area kept free
Fewer separated areas to be affected = shorter piping distances
Still requires 24,300 m ≈ 67 wells of 360+ m.
Dry cooler addition

To keep the bore hole depth at an cost efficient depth of 300 m.

Simple 500 kW dry cooler to extract heat from ambient air

Provides enough energy to the heat pumps and injects energy in the wells during the summer

Reduces the load on the wells during spring and autumn

Increases COP during the winter

Estimated saved drilling $\approx 18\%$
Necessary piping changes

Long horizontal pipelines requires thorough pressure loss calculation and planning.

Large diameter bore hole U-pipe collectors (45 mm.) to reduce flow and pressure drop.

Turbulence still secured using Muovitech Turbocollector 45®

Correctly dimensioned large diameter piping and flanges for indoor heat pump connections (200 mm.)
Thermal response testing (TRT)

Two TRTs were performed at different locations, to reveal bed rock properties.

The tests revealed:
- Undisturbed ground temperature (°C)
- Thermal conductivity (W/Km)
- Borehole resistance (Km/W)
Simulation of bored hole field

Earth Energy Designer simulation tool used to simulate the field behaviour in a 25-year perspective.

Estimated energy from dry cooler added

Only simple simulations were performed, for “proof of concept” to customer.
Energy central main components

2 x 400 kW Clivet heat pumps with screw compressors (built in) for 80% energy coverage
1200 kW re-used electro-heater for peak power
2 MW bio-oil burner for 100 % back-up
Automation / control

Full automation with temperature sensors in all vital areas.
Delivers heat to 9 sub centrals with it’s own DHW and radiator heating controls.
Historic temperatures

DHW made with heat exchangers and accumulated / peak-heated
Radiator heating temperature settings
Set-point visualization based on outdoor temperatures, with start-temperature
Current findings / best practice

Needed noise reduction inside.
For noise, visibility and safety reasons, a simple fence with visibility-blocking roof, was installed around the dry cooler.

With current operating boundaries, the dry cooler is performing better than anticipated. This can be used to reduce the dry cooler load, and noise for the residents during sensitive hours of the week. It can also be used to increase the bore hole temperature over time.
PROJECT FINANCE

Previous yearly heating and DHW cost: 585,000 €
Conservatively estimated reduction in cost, based on ¾ of a year in operation: ≈ 54%
New yearly cost: 269,900 €
Yearly heating cost reduction: 315,100 €

Yearly CO2 reduction: **640 tons**
*European Attribute Mix for Norway, done by Association of Issuing Bodies (AIB).*

Total investment cost for customer: 2,629,200 €
Of which drilling, digging and outdoors piping: 711,000 €
Optimal project finance

SUMMARY:
Potential amortising period including interest* $\approx 9,1$ years

*1,95% nominal interest

All heating cost savings used for amortising.

Cumulative cash flow without change in energy prices or interest. Savings interest set to 0%
Actual project finance

Actual customer plan:

With 0% increase in both oil- and electricity prices and interest, with actual agreed payment terms**, the total 20 year savings are \textbf{3.130.000 €} or 156.500 € yearly.

**Actual payment terms:
- 20 year amortising
- 1.95% nominal interest
- 12 payments/year

The yearly savings are used for other projects in the cooperative.
THANK YOU!

Link to (Norwegian) video: https://youtu.be/ZXG3PPBQ7XU

QUESTIONS?
Rototec References

SHOPPING MALLS

HOSPITALS

OFFICE BUILDINGS

SPA & SWIMMING HALLS

INDUSTRY & WAREHOUSES

APARTMENT HOUSES
NON-EUROPEAN PROJECTS

Geoenergy planning and installation in China

TRT (Thermal Response Test) in action (left).

Senior citizen apartment building of 60 000 m² utilizing geoenergy will have 377 energy bore holes and 3 MW of heat pump power.
Heat pumps

80 % energy coverage = 4 GWh
2 x Clivet SCREWLine³ WDH SL3 160.1 heat pumps

Noise reducing measures includes simple dry walls and roof around them, with isolation
Dry cooler

Currently it extracts energy from the air when temperature is 5°C or warmer.

Dimensioned for the same flow as one of the heat pumps.

Most efficient in the spring, when bore hole temperature is low from the winter.

Low energy consumption makes them run “continuously” through the summer, regardless of heating need.
Sub central-DHW

DHW made with heat exchangers and accumulated / peak-heated
Set-point visualization
Historic temperatures
Sub central-heating

Radiator heating with by-pas
Set-point visualization based on outdoor temperatures, with start-temperature
Historic temperatures