BH Geothermal

Optimizing the Surface & Subsurface as one...

Andrew Celin

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Contact Info

Climate Technology Solutions – Carbon Capture, Hydrogen, Geothermal

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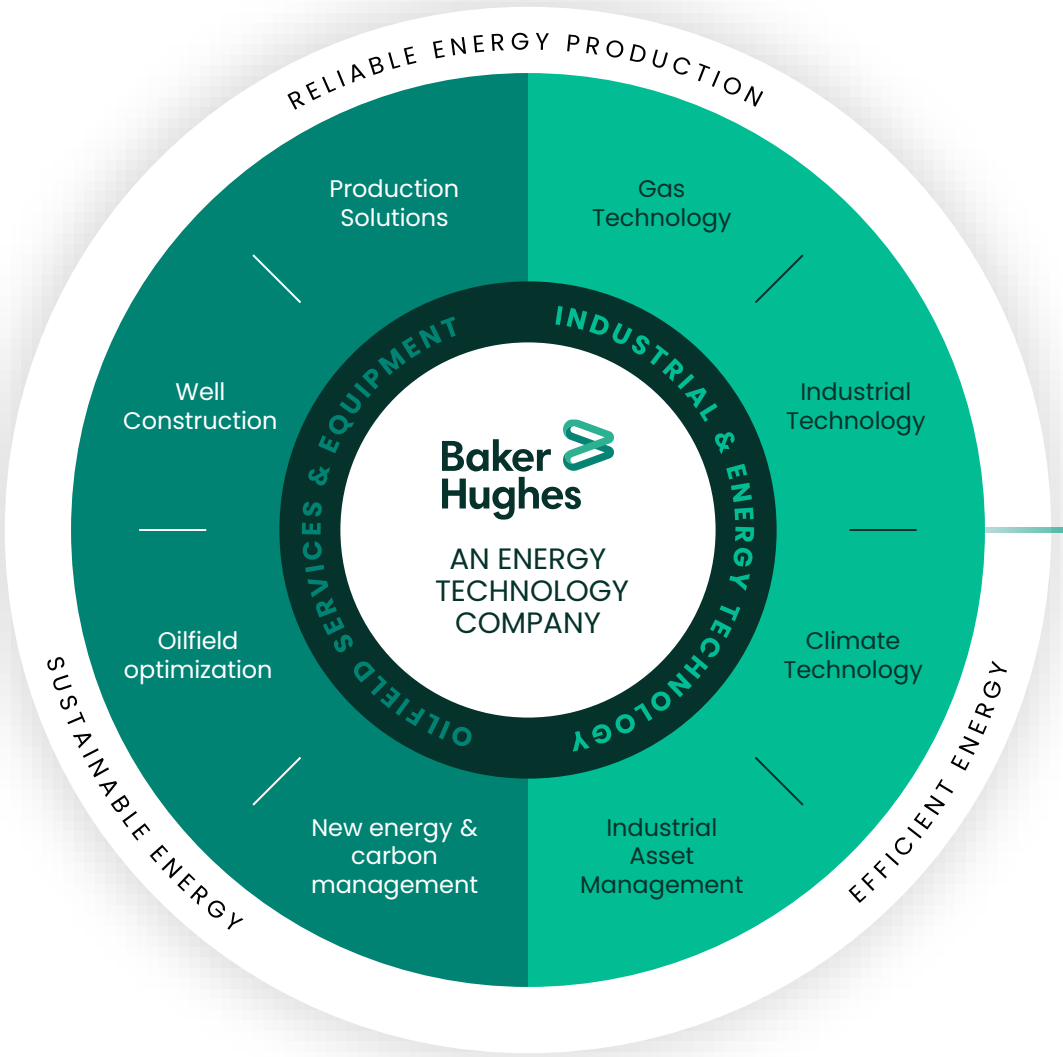
OFSE & IET

Bringing better visions of energy to life.

In pursuit of our purpose, we've built a business that can drive the next era of the energy transition.

Alongside Oilfield Services & Equipment (OFSE), Industrial & Energy Technology (IET) resolves the critical task of the energy transition: bringing energy security, sustainability, productivity, and efficiency together.



We deploy solutions to the world's greatest energy challenges

Global energy security

Climate change

Industrial efficiency and productivity

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Our 40+ years of geothermal expertise ensures success

Baker Hughes has worked in geothermal for more than 40 years, delivering subsurface and surface expertise – and well as compliant operations –and helping you clearly understand and mitigate the risks.

Planning, designing and executing well construction projects in extreme environments

- Our subsurface experts, located in nearly every geothermal region, offer a rich mix of skill in hot reservoirs, geomechanics, and reservoir chemistry, among others.
- Our technical team can determine the perfect technology fit for each application.

Surface production, both reliably conveying the heat transfer and producing power from it

Our experience as an original equipment manufacturer in power generation, plant management, control systems and condition monitoring – combined with our understanding of the subsurface – allows us to properly match the power-generating capacity to the subsurface resource.

Efficient operations that comply with environmental, social, and governance requirements

Our commitment to ESG means that we will do the right thing, always – giving you confidence in how the project is executed.

Baker Hughes geothermal experience

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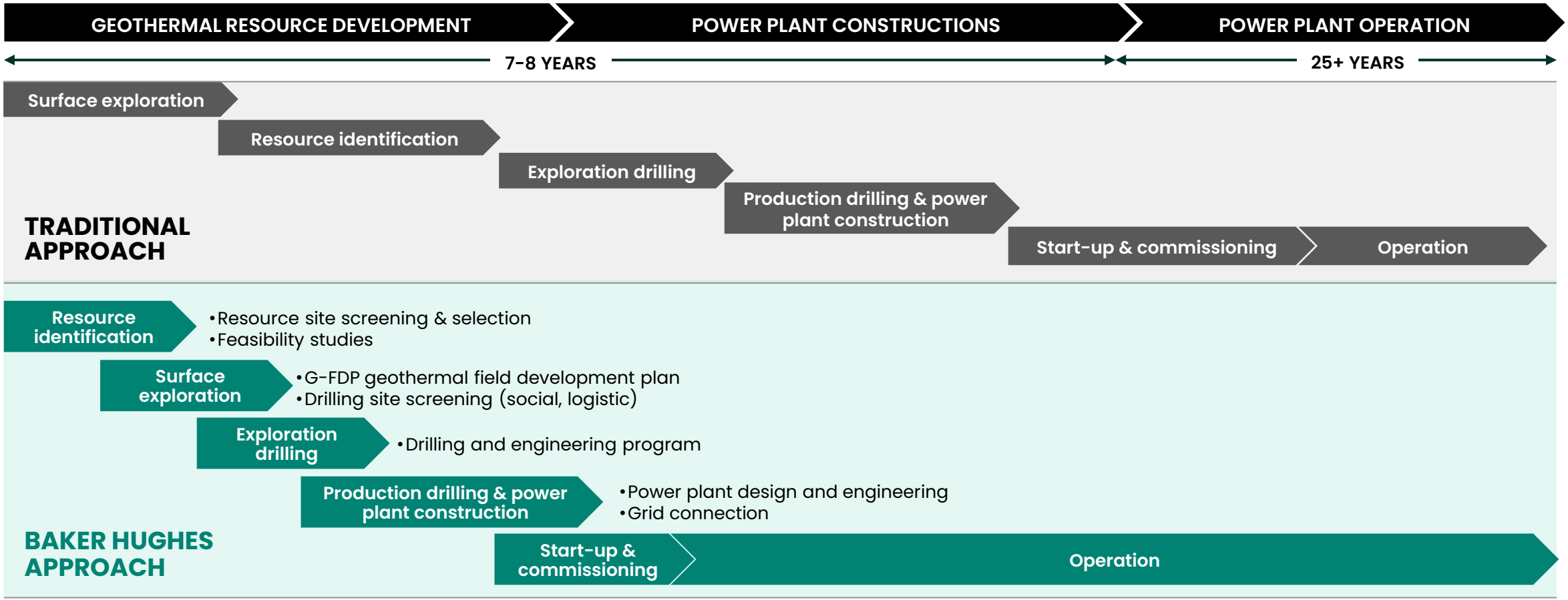
Integrated approach mitigates risk and reduces time to 1st kW



Our Turbomachinery portfolio

Drivers and expanders


Aero-derivative Gas Turbines


Heavy Duty Gas Turbines


NovaLT Gas Turbines

NovaLT Hydrogen Turbine


API Steam Turbines


Hot Gas and Turbo Expanders

Compressors, pumps, valves


Centrifugal and Axial


Integrated Compressor line


Subsea Compression


API Reciprocating


Centrifugal Pumps


Process, Control and Safety Valves

Module solutions

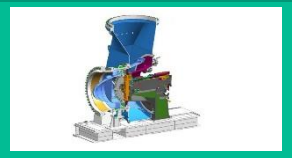

Power Generation

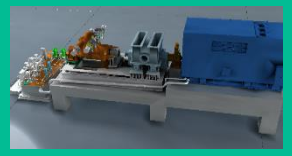

Compression


Small Scale LNG

Integrated solutions for CO2 reduction


Waste Heat Recovery


Waste Pressure Recovery


Energy storage

One-stop-shop equipment


Air-cooled Heat Exch.


Control Systems


Gear Solutions

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Building on strong foundations…

1961	First **Nuovo Pignone** Centrifugal Compressor installed at Eni Refinery in Porto Marghera
1994	GE acquires **Nuovo Pignone** … first venture into oil and gas
1997	Initiated dedicated Turbomachinery **Service** model
2000	Enlargement of rotating equipment offering through acquisition of **Thermodyn**
2011	Expansion into flow and process technologies through acquisition of **Masoneilan, consolidated, Becker and Mooney valves**
2013	Addition of **Salof's** small-scale cryogenic CO2 and LNG technologies; Addition of **Lufkin** and **Allen Gears** gear technologies
2017	Continuing to build out capabilities to focus on specific segment needs as **Turbomachinery & Process Solutions**; Creation of **BHGE**
2019	Introducing **Baker Hughes**, an Energy technology company

Current installed base	
Centrifugal compressors	> 3,500
Reciprocating compressors	> 7,000
Integrated electric-motor-driven compressors	~ 30
Gas turbines	> 3,000
Steam turbines	> 2,500
Expanders	> 1,000
Pumps	> 20,000
Valves	> 3 million
Air-cooled heat exchangers	> 4,000
Hours of machine data monitored	> 8 million / year
Hours of customer training delivered	> 130,000

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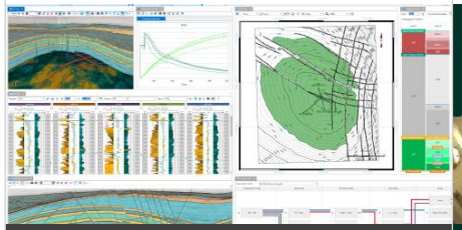
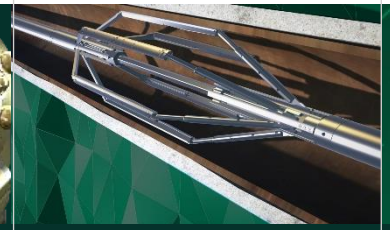
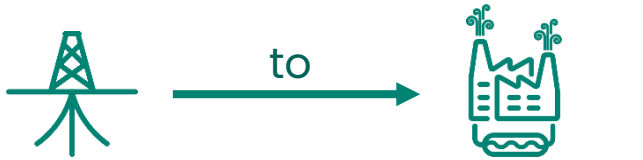
Comprehensive subsurface-to-surface experience

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 ORC / binary cycle Turboexpander generator Brush electric generators Brine pumps Valves Digital solutions NCG compressors Micro-seismic & fiber-optic monitoring

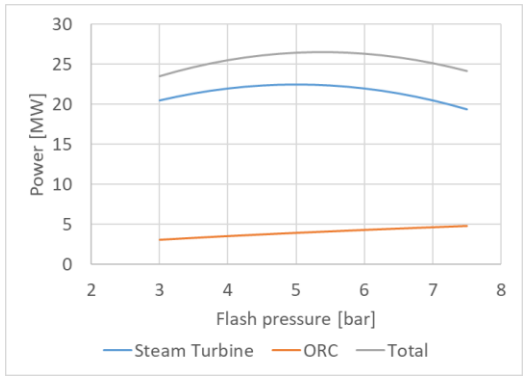
Geothermal power plant optimization

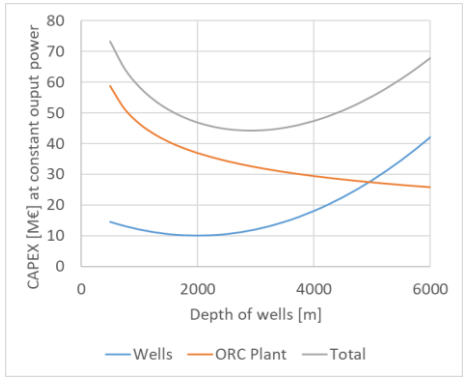
Full Resource Optimization



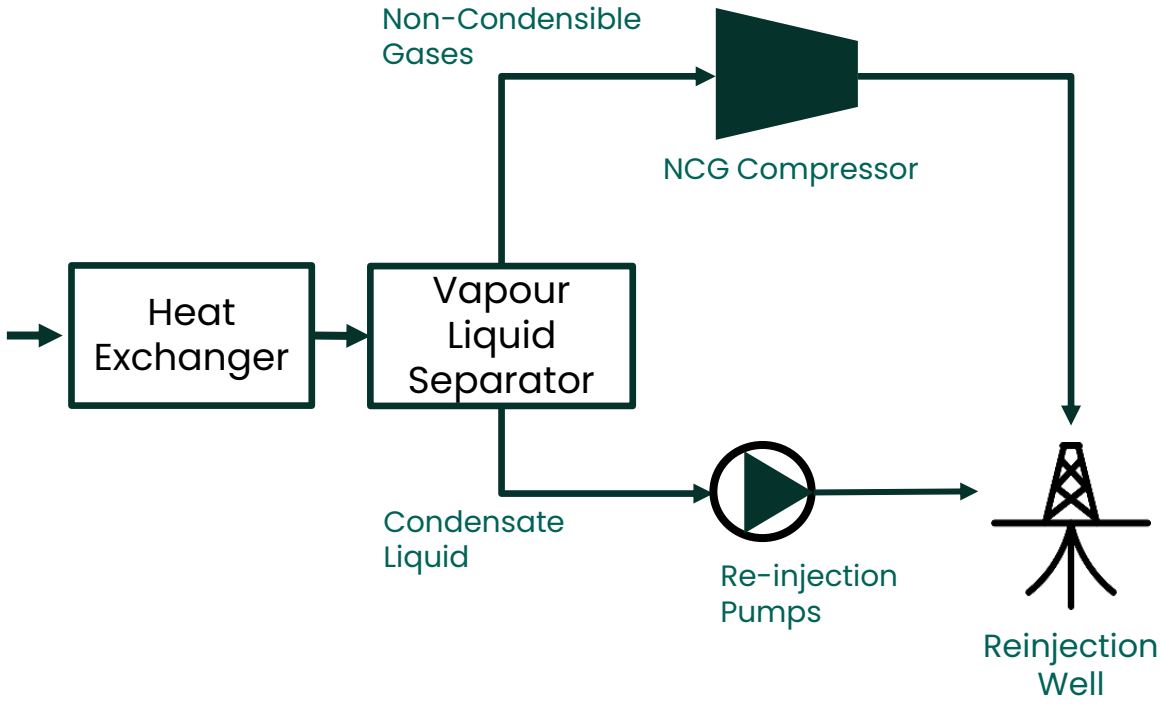
Configuration optimization:

- Plant configuration & brine/steam efficiency
- Number and depth of wells v. generated power
- Steam flash pressure optimization for hybrid solutions (e.g. ST + ORC)
- Power plant sizing trade-offs





Re-injection System Optimization



Selection of optimal reinjection strategy:

- Minimization of NCG compression power
- Quantity and diameter of re-injection wells

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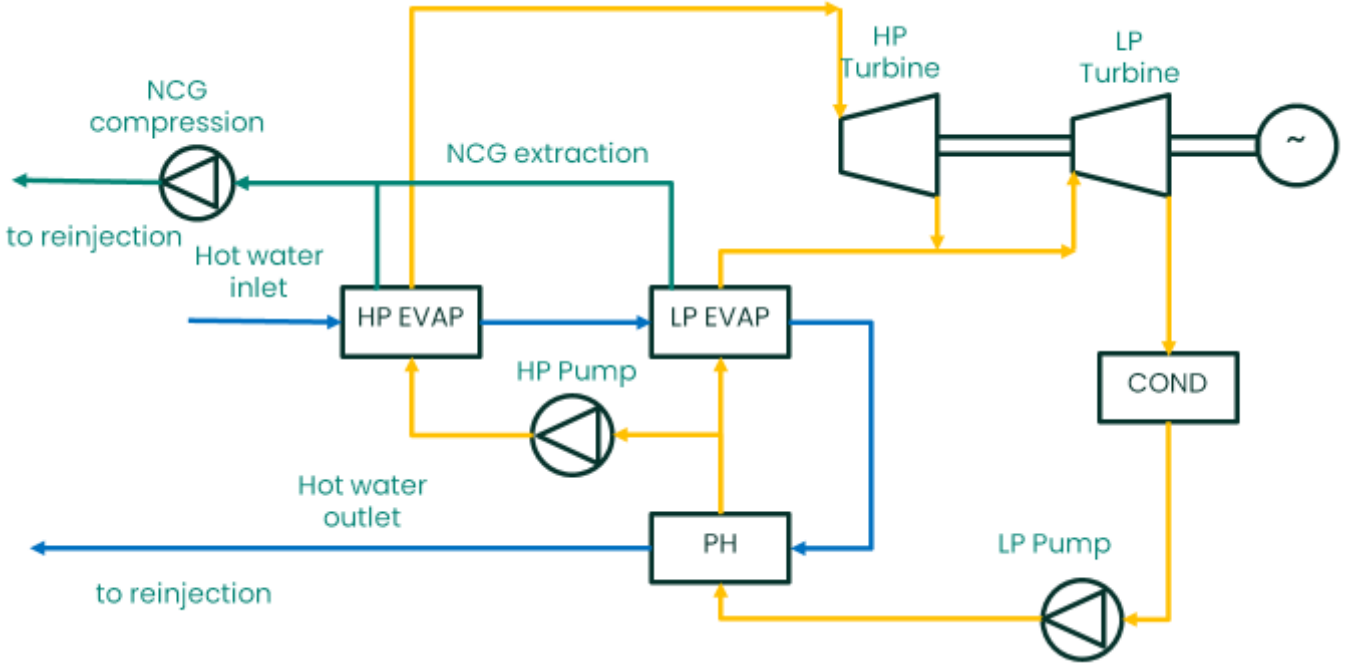
Medium Enthalpy ORC for geothermal application

BH ORC Plant Solutions

- In-house design & collab. with OFSE group to optimize overall cycle & geothermal brine eff.
- Single or multi-pressure ORC with wide selection of working fluids to target overall efficiency
- Wide range of TEX manufacturing experience in axial, radial & advanced machinery
- Driving down OPEX
  - Remote equipment monitoring with centralized monitoring & diagnostic centers
  - Collab with OFSE team to evaluate material selection v. upstream mitigations



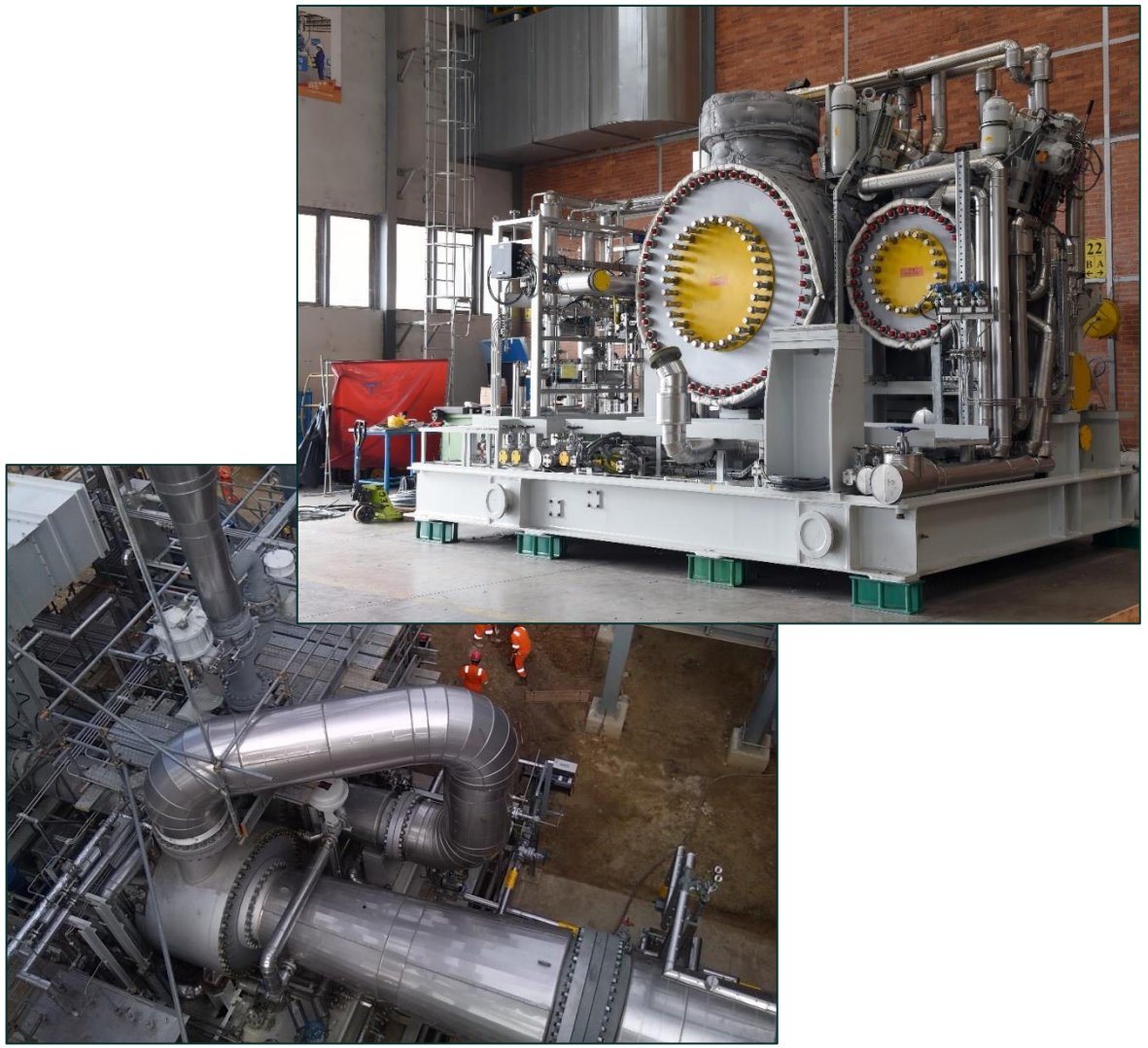
In-house Core Technology: Turboexpander-Generator, Air Cooled Condenser, Control Systems, Working Fluid Pumps

5-15+ MW ORC solutions for medium enthalpy geothermal applications

Larger Applications - ORC for waste heat recovery

Experience in larger scale units to drive larger, more CAPEX efficient Geothermal Organic Rankine Cycle

Location	Whitecourt, Canada	Berakas, Brunei	Saiyok, Thailand
Gas	CC5	CC5	CC5
P in (barA)	39.1	39.3	39.2
T in (°C)	250	250	239
T out (°C)	140	146	130
TOT EXP. Power (MW)	16.1	17.3	12.7
HP/LP Speed (rpm)	10180 / 4950	10188 / 4990	10180 / 4950
Shipped year	2012	2015	2015



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Geothermal STG - SG model

Plant Type	Geothermal / LP recovery
Power	• 5 to 80MW depending @ 50/60 Hz • Single & Double flow configuration • Condensing LP up to 6.8 m^2
Technology	• Live steam up to 30 bar and 300 °C • Reaction type technology with control stage
Benefits	• Efficiency … Outstanding heat rate due to material flexible and high performance steam path • effectiveness … Low maintenance thanks to advanced moisture removal system and anti corrosion features • Simplicity … Modular and compact concept, fabricated, welded structure with integral bearing pedestals

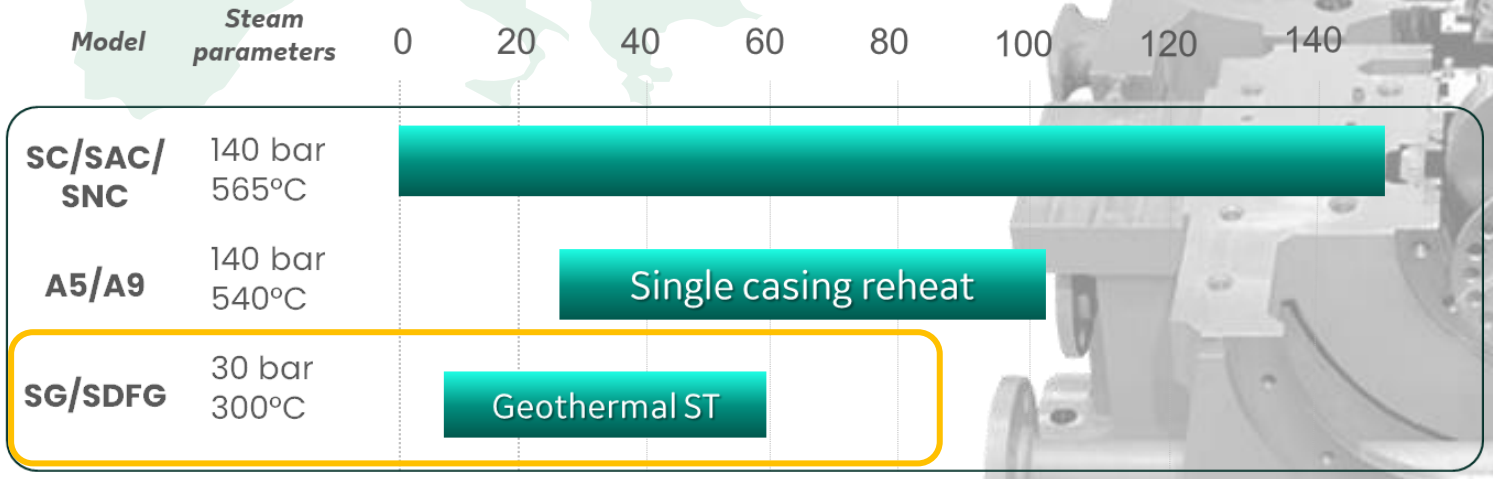
Baker Hughes – Steam Turbines

Le Creusot-France
Thermodyn
Impulse Technology:
- Boiler feed Pump Drives
- Biomass
- Captive
- Navy

Range: 2 – 45 MW

Firenze-Italia
Nuovo Pignone
Reaction Technology:
- Compressors Drives
- Combined Cycles
- Biomass
- CSP
- **Geothermal**

Range: 2 – 150 MW



NCG reinjection and extraction compressors

Re-injection Compressor

- Reciprocating compressors for total NCG reinjection
- Suitable to compress NCG mixtures, incl. CO_2 & H_2S
- Capable of reaching high reinjection pressures
- Packaged and/or Skidded solutions → ease of install
- Up to 6 cylinder per unit

Extraction Compressor

- Integrally geared compressors for NCG extraction from ST condenser
- Capability to work under vacuum (minimum inlet pressure 0.06 bar(a))
- Up to 2 MW power and 4 impellers

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