Geretsried in Bavaria – an example of a geothermal well drilling plan *vs* reality

International School on Geothermal Development

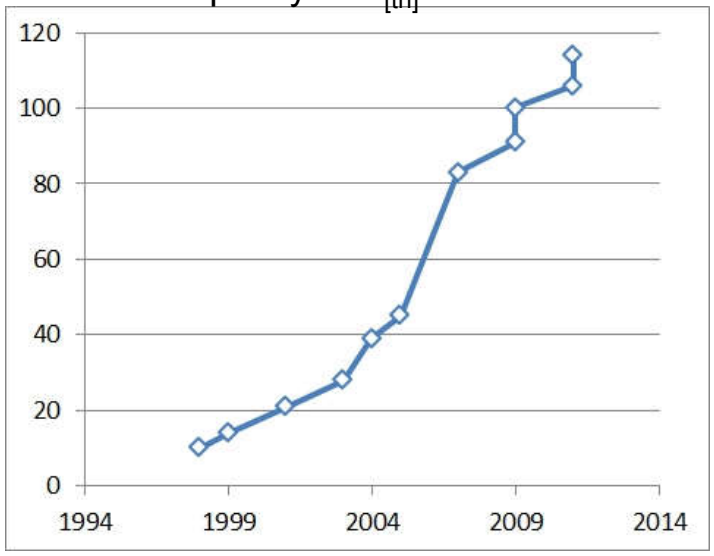
Trieste – 11-Dec-2015

Geothermal Projects in Bavaria

- Over the past 15+ years, the development of geothermal project in the Bavarian Molasse Basin enjoyed a linear growth
- A dozen geothermal projects with a total of over 110 $MW_{[th]}$ installed capacity (most of them including power generation), have been implemented mainly S-SE of Munich

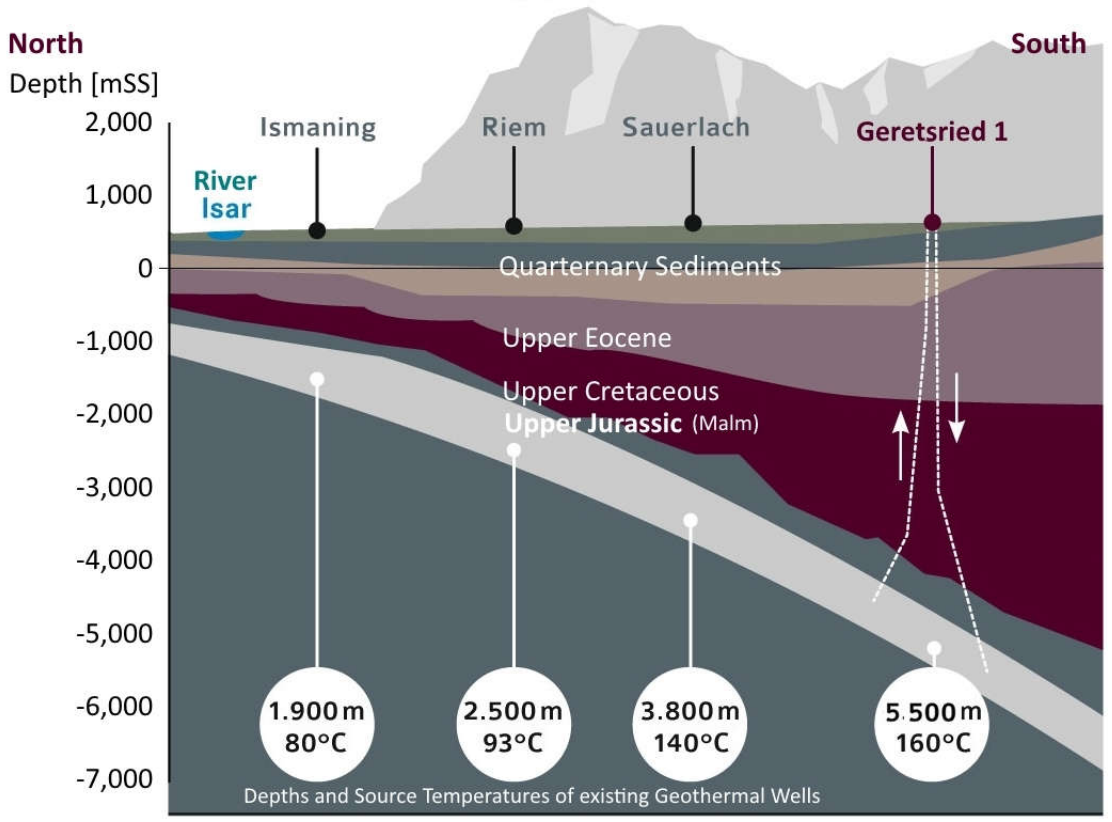
Project	Year	MW[th]
Erding	1998	10
Straubing	1999	4
Simbach	2001	7
Unterschleissheim	2003	7
Riem	2004	11
Pullach	2005	6
Unterhaching I	2007	38
Unterfoehring	2009	8
Aschheim	2009	9
Garching	2011	6
Poing	2011	8
		114

Installed Capacity $MW_{[th]}$

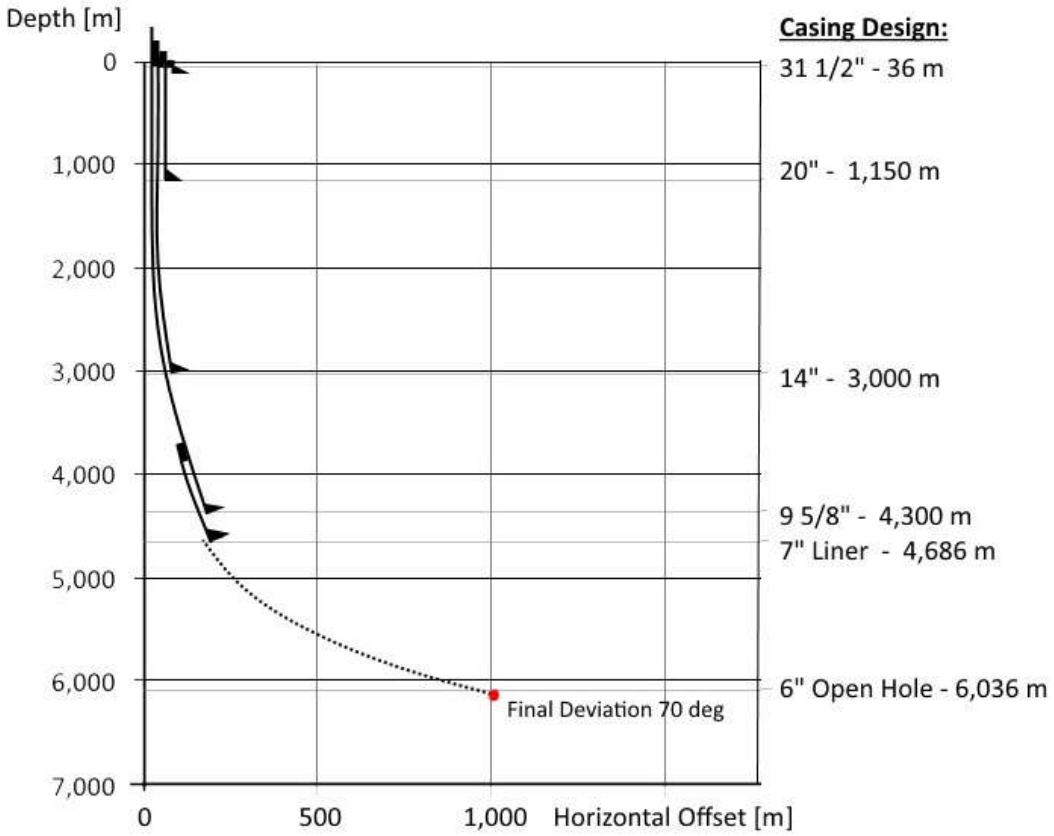


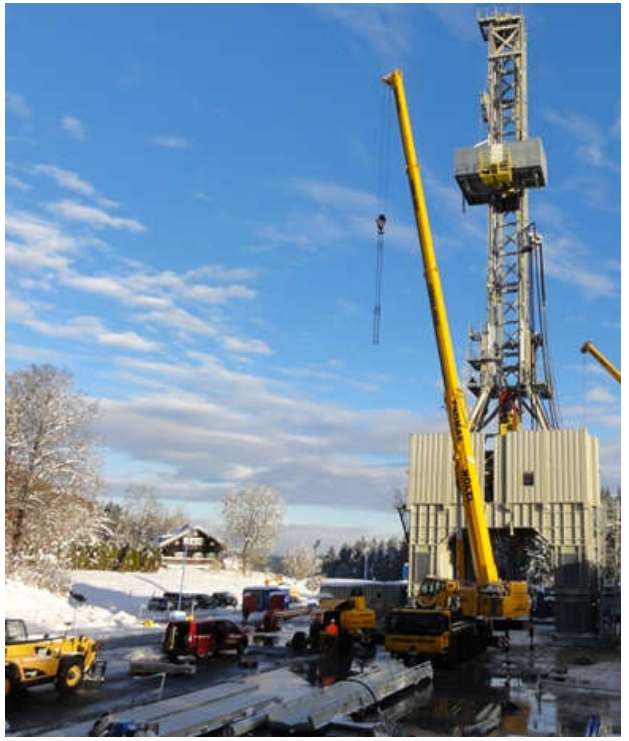
Geothermal Projects in Bavaria - Geretsried

- The Geretsried Project was planned to develop the deeper parts of the Jurassic aquifer where the expected temperature was predicted to be around 140+ deg C.
- The Geretsried-1 well was laid out to reach the Upper Jurassic aquifer at around 5,500 mSS
- At the anticipated aquifer temperature of 140+ deg C, an inflow of 100 litre/sec was required for the geothermal power generation project



Geothermal Projects in Bavaria - Geretsried





- a EURO Benteq 450 rig was used (hookload capacity: 450 tons at 2,000 Brake-Horsepower) to drill the difficult, deviated well

Geothermal Projects in Bavaria - Geretsried

- Having reached Total Depth as planned, the well was flow tested from the Upper Jurassic
- Unfortunately, the recorded inflow of some 10 l/sec was materially less than the prognosed 100 l/sec
- Although the inflow temperature was higher than expected (165 actual vs 140 Dec C prognosis), the total heat flow was insufficient
- The observed and unexpected gas inflow (as be seen at the flare on the photo) was an additional unplanned event
- Total well costs have accumulated to some 11.5 MM EUR (~ 16 MM USD in 2013)

	[EUR]
Planning and Engineering	400,000
Drilling Rig Mobilization	750,000
Site Preparation	1,750,000
Tangible Costs Drilling	2,200,000
Intangible Costs Drilling	4,680,000
Consumables	760,000
Drilling Rig De-Mobilization	1,000,000
Total Well Costs	**11,540,000**

Geretsried Project – Pre-Drilling Economics

Base Assumptions		Fill in value
		Calculated
Parameter		
Depth of the well	6,040	*[m]*
Geothermal gradient	0.0255	*[K/m]*
Reservoir temperature	154.0	*[°C]*
Flow of the well	100.0	*[l/s]*
Well head temperature	145.6	*[°C]*
Reinjection temperature	83.0	*[°C]*
Conversion efficiency thermal power	96.0	*[%]*
Full load hours per year	8,000	*[h]*
Thermal Power	25.1	*[MW]*
Thermal Energy	201.1	*[GWh]*
Heating hours per year	3,200	*[h]*
Heating energy per year	80.5	*[GWh]*
Annual growth heat sales	3.0	*[%p.a.]*
District heating wholesale price per MWh	50.0	*[EUR]*
Electricity per year	14.5	*[GWh]*
Received price per MWh electricity sold	75.0	*[EUR]*
Size of electric power station	2.6	*[MW]*
Total Investment	49.7	*[MM EUR]*
Conversion efficiency electric power	12.0	*[%]*
Price increase for electricity bought	2.0	*[%p.a.]*
Price increase general costs	2.0	*[%p.a.]*
Price of CO_2 Emission	5.0	*[EUR]*
Capacity of 1 W =	1.16222	*[kcal/h]*

CAPEX				
Parameter			***Depreciation***	
Well Drilling	25.0	*[MM EUR]*	30	*[yrs]*
Drilling Contingency	2.5	*[MM EUR]*	30	*[yrs]*
Building and Land	1.2	*[MM EUR]*	15	*[yrs]*
Submersible Pump	2.0	*[MM EUR]*	5	*[yrs]*
Heating Losses	3.0	*[MM EUR]*	5	*[yrs]*
District Heating Pipeline	10.0	*[MM EUR]*	30	*[yrs]*
Plant and Facilities	5.0	*[MM EUR]*	20	*[yrs]*
Other/Miscellaneous	1.0	*[MM EUR]*	5	*[yrs]*
Total CAPEX € million	**49.7**	*[MM EUR]*		

OPEX		
Parameter		
Increase in provisions	48.0	*[M EUR p.a.]*
Material and third party costs	0.0	*[M EUR p.a.]*
thereof electric power	0.0	*[M EUR p.a.]*
thereof oil	0.0	*[M EUR p.a.]*
Personnel costs	200.0	*[M EUR p.a.]*
Other operating expenses	300.0	*[M EUR p.a.]*
Other operating	0.0	*[M EUR p.a.]*
Start up costs	0.0	*[M EUR p.a.]*
Maintenance	100.0	*[M EUR p.a.]*
Total OPEX	**648.0**	*[M EUR p.a.]*

Results	**BT**	**AT**	
Internal rate of return (ROR)	9.5%	8.6%	*[%]*
Net present value (NPV)	16.4	11.6	*[MM EUR]*
Pay back period	13.9	15.6	*[years]*

Geretsried Project – Post-Drilling Economics

Base Assumptions		Fill in value
Parameter		Calculated
Depth of the well	6,040	*[m]*
Geothermal gradient	0.028	*[K/m]*
Reservoir temperature	169.1	*[°C]*
Flow of the well	72.0	*[l/s]*
Well head temperature	160.7	*[°C]*
Reinjection temperature	91.6	*[°C]*
Conversion efficiency thermal power	96.0	*[%]*
Full load hours per year	8,000	*[h]*
Thermal Power	20.0	*[MW]*
Thermal Energy	159.8	*[GWh]*
Heating hours per year	3,200	*[h]*
Heating energy per year	63.9	*[GWh]*
Annual growth heat sales	3.0	*[%p.a.]*
District heating wholesale price per MWh	50.0	*[EUR]*
Electricity per year	11.5	*[GWh]*
Received price per MWh electricity sold	75.0	*[EUR]*
Size of electric power station	2.1	*[MW]*
Total Investment	49.7	*[MM EUR]*
Conversion efficiency electric power	12.0	*[%]*
Price increase for electricity bought	2.0	*[%p.a.]*
Price increase general costs	2.0	*[%p.a.]*
Price of CO_2 Emission	5.0	*[EUR]*
Capacity of 1 W =	1.16222	*[kcal/h]*

- At assumed 72 l/sec the project NPV is zero; **at the actually observed flow of 10 l/sec project was uneconomic**

CAPEX				
Parameter			***Depreciation***	
Well Drilling	25.0	*[MM EUR]*	30	*[yrs]*
Drilling Contingency	2.5	*[MM EUR]*	30	*[yrs]*
Building and Land	1.2	*[MM EUR]*	15	*[yrs]*
Submersible Pump	2.0	*[MM EUR]*	5	*[yrs]*
Heating Losses	3.0	*[MM EUR]*	5	*[yrs]*
District Heating Pipeline	10.0	*[MM EUR]*	30	*[yrs]*
Plant and Facilities	5.0	*[MM EUR]*	20	*[yrs]*
Other/Miscellaneous	1.0	*[MM EUR]*	5	*[yrs]*
Total CAPEX € million	**49.7**	*[MM EUR]*		

OPEX		
Parameter		
Increase in provisions	48.0	*[M EUR p.a.]*
Material and third party costs	0.0	*[M EUR p.a.]*
thereof electric power	0.0	*[M EUR p.a.]*
thereof oil	0.0	*[M EUR p.a.]*
Personnel costs	200.0	*[M EUR p.a.]*
Other operating expenses	300.0	*[M EUR p.a.]*
Other operating	0.0	*[M EUR p.a.]*
Start up costs	0.0	*[M EUR p.a.]*
Maintenance	100.0	*[M EUR p.a.]*
Total OPEX	**648.0**	*[M EUR p.a.]*

Results	**BT**	**AT**	
Internal rate of return (ROR)	6.3%	6.0%	*[%]*
Net present value (NPV)	1.5	0.0	*[MM EUR]*
Pay back period	19.2	20.0	*[years]*

… back to main presentation