# Geothermal Power

## Siemens Energy
## ORC and SC Turbine Developments

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# Agenda

1. Siemens Energy Portfolio
2. Industrial Turbines and Generators
3. ORC Portfolio
4. SC Portfolio

# Our company structure

We support our customers along the entire energy value chain

SIEMENS energy

| Gas Services | Grid Technologies | Transformation of Industry | Siemens Gamesa |
|---|---|---|---|
|  |  |  |  |
| Large Power Generation | Resilient Grids & Reliability | Heat & Industrial Processes | Onshore & Offshore |

# Industrial Turbines and Generators

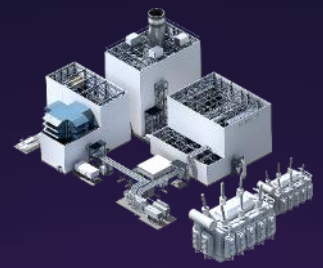
## We are
Global leader for steam turbine & generator services

**100+ years**
of strong service expertise

**~62,000**
installed equipments

We service across
**>144**
countries

Every year, we process
**>16,000**
service transactions



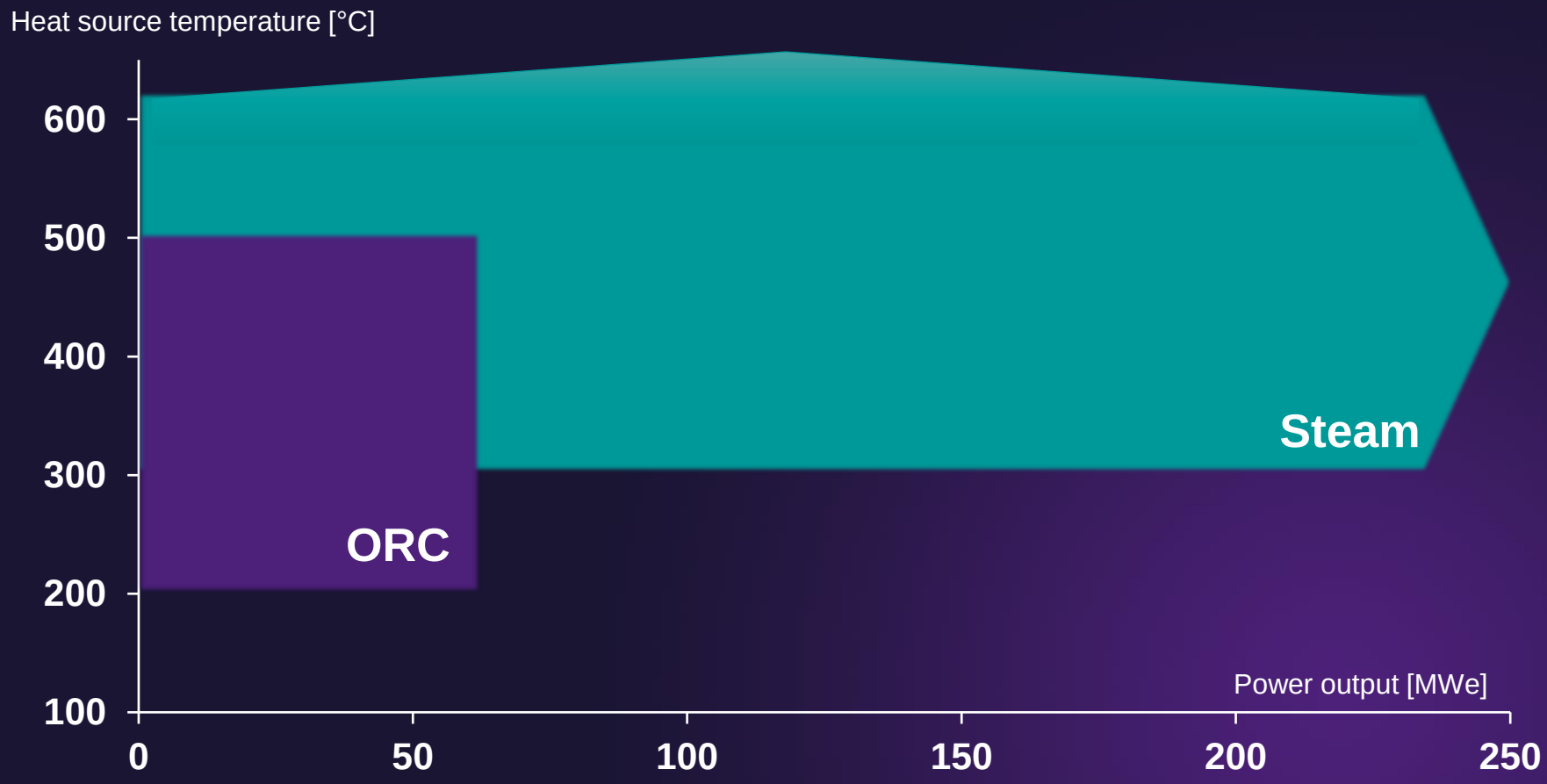
Power Generation
**~30%**

Industries
**~40%**

Oil & Gas
**~25%**

# Industrial Turbines and Generators

## Different technologies exists to convert thermal heat into power …




- Different technologies exists to convert thermal heat into power:
  - Steam Rankine Cycle
  - Organic Rankine Cycle
- **Currently Steam and ORC are fully commercialized**

**Geo:** Geothermal
**WHR:** Waste Heat Recovery
**Bio:** Biomass

# ORC Portfolio – Small ORC Modules
## ORC-Modules up to 2MW

### Heat input (Thermo-oil)

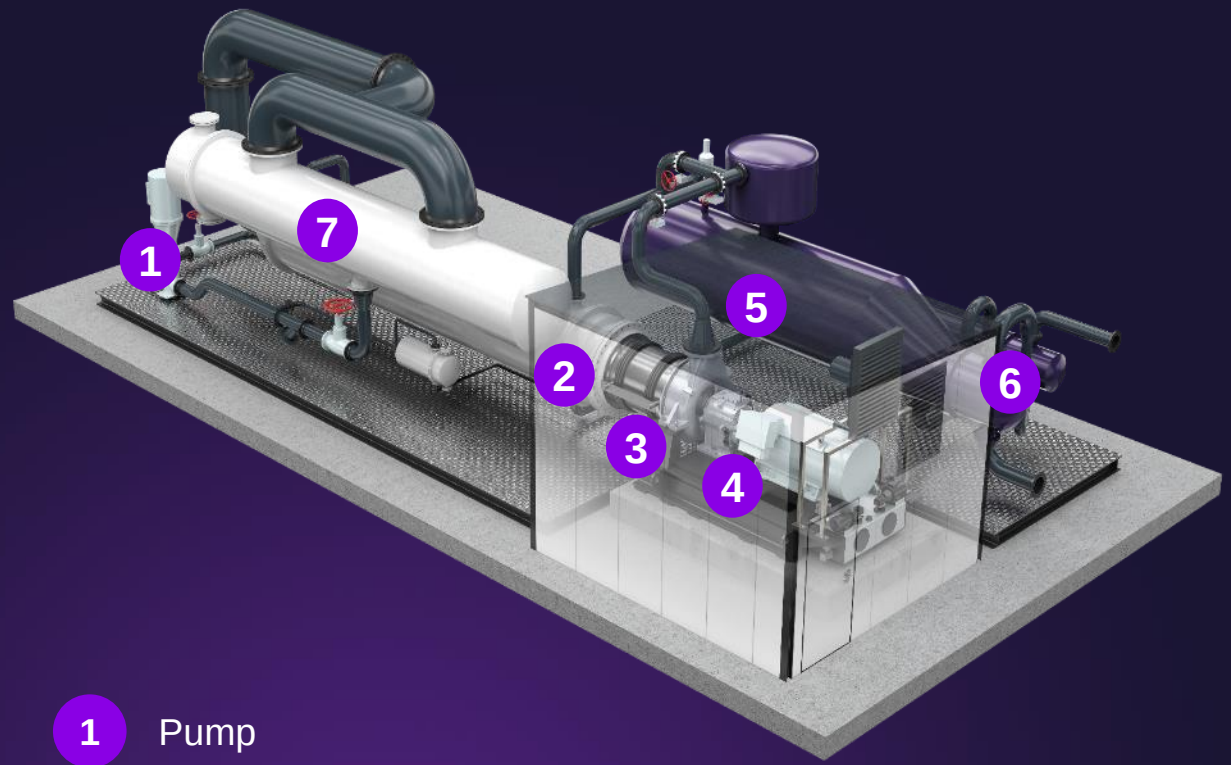
| | | |
|---|---|---|
| Total heat input | $kW_{th}$ | ~2,000 – 8,000 |
| High temperature (HT) circuit | | ~90 – 95% of total heat input |
| Nominal temperature HT circuit (in/out) | °C | 300/240 (typical values) |
| Low temperature (LT) circuit | | ~5-10% of total heat input |
| Nominal temperature LT circuit (in/out) | °C | 240/140 (typical values) |

### Electrical output

| | | |
|---|---|---|
| Power output (gross) | $kW_{el.}$ | ~350 – 2,000 |
| Own power consumption | | ~5-6% |
| Electrical efficiency (gross) | | ~19 – 20% |

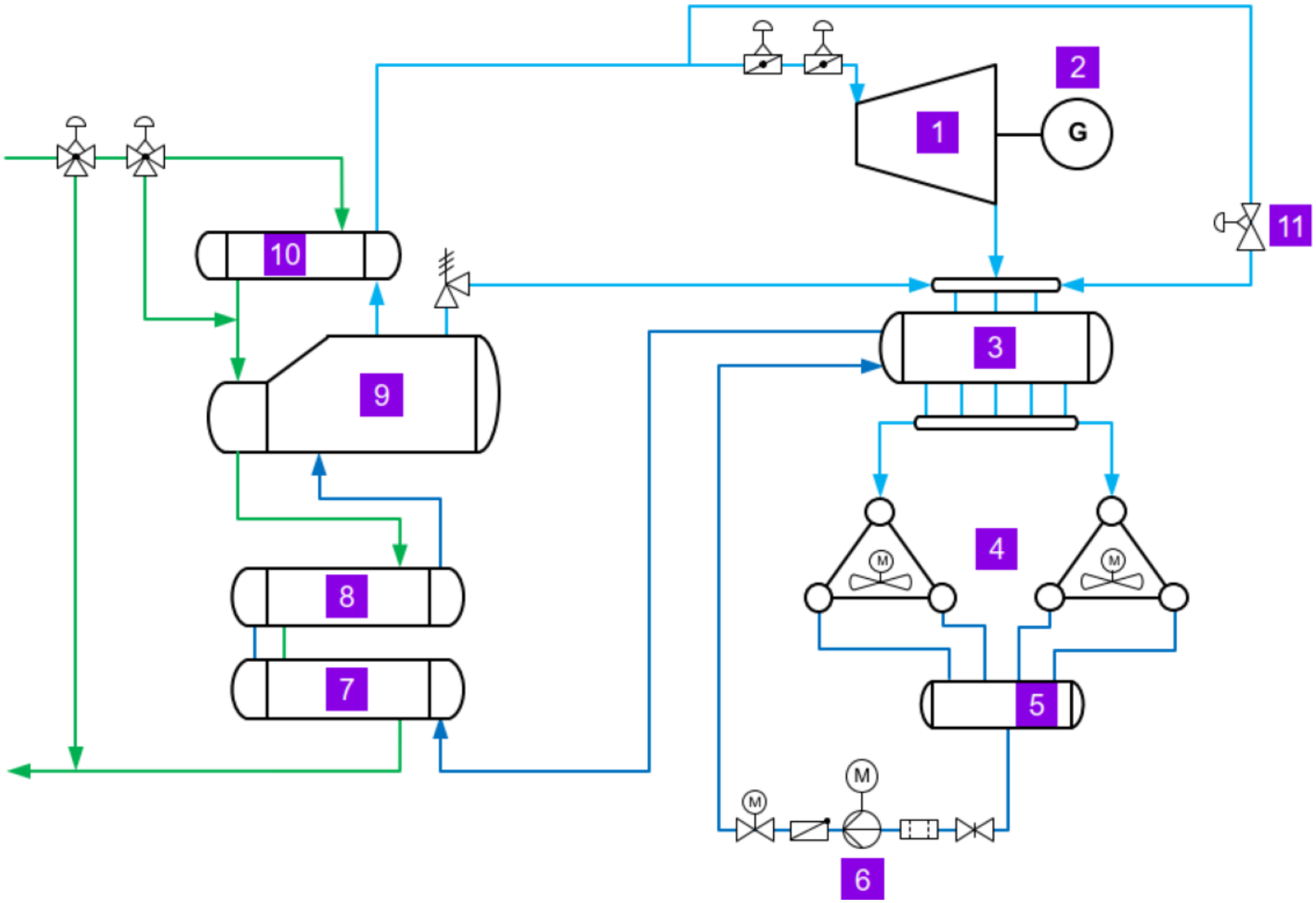
### Heat output cold end (cooling water)

| | | |
|---|---|---|
| Nominal temperature (in/out) for CHP applications | °C | 60/80 (typical values) |
| Heat transfer to district heating system | | ~80% of total heat input |




1 Pump
2 Recuperator
3 Turbine
4 Generator
5 Evaporator
6 Preheater
7 Condenser

# ORC Portfolio – Large ORC Modules
## ORC – Geothermal Application

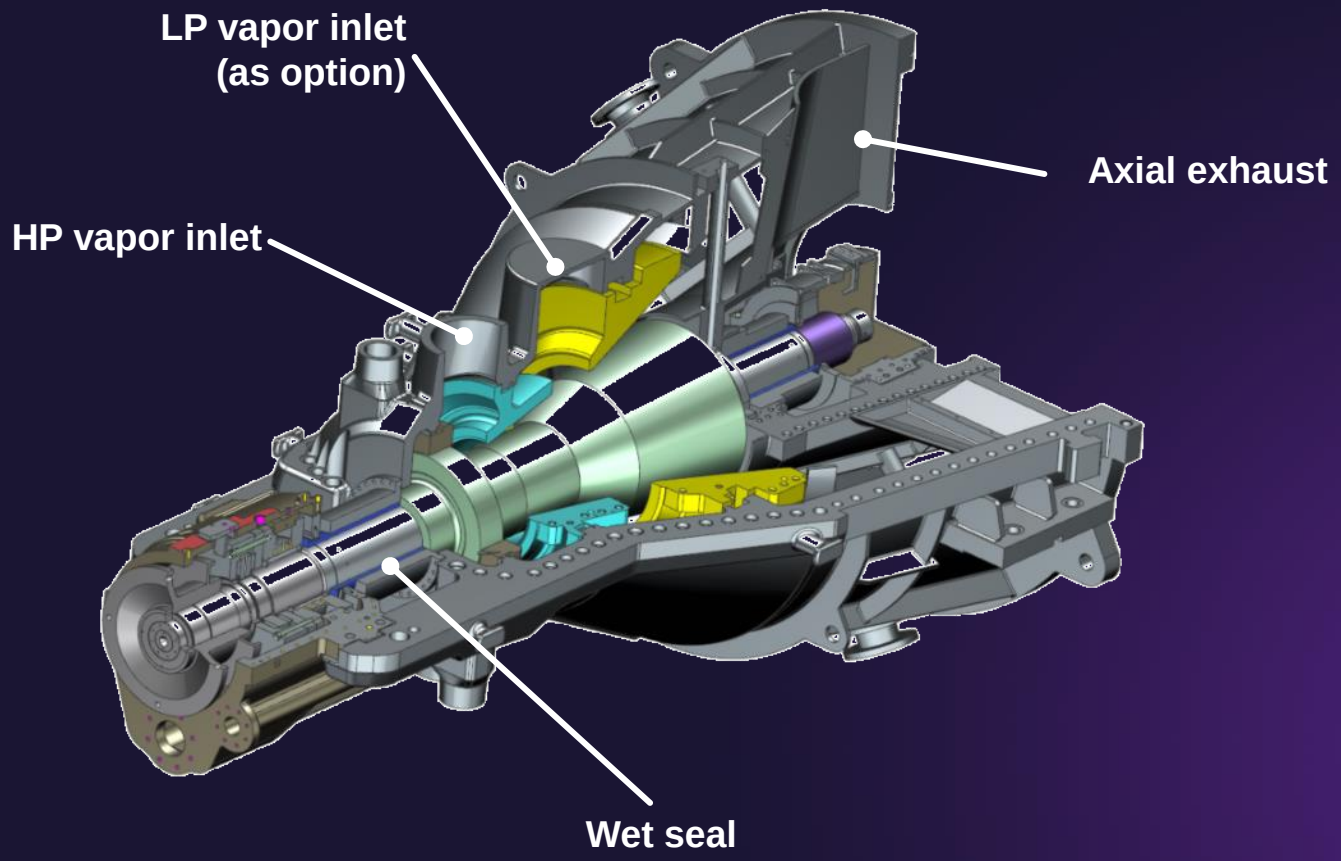



1) ORC turbine
2) Generator
3) Recuperator
4) Air cooled condenser
5) Storage tank
6) Feed pump
7) Pre-heater 1
8) Pre-heater 2
9) Evaporator
10) Super-heater
11) Bypass station

ORC Vapor
ORC Liquid
Brine

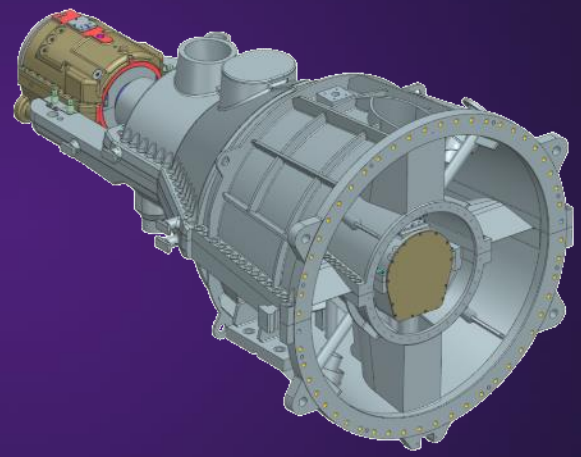
# ORC Portfolio – Same DNA as our Steam Turbines!

ORC frame up to **15-20MW** (depending on boundary conditions)



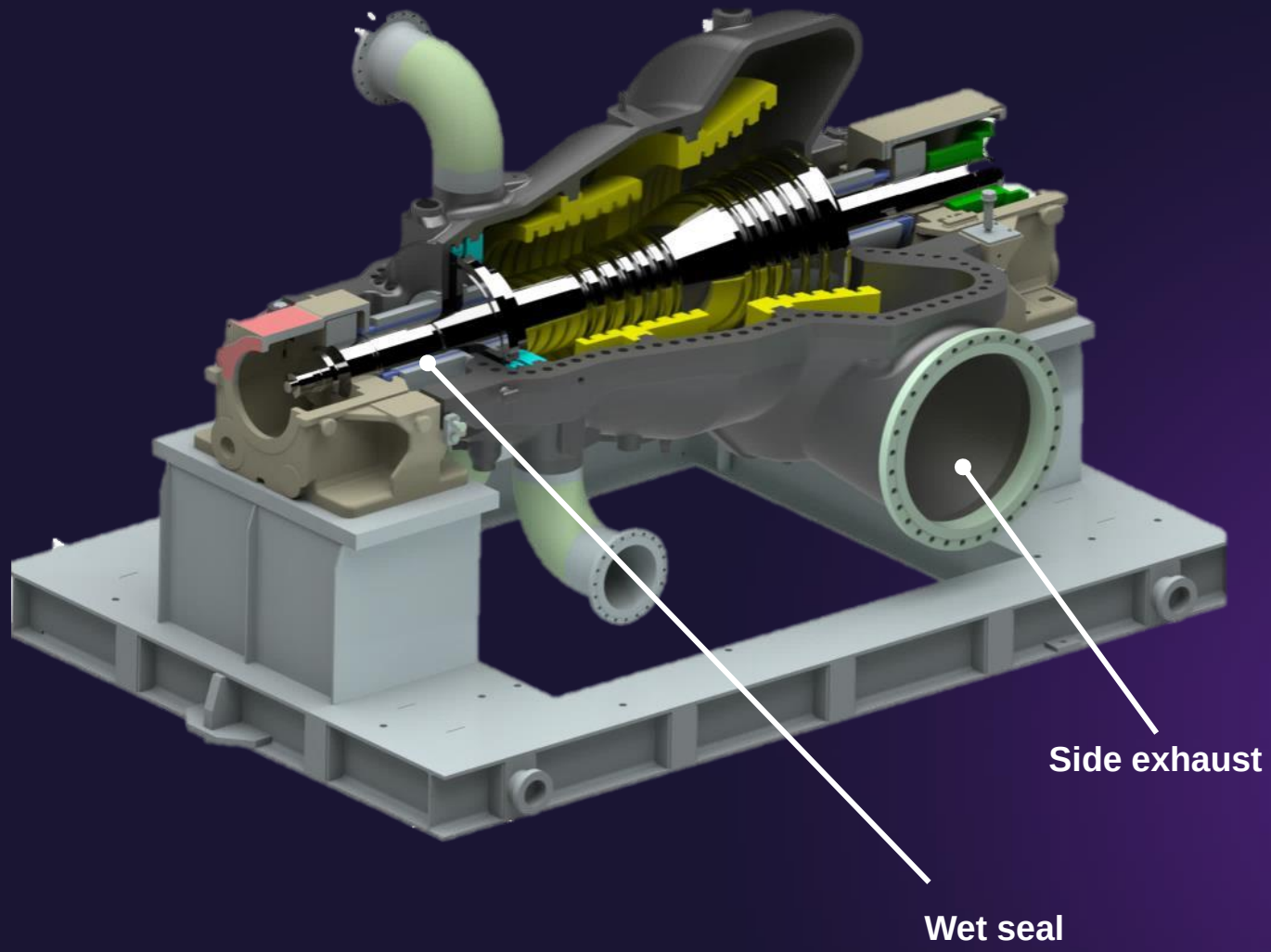

## High Synergy between SE Steam Turbine Technology and ORC

- Reaction Blade Technology
- >90% Efficiency Capability
- In-between bearing concept
- Axial Exhaust configuration (lower foundation) possible
- Single Casing Design
- Admission concept for LP cycle
- One HP and one LP blading group



# ORC Portfolio – Same DNA as our Steam Turbines!

ORC- frame up to **55-60MW** (depending on boundary conditions)

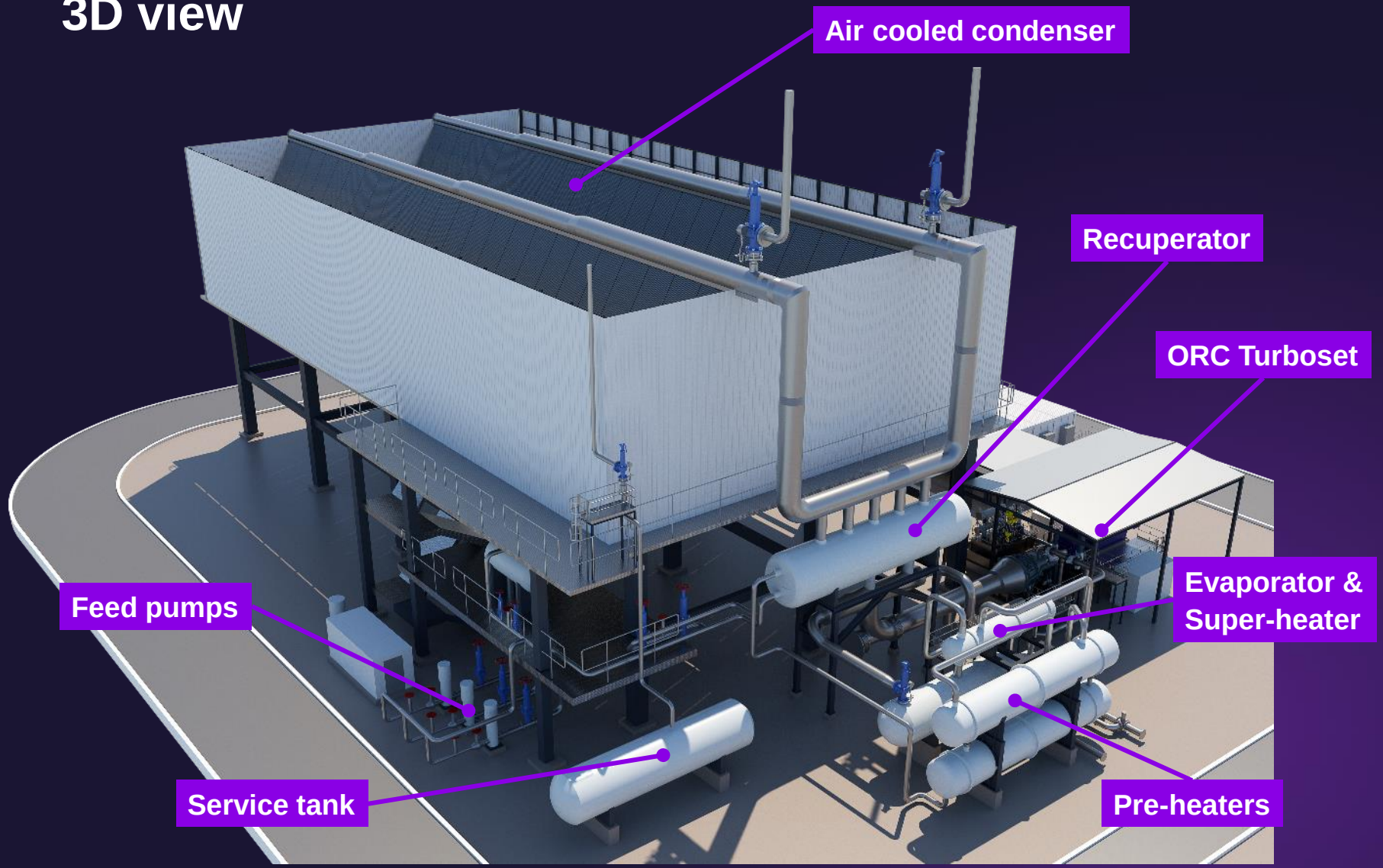



## High Synergy between SE Steam Turbine Technology and ORC

- Reaction Blade Technology
- >90% Efficiency Capability
- In-between bearing concept
- Side Exhaust configuration (lower foundation) possible
- Single Casing Design
- One HP and one LP blading group

Please scan the **QR** code to view the ORC turbine in **Augmented Reality (AR)**

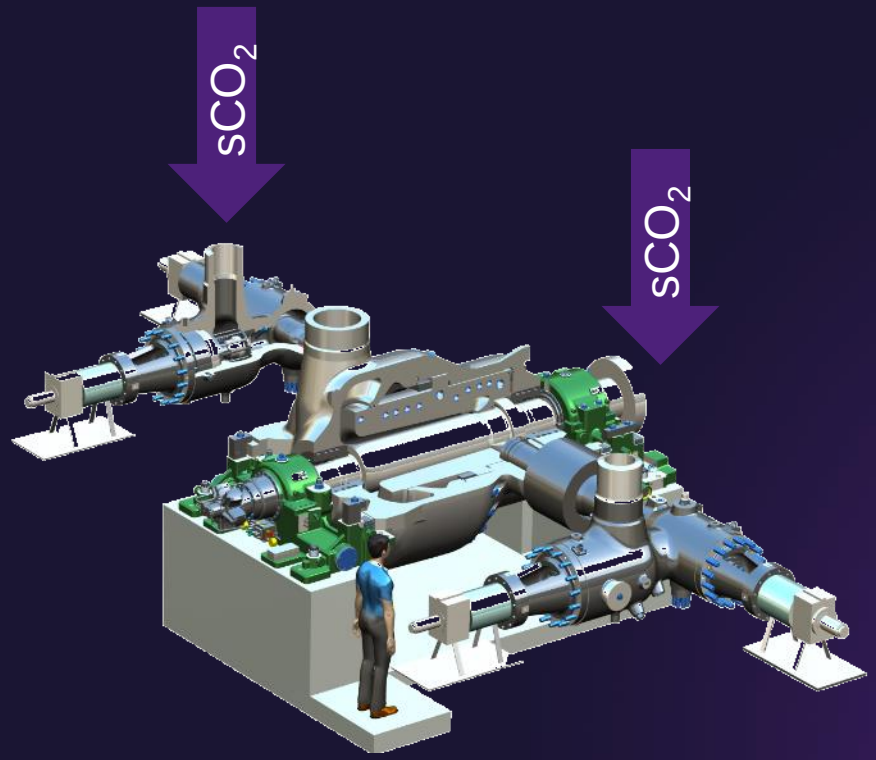
# ORC Module (> 10 MWe)
## 3D view




## Main features of the arrangement concept

- **Binary cycle ORC system** (thermal oil or brine as heat carrier)
- **Outdoor arrangement** of the main equipment
- Electrical and control system **containerized**
- Weather roof for turboset (rain & sun protection)
- **Air cooled condenser** (optimized layout/ auxiliary power consumption)
- **Air cooled** closed cooling water system via fin-fan coolers
- **Water free solution** for operation

# Overview New Technologies
## $sCO_2$ Power Cycles




### Advantages & Contribution to the Energy Transition

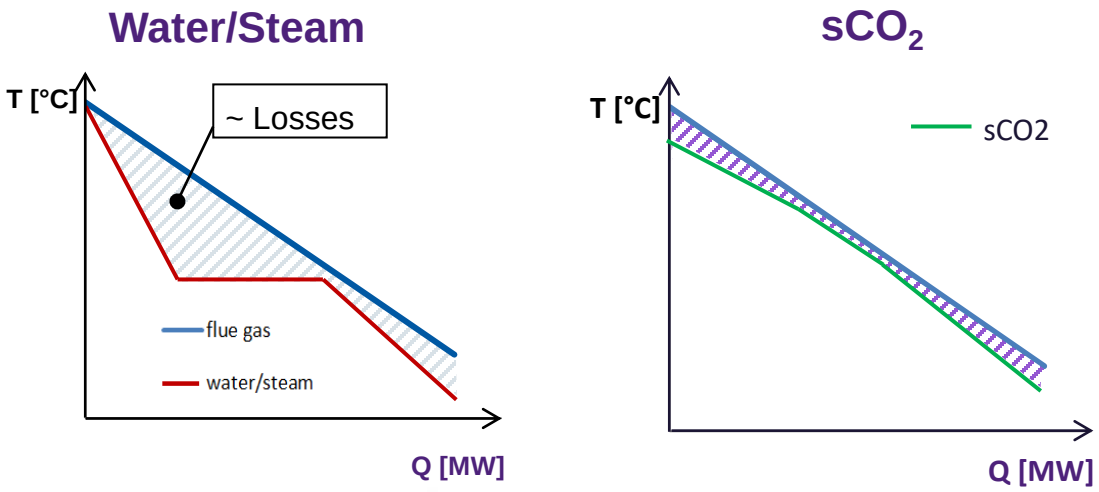
The high energy density of the medium $sCO_2$ enables a **significantly more compact and efficient** turbine design compared to conventional steam cycles. This leads to smaller components, reduced material usage, and potentially lower investment costs.

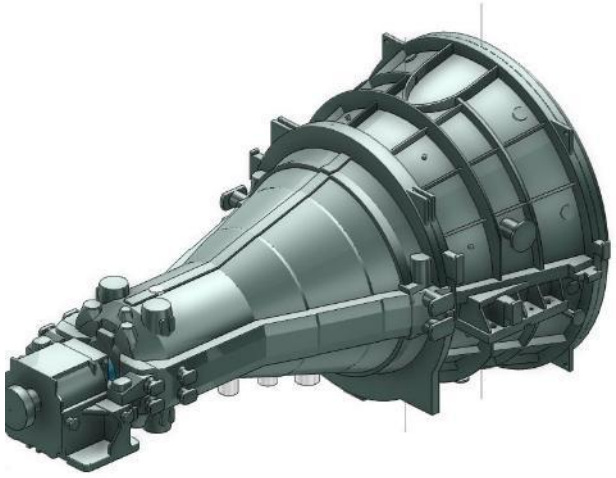
### Versatile Applications Fields

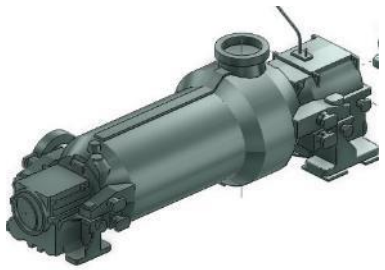
sCO2 is highly attractive for making use of low-temperature heat sources such as **industrial waste heat** and **geothermal energy**. Its high thermodynamic efficiency makes it **economically viable** to recover energy from these sources.

Additionally, $sCO_2$ creates new opportunities for **energy storage solutions**, like Carnot batteries, making it highly relevant for cross-sector applications

# Technology Description - Why sCO2 ?
## Benefits & Challenges





36 MWel WHR solution developed within CARBOSOLA project

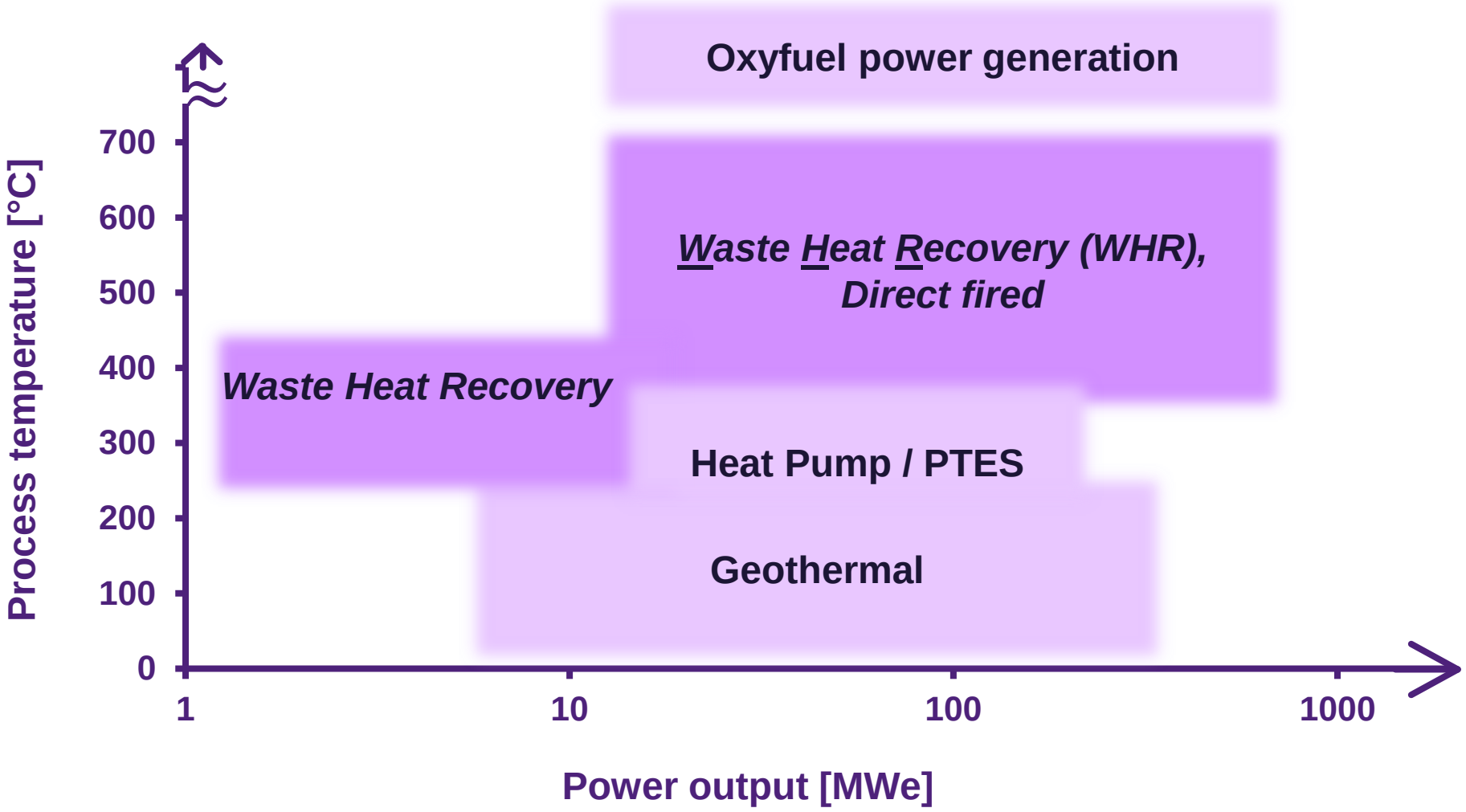
## Potential Benefits

- Better thermal coupling results in higher efficiency compared to water/steam and ORC
  → Depending on heat source, power output and heat sink temperature
- High fluid energy density leads to smaller turbines & footprint
- Lower LCOE compared to water/steam
  → Depending on heat source, power output and heat sink temperature
- Less hazardous fluid (not flammable/toxic) compared to ORC

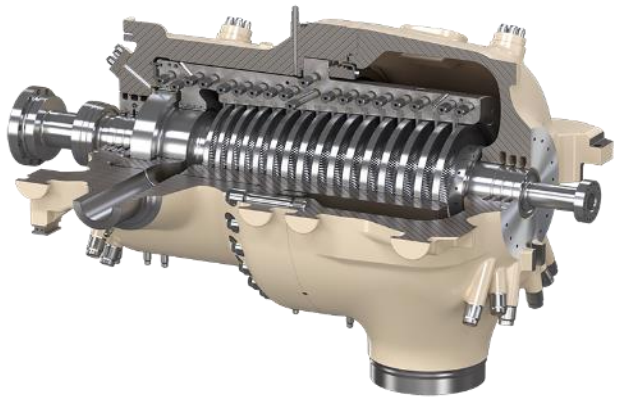
## Technical Challenges

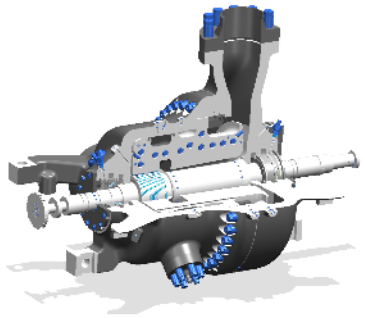
- Operational concept for closed loop in the vicinity of the critical p.
- Good cooling conditions preferable (use pump instead of compressor)

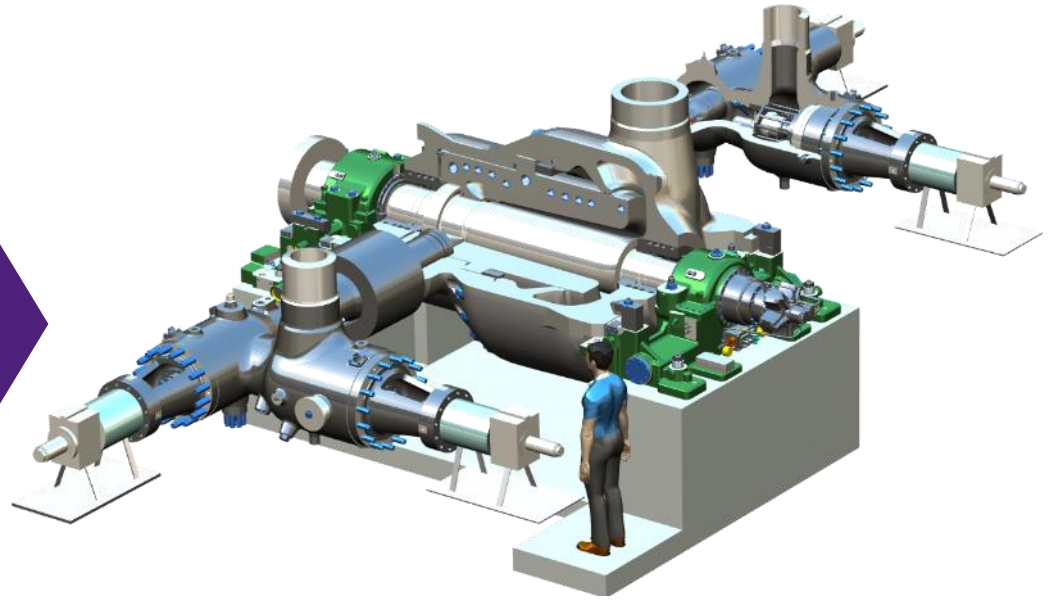
# Overview of $sCO_2$ applications



# Technology Readiness
# Turbine development







High pressure steam turbine:
- up to 325 bar, 610°C, 300 MW
- Broad operational experience

$sCO_2$ turbine:
- 215 bar, 320°C, 3 MW
- Basic design for demonstrator released

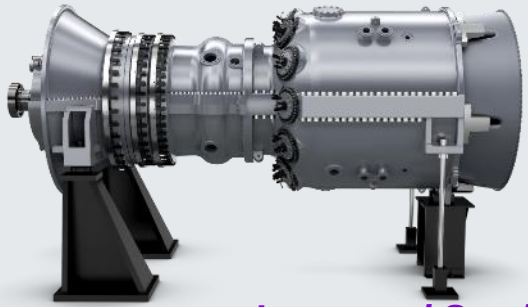
$sCO_2$ turbine:
- 300 bar, 70…200 MW
- Design studies done

# At the heart of the cycle:
# The Supercritical Turbine SCT6-6000

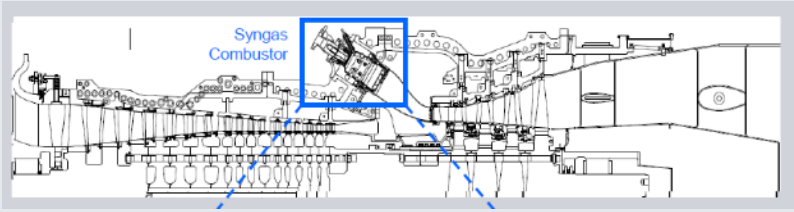
**How does the SCT6-6000 Turbo-Machinery work?**

- Solid fuels are converted to syngas via gasification for combustion into SCT6-6000 Turbine
- **A combination of a gas turbine and a supercritical steam turbine**
  - Inlet mass flow ~1230 kg/s, pressure 325 bar, temp. ~1000-1100OC
  - Exit pressure 40 bar, temp. 600OC
- Barrel type casing and mono-block rotor from steam turbine
- Combustion system, transition, and cooled bladepath from gas turbine
- Generator standard SGEN6-2000P, 284 MWe Output
- Fuel and oxygen are combusted in a CO2 working fluid to drive a turbine, generating power at high efficiency

# Technology Download from Across Siemens Energy One Team



*Large and Small Gas Turbine*



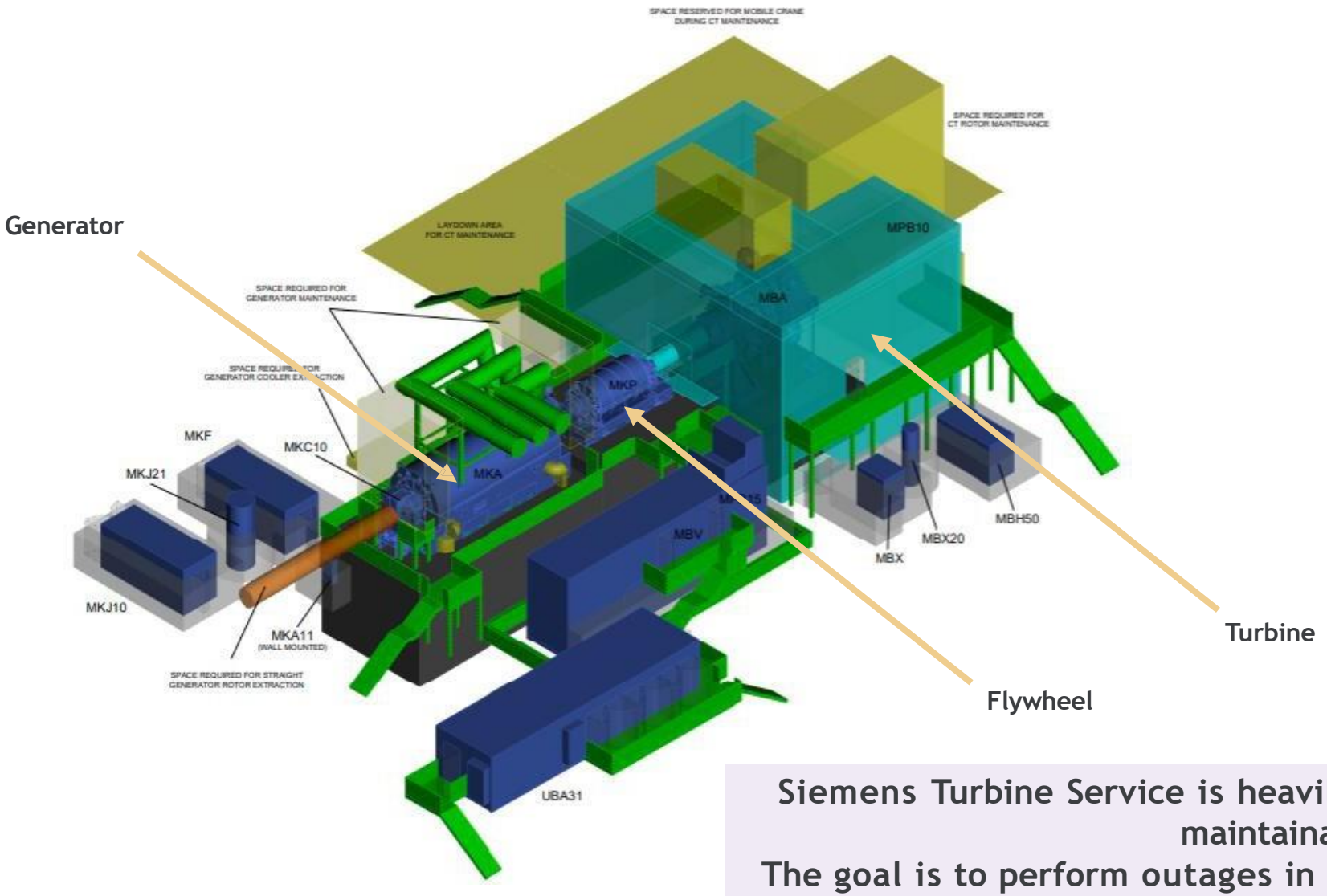

*Combustion and Operational Experience with Syngas*

*Super-critical Steam turbine*

*Compression*

***Siemens Energy is uniquely positioned to develop sc - urbines. Experience from across multiple platforms and technologies.***

# Turbine-Generator Isometric View




## EQUIPMENT LEGEND

| | |
|---|---|
| MBA | COMBUSTION TURBINE |
| MBH50 | FUEL GAS PURGE SYSTEM, COMPRESSOR AND TANK |
| MBV | LUBE OIL MODULE |
| MBX | HYDRAULIC OIL SKID |
| MBX20 | INSTRUMENT AIR SYSTEM |
| MKA | GENERATOR |
| MKA11 | LIQUID LEVEL DETECTION RACK |
| MKC10 | COLLECTOR |
| MKF | STATOR WATER UNIT |
| MKJ10 | AIR COOLING SYSTEM COMPRESSOR |
| MKJ21 | AIR COOLING SYSTEM VESSEL |
| MKJ31 | AIR COOLING SYSTEM PRESSURE RACK |
| MKJ50 | FLYWHEEL VACCUM SKID |
| MKP | FLYWHEEL |
| MPB10 | ENCLOSURE FOR COMBUSTION TURBINE |
| MPB15 | ENCLOSURE FOR LUBE OIL MODULE |
| UBA31 | POWER CONTROL CENTER |

**Siemens Turbine Service is heavily involved in design to ensure maintainability.**
**The goal is to perform outages in the same time as a gas turbine.**

# How can we help?

A successful energy transition requires balancing

**affordability, reliability, and sustainability.**