Geothermal Energy in Munich (and beyond)
A Geothermal CITY Case Study

With thanks to the Erdwerk Team and special thanks to Dr. Achim Schubert & Ulrich Steiner

Neil Farquharson
Outline

1. ERDWERK GmbH
2. Munich
3. The Southern German Molasse Basin
4. Geothermal Development in Bavaria
5. Project Optimization
6. SWM – GRAME
7. Beyond Munich
8. Geothermal Worldwide Potential
The Southern German Molasse Basin

~ 130 km

Upper Jurassic

Malm Reservoir

Munich

Alpine Foothills

~ 85 - 120 °C

~ 150 °C

Adapted from 'Geologische Karte von Bayern 1:500000', Bayerisches Geologisches Landesamt, 1996
The Southern German Molasse Basin

Carbonate platform (Australia)
The Southern German Molasse Basin

The Malm has the characteristics of many different aquifer types
Evolution of the annual drilling meters
Deep geothermal projects in Bavaria (status: October 2016)

- Realized drilling meters (annual total)
- Realized drilling meters by ERDWERK (annual total)
- Planned drilling meters (annual total - expected)
- Number of active well sites

Year
Drilling meters [m MD]
0 5,000 10,000 15,000 20,000 25,000 30,000 35,000 40,000 45,000
Geothermal Development in Bavaria
Geothermal Development in Bavaria

Deep geothermal wells (excluding balneology):
- Green circle: Active well sites, realised by ERDWERK (10/15)
- Red circle: Wells realised by ERDWERK
- Yellow circle: Other realised wells

Max. pumping rate [l/s] and wellhead temperature [°C]
*: no information; source: http://www.geotis.de; 04/14

Blue circle: Planned well sites (approximate location)

Molasses Basin

- Munich
- Bad Wörishofen
- Mauerstetten - 1 l/s, 130 °C (reservoir-temperature)
## Geothermal Development Riem

<table>
<thead>
<tr>
<th></th>
<th>Riem Th. 1</th>
<th>Riem Th. 2</th>
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</thead>
<tbody>
<tr>
<td><strong>Depth</strong></td>
<td>3,275 m MD</td>
<td>3,400 m MD</td>
</tr>
<tr>
<td></td>
<td>3,020 m TVD</td>
<td>2,900 m TVD</td>
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<tr>
<td><strong>Water Temperature</strong></td>
<td>94 ° C</td>
<td></td>
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<td><strong>Production Rate</strong></td>
<td>75l/s</td>
<td></td>
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<td><strong>Maximum available heat</strong></td>
<td>8 MW</td>
<td></td>
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Project Optimization

• Uncertainty = project risk
  – Geological risks to drilling and
  – Hydrological output during production.

• Understanding/mitigating risks = Optimization = Cost savings

• Greater the certainty of envisaged productivity greater the chance a project will succeed at the planning and funding stage.

• Geothermal experience in Munich = reduction in uncertainties through
  – education,
  – Technical innovation
  – collaborative private and university lead research projects.

• Data obtained is utilized, analyzed and fed back
Project Optimization

- Simulation
- Design
- Execution
- Lessons Learnt
Project Optimization

Reduction in Normalised Drilling Time

- Unterföhring Th1
- Aschheim Th2
- Aschheim Th1
- Unterföhring Th2
- Ismaning Th1
- Ismaning Th2
- Pullach Th3
- Unterföhring Th3
- Unterföhring Th4
- Freiham Th1
- Freiham Th2

Normalized Total Drilling Time (days/1000m)

- ~1500 €/m
- ~1150 €/m
- ~1100 €/m

Spud Date

22.02.2008 to 10.05.2016

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SWM - GRAME
SWM - GRAME
Beyond Munich

- Holzkirchen 150° C at approximately 5000m TVD
- Direct use DHN
- Combined heat & power
- DHN already constructed
- Possibilities for smaller communities
Worldwide Geothermal Potential

- More stable political and regulatory framework is required to reach EU 2030 targets
- Geological risk insurance schemes (EU, Americas)
- Changing the norm so that geothermal heat becomes a standard practice in construction
- Share experiences & learn from challenges and success of others
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