ARUP

Annex B

Department for Energy Security and Net Zero

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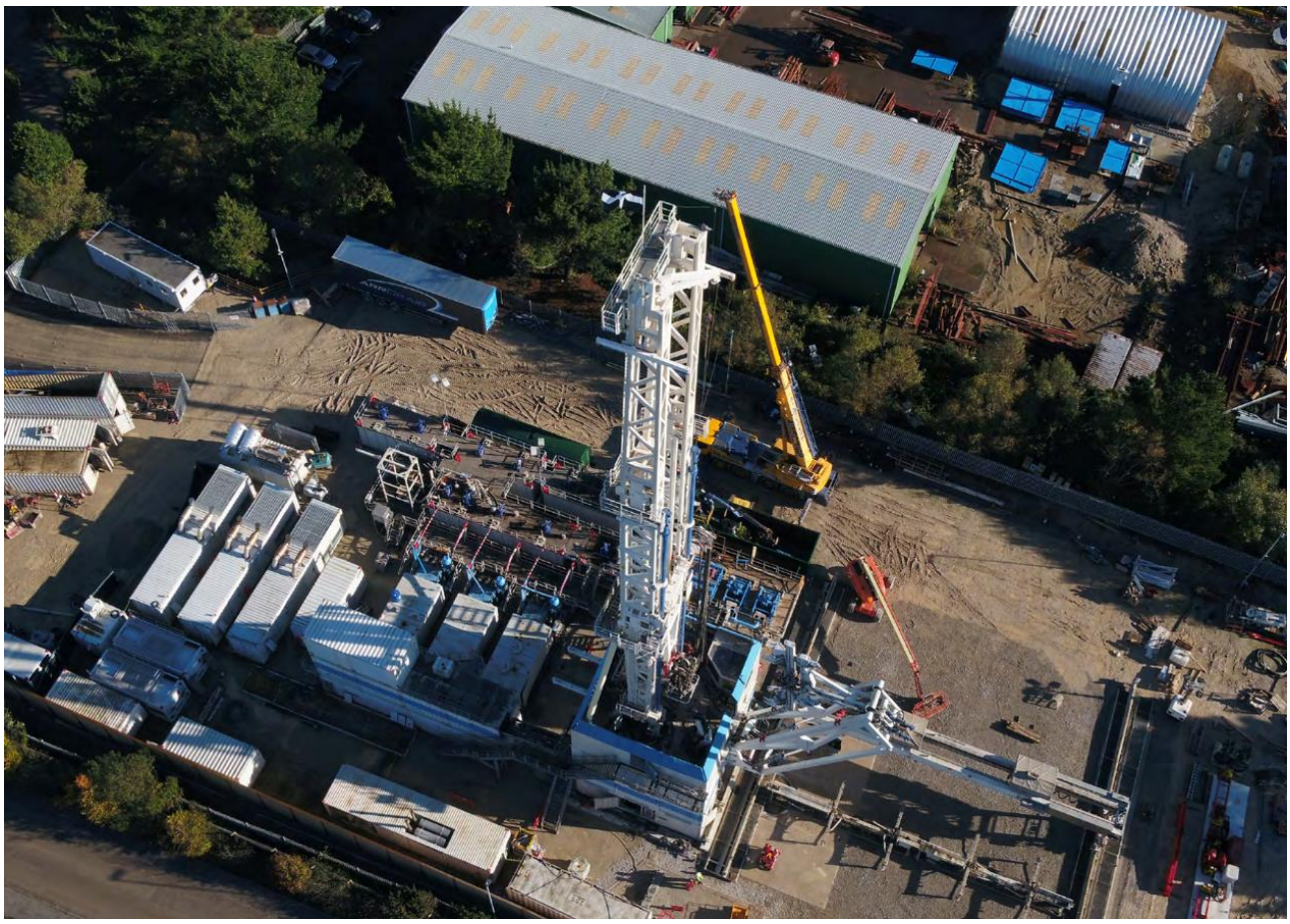

@Arup (2021) Deep Geothermal Energy – Economic Decarbonisation Opportunities for the United Kingdom

Job number 298791-00

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Contents

Tables

B.1 Levelised Cost of Heat (LCOH) – Data Tables

This appendix contains the input and output tables from the LCOH model. Discussion of the data inputs is provided in Table 1. This table should be reviewed in conjunction with Section 3 (LCOH) of the Main Report which outlines the data sources and references.

Table 1: Summary of data inputs and rationale for use in LCOH model

Description	Closed loop	Open loop	Minewater	O&G Conversion	Coaxial	Deep Geothermal
Technical						
Timescales	Stakeholders (4 UK Consultants): Overall timescale: 20 BHs (6 to 12 months), 12 to 24 months (100 BHs). Pre-development is typically 6 months (4 to 8 months) Construction period (wells and plant) typically 9 - 12 months	Stakeholders (3 UK Consultants): Owing to EA permitting, pre-development 1 - 2 years Drilling and testing can take 9 to 12 months	Stakeholders (3 UK Consultants): Owing to EA permitting, pre-development 1 - 2 years Drilling and testing can take 9 to 12 months	Stakeholder (1 UK Consultant): Permitting between 0.5 to 1.5 years Construction couple of months to 1 year	Stakeholder (1 UK Consultant): Permitting between 0.5 to 1.5 years Construction couple of months to 1 year	Used same literature and stakeholder data as from the LCOE inputs (see Appendix C)
Plant Operating Period	All GSHP system assumed at 25-years (lower 20yrs, upper 40 yrs.). Consistent with stakeholder engagement. However, is noted that many GSHP system may operate for >25 yrs.					
Heat output	Calculated with 50 no. boreholes, 40W/m assumption, 150m depth, SPF 3 (based on stakeholder data).	Calculated with ΔT 8°C (based on stakeholder data, 6°C to 10°C), and low/medium/high flow rates of 10l/s, 20l/s, 40l/s, SPF 4 (based on stakeholder data)	Calculated with ΔT 8°C (based on stakeholder data, 6°C to 10°C), and low/medium/high flow rates of 20l/s, 60l/s, 120l/s, SPF 4 (based on stakeholder data)	Coaxial end member: Heat output same as Coaxial. Open loop end member: O&G wells produce c. 100 to max 1000 barrels of oil per day. This is equivalent to 0.185 to 1.85 l/s. This flow rate was used to inform the energy capacity assessment.	Low/medium/high: 1km well (130kW, 150kW, 170kW) with SPF 6. 2km well (200kW, 240kW, 280kW) no HP 4km (470kW, 490kW, 510kW) no HP (HP not used for 2km or 4km system as temperature suitable for direct heating)	Used TNO DoubletCalc, see Appendix A. NOAK system output based on ×4 factor relative to FOAK system.
Cooling output	As above but cooling calculation with SPF of 5	As above but cooling calculation with SPF of 5	As above but cooling calculation with SPF of 5	None (production fluid too hot). Use of absorption/adsorption chillers have yet to be extensively deployed economically; so cooling has been excluded		
Availability	NOAK only (Hospital), 60% heating, 20% cooling annual capacity. Assume 80% annual operation, owing to need for heating (hot water), and cooling (refrigeration).	Hospital (same as closed loop assumption) DHN: FOAK, 2000 annual hours (stakeholder data), NOAK, 6000 hours (based on Danish	Same assumptions as open loop	DHN: FOAK and NOAK systems assume 6000 annual hours (based on Danish publication/ Europe operations) DHN: FOAK, 2000 annual hours (stakeholder data), NOAK, 6000 hours (based on Danish publication/ Europe operations)		

Description	Closed loop	Open loop	Minewater	O&G Conversion	Coaxial	Deep Geothermal
		publication/ Europe operations)				
Learning Rates	Publication indicates -0.8% to 3.3% learning rate (with doubling of HP numbers)[1,2]. Report suggests heat pump growth; from 20 million units in Europe in 2022, to 60 million in 2030[3]. This assessment inferred 40 million heat pump units (i.e., double 2022, 20 million value) in 2026, indicates a doubling in 4 years; equivalent to annual learning rates of 0.8% to -0.2% (3.3%/4, -0.8%/4).				Consistent with LCOE learning rates for deep well drilling. See Appendix C.	
Hurdle Rate	7.5% for shallow geothermal systems, consistent with previous internal DESNZ analysis, noting that this analysis was not specific to geothermal. 10.1%. Consistent with 2025 DESNZ commissioned research[4] for deep geothermal.					
Back-up heat source	A back up heat source was applied to all scenarios as requested by DESNZ. Within the model back-up heat source (gas boiler) was implemented and scaled to cover 100% redundancy of the geothermal system (i.e., a 2MW geothermal system would also have a 2MW gas boiler system). The gas boiler costs are based on Arup experience and based on the following assumptions: £8/kW (Pre-development), £49/kW (Construction), including boilers, pumps, but excluding piping (as this is a back-up system so is assumed to interface with existing heating network), and Fixed O&M of £0.49/kW. Fixed O&M costs were included as the system needs to be maintained, however variable O&M was excluded as the system is back up and therefore unlikely to be operational (so operational costs should be excluded). The impact of back-up heat sources on levelised costs was minor.					
Costs						
Pre-development	Three stakeholders provided data generally ranging from £20k to £50k.	Three stakeholders provided data generally ranging from £25k to £150k. Depends on EA requirements, for Water Feature Surveys (WFS), Hydrological Impact Assessments (HIA), well monitoring, modelling, etc.	Three stakeholders provided data generally ranging from £45 to 200k.	Informed from stakeholder data (only single data point). Cannot share directly as range not possible	3 stakeholders: £400k, £500k, £>1M (with depth and design caveats). Used these values directly for low, med, high	Same as LCOE assumptions – see Appendix C

[1] Renaldi et al., Experience rates of low-carbon domestic heating technologies in the United Kingdom, web link: https://www.sciencedirect.com/science/article/abs/pii/S0301421521002573

[2] Haas et al, Technological learning: Lessons learned on energy technologies web link: https://wires.onlinelibrary.wiley.com/doi/full/10.1002/wene.463#:~:text=In%20another%20recent%20study%2C%20(Renaldi,project%20cost)%20in%20Great%20Britain.

[3] Europe's leap to heat pumps, European Heat Pump Association (EHPA), web link: https://europeanclimate.org/wp-content/uploads/2023/04/heat-pumps-summary-report-ehpa-ecf.pdf

[4] https://www.gov.uk/government/collections/energy-generation-cost-projections

Description	Closed loop	Open loop	Minewater	O&G Conversion	Coaxial	Deep Geothermal
Construction & Infrastructure	12 data points from 4 stakeholders. Assuming 50no. 150m boreholes, and Low of £67/m, medium of £100/m, high of £137/m Plant costs informed from stakeholder data of comparably sized systems. Ranged from EUR600/kW energy centre, and £700/kW, £400 to £600/kW heat pump only. Provided with range set at £520/kW, 800/kW, £1000/kW.	7 data points from 4 stakeholders. Costs per m drilling ranged from: £1,000/m, £1333/m, £1187/m, £785/m, £1775/m, £1065m across various system depths and well designs. Same HP/plant cost data as closed loop	8 data points from 2 stakeholders. Costs per m drilling ranged from: £666/m, £1065/m, £1666/m, £1375/m across various system depths and well designs. Same HP/plant cost data as closed loop	Based on discussions with 5 deep geothermal stakeholders. O&G wells require tubing which is relatively inexpensive. The biggest cost is 'perf-and-squeeze' (sealing up of existing perforations in casing, EA requirements. This can cost £100k each. For Low, Med, High assumed 1, 3, 5 (equivalent to £100k, £300k, £500k) cost for perf-and-squeeze operations. Same HP/plant cost data as closed loop	Drilling rates assessed for various depths from more than 5 stakeholders, literature, and global publications. Assumed cost curve for FOAK and NOAK drilling and applied drilling rate cost to the system depths. Additionally added cost for insulated tubing.	Same as LCOE assumptions – see Appendix C
Decommission	No decommissioning requirement for closed loop	Assume handover to Environment Agency for monitoring at end of life (no cost)	Assume handover to Coal Authority for monitoring at end of life (no cost)	Decommissioning of O&G wells is very expensive (owing to requirement to seal perforations). Based on 5 stakeholders, assumed costs of £450k, £725k, and £1,000k per well. However, this cost is already part of the O&G well. It is not a cost borne from using the asset as a geothermal system. Arup model excluded decommissioning costs.	Simple coaxial 1-2km <£5k. Complex 4-5km well >£5-£6M. Based on single stakeholder. We assumed £5, 10k, 15k low-med-high	Based on cost per well of £300k, £500k, £1,200k (low-med-high)

Description	Closed loop	Open loop	Minewater	O&G Conversion	Coaxial	Deep Geothermal
Fixed O&M	Literature and stakeholder data used to inform assessment. Table 14 from 'Long term (2050) projections of techno-economic performance of large-scale heating and cooling in the EU'[5] used as priority. Provides value of £2,040 to £2,550. This was used for low and medium values, respectively. High value was set at the difference between £2040 and £2550 (£510) more than £2550. I.e., £3,060					Based on stakeholder data and Danish cost models (£8,800/MW, 16,700/MW, £21,500/MW - low-med-high)
Variable O&M	Included as a total of maintenance & electrical running costs (of pumps and heat pumps). Maintenance informed from literature and stakeholder data. Literature (Table 14 from 'Long term (2050) projections of techno-economic performance of large-scale heating and cooling in the EU') suggest £1.45/MWh; stakeholder suggest £2/MWh. These were used for low and medium, respectively. High was set at difference between low and medium (£0.55) above medium (£2.55/MWh). Electrical running cost was calculated as Heat pump electrical demand (annual heating output MWh divided by SPF, plus annual cooling output MWh divided by SPF (cooling)) + the circulation pump electrical demand; multiplied by Gov Green Book forecast electricity prices					
Insurance	Excluded					

[5] Europe's leap to heat pumps, European Heat Pump Association (EHPA), web link: https://europeanclimate.org/wp-content/uploads/2023/04/heat-pumps-summary-report-ehpa-ecf.pdf

B.1.1 LCOH – Inputs

		1			2			3			4			5		
		Closed Loop - Hospital - NOAK			Minewater - Hospital - NOAK			Minewater - DHN 55 - FOAK			Minewater - DHN 55 - NOAK			Minewater - DHN 85 - FOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	0.3	0.5	0.7	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Construction start	Yr.	0.8	0.9	1.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	40	70	100	11	45	225	11	45	225	11	45	225	9	36	180
Construction	£/kW	1,480	2,308	3,055	773	1,502	2,607	779	1,519	2,675	773	1,502	2,607	763	1,485	2,540
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	2	2	2	4	5	7	7	9	13	4	4	7	7	8	12
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	0.5	0.5	0.5	5.3	2.7	0.9	5.3	2.7	0.9	5.3	2.7	0.9	6.7	3.3	1.1
SPF	-	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.5	2.5	2.5
Load Factor	%	60%	60%	60%	60%	60%	60%	23%	23%	23%	68%	68%	68%	23%	23%	23%
Net Heat output	MWh	2,628	2,628	2,628	28,037	14,019	4,673	10,669	5,334	1,778	32,006	16,003	5,334	13,336	6,668	2,223
Net Cooling output	MW	0.25	0.25	0.25	3.33	1.67	0.56	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	5.0	5.0	5.0	5.0	5.0	5.0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	20%	20%	20%	20%	20%	20%	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	438	438	438	5,841	2,921	974	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		6			7			8			9			10		
		Minewater - DHN 85 - NOAK			Open Loop - Hospital - NOAK			Open Loop - DHN 55 - FOAK			Open Loop - DHN 55 - NOAK			Open Loop - DHN 85 - FOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Construction start	Yr.	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	9	36	180	22	107	337	22	107	337	22	107	337	18	85	270
Construction	£/kW	758	1,471	2,486	767	1,519	2,540	767	1,519	2,540	767	1,519	2,540	754	1,485	2,432
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	4	5	6	4	5	9	7	10	18	4	5	8	7	10	16
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	6.7	3.3	1.1	1.8	0.9	0.4	1.8	0.9	0.4	1.8	0.9	0.4	2.2	1.1	0.6
SPF	-	2.5	2.5	2.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.5	2.5	2.5
Load Factor	%	68%	68%	68%	60%	60%	60%	23%	23%	23%	68%	68%	68%	23%	23%	23%
Net Heat output	MWh	40,008	20,004	6,668	9,346	4,673	2,336	3,556	1,778	889	10,669	5,334	2,667	4,445	2,223	1,111
Net Cooling output	MW	0	0	0	1.11	0.56	0.28	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	5.0	5.0	5.0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	20%	20%	20%	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	1,947	974	487	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		11			12			13			14			15		
		Open Loop - DHN 85 - NOAK			O&G - Coaxial 1km DHN 55 - NOAK			O&G - Coaxial 2km DHN 55 - NOAK			O&G - Coaxial 1km DHN 85 - NOAK			O&G - Coaxial 2km DHN 85 - NOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	1.0	1.5	2.0	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
Construction start	Yr.	1.0	1.5	2.0	0.3	0.5	1.0	0.3	0.5	1.0	0.3	0.5	1.0	0.3	0.5	1.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	18	85	270	1,324	1,667	2,115	964	1,250	1,650	1,191	1,500	1,904	804	1,042	1,375
Construction	£/kW	754	1,485	2,432	1,386	3,372	5,718	1,343	3,133	5,300	1,318	3,170	5,346	1,117	2,614	4,417
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	4	5	8	2	2	3	0.1	0.2	0.2	2	2	3	2	2	3
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	2.2	1.1	0.6	0.20	0.18	0.16	0.28	0.24	0.20	0.23	0.20	0.17	0.34	0.29	0.24
SPF	-	2.5	2.5	2.5	6.0	6.0	6.0	0.0	0.0	0.0	4.0	4.0	4.0	6.0	6.0	6.0
Load Factor	%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Net Heat output	MWh	13,336	6,668	3,334	1,224	1,080	936	1,680	1,440	1,200	1,360	1,200	1,040	2,016	1,728	1,440
Net Cooling output	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	0	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		16			17			18			19			20		
		O&G - Coaxial 4km DHN 85 - NOAK			O&G - Open 1km DHN 55 - NOAK			O&G - Open 2km DHN 55 - NOAK			O&G - Open 1km DHN 85 - NOAK			O&G - Open 2km DHN 85 - NOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
Construction start	Yr.	0.3	0.5	1.0	0.3	0.5	1.0	0.3	0.5	1.0	0.3	0.5	1.0	0.3	0.5	1.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	529	612	702	1,459	16,213	178,344	1,167	12,971	142,676	1,313	14,592	160,510	1,167	12,971	142,676
Construction	£/kW	975	2,093	3,234	1,646	11,618	110,088	1,565	11,294	110,088	1,551	10,591	99,279	1,565	11,294	110,088
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	2	2	3	2	3	4	2	3	4	2	3	4	2	3	4
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	0.51	0.49	0.47	0.19	0.02	0.00	0.23	0.02	0.00	0.21	0.02	0.00	0.23	0.02	0.00
SPF	-	0.0	0.0	0.0	6.0	6.0	6.0	0.0	0.0	0.0	4.0	4.0	4.0	6.0	6.0	6.0
Load Factor	%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Net Heat output	MWh	3,060	2,940	2,820	1,110	111	11	1,388	139	14	1,234	123	12	1,388	139	14
Net Cooling output	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		21			22			23			24			25		
		Coaxial - 1km DHN 55 - FOAK			Coaxial - 1km DHN 55 - NOAK			Coaxial - 2km DHN 55 - FOAK			Coaxial - 2km DHN 55 - NOAK			Coaxial - 1km DHN 85 - FOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
Construction start	Yr.	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	1,961	2,778	6,410	1,961	2,778	6,410	1,786	2,917	6,000	1,786	2,917	6,000	1,765	2,500	5,769
Construction	£/kW	13,175	21,194	31,423	4,842	7,306	10,269	16,021	24,867	40,400	8,164	11,533	15,900	11,928	19,210	28,481
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	25	56	96	25	56	96	36	8	150	36	8	150	22	50	87
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	4	4	7	2	2	5	2	2	5	2	2	5	5	5	8
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	0.20	0.18	0.16	0.20	0.18	0.16	0.28	0.24	0.20	0.28	0.24	0.20	0.23	0.20	0.17
SPF	-	6.0	6.0	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	4.0
Load Factor	%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Net Heat output	MWh	1,224	1,080	936	1,224	1,080	936	1,680	1,440	1,200	1,680	1,440	1,200	1,360	1,200	1,040
Net Cooling output	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Key	Standard - per technology	Varies per case study	No data available

		26			27			28			29			30		
		Coaxial - 1km DHN 85 - NOAK			Coaxial - 2km DHN 85 - FOAK			Coaxial - 2km DHN 85 - NOAK			Coaxial - 4km DHN 85 - FOAK			Coaxial - 4km DHN 85 - NOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5	0.5	1.0	1.5
Construction start	Yr.	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0	0.8	1.0	2.0
Operation start	Yr.	20	25	40	20	25	40	20	25	40	20	25	40	20	25	40
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	1,765	2,500	5,769	1,488	2,431	5,000	1,488	2,431	5,000	1,961	3,061	4,255	1,961	3,061	4,255
Construction	£/kW	4,428	6,710	9,442	13,468	20,947	34,000	6,920	9,836	13,583	11,445	17,244	32,553	5,955	8,672	12,553
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	22	50	87	15	35	63	15	35	63	39	8	128	39	8	128
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060	2,040	2,550	3,060
Variable O&M	£/MWh	2	2	5	4	4	7	2	2	5	2	2	5	2	2	5
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	0.23	0.20	0.17	0.34	0.29	0.24	0.34	0.29	0.24	0.51	0.49	0.47	0.51	0.49	0.47
SPF	-	4.0	4.0	4.0	6.0	6.0	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0
Load Factor	%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Net Heat output	MWh	1,360	1,200	1,040	2,016	1,728	1,440	2,016	1,728	1,440	3,060	2,940	2,820	3,060	2,940	2,820
Net Cooling output	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		31			32			33			34			35		
		Deep Geothermal - 2km DHN 55 - FOAK			Deep Geothermal - 2km DHN 55 - NOAK			Deep Geothermal - 2km DHN 85 - FOAK			Deep Geothermal - 2km DHN 85 - NOAK			Deep Geothermal - 3km DHN 85 - FOAK		
Description		**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Project start	Yr.	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0	1.0	1.5	2.0
Construction start	Yr.	4.0	5.3	6.5	3.3	4.5	6.0	4.0	5.3	6.5	3.3	4.5	6.0	4.0	5.3	6.5
Operation start	Yr.	20	25	30	25	30	40	20	25	30	25	30	40	20	25	30
Plant decommissioned	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cool revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Power revenue ends	Yr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-development	£/kW	95	381	1,300	24	95	325	80	317	1,083	20	79	271	55	191	542
Construction	£/kW	4,055	6,763	17,500	2,979	4,137	7,700	3,713	6,011	15,000	2,815	3,823	6,833	3,347	5,013	10,833
Infrastructure	£'000s	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Decommission	£/kW	261	651	3,106	175	470	2,576	218	542	2,588	146	392	2,147	150	327	1,294
Total fixed O&M	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fixed O&M	£/MW	8,858	16,783	21,512	8,858	16,783	21,512	8,858	16,783	21,512	8,858	16,783	21,512	8,858	16,783	21,512
Variable O&M	£/MWh	3	6	11	3	6	11	6	9	15	4	7	13	2	5	8
BSUoS	£/MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insurance	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UoS	£/MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Heat output	MW	4.1	2.4	1.0	16.4	9.8	4.0	4.9	2.9	1.2	19.6	11.7	4.8	7.1	4.9	2.4
SPF	-	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.0	6.0	6.0	6.0	6.0	0.0	0.0	0.0
Load Factor	%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%	68%
Net Heat output	MWh	24,525	14,625	6,000	98,100	58,500	24,000	29,430	17,550	7,200	117,720	70,200	28,800	42,750	29,100	14,400
Net Cooling output	MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SPF (cooling)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Capacity Factor (cooling)	%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cooling output	MWh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Availability	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

		36		
		Deep Geothermal - 3km DHN 85 - NOAK		
Description		**Low**	**Medium**	**High**
Project start	Yr.	1.0	1.5	2.0
Construction start	Yr.	3.3	4.5	6.0
Operation start	Yr.	25	30	40
Plant decommissioned	Yr.	0	0	0
Cool revenue ends	Yr.	0	0	0
Power revenue ends	Yr.	0	0	0
Power revenue ends	Yr.	0	0	0
Pre-development	£/kW	14	48	135
Construction	£/kW	2,618	3,322	5,167
Infrastructure	£'000s	0	0	0
Decommission	£/kW	101	236	1,073
Total fixed O&M	£/MW	0	0	0
Fixed O&M	£/MW	8,858	16,783	21,512
Variable O&M	£/MWh	2	5	8
BSUoS	£/MWh	0	0	0
Insurance	£/MW	0	0	0
UoS	£/MW	0	0	0
Net Heat output	MW	28.5	19.4	9.6
SPF	-	0.0	0.0	0.0
Load Factor	%	68%	68%	68%
Net Heat output	MWh	171,000	116,400	57,600
Net Cooling output	MW	0	0	0
SPF (cooling)	-	0	0	0
Capacity Factor (cooling)	%	0	0	0
Net Cooling output	MWh	0	0	0
Hours per year	No/hrs	8,760	8,760	8,760
Fuel calorific value (gross)		0	0	0
Availability	%	100%	100%	100%

Key	Standard - per technology	Varies per case study	No data available

B.1.2 LCOH - Outputs

Shallow Geothermal - Heating Only

Closed Loop - Hospital - NOAK	2024	2030	2035	2040	2050
Low	32	31	31	30	29
Medium	44	44	43	43	41
High	52	51	50	50	48

Minewater - Hospital - NOAK	2024	2030	2035	2040	2050
Low	20	20	20	19	19
Medium	34	34	33	33	32
High	53	53	52	51	50

Minewater - DHN 55 - FOAK	2024	2030	2035	2040	2050
Low	50	49	49	48	47
Medium	87	86	85	84	82
High	138	137	135	133	130

Minewater - DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	18	18	18	17	17
Medium	30	29	29	29	28
High	48	47	46	46	45

Minewater - DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	49	48	48	47	46
Medium	85	84	83	82	80
High	130	128	127	125	122

Minewater - DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	18	18	17	17	17
Medium	30	30	29	29	28
High	45	44	44	43	42

Shallow Geothermal - Heating Only

Open Loop - Hospital - NOAK	2024	2030	2035	2040	2050
Low	20	20	20	20	19
Medium	37	36	36	35	34
High	56	56	55	54	53

Open Loop - DHN 55 - FOAK	2024	2030	2035	2040	2050
Low	50	49	49	48	47
Medium	92	91	90	89	87
High	143	141	139	138	134

Open Loop - DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	18	18	18	18	17
Medium	33	32	32	31	31
High	50	49	49	48	47

Open Loop - DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	49	49	48	47	46
Medium	89	88	87	86	83
High	133	132	130	129	125

Open Loop - DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	18	18	17	17	17
Medium	31	31	31	30	30
High	47	46	46	45	44

Shallow Geothermal - Heating and Cooling

Closed Loop - Hospital - NOAK	2024	2030	2035	2040	2050
Low	8	9	9	9	8
Medium	23	24	23	23	22
High	33	33	33	32	31

Minewater - Hospital - NOAK	2024	2030	2035	2040	2050
Low	-9	-8	-8	-8	-8
Medium	8	9	9	8	8
High	30	30	30	29	28

Open Loop - Hospital - NOAK	2024	2030	2035	2040	2050
Low	-9	-8	-7	-8	-8
Medium	10	11	11	11	10
High	33	33	33	32	31

Deep Geothermal – Heating Only

O&G - Coaxial 1km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	59	58	58	57	55
Medium	100	99	97	96	93
High	145	144	142	139	135

O&G - Coaxial 2km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	49	48	48	47	46
Medium	85	84	83	82	79
High	126	125	123	121	117

O&G - Coaxial 1km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	55	54	53	53	51
Medium	93	92	90	89	87
High	135	133	131	129	126

O&G - Coaxial 2km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	43	42	41	41	40
Medium	73	72	71	70	68
High	108	107	105	104	101

O&G - Coaxial 4km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	34	33	33	32	32
Medium	55	54	53	53	51
High	74	73	72	71	69

O&G - Open 1km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	68	67	66	65	63
Medium	550	543	535	527	511
High	5,504	5,443	5,362	5,282	5,126

O&G - Open 2km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	60	59	58	58	56
Medium	478	472	465	458	444
High	4,783	4,728	4,658	4,589	4,453

O&G - Open 1km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	63	62	61	60	59
Medium	498	491	484	477	463
High	4,957	4,903	4,830	4,758	4,617

O&G - Open 2km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	60	59	58	58	56
Medium	478	472	465	458	444
High	4,783	4,728	4,658	4,589	4,453

Coaxial - 1km DHN 55 - FOAK	2024	2030	2035	2040	2050
Low	307	300	293	286	272
Medium	455	444	433	422	402
High	719	706	689	672	640

Coaxial - 1km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	141	138	135	131	125
Medium	195	191	186	182	173
High	334	329	321	314	298

Coaxial - 2km DHN 55 - FOAK	2024	2030	2035	2040	2050
Low	358	349	340	332	316
Medium	523	511	498	486	462
High	870	854	833	812	773

Coaxial - 2km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	203	198	193	188	179
Medium	277	270	263	257	245
High	427	420	410	400	381

Coaxial - 1km DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	280	273	266	260	248
Medium	413	404	394	384	366
High	653	641	626	610	581

Coaxial - 1km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	129	126	123	120	114
Medium	179	175	170	166	158
High	305	301	293	286	272

Coaxial - 2km DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	303	296	289	282	268
Medium	443	432	422	412	392
High	734	721	703	686	653

Coaxial - 2km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	172	168	164	160	152
Medium	235	230	224	219	208
High	363	357	348	340	323

Coaxial - 4km DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	271	265	258	252	240
Medium	385	376	367	358	340
High	689	676	660	644	613

Coaxial - 4km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	163	159	155	152	144
Medium	227	221	216	211	201
High	328	322	314	307	292

Deep Geothermal - 2km DHN 55 - FOAK	2024	2030	2035	2040	2050
Low	98	97	95	93	89
Medium	172	171	167	163	156
High	446	446	436	426	406

Deep Geothermal - 2km DHN 55 - NOAK	2024	2030	2035	2040	2050
Low	72	72	70	69	66
Medium	105	104	102	100	95
High	197	197	193	189	180

Deep Geothermal - 2km DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	94	93	91	89	85
Medium	157	156	153	149	143
High	387	387	379	370	353

Deep Geothermal - 2km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	70	69	68	66	63
Medium	99	98	96	94	90
High	178	178	174	170	163

Deep Geothermal - 3km DHN 85 - FOAK	2024	2030	2035	2040	2050
Low	81	80	78	77	73
Medium	126	126	123	120	115
High	271	271	265	259	247

Deep Geothermal - 3km DHN 85 - NOAK	2024	2030	2035	2040	2050
Low	64	63	62	60	58
Medium	84	84	82	80	77
High	132	132	129	127	121