Baker Hughes
Rewriting The Energy Equation™

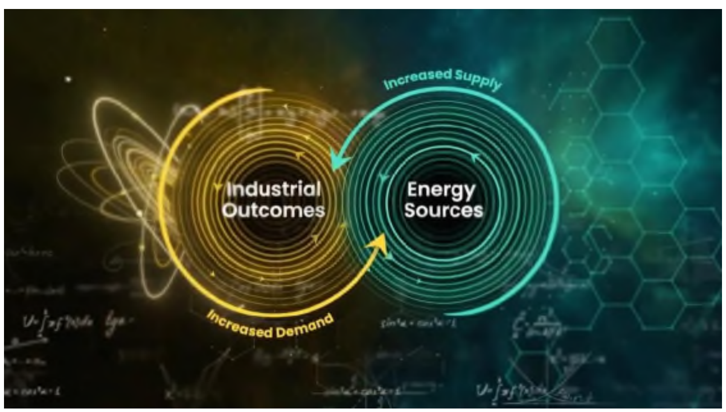
sCO2 for SMR Power Conversion: High Efficiency in a Small Footprint for Future Energy Scenarios

Davide Biliotti
Centrifugal Compressor Senior Product Manager

03/03/2026, Pittsburgh, Pennsylvania, US

Agenda

- Nuclear: a concrete opportunity
- Baker Hughes experience with sCO2
- sCO2 and Nuclear: a perfect match
- Promising applications
- Final remarks



"..as the world aspires to better things – vibrant communities, abundant food, resilient economies – it demands more of industry to make those things possible.

This is why industry must respond with innovative breakthroughs, scalable processes, and continuous improvements.

...

The interdependence between industrial outcomes and energy sources are what we call "The Energy Equation™."

Of course, the world is never stagnant. That dynamic pace impacts everything. External forces — geopolitics, climate pressure, rising demand, new industrial frontiers, and financing constraints — are coming at a relentless pace. What we have done before is not enough to meet these growing and rapid changes.

*That is why we believe that the time is now to rewrite "**The Energy Equation**"*

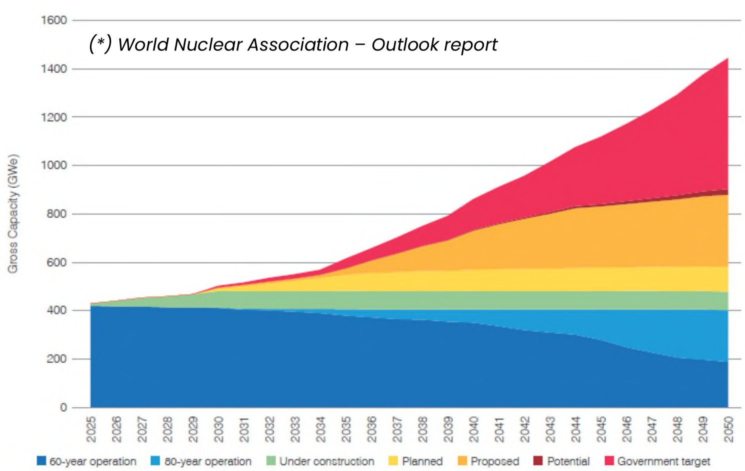
Lorenzo Simonelli

Chairman & CEO, Baker Hughes

Nuclear: a concrete opportunity

World Nuclear Association – Outlook report - *Jan '26*

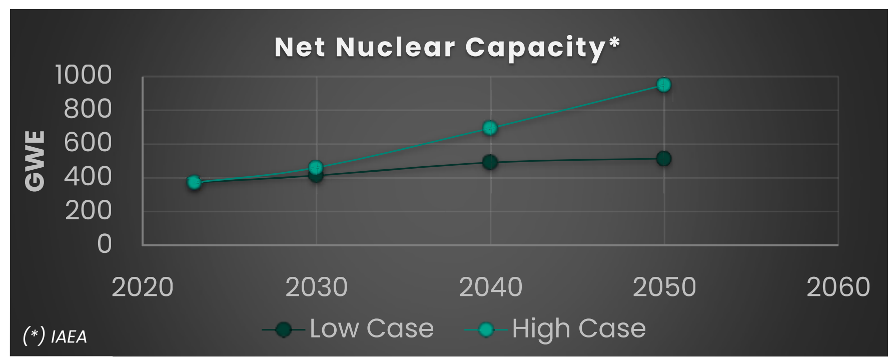
- Global nuclear capacity could reach **1,446 GWe** by 2050, exceeding the **~1,200 GWe** goal set by the *Declaration to Triple Nuclear Energy*
- Capacity growth will occur in stages:
  - **Through 2030**: expansion driven mainly by reactors already under construction
  - **2030–2035**: growth led by planned projects
  - **After 2035**: further increases fueled by proposed projects, emerging opportunities, and government-backed programs
- **China**, **France**, **India**, **Russia**, and **US** together could account for nearly **980 GWe** of total capacity by 2050, playing a key role
- Newcomer countries aiming to build **157 GWe** of capacity by 2050



IAEA press release **-** *Sep '25*

- IAEA raises nuclear projections for the **5th consecutive year**, reflecting accelerating global momentum
- High-case forecast: Global nuclear capacity more than doubling by 2050 — reaching 2.6× 2024 levels, with SMRs playing a pivotal role
- 2024 baseline: 417 reactors, **377 GW(e)** global capacity
- 2050 projections
  - 992 GWe in the high case
  - 561 GWe in the low case (+50%)
- SMR contribution
  - 24% of new capacity in the high case

Grossi R. M., IAEA's Director General: "*Nuclear power is indispensable for achieving clean, reliable and sustainable energy for all*"



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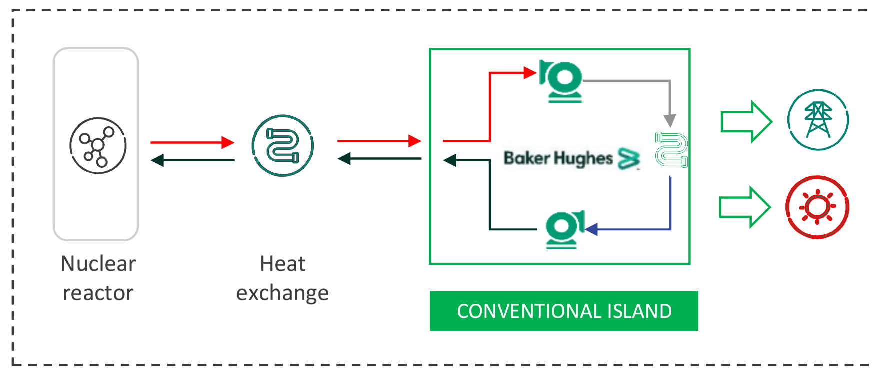
What is SMR?

Small – fraction of conventional nuclear power plant, power output < 300MWe per unit
Modular – divided in sub systems factory-assembled
Reactor – exploiting nuclear fission to generate thermal and electric power

- **Better Affordability –** Lower upfront investment for single unit, economy of serial production. Design one build many (D1BM) approach
- **Shorter construction time & flexibility –** Stand-alone modules transported to the site and installed. Minimization of site activities, modularity enabling potential in remote areas and for small grids
- **Enhanced safety –** Inherent passive cooling and safety systems by design
- **Cutting-edge technology –** From III generation reactors to Advanced Small Modular Reactors (AMR), designed to use reprocessed spent fuel from traditional NPP



Small Modular Reactor is gaining a leading role in the Nuclear Power Gen expansion, with a pipeline of projects for **33 GWe** (@ Q4 2024)*

SMR expected to cover <u>more than 40%</u> of nuclear capacity increase within **2050****

(*) Wood Mackenzie, "SMR Nuclear Market update Q4 2024", Feb 2024
(**) IEA 2024

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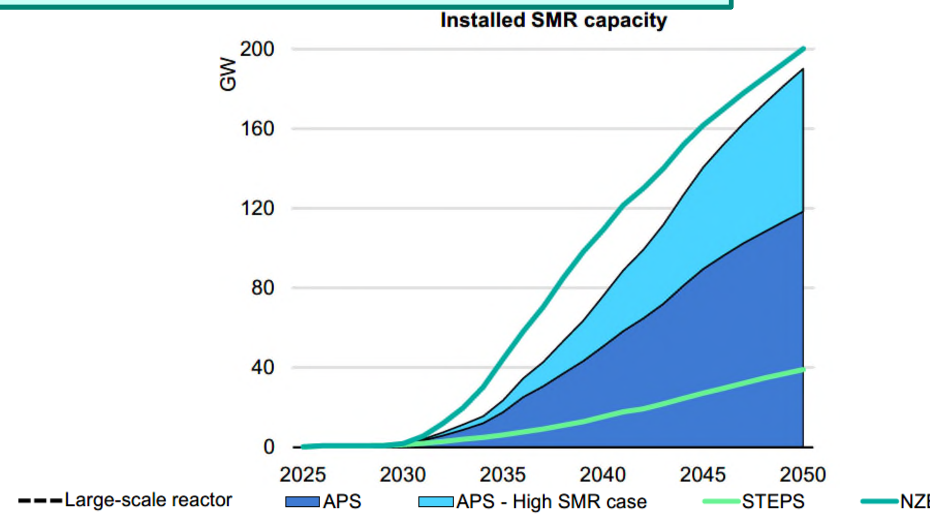

(**) Source: IEA 2024

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BH - sCO2 Programs Summary
Externally Heated Power Cycles

Project	Region	Objective	Application	BH scope	Plant output (MWe)	Plant max T (°C)
CO2OLHEAT	EU	WHR from Industrial exhaust gases	Waste Heat to Power	Compressor & HP Turbine Design Compander mfg & Test	2-25	360 - 720
STEP DEMO	US	sCO2 tech. for utility scale conventional PP (gas-fired)	PowerGen	Compressor Design, Mfg, Type 2 Test		
sCO2flex	EU	sCO2 tech. for utility scale conventional PP (gas-fired)	PowerGen	Compressor Design, Mfg, Test in actual condition Expander Deign		
SOLAR sCO2OL	EU	Pilot thermal Energy Storage for CSP	CSP	Compressor, Mfg & Test		
DeSOLination	EU	sCO2 tech for CSP to improve efficiency of desalination plant	CSP	Pump		
SCARABEUS	EU	sCO2 blends definition to improve CSP cycle eff. @ambient T>40°C	CSP	Design pump & turbine	Design only	
sCO2-4-NPP	EU	Consultancy for turbomachinery design under Nuclear regulation	Nuclear	Design compressor & turbine		

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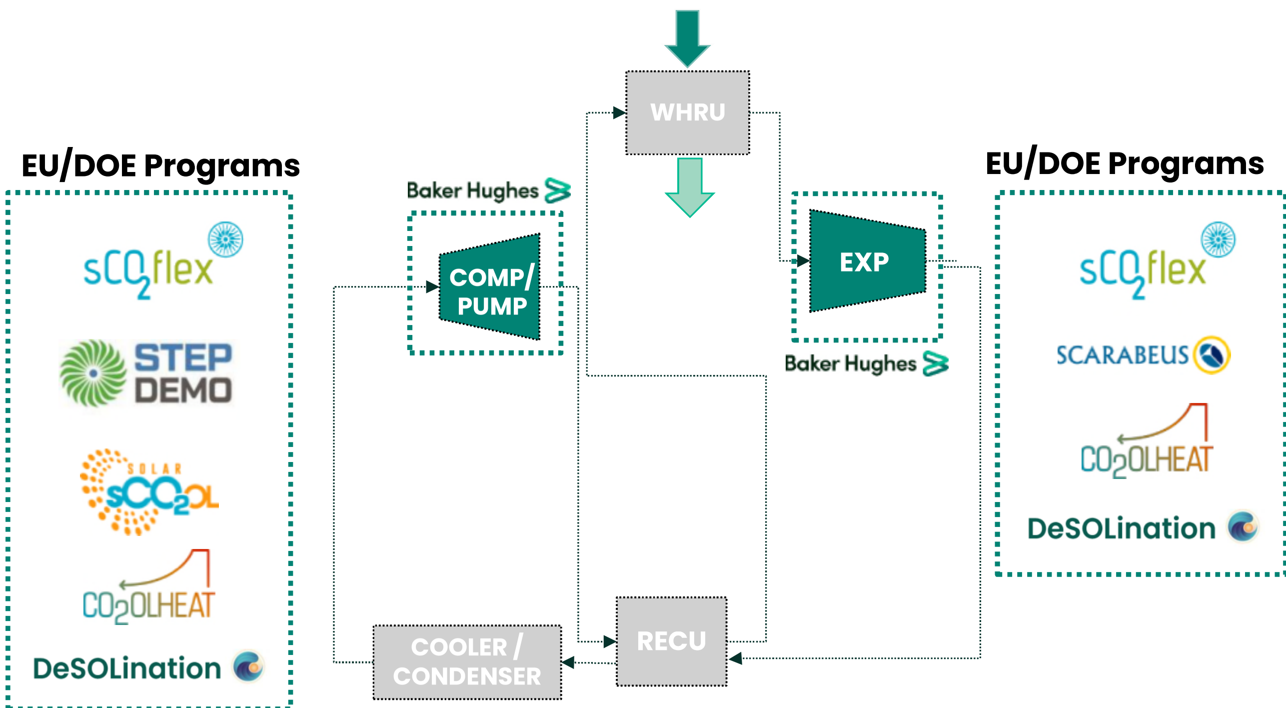
Externally heated sCO2 cycle - BH engagement overview



	Compressor		Turbine
	BCL	SRL	RAD/AX
2023	TRL6	TRL5	TRL3
2025-26	TRL7	TRL5	TRL7

Developed know-how to provide **complete plants solutions**

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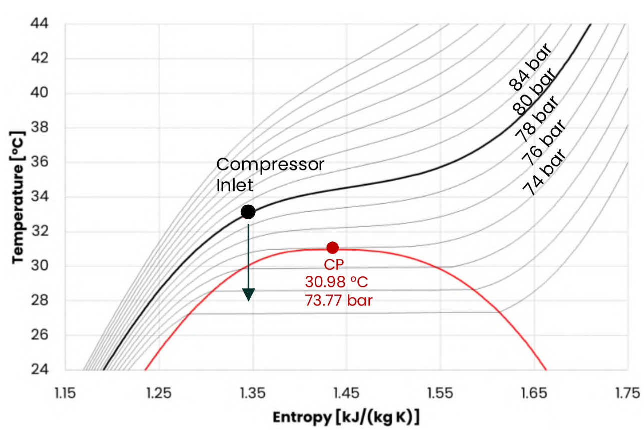
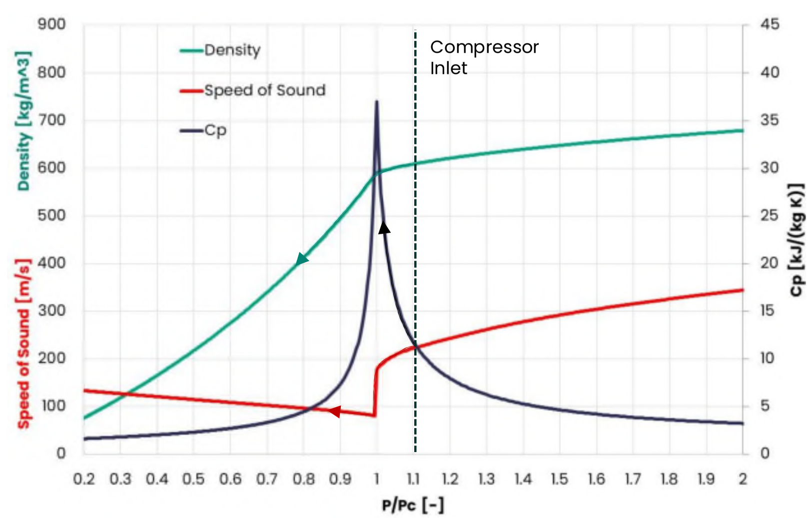
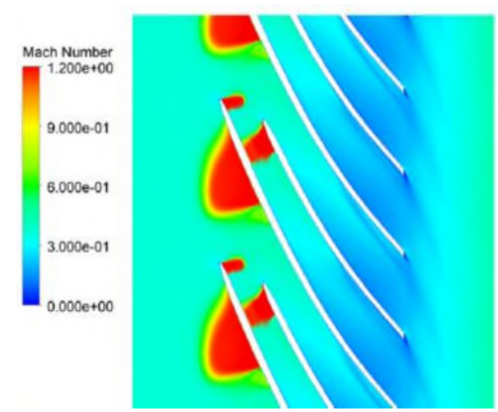
sCO_2 Compressors Design Challenges

- Compressor **suction near the CO_2 critical point** causes performance uncertainty due to steep property gradients
- Local expansions near blades may trigger phase change and sudden changes in speed of sound, requiring **optimized design** to limit two-phase regions
- A safety margin from the saturation line and critical point is needed to ensure stable and controllable compressor operation
- High **power-density machine** with flexible rotor requires robust mechanical layout and rotordynamic management
- DGS and auxiliary systems may face condensate formation or **phase transition** during operation

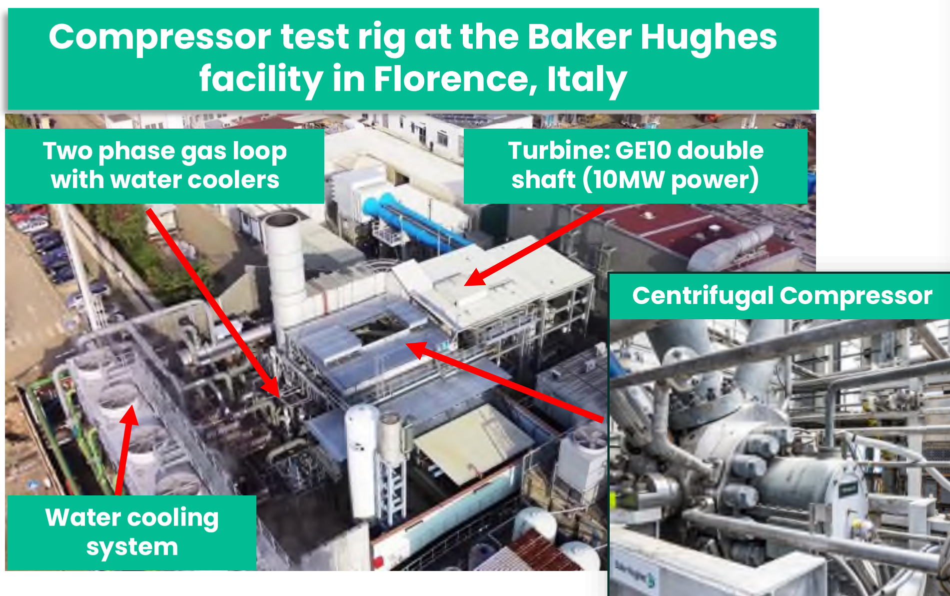






sCO2 Flex Project: a successful story

- Test performed at Turbomachinery Testing Laboratory (TTL), at Baker Hughes, Florence
- 5.4 MW centrifugal compressor prototype
- Closed-loop test rig, with gas turbine as driver and a bypass loop for temperature control



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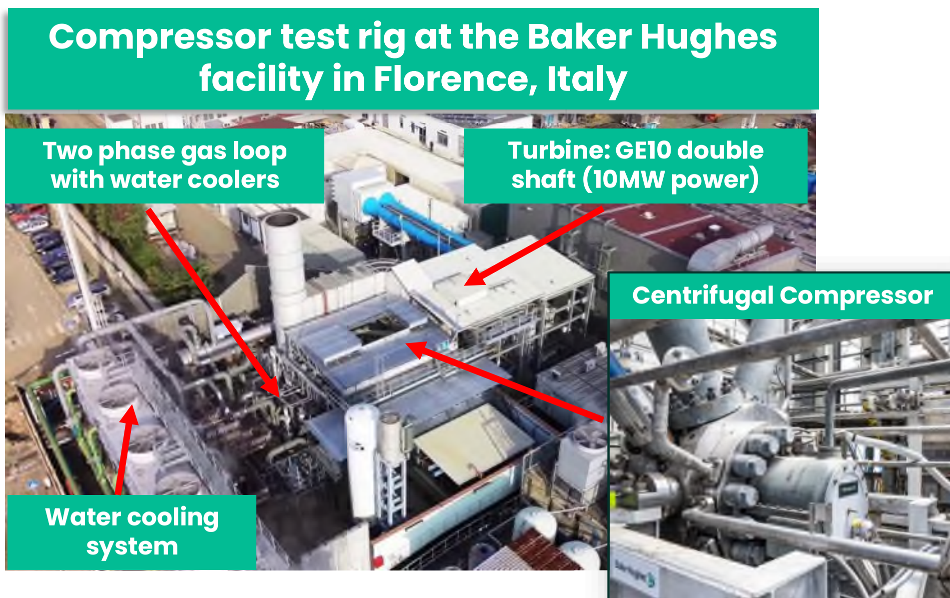
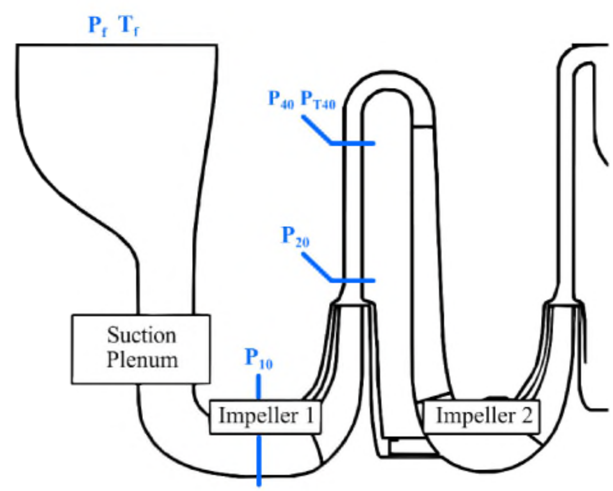


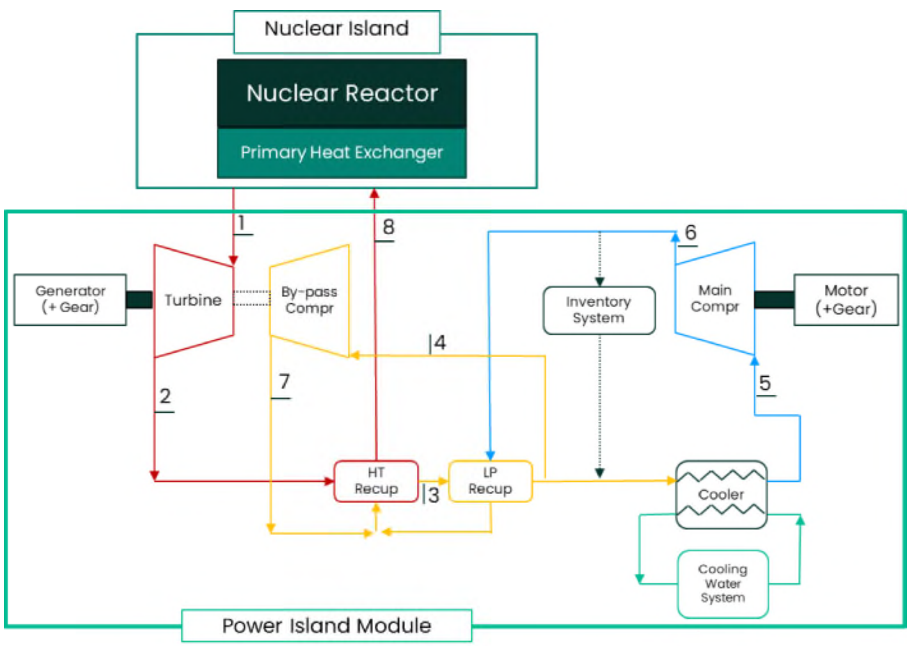
Instrumentation

Section	Instrumentation
Inlet Flange	P_{tot}, T_{tot}
Impeller Inlet – Sec 10	P_{stat}
Diffuser Inlet – Sec 20	P_{stat}
Diffuser Outlet – Sec 40	P_{tot}, T_{tot}
Outlet Flange	P_{tot}, T_{tot}

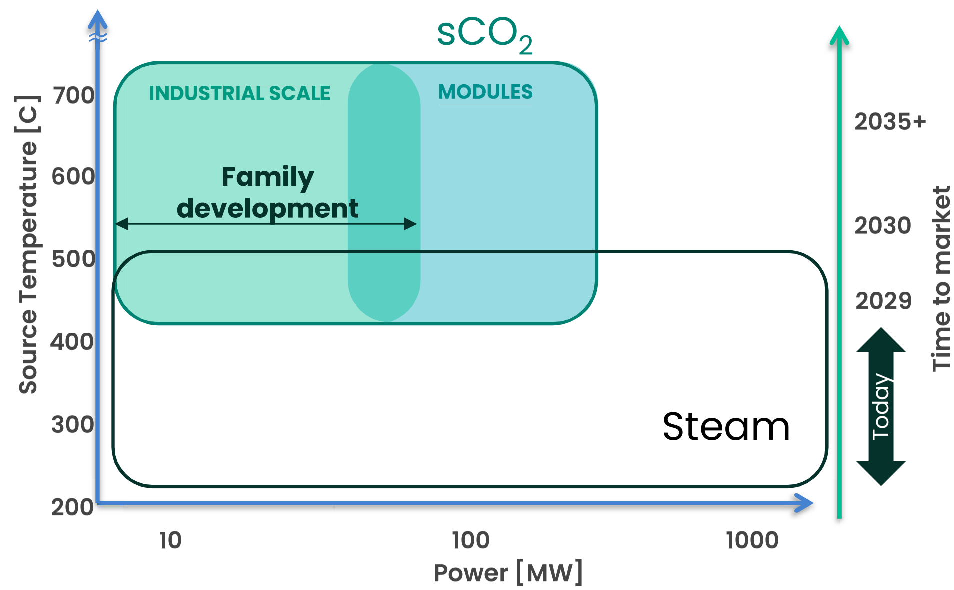


sCO2 and Nuclear: a perfect match!

- **High Temperature** heat source **T>400-450°C**
  - **High efficiency** cycle
- **High power density** enables reduced machinery footprints
- Inert fluid with different heat sources, no water needed
  - Improved **safety**



- **Industrial scale**:
  - Power & Heat Gen, Naval propulsion, Mining, Remote area, Hard to abate sector
- **Modular concept**:
  - FNPP, Utility, Data center



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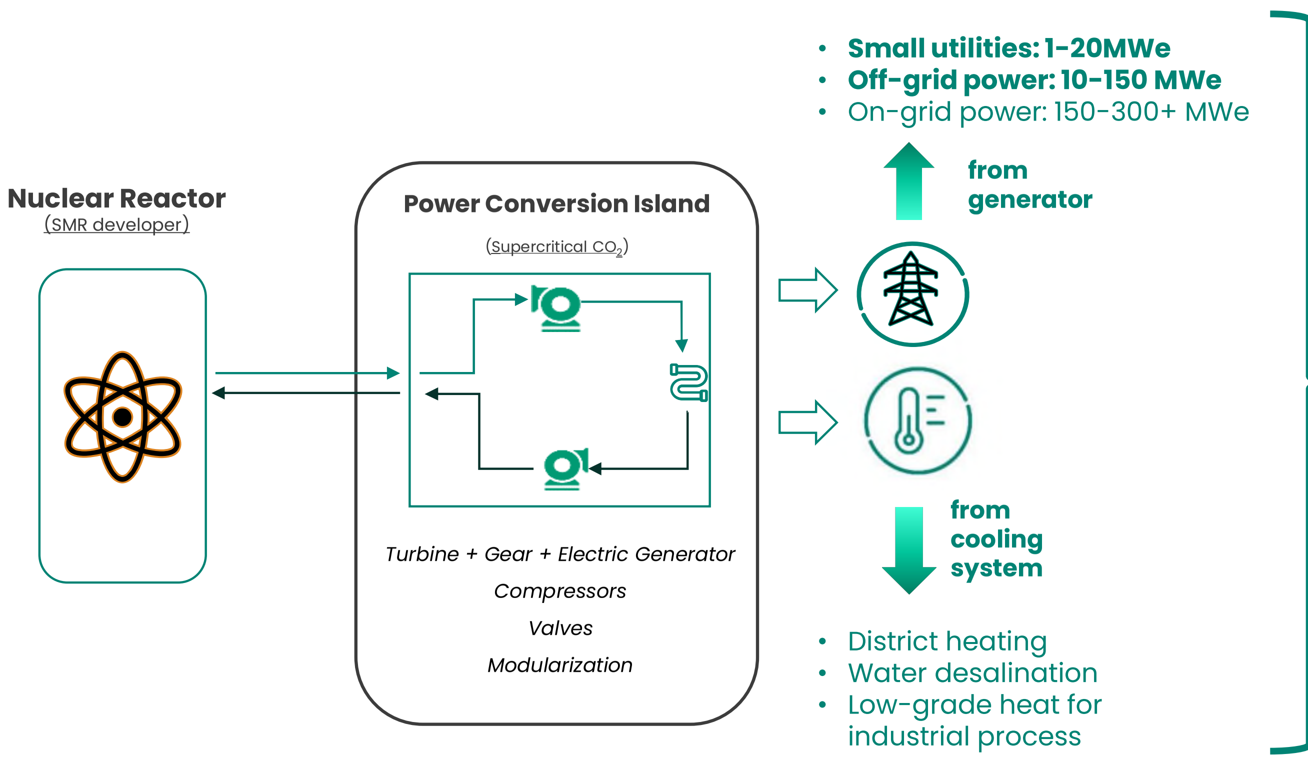
sCO2 for Small Modular Reactors in Power & Heat Generation



Power & Heat Generation

- Enabling decentralized production
  - Industrial plants in remote areas
- Mining
  - Remote areas with poor water presence to contain energy cost and environmental impact
- Communities
  - Local and clean energy
  - Remote and rural cities
  - Islands
- Energy-intensive industries
- Clean fuel production
  - Hydrogen, ammonia, methanol

sCO2 Brayton cycle to be properly selected as a compromise of performance, footprint and application

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sCO2 for Small Modular Reactors in naval propulsion

Case study

- Naval propulsion example: 2x35MWe power to feed all the vessel demand (12000-15000 TEU large container ship, LNG Carrier)
- Footprint KPI: installed within existing diesel engine/methanol engine room
- Advanced Nuclear Reactor: Thermal Power from each primary heat exchanger: ~ 90 MWth
- sCO_2 fluid conditions @Turbine inlet: T > 550°C, Pressure ~ 250 bar

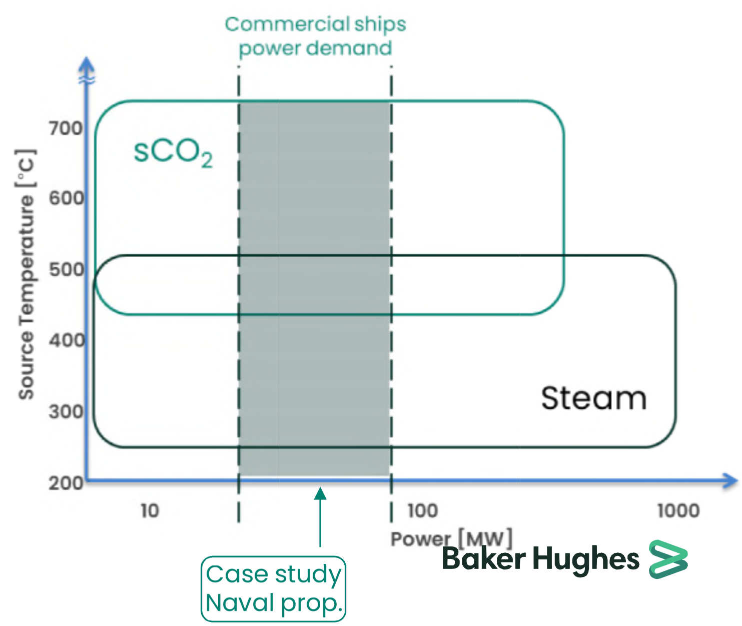
A rendering of a 15,000 TEU-class SMR-powered containership (image: HD KSOE)

Power Conversion Island comparison

	Rankine w/steam VS Brayton w/sCO_2	
Cycle eff	~ 5 pts	10% higher speed
Footprint (*)	↓27%	equiv to ~30 TEU
Weight (*)	↓15%	less supporting structures

- No need for fuel oil tank (approx **300 TEU** free space)
- **BOG** fully recompressed with **no burnoff** and **zero emission**

(*) related only to Power Gen module



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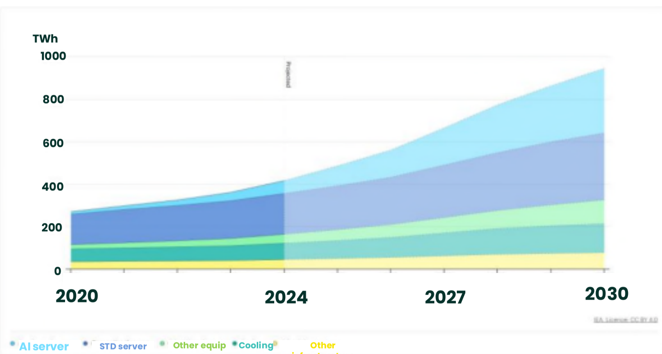
sCO2 for Small Modular Reactors in Data Center

Power demand

- Traditional datacenters growing power demand by 9%*
- AI datacenters energy demand growing **30% YoY*** or **4x** in **2030** wrt 2024 → 3% of the global consumption!!
- Location driven installation, where electricity cost is lower!
  - USA green PPA
  - Saudi Arabia, UAE and others

*IEA



Computational hardware

- Computational hardware is the core of technology
- Up to **hundreds of thousands** servers in a single data center

Cooling

- Datacenters convert electricity to storage, computational power and intelligence
- Cooling is necessary to protect IT hardware and allow it to work at 100% of the load

Power

- Providing uninterruptible, high-quality power is key for datacenters
- AI datacenters are demanding in terms of **power fluctuations and ramp-up/down**

Standard DCs

- Suitable for **steady workloads** and **moderate rack densities**
- Cooling systems can be **air-based**, with **economizers** and **chillers**
- Redundancy at **N+1** is typically sufficient

AI DCs

- Require **liquid cooling**, **immersion**, or **rear-door heat exchangers**
- Must support **dynamic thermal loads** and **burst behavior**
- Redundancy at **2N** ensures resilience for mission-critical AI workloads

- **Reliability** as the right size of the power conversion island
- **Compactness** and **modular approach** are required

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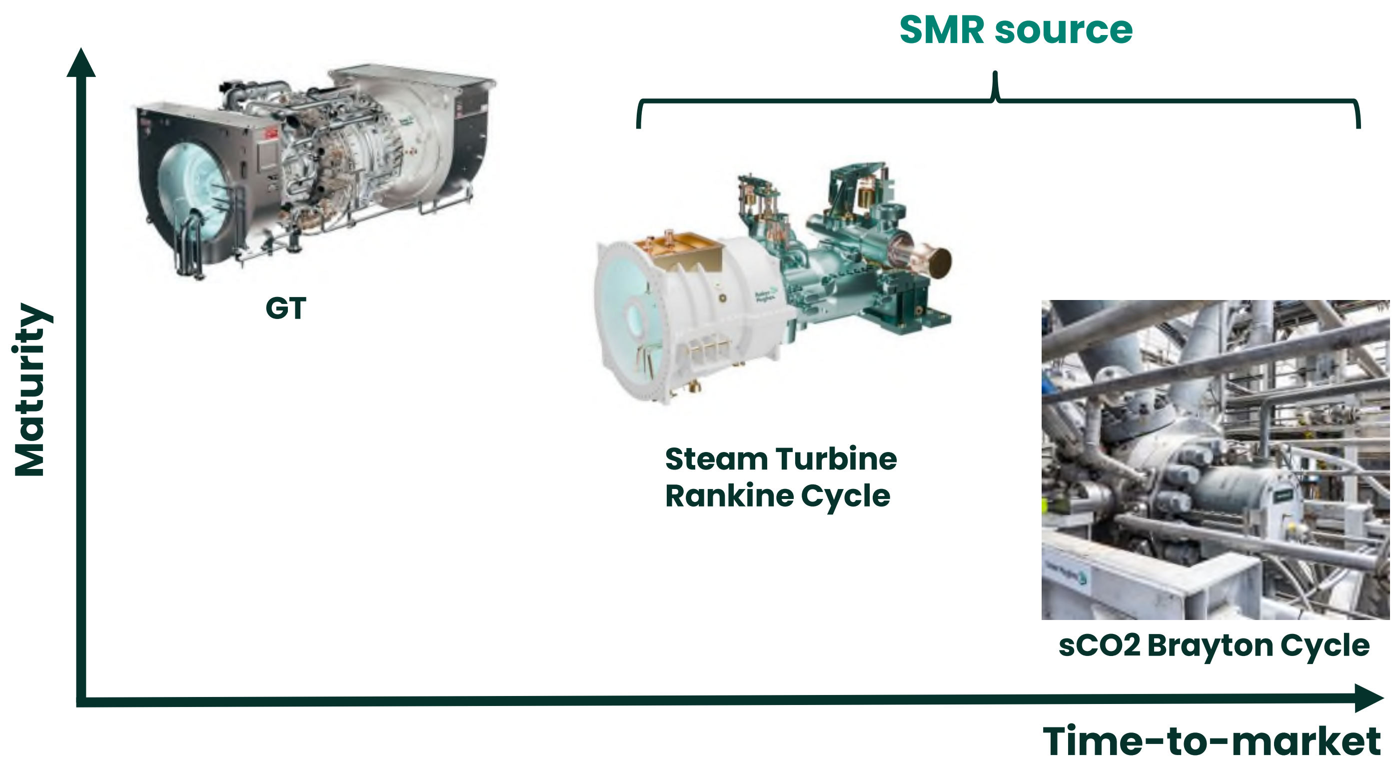
sCO2 for Small Modular Reactors in Data Center

Data Center Roadmap



sCO2 Brayton key adv

- Reduced footprint
- Reliability
- Clean energy to fulfil increasing energy demand
- No water needed
- Remote area accessibility

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Modularization for SMR Conventional Power Island

From Industrial to Utility Scale

- **Scalability**: sCO_2 turbomachinery technology can be scaled up from 80MWe (industrial scale) to ~ 250MWe (utility scale) power output
- Ideal for remote regions, maritime industries, and modular decarbonization needs

Solution

Proven practice already consolidated in oil & gas industry, LNG experience, modularization of SMR Conventional Power island can bring:

- Main equipments all integrated on a single structure
- Pre-assembled **Plug & play solution**

Advantages

- Installation **time reduction** and **on-site personnel reduction**
- **Project de-risk**: higher control of budget and schedule using modules fully constructed, tested and commissioned in factory
- **Expandable capacity** with standardized design (e.g. FNPP)
- Compactness with high potential for offshore and naval applications

Video:
Baker Hughes Modules Construction
Avenza (Italy) Yard

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Closing remarks

- SMRs are going to **play a central role** in meeting growing global power demand with clean, reliable energy
- sCO_2 Brayton cycles enhance next-generation reactors with **higher efficiency** and a significantly **smaller footprint**
- Validated sCO_2 technology, turbomachinery expertise, and proven test results to **accelerate SMR deployment**
- **Modularization** of the power conversion island reduces installation time, cost, and project risk while enabling scalable designs
- Combining advanced nuclear solutions with sCO_2 technology open to **multiple market possibilities** from power generation to naval propulsion up to data center

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Thank you!

Let's rewrite The Energy Equation™ together.

Davide Biliotti
Centrifugal Compressor Product Leader
Compressors
Industrial & Energy Technology
Baker Hughes

Back up

Horizon 2020 European Union Funding for Research & Innovation

sCO2 Flex Project: few details

Main CC Design features

Parameter	Unit	Value
Suction Pressure	[bar-A]	79.8
Suction Temperature	[°C]	33°
Discharge Pressure	[bar-A]	250.1
Gas power	[MW]	5.4

- **2 stages barrel type compressor** with a head flange; all connections are flanged type.
- **Movable IGVs** installed at compressor suction
- Rotor composed by shaft and **2 impellers**. The first impeller has a dedicated design to cope with the CO_2 supercritical characteristics.
- Direct lube journal and thrust bearing, **tandem Dry Gas Seals**.

Main CC Test results

Total running hours	**126**
Running hours @ full speed	46
Test days	16
# of start-ups	54
# of trips	40

- Validated innovative **calculation method** specifically developed to simulate CO_2 condition **near critical point** (real gas with possible phase changes)
- **Accurate prediction** of full operating envelope, including choke limit
- Explored **off-design conditions** (low/high temperature)
- Good **rotordynamic behavior**, stability achieved also close to surge

Compressor prototype installed on the test rig at the Baker Hughes facility in Florence, Italy

Prototype compressor test rig at the Baker Hughes facility in Florence, Italy

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