



Risk Mitigation and Well Design - from an Economic Perspective -

Internationale Geothermiekonferenz · Freiburg, 20. May 2010

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Topics

1. Well Design & Economics – Electricity Project
2. Well Design & Economics – District Heating Project
3. Conclusion
4. [GGSC]



1. Well Design & Economics – Electricity Project

Project parameters

Drilling	
Final diameter	8 1/2"
TVD in m	4.500
Cost per m	1.800
Geology	
Delivery temperature in °C	150
Flow rate in kg/s	120
Power plant	
Cycle process	ORC
Electricity generation capacity in kW	5.446

**Project investment
total of 50 Mio. €**

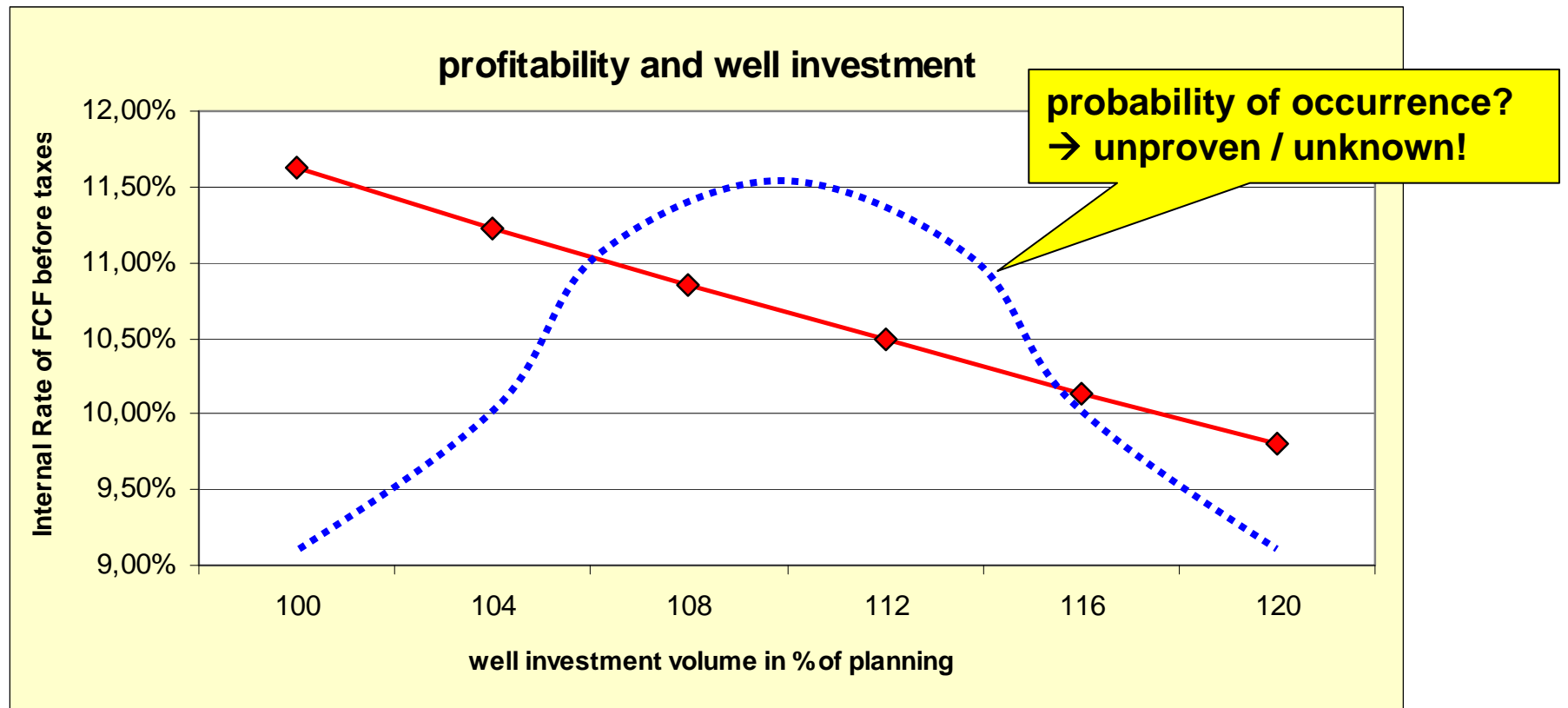
Options:

- 2 drill pads:
→ moderately deviated drilling
- 1 drill pad:
→ deviated drilling
- ...

Investment overview (no disruptions / reserves)

	2 drill pads => 5.000m MD	1 drill pad => 5.500m MD
planning	1.500.000	1.300.000
3D-seismic	2.000.000	2.000.000
drill site 1	800.000	1.000.000
drill site 2	800.000	
carriage / building / transfer drill equipment	1.200.000	800.000
well 1	9.000.000	9.900.000
well 2	9.000.000	9.900.000
long-term pumping test	1.500.000	1.500.000
constructors all risk insurance	860.000	940.000
discovery insurance	4.758.810	4.880.190
thermal water pipeline	2.500.000	0
other	1.000.000	1.000.000
SUM	34.918.810	33.220.190
Project IR of FCF	11,11%	11,63%

Sensitivity analysis



20% increase in cost of double well → 16% decrease in profitability

Economic evaluation:

➔ 1 drill pad is economically advantageous if reality matches planning

Risks:

- 1 drill pad concept
 - Drilling risk is significantly higher when large diameters and TVD > 4000m are required (probability of disruptions)
- 2 drill pad concept
 - Identification / planning / acceptance of 2nd drill site necessary
 - Coordination of drilling and pipeline challenging (→ long term pump testing)
 - Higher „sunk costs“ after well 1
 - No reskidding possible → makes well optimization more expensive

2. Well Design & Economics – District Heating Project

Project parameters

Drilling	
Final diameter	6 1/8"
TVD in m	2.700
Cost per m	1.400
Geology	
Delivery temperature in °C	90
Flow rate in kg/s	100
Sales	
Installed load (customer) in kW	120.000
Total heat consumption in MWh	210.000

**Project investment
total of 153 Mio. €**

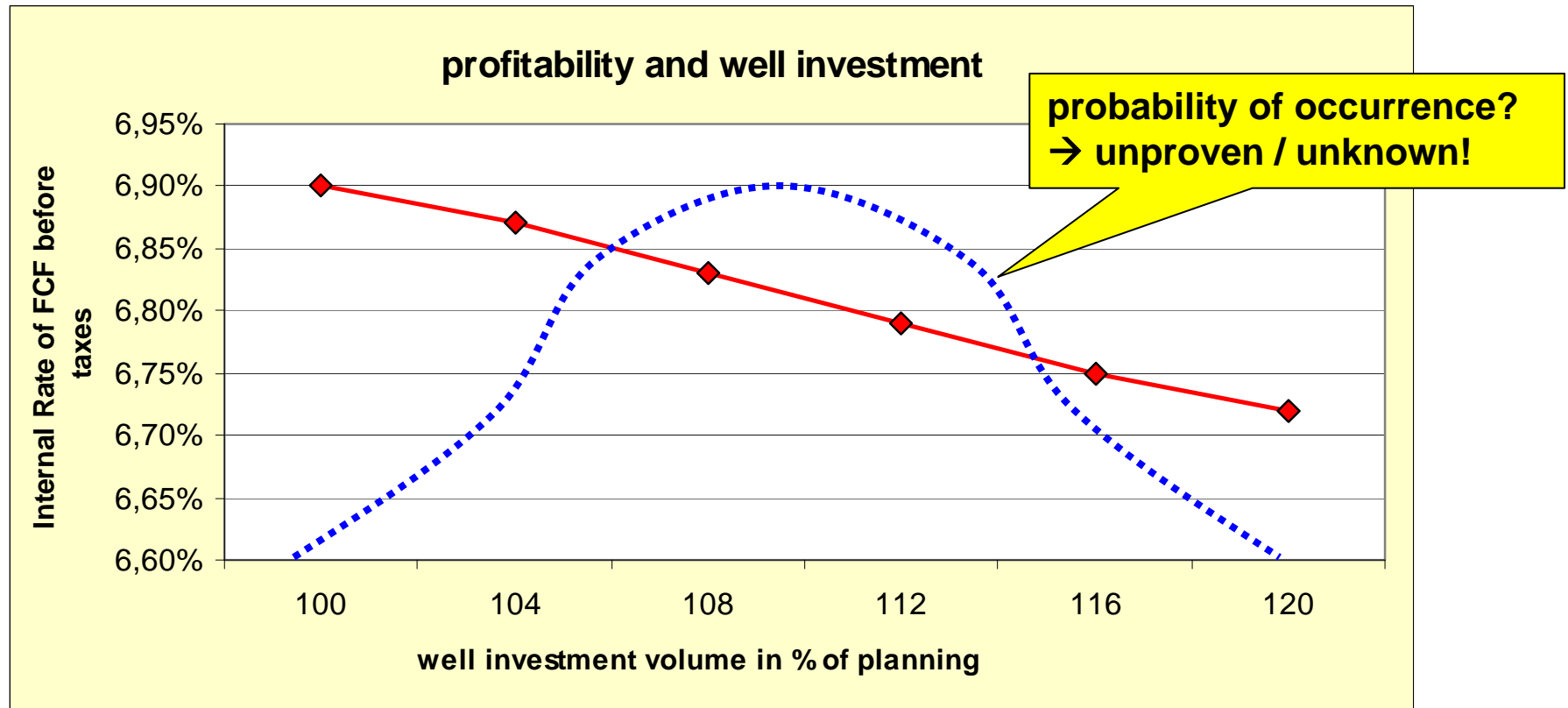
Options:

- 2 drill pads:
→ moderately deviated drilling
- 1 drill pad:
→ deviated drilling
- ...

Investment overview (no disruptions / reserves)

	2 drill pads => 2.900m MD	1 drill pad => 3.500m MD
planning	1.000.000	800.000
3D-seismic	1.000.000	1.000.000
drill site 1	700.000	900.000
drill site 2	700.000	
carriage / building / transfer drill equipment	750.000	450.000
well 1	4.060.000	4.900.000
well 2	4.060.000	4.900.000
long-term pumping test	1.000.000	1.000.000
constructors all risk insurance	390.000	470.000
discovery insurance	0	0
thermal water pipeline	1.200.000	0
other	500.000	500.000
SUM	15.360.000	14.920.000
Project IR of FCF	6,72%	6,90%

Sensitivity analysis



20% increase in cost of double well → 3% decrease in profitability

Economic evaluation:

➔ 1 drill pad is somewhat advantageous if reality matches planning

Risks:

- 1 drill pad concept
 - Drilling risk is just moderately higher when smaller diameters and TVD < 3000m are required
- 2 drill pad concept
 - Identification / planning / acceptance of 2nd drill site necessary
 - Coordination of drilling and pipeline challenging (→ long term pump testing)
 - Higher „sunk costs“ after well 1
 - No reskidding possible → makes well optimization more expensive

3. Conclusion

- From an economic perspective there is no general recommendation for the choice of drilling concepts (deviated, 1 or 2 drill pads ...)
- Projects with smaller diameters and TVD < 3000m required may tend to make use of presumably smaller drilling investments of 1 drill pad concepts and benefit from the “nonmonetary” pros, too.
- Projects with larger diameters and TVD > 4000m required may tend to concepts with 2 drill pads to reduce the serious risk of significant drilling budget overruns
 - unless optimized planning / preparation has reduced these risks in advance or
 - unless the local / regional learning curve has shown how to handle the risks
- Besides that, the availability / acceptance / permission concerning a second drill site is a crucial point by itself

4. [GGSC]

Gaßner, Groth, Siederer & Coll [GGSC] are the leading German business & legal consultants for deep geothermal projects with multiple project references in district heating and electricity production.

More than 30 professionals in multidisciplinary teams based at the [GGSC] offices in Berlin, Cologne, Frankfurt (O), Augsburg and Hannover do their utmost to exceed client's expectations.

The [GGSC] business consultants are specialized in planning, financial modelling and risk management of renewable energy projects. The [GGSC] lawyers are experts in all corresponding legal aspects to guarantee your success.

Together with our specialised network partners we offer you our guidance during your deep geothermal energy project and advise you on all operational and economic questions – from the idea to its implementation.

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Project references - www.geothermiekompetenz.de

national

- geothermal project Pullach (heat) – operating (www.iep-pullach.de)
- geothermal project Aschheim/Feldkirchen/Kirchheim (heat) – operating (www.afk-geothermie.de)
- geothermal project Unterföhring (heat) – operating (www.geovol.de)
- geothermal project Mauerstetten/Kaufbeuren (electricity/heat) – switched to research EGS
- geothermal project Garching (heat) – in realization (www.ewg-garching.de)
- geothermal project Oberhaching (heat) – in realization
- geothermal project Waldkraiburg (heat) – in realization
- geothermal project Geretsried (electricity/heat) – in planning
- geothermal project Vaterstetten/Grasbrunn/Haar/Zorneding (heat) – in planning
- geothermal project Holzkirchen (electricity/heat) – in planning
- geothermal project Puchheim (heat) – in planning
- Various Due Diligences of geothermal projects for MVV AG, RWE Innogy GmbH, Axpo AG
- And further more ...

international

- geothermal project Manchester (heat) – in planning (www.gtenergy.net)
- geothermal project Dublin (heat) – in planning (www.gtenergy.net)
- geothermal project Assal, Djibouti (electricity) – in planning (REI/Weltbank)
- East African Geothermal Initiative (electricity) – in planning (KfW with East African countries)
- geothermal use in Estonia – feasibility studies (Eestimaa Rohelised)

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