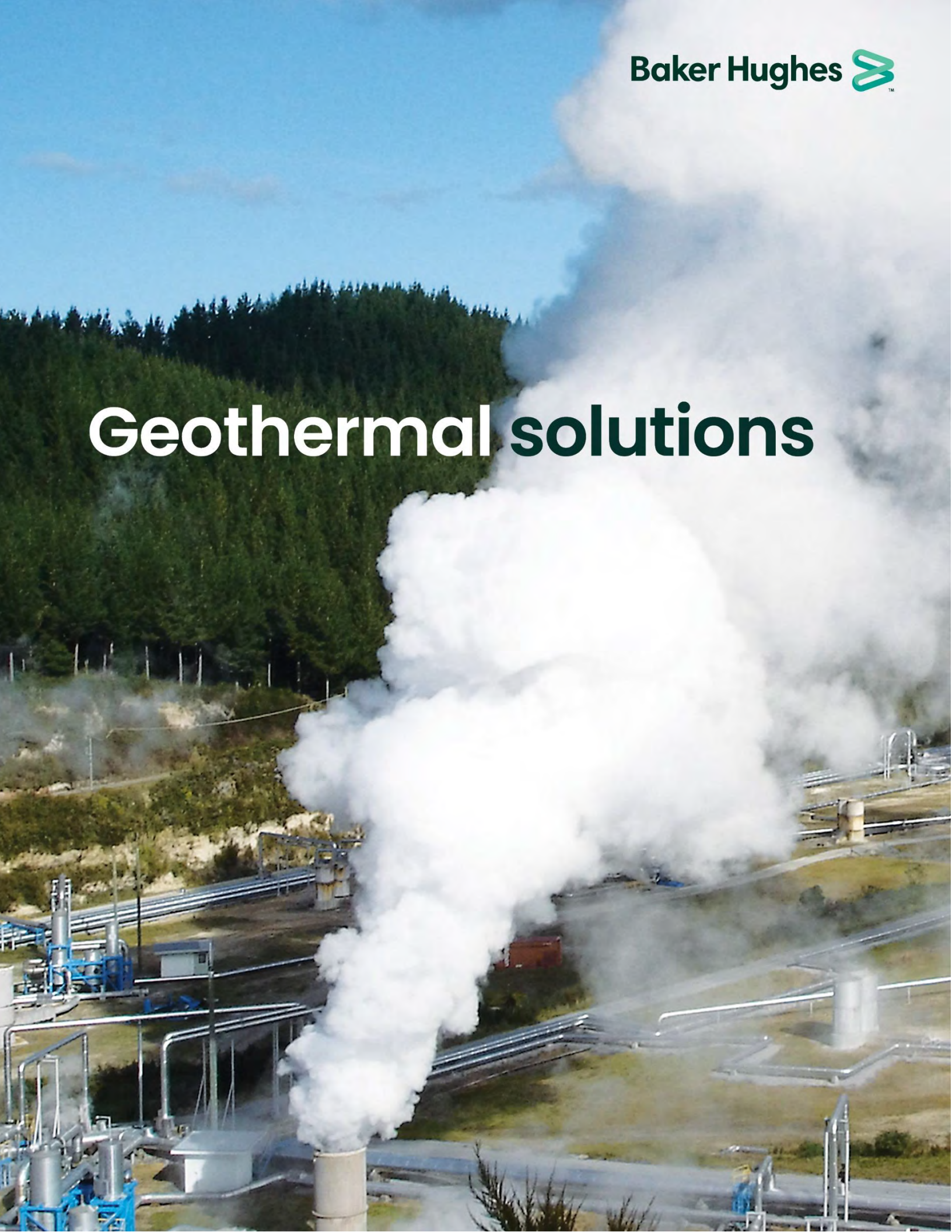


Geothermal solutions



Energy production is evolving

The IEA estimates that a 10% annual increase in geothermal well production over the next 10 years is the bare minimum needed to meet future demands on geothermal energy¹. With 2020 generation rates of 15.4 GW, the world will need geothermal sources to provide at least 40 GW annually by the year 2030 and 103 GW by the year 2040 to meet global carbon neutrality by 2050.

Baker Hughes is the geothermal energy expert

Baker Hughes is the only company in the world that can provide subsurface and surface products and services from planning to power generation. We are leaders in technology and commercial innovation, and hold strong partnerships in the services community. Baker Hughes provides geothermal power management responsive to the specific needs of geothermal projects.



Baker Hughes geothermal experience

Baker Hughes' geothermal portfolio spans subsurface to power generation



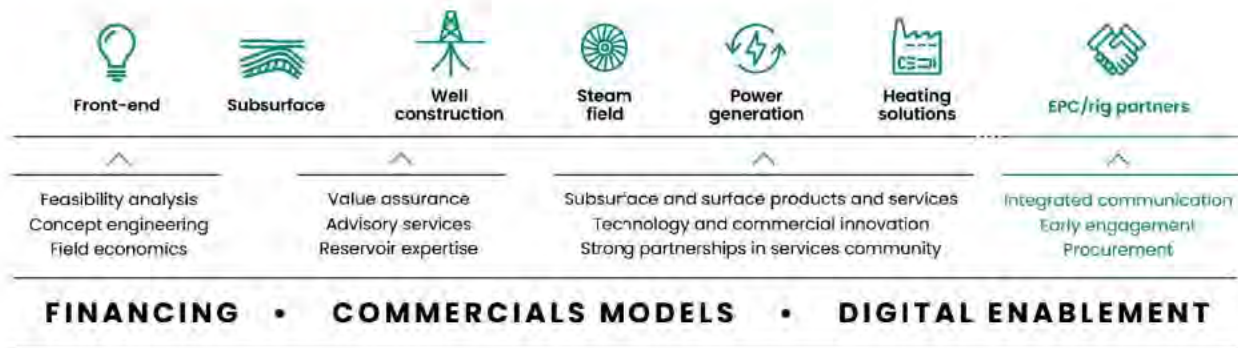
Baker Hughes is a leader in providing high-temperature products and services for geothermal development around the world by offering a complete range of capabilities and when necessary, forging strategic alliances with others in the service industry. From initial feasibility studies and wellbore construction, through stimulation, steam production, and power generation of your geothermal well, Baker Hughes draws on more than 40 years of geothermal experience, reliable equipment, and specialized technologies to safely and efficiently tap into this clean, renewable energy source.

Our comprehensive technology portfolio delivers reliable and predictable performance.

Our advanced technology tackles challenging rock formations, high temperatures, and harsh well conditions to tap geothermal energy's potential. Our focus on geothermal technology ranges from emulating the wellbore conditions of geothermal wells, to testing high-temperature materials and components, full bottomhole assemblies, submersible pumps and total integration and project management for geothermal well construction and power generation.

DESIGN AND SOFTWARE SERVICES	SUBSURFACE SYSTEMS			SURFACE SYSTEMS	
					
RESERVOIR MODELING	WELL CONSTRUCTION	EVALUATION & MONITORING	COMPLETION & PRODUCTION	EQUIPMENT	PLANT ENGINEERING & MONITORING
JewelSuite™ subsurface modeling JewelSuite geomechanics JewelSuite reservoir modeling Connection to simulation engines	Drill bits Drilling services Drilling & completion fluids Cementing	Wireline services Coring Wellbore monitoring Integrated reservoir characterization	Completions & well intervention Hydraulic fracturing/stimulation Artificial lift Specialty chemicals	Surface trees Wellhead systems Flow control Field service	Steam turbines Turboexpander generator Digital solutions Artificial intelligence application Microseismic and fiber-optic monitoring


Baker Hughes has years of geothermal experience



Baker Hughes has provided products and services for decades on geothermal wells and power generation and has the experience of many major international projects.

- We have over 40 years of expertise working in harsh geothermal environments
- We have supplied equipment, products, and services on over 1,800 geothermal wells in 25 countries
- We are committed to the research and development of high temperature drilling equipment and products
- We have qualified experienced personnel and high temperature equipment & products
- We have a substantial R&D program dedicated to geothermal specific technology, including high temperature drilling and efficient power production from geothermal resources
- Our subsurface experts, located in nearly every geothermal region, offer a rich mix of skill in hot reservoirs, geomechanics, and reservoir chemistries
- Our centralized HQ Geothermal Solutions organization manages and ensures knowledge transition for execution excellence, consistently determining the right technology for each application
- Our surface power generation engineers apply their expertise to original equipment manufacturer in power generation, plant management, control systems and condition monitoring

Our geothermal experience is global



Iceland

- 300°C directional drilling system
- Deepest and hottest well ever drilled

New Zealand: Optimized plan for new well development

- High-temperature reservoir
- Wellbore instability and losses
- Local restrictions

USA: Enhanced production by 20 MW

- Characterization of in situ state of stress
- Geothermal production

Japan: Reduced AFE by 50%, saving \$2MM and enabling customer to drill one additional well

Igneous rocks, multiple bit trips, low ROP

Indonesia: Optimized well trajectories to increase well productivity

- Stress sensitive fractures
- Drilling and stimulation

Indonesia: Increased output up to 424 MW and saved \$25 million

- Geothermal production
- Wellbore instabilities

USA: Exact wellbore place with minimal losses

- Deep directional drilling
- Basalt formation
- High temperature ~343°C

Germany: Saved 16 days of operation and 8 days of completion operations

- Deep directional drilling
- Precise wellbore placement

Finland: Saved 50 days of AFE

- Basement granite (UCs 85kcal)
- Deep directional drilling

Indonesia: Saved 5 days of drilling

Igneous rocks, UCS 15-35kpsi, high temperature ~200°C

Turkey: Saved 5 days of drilling

- High temperature ~250°C, 4509m deep
- Abrasive formation with high vibrations

Australia: Proved electricity generation feasible and profitable

- Wellbore instabilities
- Optimize production

Philippines: Expanded power plant within existing development block

- Drilling and production
- Reservoir within existing permit area

Baker Hughes' experience in subsurface geothermal well development and production combined with our history in reliably conveying the heat transfer and producing power from it gives us the unparalleled capability to create high quality geothermal power generation while reducing project capex and time to getting power generation online.

Integration and project management ensure more efficient operations

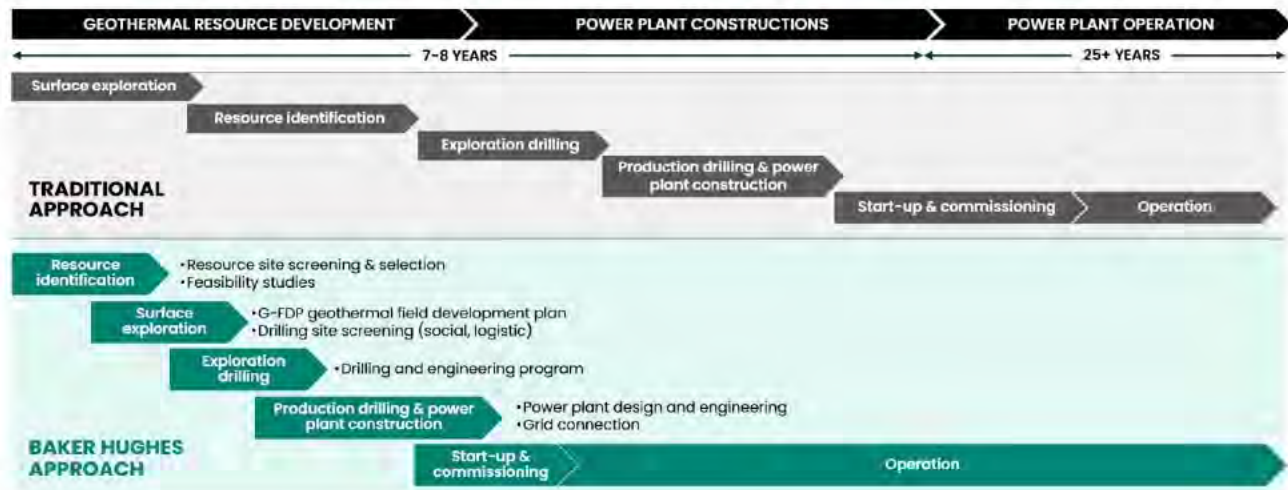
Our project teams are experienced in working in the most challenging conditions and trained to execute efficiently in the geothermal field.

PROJECT MANAGEMENT							
	RESERVOIR OPTIMIZATION	LEAN WELL CONSTRUCTION & WELLHEAD	PLANT ENGINEERING & CONSTRUCTION	INNOVATIVE COMMERCIAL MODELS	FINANCING		
GEOTHERMAL VALUE CHAIN	Administration and project management	Establishment	Resource exploration	Production and injection wells	Production and injection system	Power plant	Grid connection
	Project management	Concession or lease acquisition	Surface exploration	Mobilization	Separators	Power plant design and engineering	Grid connection
	Project and company administration	Permitting	Shallow drilling	Drilling	Production pumps	Turbines	Switch yards
	Insurance costs	Environmental studies	Assessment through pre-feasibility and feasibility studies	Logging	Production pumps	Digital controls	Transmission
	Financing contingencies	Civil works	EPC partners	Testing	Injection pumps	Complete phase of construction	
				Corrosion inhibition systems	Testing and controlling		

Baker Hughes
 Baker Hughes and partners



Our integrated approach mitigates risk and gets projects online faster



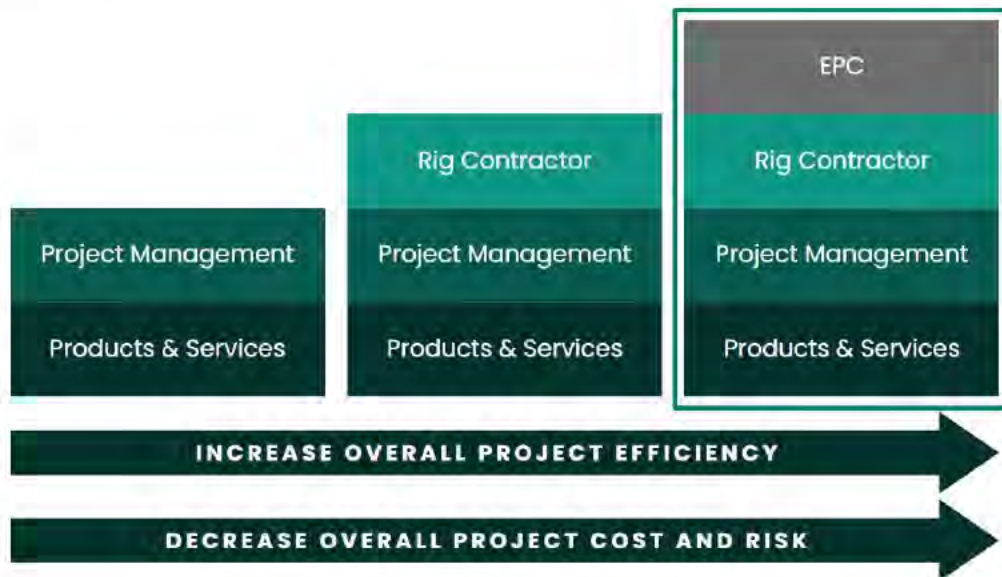
Service delivery models improve efficiency and reduce risks

Because geothermal projects require high capital investment up-front, you may need a partner with the confidence and willingness to invest in the project’s success.

Our understanding of a project’s risks, both subsurface and surface, as well as our access to capital resources, enables us to offer unique commercial opportunities through equity mechanisms and financial lending practices.

Service delivery models

- We provide products and services through a range of delivery models, ranging from discrete supply to a turnkey approach, where incentives of the rig and EPC contractors are aligned with Baker Hughes
- Models for service delivery are also paired with unique commercial and financial models that can only be offered by Baker Hughes. We want to be your partner, rather than your contractor.



Baker Hughes and carbon neutrality

We will accelerate the reduction of our own carbon emissions. We will achieve 50% carbon footprint reduction of all Baker Hughes production sites by 2030 and net-zero carbon emissions by 2050.

We will promote your carbon emission reduction. We will provide products and services with reduced emissions to decrease our customers' respective carbon footprints for their operations, projects, and products.

We will position for new frontiers. We will innovate and develop new physical and digital technologies and business models to capitalize on energy transition.

Baker Hughes is ready to take geothermal forward



WE ARE COMMITTED

Baker Hughes is committed to making energy cleaner, safer, and more efficient. We are developing new geothermal technologies to help the world meet net-zero emissions targets. Geothermal isn't new to us. Our experience includes 40+ years in the industry, working on 1800 wells in 25+ countries.

We're ready to take geothermal forward. Advanced geothermal systems (AGS) and enhanced geothermal systems (EGS) promise new opportunities.



WE ARE DIFFERENT

We connect subsurface and surface to deliver commercial success. We have horizontal expertise in subsurface equipment and systems as well as surface acumen and technology. We focus on outcomes. We are committed to reducing CapEx/TotEx, improving NPV, and increasing ROI.

We reduce time to first power. From feasibility studies to well construction and production integrity technology and services to turbomachinery, advanced process solutions, digital, and automation capabilities, we provide integrated rapid execution.

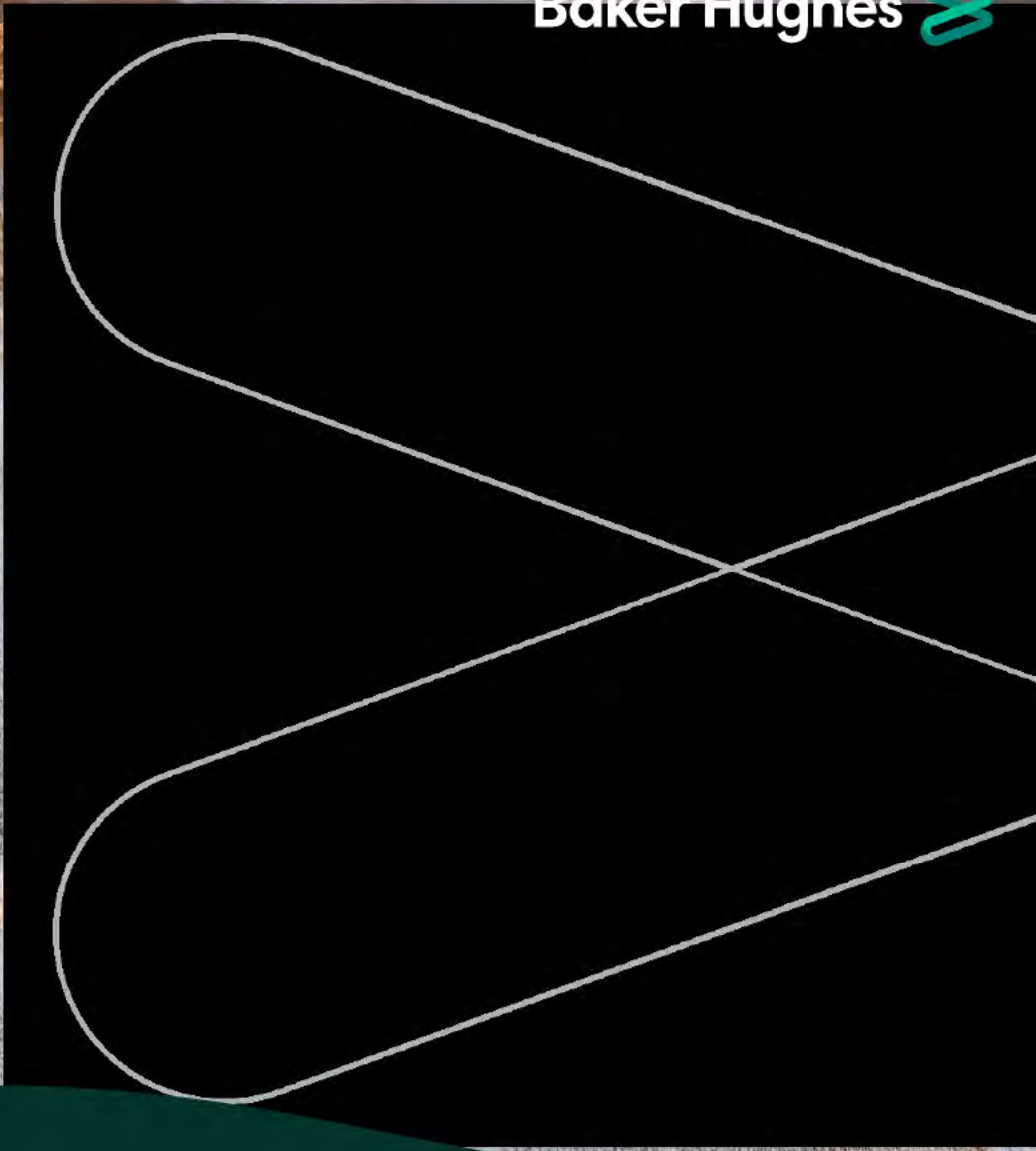


WE ARE READY

Our value comes from what we know – and how we apply challenges. We have expertise to assess and optimize reservoir models and well operations, from exploration to heat utilization. We have advanced technology to tackle reservoir evaluation, well construction, and geothermal power generation. We have proven project management to make geothermal projects economic.

Our partnerships bring a complete solution. From rig contractors to EPC companies, we provide the solution, start to finish.

Our commercial models meet any need. Our commercial payment is performance-linked and outcome-based.



RESERVOIR TECHNICAL SERVICES | RTS

Geothermal Energy Subsurface Consultancy

Do you really know how much potential your geothermal reservoir has?

We can help you find out.

bakerhughes.com/geothermal-solutions

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Why geothermal?

Geothermal energy is the heat that comes from the sub-surface of the earth. It is contained in the rocks and fluids beneath the earth's crust and can be found at all depths from near surface (as used by domestic heat pumps) to depths of several kilometers or more.

To produce power from geothermal energy, wells are drilled into high temperature (approximately 150°C or greater) underground formations to access steam and hot water which is then produced to surface. This can then be used to drive turbines connected to generators to generate electricity that can then be delivered to the grid. Examples of this are found in Iceland, California and Kenya.

Lower temperature (20 °C or greater) geothermal energy is used in for heating solutions, For example for domestic district heating in France (Paris and Strasbourg) and Germany (Munich). It is commonly used for industrial purposes too – for example in the Netherlands to heat giant greenhouses (think tomatoes and other vegetables exported all over Europe),

A further benefit of geothermal is it is potentially available everywhere! So reduces the reliance on imported energy sources (such as natural gas) for countries that do not have their own abundant fossil fuel resources (for example New Zealand, Japan, and Iceland)

In order to generate power, geothermal fluids can be used directly in steam turbines where the produced fluid is in the state of superheated steam, that can be sent directly to the turbine, or high temperature liquids can be passed through a heat exchanger to vaporize a working fluid for passing through the turbines.

However, where temperatures of the fluids are lower preventing the use of a steam turbine, an Organic Rankine Cycle (ORC) can be used for power generation. Because superheated steam is not as common to find as lower temperature geothermal resources, ORC turbines are able to be used in many more locations around the world for geothermal power generation. In this case the geothermal fluid is exploited in a binary cycle, transferring its heat to the working fluid (typically a light hydrocarbon) that is then expanded in a turboexpander to generate electricity. The geothermal fluid is then reinjected in the ground, having no contact with atmosphere, for a zero-leakage solution.

The distinct advantage over other renewable sources of energy it provides a constant baseload – it is always 'on'. Unlike alternatives such as solar panels and wind turbines, it doesn't matter if it's cloudy or if the wind isn't blowing. Once it's online, it stays online. And as a completely renewable green clean emission-free source of energy, it can be utilized for any application where a dependable consistent source of heat is required.

Ok, but geothermal energy is not new so why is there renewed interest now?



Much of the renewed interest in geothermal energy started from the Paris Climate Agreement in 2015, where 195 countries committed to undertake initiatives towards carbon reduction, increased use of renewable energy and emission reduction by 2050.



A mixture of government initiatives, societal support for green energy together with adapted technology developed by oilfield services companies, first for shale exploration and more specifically for geothermal, have helped with the recent uptake in geothermal energy.



Increased funding, subsidies and insurances from governments to support the development of geothermal energy production, directly impacted new projects and technology development.

MARKET GROWTH

Investments are skyrocketing

First used in by the Greeks and Romans in ancient times, geothermal has been a consistent – and expanding – source of energy in recent years. According to the International Renewable Energy Agency (IRENA), geothermal energy has grown steadily from around 10GW worldwide in 2010 to circa 15GW in 2020.

40%

increase in wells drilled per year between 2015 and 2020

110%

projected increase in wells drilled per year between 2020 and 2025

Double

projected installed capacity increase between 2020 and 2030: from 15 to 30GW

US\$ 5B

projected CAPEX increase between 2020 and 2025. Expected expenditure in 2025 to be US\$ 9.5B



GEOTHERMAL POWER GENERATION

- Currently 57 systems > 106+ new next 5-8 years
- 1.8 Gwe > 3 Gwe by 2030 > 15-30 Gwe by 2050



GEOTHERMAL DISTRICT HEATING

- Currently 250 systems > 750+ by 2030 > 3,000+ by 2050
- 4.4 GWth > 14+ GWth by 2030 > 50 GWth by 2050



HEAT PUMPS

- Currently 50 GWth > 2030 up to 75 GWth
- 2 million pumps installed, 80k new units/year

THE INTEREST CAN BE NEW – BUT WE ARE NOT

Baker Hughes Reservoir Technical Services (RTS)

We have been active in geothermal subsurface consultancy for more than 40 years now

We have been working to advance sustainable energy for decades – our advanced technology tackles challenging rock formations, high temperatures, and harsh well conditions to tap geothermal energy's potential.

Our focus on geothermal technology ranges from emulating the wellbore conditions of geothermal wells, to testing high-temperature materials and components, full bottomhole assemblies, and submersible pumps.

For optimal heat production, several key properties of the subsurface need to be analyzed so that wells can be planned and placed in the optimal location, and that risks associated with geothermal exploration and development can be minimized and mitigated.



We are global experts in gathering, analyzing and interpreting subsurface data so you can take the best decisions to maximize your geothermal project performance and monitor impact throughout execution

Baker Hughes RTS is a diverse, multidisciplinary organization supporting projects on many fronts, including:

- 1 High potential geothermal site identification
- 2 Feasibility study: initial funding, technical and commercial assessment
- 3 Exploration and appraisal subsurface analysis
- 4 Full geothermal project design and management
- 5 Integrated well planning and construction
- 6 Induced seismicity risk assessment and monitoring
- 7 Well abandonment

THE CHALLENGE

It is all about risk specifically subsurface risk

Although geothermal is a reliable, clean and safe source of energy with relatively low-cost of maintenance, many projects face big challenges in regard of large upfront capital costs, potentially low and delayed return on investment, as well as strong resistance of acceptance from local communities and

environmental entities due to lack of knowledge and the risk of triggering earthquakes. These three key points must be evaluated on any geothermal project to ensure its feasibility.

WE SEE THREE HARD THRUTHS ABOUT WHY GEOTHERMAL PROJECTS OFTEN FAIL:

#1 Unforeseen drilling issues escalate upfront costs

- Challenging rock formations
- Wellbore stability issues
- Unplanned sidetracks and equipment lost in hole

#2 Reduced flow and heat production lowers ROI

- Suboptimal well placement
- Poor reservoir cooling management
- Corrosion, scaling and plugging
- Inappropriate completion design

#3 Induced seismicity risks public acceptance

- Lack of geomechanical knowledge
- No passive seismic monitoring
- Unsuitable injection and production rates
- Reservoir containment issues

Do you really know your geothermal reservoir full potential?



SUBSURFACE KNOWLEDGE IS THE KEY

Historically, many geothermal prospects disappoint in their return, often related to limited detailed knowledge of subsurface properties being available. In many cases these properties are either estimated from local assumptions inferred from low resolution measurements such as surface seismic, or inferred from measurements in offset wells, with little accounting for possible lateral variations in formation properties. As a result, estimations of the expected performance of a prospect may have a very high uncertainty. Hence, further decisions on development, completion and production may not be optimal, and risks such as seismicity, corrosion, scaling and well integrity may be increased.

Geothermal energy: potentially the largest – and presently the most misunderstood – source of energy in the U.S. and the world today.

Al Gore "Our choice", 2009

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

**HARD
THRUTH** #1 **Unforeseen drilling issues
escalate upfront costs**

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

HARD THRU #1

Unforeseen drilling issues escalate upfront costs

- Challenging rock formations
- Wellbore stability issues
- Unplanned sidetracks and equipment lost in hole

THE KEY TO SUCCESS HERE IS: RISK MITIGATION

Accurately predict drilling cost and avoid AFE overruns by identifying drilling risks by characterizing challenging geomechanical conditions that will impact drilling and well planning to ensure that the target is safely and efficiently reached whilst avoiding unplanned drilling issues such as sidetracks, geohazards, wellbore collapse, and equipment lost in hole risks.

FEATURED OFFERINGS

JEWELSUIE™ SUBSURFACE CHARACTERIZATION MODULED PACKAGE

Innovative, powerful modular software package to quickly create precise geomodels — regardless of the reservoir's structural complexity — in half the time as traditional solutions. This modeling tool can seamlessly transfer into any industry standard simulator. Different modules can be unlocked/combined based on your needs.

JEWELSUIE™ SOFTWARE CAPABILITIES TO MITIGATE RISK

Geological and reservoir model

- High potential geothermal site identification
- Subsurface characterization (exploration and appraisal)
- Conceptual and detailed design
- Economic evaluation
- Risk Management

Geomechanical model

- Pre-well modelling to ensure target can be safely and economically reached
- Well trajectory design
- Real time monitoring and optimization of drilling parameters and wellbore trajectory
- Targeting most productive zones using reservoir navigation

RISKGUARD™ REAL TIME DRILLING

In real-time engineers provide 24-hour interpretation of data trends and provide solutions when necessary. Real-time data is integrated into the pre-well models to observe deviations if any.

RISKGUARD™ SOFTWARE CAPABILITIES TO REDUCE DRILLING ISSUES

- Pre-well modelling to ensure target can be safely and economically reached
- Well trajectory design
- Real time monitoring and optimization of drilling parameters and wellbore trajectory
- Targeting most productive zones using reservoir navigation

INTEGRATED PROJECT MANAGEMENT

To keep costs under control and avoid AFE overruns, we can provide you integrated consultancy solutions in project feasibility, design and management.

OUR PROJECT MANAGEMENT CAPABILITIES TO REDUCE OVERALL RISK

- Initial technical and commercial assessment, including funding analysis
- Integrated wellbore construction services
- Project design and management
- Economic evaluation

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

**HARD
THRUTH** #2 **Reduced flow and heat
production lowers ROI**

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

**HARD
THRUH
#2**

**Reduced flow and heat production
lowers ROI**

- Suboptimal well placement
- Poor reservoir cooling management
- Corrosion, scaling and plugging
- Inappropriate completion design

**THE KEY TO SUCCESS HERE IS:
PRODUCIBILITY**

By optimized flow, heat production, and well placement to accelerate ROI. We focus on developing and enhancing production in potential zones with developed producible rock matrix, fracture porosity/permeability and subsurface pressure that exhibit sufficient temperature and sustainable high heat flow. Manage formation cooling to ensure sustainable, long term heat production. Geochemical characterization to minimize formation plugging and scaling in tubing to ensure optimal flow.

FEATURED OFFERINGS

JEWELSUIE™ SUBSURFACE CHARACTERIZATION MODULED PACKAGE

Reservoir models can be updated and modified easily with new well information or alternative geological scenarios to optimize field development plans and drive greater production. Different modules can be unlocked/combined based on your needs.

PRODUCTION OPTIMIZATION

In real-time engineers provide 24-hour interpretation of data trends and provide solutions when necessary. Real-time data is integrated into the pre-well models to observe deviations if any.

COMPLETIONS OPTIMIZATION

Engineers use the subsurface models to design completions that are resistant to corrosion, ensure well integrity, isolate producing formations to ensure long wellbore life

JEWELSUIE™ SOFTWARE CAPABILITIES TO INCREASE PRODUCIBILITY

Integrated subsurface model

- Integrated geological, geomechanical and petrophysical modeling to fully characterize the geothermal potential
- Geothermal sites identification
- Digital twin of prospects – model future life of sites
- Model subsurface fluid flow
- Subsurface fluid characterization

Thermal resources assessment

- Temperature profile characterization
- Model total thermal capacity
- Model thermal cooling and recovery
- Identify potential targets for geothermal development

Production optimization and site expansion evaluation

- Flow assurance
- Reservoir stimulation design
- Chemical injection
- Scale and plugging mitigation
- Sand production mitigation
- Thermal recovery management
- Thermal recovery management
- Injection management
- Real time temperature and pressure monitoring (fiber optics)
- Reservoir life extension

OUR WELL COMPLETIONS CAPABILITIES TO BOOST PRODUCTIVITY

- Optimal completion design
- ESP (Electrical Submersible Pump) selection
- Corrosion mitigation
- Sand screen selection
- Zonal isolation strategies to prevent aquifer contamination
- Full wellbore construction design

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

**HARD
THRUTH** #3 **Induced seismicity risks
public acceptance**

LET'S DEEP DIVE AND TALK ABOUT SOLUTIONS

**HARD
THRUH
#3**

Induced seismicity risks public acceptance

- Lack of geomechanical knowledge
- No passive seismic monitoring
- Unsuitable injection and production rates
- Reservoir containment issues

THE KEY TO SUCCESS HERE IS:

RESERVOIR AND WELL INTEGRITY

By ensuring safety to gain public acceptance, minimizing and mitigating risks such as those posed by induced seismicity which can lead to earthquakes, reservoir containment, compaction, cap rock integrity, and ensuring well integrity by mitigating and managing corrosion and leakage to prevent contamination of potable water aquifers.

FEATURED OFFERINGS

JEWELSUIE™ SUBSURFACE CHARACTERIZATION MODULED PACKAGE

Reservoir models can be updated and modified easily with new well information or alternative geological scenarios to optimize field development plans and drive greater production. Different modules can be unlocked/combined based on your needs.

JEWELSUIE™ SOFTWARE CAPABILITIES TO ENSURE RESERVOIR AND WELL INTEGRITY

Integrated subsurface model

- Integrated geological, geomechanical and petrophysical modeling to fully characterize the geothermal potential
- Identification of fractured zones with potential for seismicity
- Subsurface flow and pore pressures modelling

Geomechanical model

- Safe injection and production rates modelling
- Unintended stimulation avoidance
- Sand production mitigation
- Completion and wellbore collapse avoidance
- Avoid compaction and uplift
- Zonal isolation and cap rock integrity analysis to avoid aquifer contamination

SEISMICITY MONITORING AND MITIGATION

We engineer and operate monitoring solutions to map subsurface microseismic activity to avoid earthquakes and water aquifer contamination.

OUR MICROSEISMIC SERVICES TO ENSURE SAFE INJECTION AND PRODUCTION

- Pre-development monitoring of natural seismicity baseline
- Model and mitigation of potential seismicity
- Real time monitoring and reporting of seismicity throughout the entire project life

COMMUNITIES AND GOVERNMENT OUTREACH

We understand that to develop the geothermal market to its full potential we must work in close collaboration with our customers to increase public awareness and acceptance.

OUR CONSULTANCY SERVICES TO INCREASE PUBLIC AWARENESS

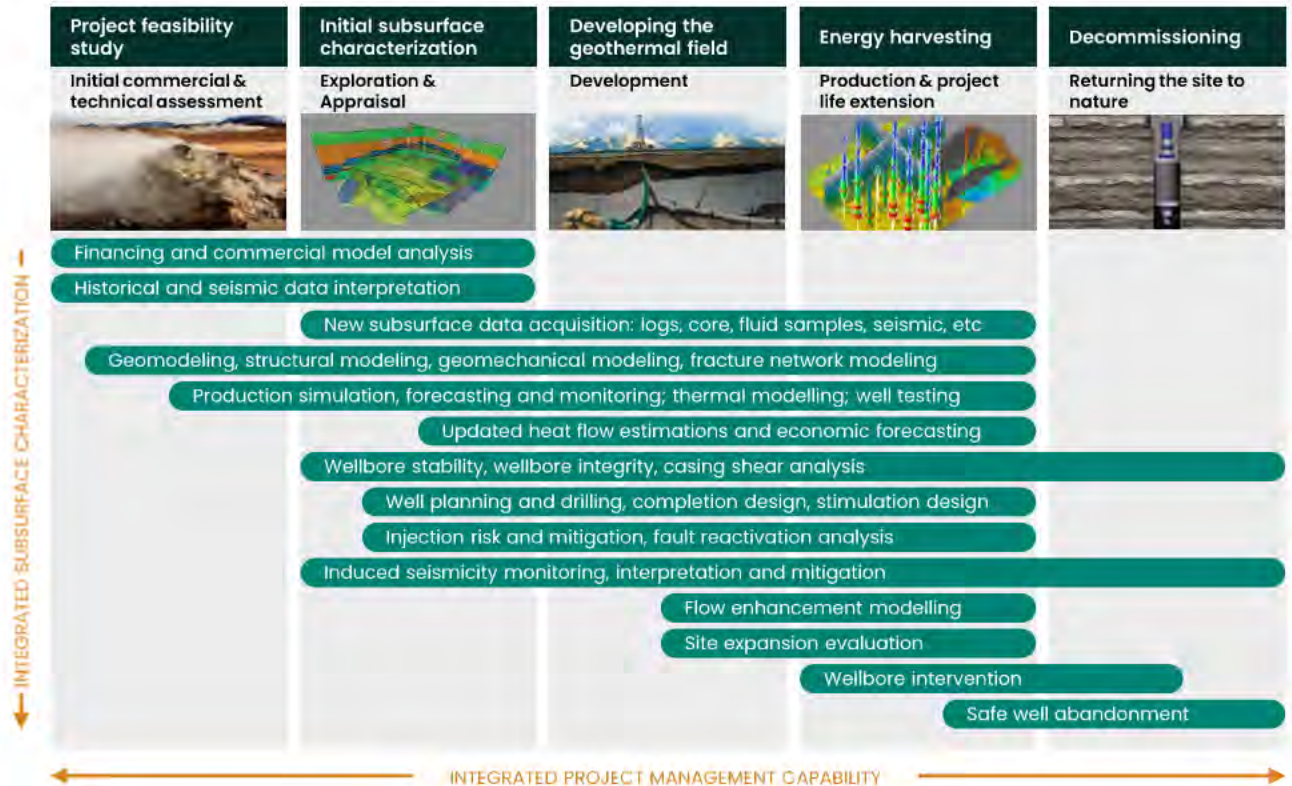
- Project design and management
- Technical consultancy for license application
- Project advocacy and publicity
- Educational workshops and training to increase awareness
- Research & development projects with universities and/or private institutions

RTS INTEGRATED SUBSURFACE PROJECT MANAGEMENT CONSULTANCY

We can de-risk your geothermal project from the beginning to the end

We applied our comprehensive advanced integrated methodology to improve recovery and reduce uncertainty in the exploitation of geothermal reservoirs. Recommendations based on simulation results enable improved decisions leading to better well performance, enhanced permeability and optimal production. Baker Hughes has assembled an integrated multi-discipline team for geothermal applications, of experts in geology, petrophysics, geophysics, geomechanics, reservoir engineering, geomodeling and reservoir services.

Baker Hughes Reservoir Technical Services (RTS) provides a range of consultancy services in project feasibility and management, subsurface characterization and field development to optimise geothermal projects technically and financially through all stages in a project's life. Additional to subsurface characterization, Baker Hughes can provide fully integrated solutions, technologies and operations for geothermal projects in all applications: district heating, direct use and power generation for the full range of temperatures; including project management and turnkey projects.



Our approach: we develop solutions in close collaboration with you to ensure the best results technically and commercially

ADDITIONAL RESOURCES TO ENBALE YOUR
GEOTHERMAL PROJECT

Baker Hughes GaffneyCline Consulting

CONSULTING AND ADVISORY SERVICES

Industry leading consultation for feasibility and economics

Gaffney, Cline & Associates (GaffneyCline) enables energy companies and governments to navigate economic and technical uncertainties by providing creative and practical solutions.

KEY DIFFERENTIATORS

- Strong technical expertise, commercial acumen, and strategic insight
- Multi-disciplinary, global teams have practical real-world experience
- Actively engaged in the energy transition, assisting clients to measure, report and reduce greenhouse gas emissions
- Independent, impartial advice and assurance
- Reliable reputation gained over more than five decades

Baker Hughes Capital Solutions

CONSULTING AND ADVISORY SERVICES

Enabling market growth by providing financing expertise and support

Baker Hughes Capital Solutions offers financial advisory, structuring and tailored financing solution to Baker Hughes customers.

KEY DIFFERENTIATORS

- Deep energy investment expertise and credibility
- Backgrounds from GE Capital, private equity, and investment banking
- Strong Investor Network: Diversified Funding Sources
- Global Coverage and Origination



Want to learn more about our solutions or more about our track record in geothermal projects?

Contact us

RTS.Geothermal@bakerhughes.com

Or visit our website

bakerhughes.com/geothermal-solutions

Baker Hughes 

Baker Hughes' response to the Consultation on Geothermal Policy in Ireland

About Baker Hughes

Baker Hughes is a leading energy technology company providing solutions for energy and industrial customers worldwide. We design, manufacture, and service transformative technologies to take energy forward – making it safer, cleaner, and more efficient for the people and the planet. We conduct business in over 120 countries around the world. While we operate globally, Europe is a key market and corporate home for Baker Hughes. Across the EU, Norway, and the UK, Baker Hughes employs approximately 16,000 people at 40 sites, including in engineering, manufacturing, and research and development roles. Specifically, in Ireland, we provide over 200 jobs at our facility in Shannon, where we develop a wide range of digital solutions enabling the energy transition.

Baker Hughes supports the Paris Agreement objectives and stands ready to provide support to various jurisdictions to achieve their energy and climate goals. We believe that climate change is one of the most significant challenges facing the world and warrants meaningful action to reduce the environmental impact of the energy industry on our planet.

Baker Hughes brings a unique value proposition for developing geothermal energy. Its expansive energy portfolio enables the geothermal sector to utilize relevant technology and an experienced workforce in oilfield services for reservoir management and downhole solutions, and rotating equipment for geothermal topsides. We have over 40 years of expertise working in harsh geothermal environments and supplied equipment, products and services to approximately 2,000 geothermal wells in roughly 30 countries, including Iceland, the UK, Belgium, the Netherlands, and Germany.

Geothermal technology is constantly advancing, and Baker Hughes has unique capabilities to be a strong partner for innovation. We are exploring a variety of promising geothermal

innovations and have testing facilities in Germany and around the world where we simulate actual geothermal conditions, mimic well fluid compositions, and deploy our advanced design and additive manufacturing capabilities to create and build 3D printed prototypes and end use parts optimized for form, fit, and function.

To broaden our portfolio, in December 2021, we signed a Memorandum of Understanding with CausewayGT, a renewable energy company founded in Ireland. Addressing climate change requires partnerships and, together with CausewayGT, we will collaborate on geothermal projects and technology development designed to deliver low carbon heating and cooling for commercial and industrial facilities and processes. Our joint work will be initially focused on Ireland and the UK.¹

As pointed out by Minister Eamon Ryan, geothermal energy is a renewable energy source with diverse applications to heating, cooling, and power generation.² Its development will be also crucial to secure natural resources, such as lithium which is needed for the development of electric vehicles.

Baker Hughes welcomes the consultation on the Draft Policy Statement on Geothermal Energy and hopes that these endeavours will be promoted among other European countries to ensure achieving the Paris Agreement goals on time.

Baker Hughes' recommendations to the Draft Policy Statement on Geothermal Energy

Baker Hughes believes that geothermal energy is a reliable source of energy with a significant potential for growth and deployment across Ireland, but it is currently underutilized. To ensure its uptake at scale, a robust regulatory and policy framework is required to provide the foundation for a sustainable commercial market. The work undertaken by the Irish government is a welcomed starting point, and we would like to offer the following recommendations for your consideration in the next steps:

¹ Press release – December 2021 [here](#)

² Policy Statement on page 4 in pdf.

Recommendation 1: Development of holistic national and regional strategies with clear objectives.

As countries across the globe develop strategies on hydrogen, offshore wind, in our view, it is very important to establish a **geothermal strategy for Ireland with clear objectives and support mechanisms**. This type of strategy could facilitate policy support for power and district heating/cooling, and outline vision for multi-stakeholder initiatives, such as public-private partnerships covering the entire geothermal value chain.

In July 2021, the European Commission proposed to increase the share of renewables in the energy mix and the requirements in the volume of renewable heating and cooling to 1.1 percentage point on annual basis.³ There is a clear opportunity for the Irish government to outline how geothermal energy is going to contribute to these new objectives.

While developing the geothermal industry, we recommend **avoiding placing local content requirements**. Geothermal energy is a dynamic industry based on international partnerships; therefore, a global expertise must be leveraged to innovate and expand its use.

We support the establishment of the Irish **Geothermal Energy Advisory Group** which could, for example, facilitate a dialogue with other countries across Europe to exchange views on best practices related to the development of geothermal energy. Creating partnerships among governments, industry and academia is a critical factor to drive the scale up of projects. Baker Hughes also supports the proposals to provide **information to the public**. Providing information to all stakeholders can help various players understand the benefits, such as the positive impact on energy bills, of geothermal use for heating, cooling and power generation. As rightly pointed out in the Draft Policy Statement, **data gathering** is a critical prerequisite to facilitate the successful delivery of geothermal projects. Baker Hughes Reservoir Technical Services has been active in geothermal subsurface for more than 40 years.

³ Proposal for a revised Renewable Energy Directive (COM/2021/557 final) [here](#).

Recommendation 2: Streamlined licensing and permitting process is a prerequisite to unlock the potential of geothermal energy.

The licensing and permitting process is a major cause of delays to large and small-scale geothermal applications. Appropriate and efficient process, while respecting all environmental and safety requirements, is needed for geothermal projects. In its upcoming Communication on affordable and sustainable energy, the European Commission intends to encourage all EU Member States to use the framework of projects of common interest (PCI) to accelerate and scale up the deployment of renewable energy. The PCIs can benefit from fast-tracked planning and permit granting and obtain permits from a single national authority. The Irish government could assess the possibility of using **this PCI system for various geothermal projects**. Failure to reduce administrative burdens may slow down the pace of emissions reductions needed to achieve the Irish climate goals.

Recommendation 3: Support for R&D and risk mitigation schemes are needed to tap into geothermal energy sources.

Geology varies from one country to another, and first movers in a country have a relatively greater risk profile due to the fact that a disproportionate amount of exploration must be performed. When the geothermal sector is more established in an area, knowledge of the geology improves, and costs decrease significantly. In mature markets private insurance products manage commercial risks. In less mature markets different risk instruments are required. **That is why a risk mitigation framework is needed to develop a market for geothermal.** Loans, grant schemes, exploratory phase insurance, and feed-in tariffs are all mechanisms the Irish government can explore and employ to help reduce financial risks for project developers. Risk insurance funds, set up by some European countries, have been successful in managing geological risk as a means to advance regional geothermal energy projects. **We recommend the Irish government strengthen the Draft Policy Statement by considering a detailed assessment of a wide range of de-risking mechanisms covering all phases of geothermal projects. Additionally, funding for geothermal R&D projects is needed to develop innovative solutions.**

Conclusions

Baker Hughes hope this feedback will be taken into account by the Irish government while further developing the regulatory and policy framework for geothermal energy. We would be pleased to assist should you have any questions.

About Baker Hughes:

Baker Hughes is an energy technology company that provides solutions to energy and industrial customers worldwide. Built on a century of experience, our innovative technologies and services are taking energy forward – making it safer, cleaner, and more efficient for people and the planet. We conduct business in over 120 countries around the world employing around 54,000 people.

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Appendix: About Baker Hughes' involvement in geothermal energy

1) About Baker Hughes' expertise

Baker Hughes has been active in geothermal hotspots for more than 40 years with projects in more than 20 countries across five continents. We have around 2000 geothermal wells using our technology, representing 144 total projects. Our advanced technology tackles challenging rock formations, high temperatures, and harsh well conditions to tap geothermal energy's potential. Our focus on geothermal technology ranges from emulating the wellbore conditions of geothermal wells, to developing high-temperature materials and components, full bottomhole assemblies, and submersible pumps.



We are exploring a variety of promising geothermal innovations in the space of enhanced geothermal systems (ESG), advanced geothermal systems (AGS), oil-to-geothermal well conversion, and conventional geothermal. For instance, we see the potential for geothermal power from “superhot rock.” This will require development of engineered reservoirs in deep basements, where hotter temperatures can yield up to 10 times more energy than a conventional geothermal well. Baker Hughes’ technology portfolio and subsurface expertise, as well as strong partnership with superhot rock developers, will allow us to accelerate development to scale this resource around the globe – potentially developing terawatts (TW) of clean, low-cost baseload power.

2) Case study

In 2017, Baker Hughes provided drilling services to the Iceland Deep Drilling Project (IDDP). We successfully drilled the longest, deepest, and hottest geothermal well in Iceland. As part of the project, we developed and tested the first all-metal mud motor and drill bits designed for 300°C. This technology was a steppingstone for several other systems that have since been developed. See [a full case study](#) on our [Geothermal Solutions web page](#) and [a technical paper](#) about our involvement in the project.