



Slim hole Drilling for Geothermal wells



Ministerie van Economische Zaken



Presentation Outline

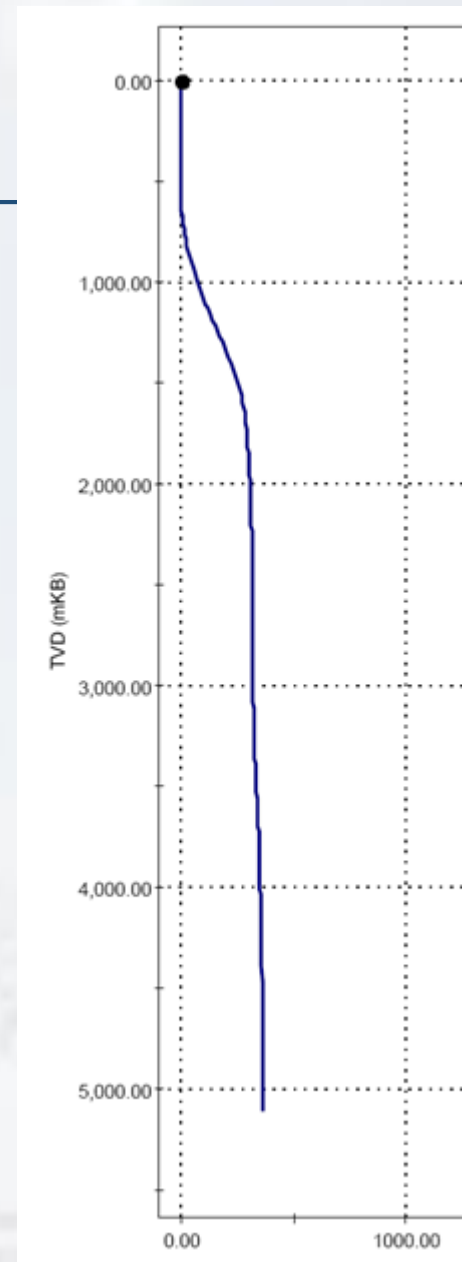
- Doelstelling
- Luttelgeest-01 well
- Slim down mogelijkheden ultradiepe geothermie
- Design/ontwerp overwegingen
- Kosten en tijd analyse
- Risico analyse
- Algemene beschouwingen slimhole

Doelstelling Onderzoek

- Haalbaarheid Slimhole welldesign voor ultradiepe geothermie
- Kosten en tijd analyse
- Beperkte risico analyse
- Vertaling naar diepe geothermie

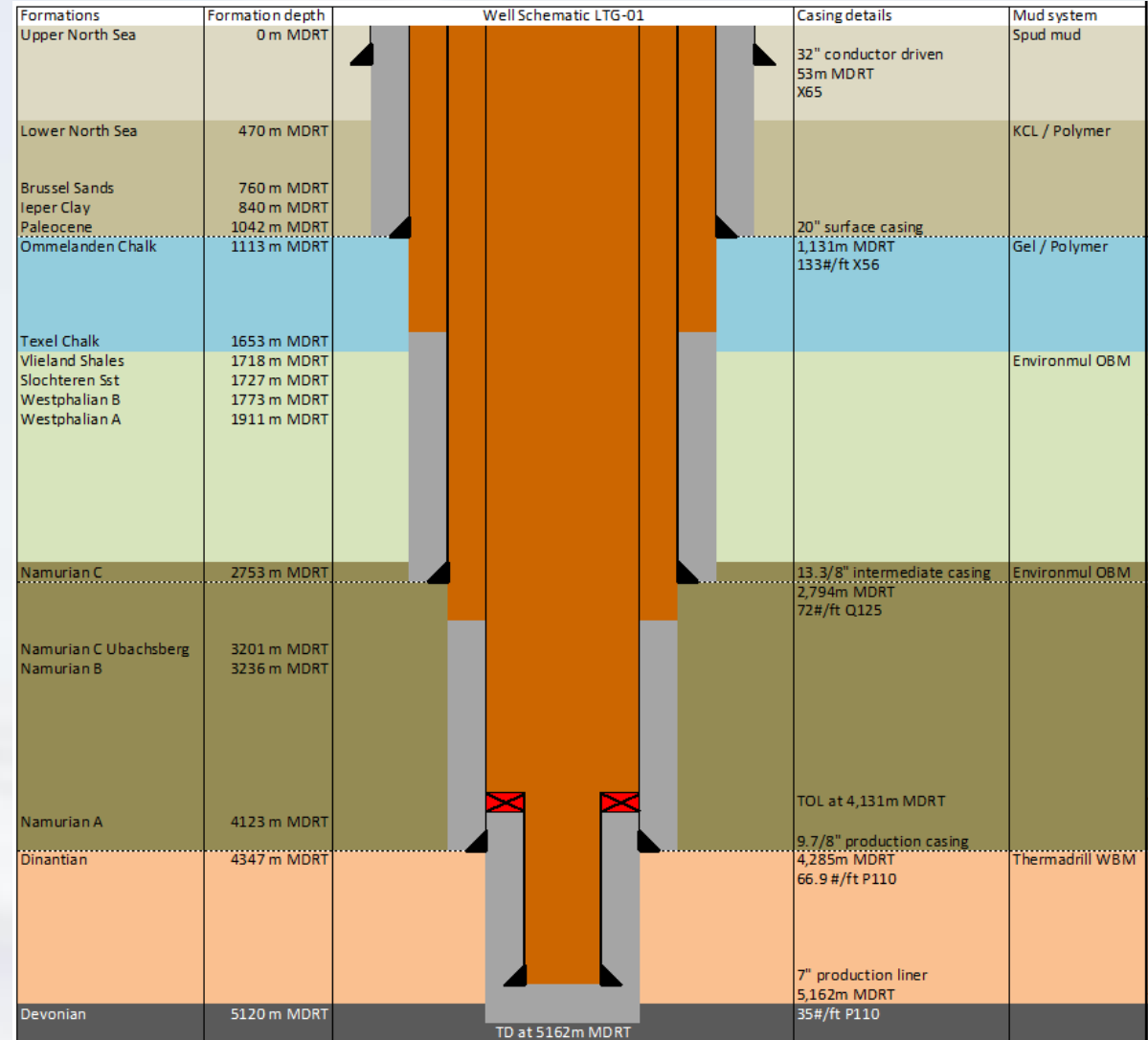
Luttelgeest-01 put (LTG-01)

- Geboord door Total E&P in 2004
- Totale diepte 5,162mMD (5109.6 TVD/NAP)
- Totaal aantal dagen 141
- Target reservoir Dinatiën carbonaten formatie (hydrocarbons)
- Temperatuur op TD was 204°C
- Lage Porositeit in de Carbonaten
- Re-entry in 2005, voor puttest en abandonment
- Geschatte kosten 21 Miljoen Euro
- Non productive time +/- 6.3%



Luttelgeest-01 put (LTG-01)

- 32" conductor pipe was driven to 53m
- 20" casing set at 1131m
- 13 3/8" casing set at 2794m, low ROP's in Lower Westphalian
- 9 7/8" casing set at 4285m. 10 bitruns, heavy reaming, tight spots and several stuckpipe incidents.
- 8 1/2" section drilled to TD @ 5162m in 8 bit runs & two coring runs. Some downhole losses up to 25 m3/hr. 7" liner set at 4950m.
- After extensive wireline logging program well was suspended with 3 cement plugs and HBP Bridgeplug.



Slimhole opties

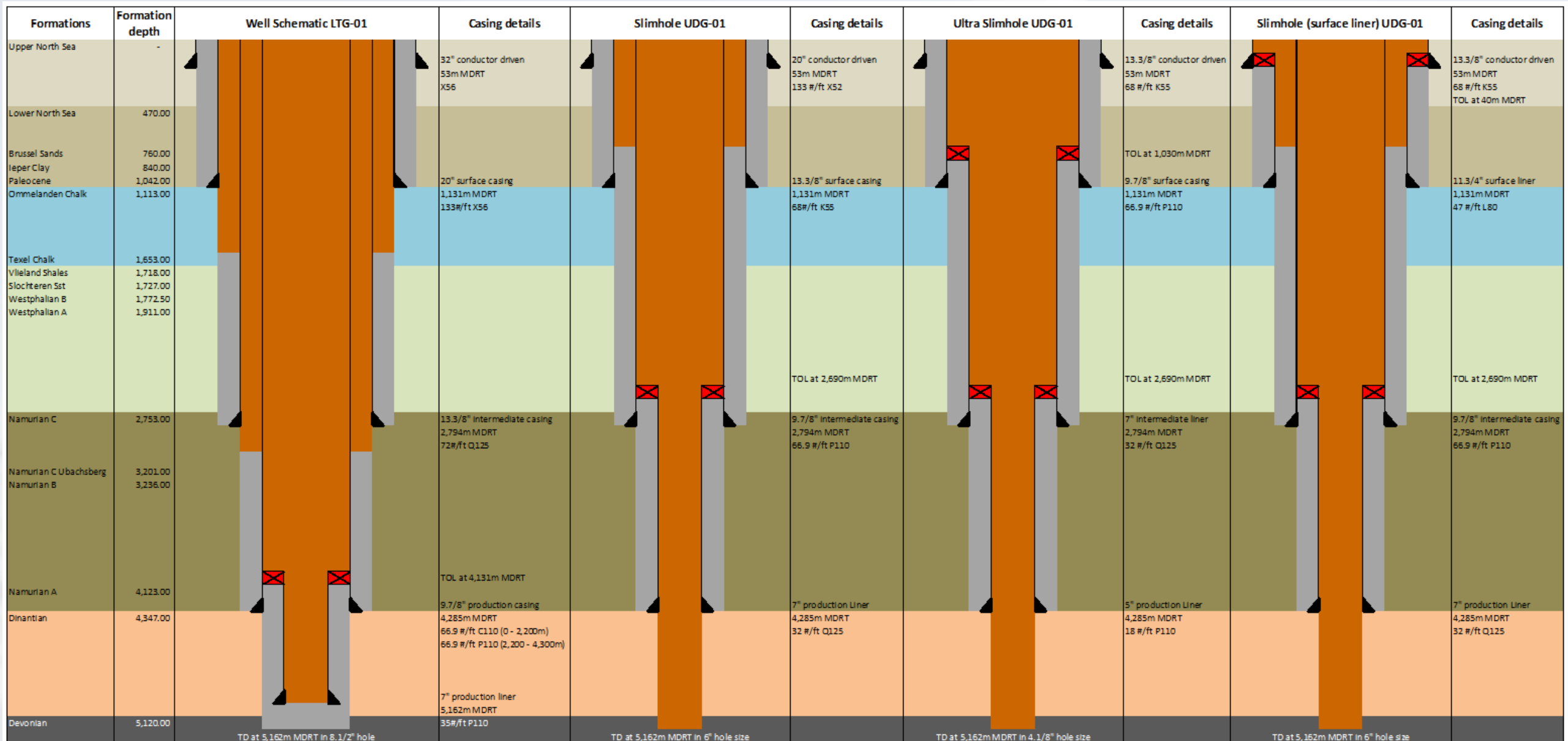
LTG-01, 5 verbuizingen van de oppervlakte naar totale diepte (incl. conductor and liner). Reservoir sectie geboord in 8 ½"

String	LTG-01	Slim hole design	Ultraslim hole design	Slimhole (surface liner)
Conductor	32"	20"	13.3/8"	13.3/8"
Surface Casing	20"	13.3/8"	9.7/8"	11.3/4" (L)
Intermediate Casing	13.3/8"	9.7/8"	7" (L)	9.7/8"
Production Casing	9.5/8"	7" (L)	5" (L)	7" (L)
Production Liner	7" (L)	5" (L)	3.1/2" (L)	5" (L)

Slim down opties:

- Reservoir sectie in 3 7/8", niet mogelijk vanwege torque limieten 2 7/8" boorpijp. (geen contingency!!)
- Reservoir sectie in 4 1/8", **ultra slim design** (geen contingency!!)
- Reservoir sectie in 6", **slim hole design** (4 1/8" contingency)
- Slim hole (surface liner) well design

Slimhole opties



Slimhole opties – Ontwerp overwegingen

- Casing Design
- Underreaming
- Cementing Design
- Mud Design



Slimhole opties – Mud Design

Mud type	OHXS	LTG-01	Slim hole	Ultra-slim hole	Slim hole (surface liner)
[-]	[%]	[m ³]	[m ³]	[m ³]	[m ³]
Spud mud	30%	725	300	175	225
KCL/Polymer	20%	1625	625	375	500
Gel/Polymer	10%	1225	550	300	475
<u>Environmul OBM</u>	10%	1775	875	450	825
<u>Environmul OBM</u>	10%	1425	675	425	675
<u>Thermadrill</u>	10%	850	600	400	600

Cuttings	LTG-01	Slim hole	Ultra-slim hole	Slim hole (surface liner)
[-]	[mT]	[mT]	[mT]	[mT]
WBM cuttings	5847	2439	1355	2127
OBM cuttings	2894	1560	762	1560
Total cuttings	8740	3999	2117	3687
OBM skips	579	312	152	312

Slimhole opties – Ontwerp overwegingen

- Casing Design
- Underreaming
- Cementing Design
- Mud Design
- E-line and LWD tools
- Wellhead and Christmas trees



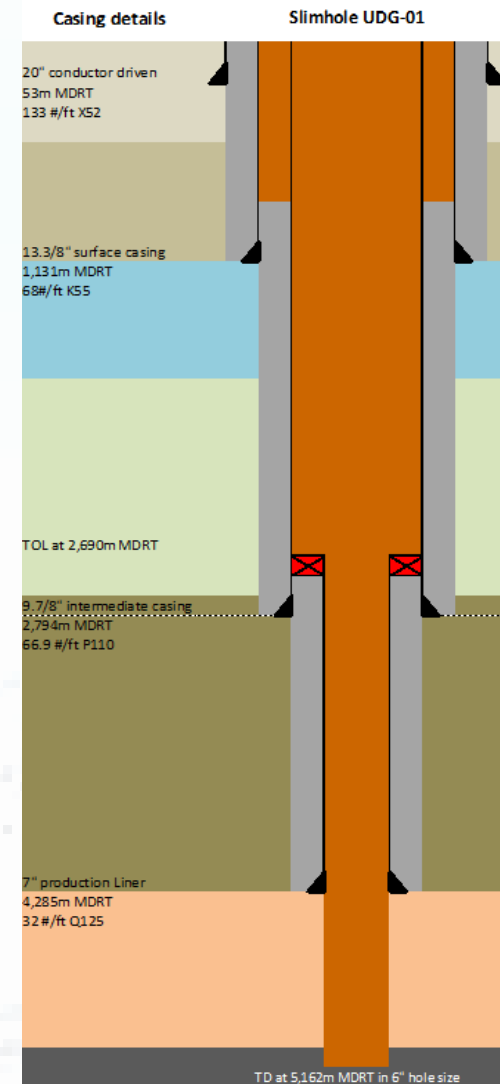
Geselecteerde Slimhole optie

- Ultra slimhole design – geen contingency / geen LWD in reservoir sectie
- Slimhole Design(surface liner) - Underreaming

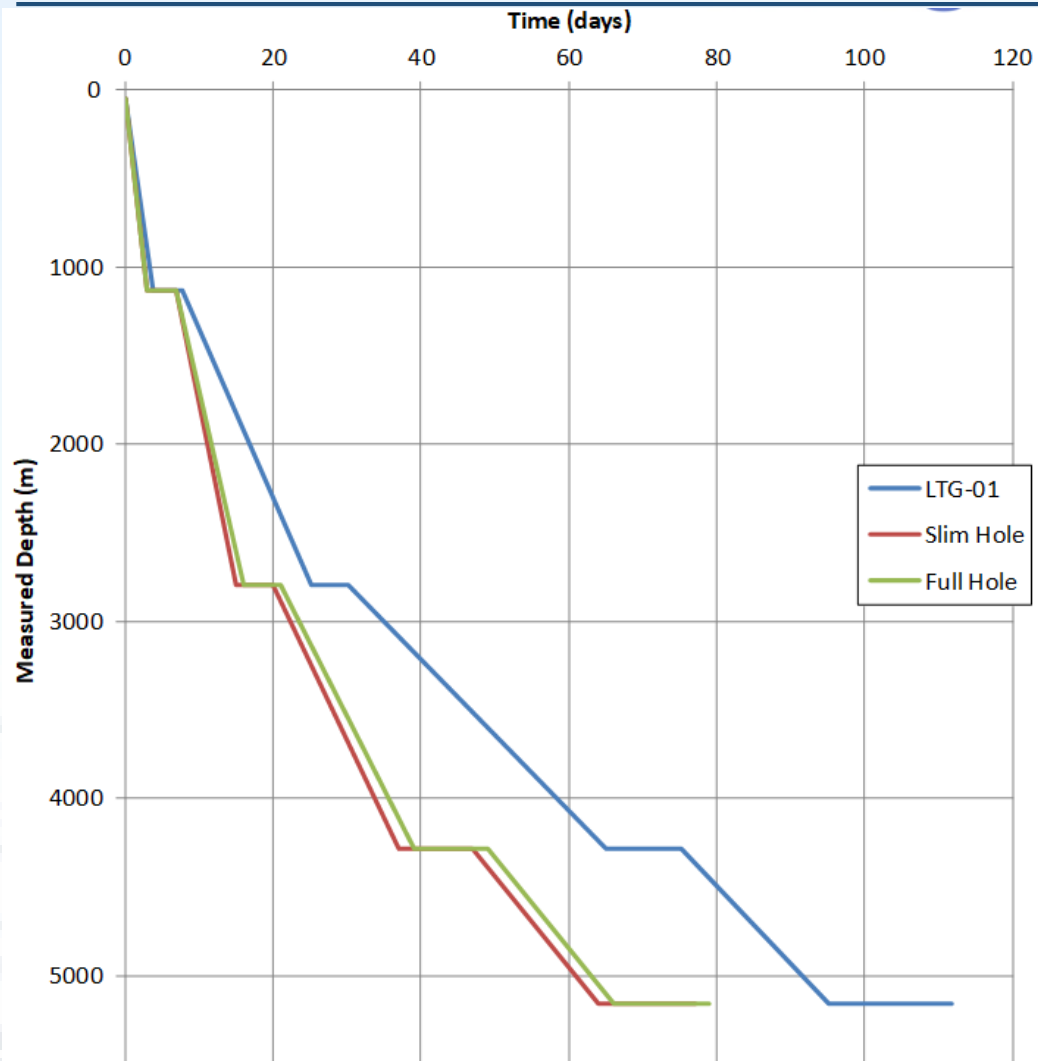
Slim Hole Well Design

Slim Hole Well Design

- Contingency hole size
- Reservoir sectie loggen met LWD
- Gangbare maten voor tools, verbuizingen en boorpijpen
- Geen underreaming nodig
- Aanzienlijke spoelings en boorgruis besparingen



Tijd & Kosten - Tijd



- E-line logging & Coring excluded
- Reservoir liner & abandonment included
- ROP analyzed by bit vendor
- Slimhole vs Full hole, 77-79 days
- Luttelgeest 01, 112 days

Tijd & Kosten - Kosten

	COSTS SLIM HOLE	COSTS FULL HOLE
OCTG	€ 875,000.00	€ 2,147,000.00
Tubular running	€ 107,000.00	€ 120,000.00
Wellhead & tools	€ 791,000.00	€ 946,000.00
Liner hanger(s)	€ 810,000.00	€ 405,000.00
Rig	€ 2,756,000.00	€ 3,295,000.00
Operator costs	€ 1,370,000.00	€ 1,387,000.00
Rigsite	€ 830,000.00	€ 996,000.00
Cement	€ 201,000.00	€ 329,000.00
Mud	€ 676,000.00	€ 1,257,000.00
Drilling Tools	€ 807,000.00	€ 833,000.00
Drilling Bits	€ 395,000.00	€ 608,000.00
Surface logging	€ 145,000.00	€ 149,000.00
E-line logging	€ -	€ -
Solids Control	€ 747,000.00	€ 1,348,000.00
Logistics	€ 119,000.00	€ 219,000.00
Total	€ 10,624,000.00	€ 14,034,000.00

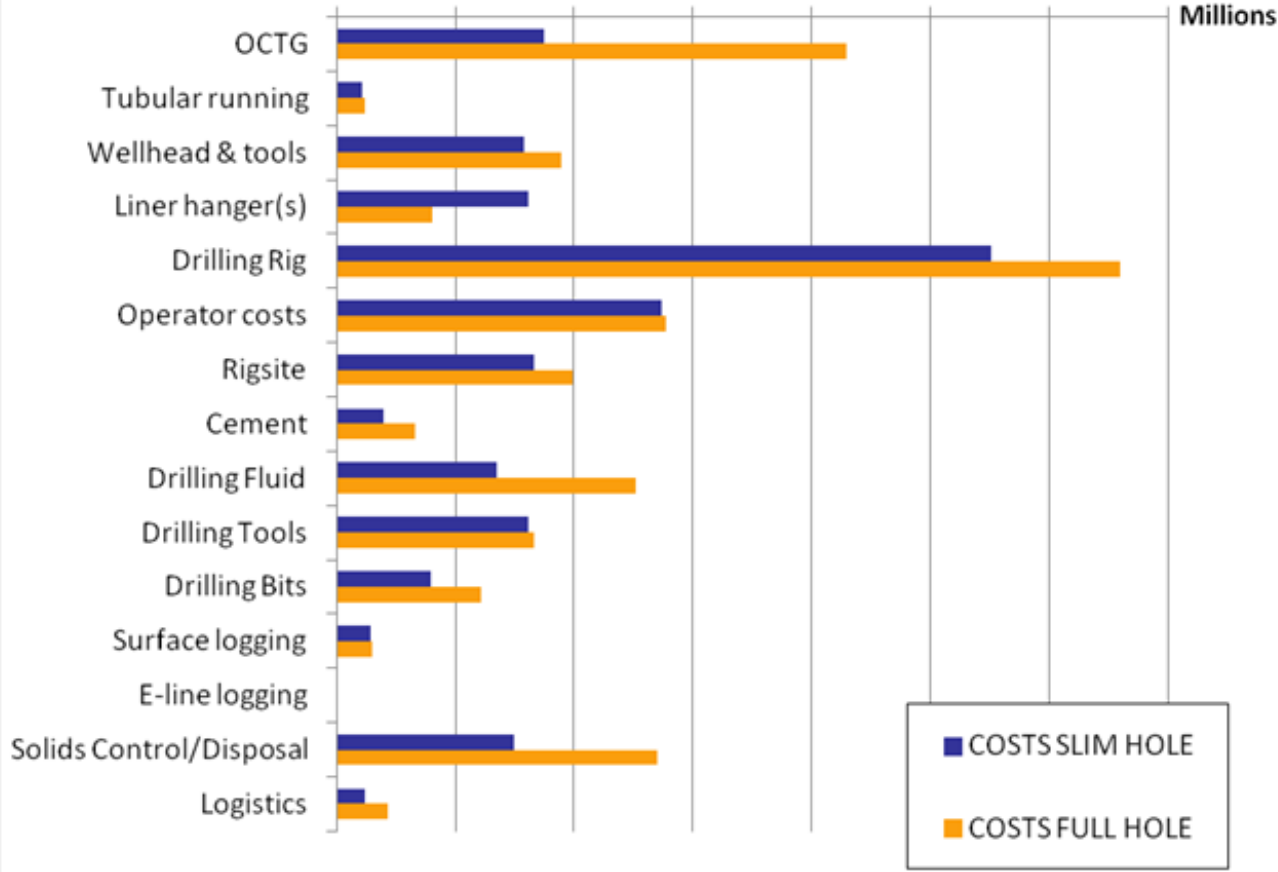
32%

Tijd & Kosten - Kosten

Cost comparison slim hole vs full hole

€ - € 0.50 € 1.00 € 1.50 € 2.00 € 2.50 € 3.00 € 3.50

Millions



- OCTG (1.3M€)
- Drilling rig (540k€)
- Drilling Fluids (580k€)
- Solids Control/disposal (600k€)

Risico Analyse

- Kans op boorpijp of tool falen
- Hogere drukverliezen (hogere ECD)
- Well Control
- Cement Design
- Coring
- Toekomstig gebruik van de put als injector/producer

No	Hazard	Consequence	Impact type	Probability	Impact	Risk
1	Drill string failure	* Due to the drilling of smaller hole sizes, smaller tools and pipe is required with lower torque limits. This may lead to drill string failures. * Fish in hole. Attempt to retrieve. * If unsuccessful, cement and sidetrack	Financial (Slimhole)	3-Moderate	4-High	MEDIUM
			Financial (Conventional)	2-Unlikely	4-High	MEDIUM
2	Drilling induced losses	* Due to smaller hole sizes, the equivalent circulation density (ECD) pressure acting on the formation while drilling, is higher. It is therefore more likely that the ECD will exceed the fracture strength of the formation at a certain point. This will lead to drilling induced losses. * It can be attempted to combat these using LCM-pills, but that will not increase formation strength. Some stress caging may be attempted, but in the end, pump rate needs to be reduced leading to hole cleaning issues and the risk of not being able to reach section TD. (Ref to commit to casing prematurely hazard). * When massive losses are induced, a cement plug may need to be set from which a sidetrack needs to be initiated.	Financial (Slimhole)	3-Moderate	5-Very High	HIGH
			Financial (Conventional)	2-Unlikely	4-High	MEDIUM
3	The need to commit to a casing seat prematurely	When having to commit to a casing seat prematurely, the risk is greater than compared to a full hole well. * Losing a hole size results in the need to drill 4.1/8" reservoir section, with higher risk of drill string failure; * Unable to acquire logs; * Not achieving well objectives.	Financial (Slimhole)	3-Moderate	5-Very High	HIGH
			Financial (Conventional)	3-Moderate	3-Moderate	MEDIUM

Algemene beschouwingen

- Aanzienlijke kosten besparing
- Verhoogd risico profiel
- Wenselijkheid van contingency hole sectie
- Gebruik van de put als injector/producer
 - ESP size / drukverliezen
 - Hogere injectie drukken/zwaardere pompinstallatie
 - Kans op geïnduceerde seismische activiteit
 - Versneld optreden van scaling
- Vertaling productie test naar full hole putmaat
- Prove up project of play?!

Voor- en Nadelen

Slimhole Exploration for UDG

ADVANTAGES

- Significant Cost reduction >30%
- Lower environmental impact
 - Smaller rig & smaller footprint
 - Less cuttings/drilling mud
 - Less flow on well test
- Lower project cost at front end
- Potential use as monitoring well

DISADVANTAGES

- Well likely not suitable for production/injection or limited flow.
- Higher total project cost (cost of additional exploration well)
- Increased risk of drilling difficulties
- Reduced Logging capabilities
- Extrapolation of test data to largebore wells not proven
- Higher injection pressures
- Higher pressure drop can cause increase rate of scaling

En hoe zit het dan met de diepe geothermie!?

Pijnacker Wells	The Hague Wells	Koekoekspolder Wells	Honselersdijk Wells
14" @ 72m	13 3/8" @ 262m	13 5/8" @ 72m	20" @ 100m
12 1/4" hole	12 1/4" hole	12 1/4" hole	12 1/4" hole
9 5/8" @ 1050m	10 3/4" @ 1190m	9 5/8" @ 1117m	9 5/8" @ 1102m
8 1/2" hole	8 1/2" hole	8 1/2" hole	8 1/2" hole
7" @ 2369m	7" @ 2163m	7" @ 2097m	7" @ 2471m
6" hole	6" hole	6" hole	6" hole
4 1/2" @ 2825m	4 1/2" @ 2327m	4 1/2" @ 2258m	4 1/2" @ 3180m

- Kostenbesparing aanzienlijk minder dan bij ultra diepe geothermie
- Ultraslim maakt de put hoogstwaarschijnlijk ongeschikt voor ontwikkeling
- Lager debiet vs warmtevraag
- Nadelen vergelijkbaar.
- Project or play!?

Einde

