clean energy ahead
TURBODEN

SIEMENS
Ingenuity for life

HEAT RECYCLE SOLUTIONS

THE CLEANER AND EFFICIENT ALTERNATIVE.

Cod. 19-COM.P-2-rev.2

Start with why –
Heat ReCycle response to current market challenges

Water scarcity
United Nations: ”Over 2 billion people live in countries experiencing high water stress”

Water-free
Allowing water to be used for people, not power

Climate
Following Paris agreement: keeping the world within the 2°C scenario; lowering our global emissions footprint

Lower GHG
Producing power with lower emissions

Efficiency
International Energy Agency: ”Efficiency and renewables key to global climate change mitigation”

Lower LCoE
Providing affordable electricity with high efficiency

Decentralization
Worldwide, two billion people lack reliable electricity supply

Compact
Developing remote and isolated areas

Global trends are creating market challenges

Demographic change

9.6 BN

Increase in the earth's population in 2050 from 7.3 billion people today. Average life expectancy will then be 82 years.

Urbanization

70%

Of the world's population will live in cities by 2050 (2009: 50%).

Climate change

2013

Scientists measured the highest CO_2 concentration in the atmosphere in the last 800,000 years.

Electricity

1,000 TWh

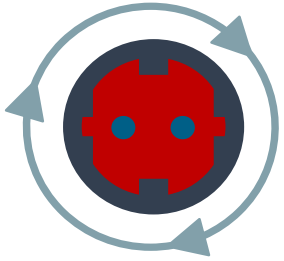
The global demand for electricity will continuously increase. Fossil Power Generation will continue to be the mainstay of power generation in 2030.

Globalization

2x

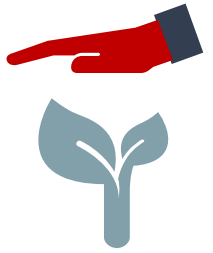
Since 2000, the volume of world trade has nearly doubled.

Population growth



Need for a reliable power supply

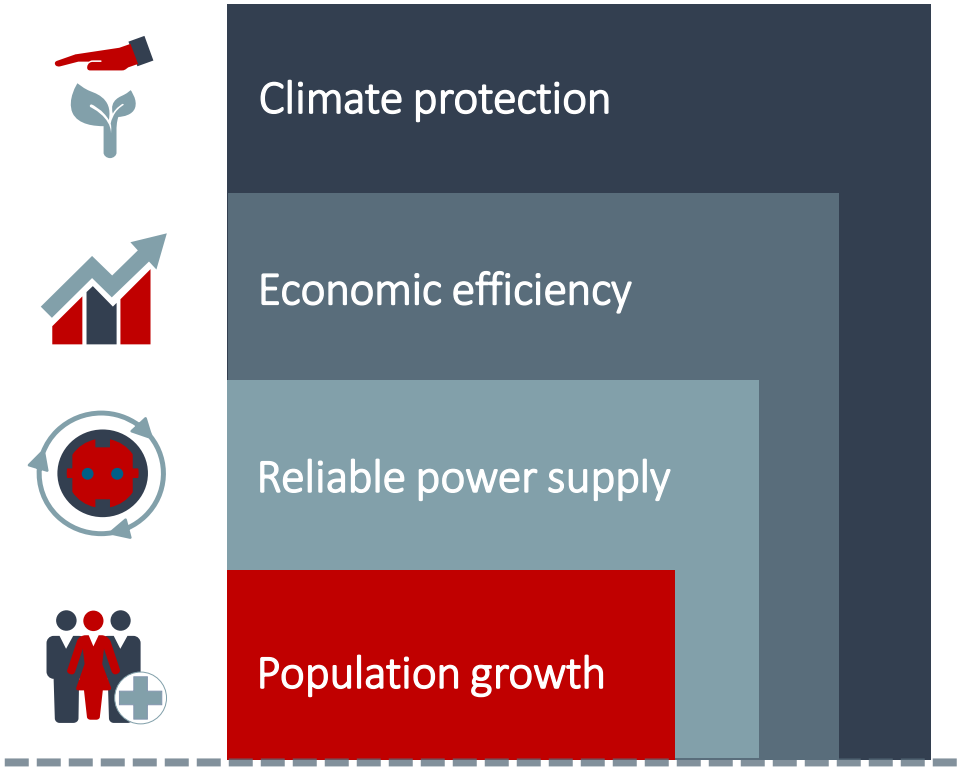
Economic efficiency



Climate protection

Heat ReCycle solutions
Our response to today‘s and tomorrow‘s challenges

MARKET CHALLENGES

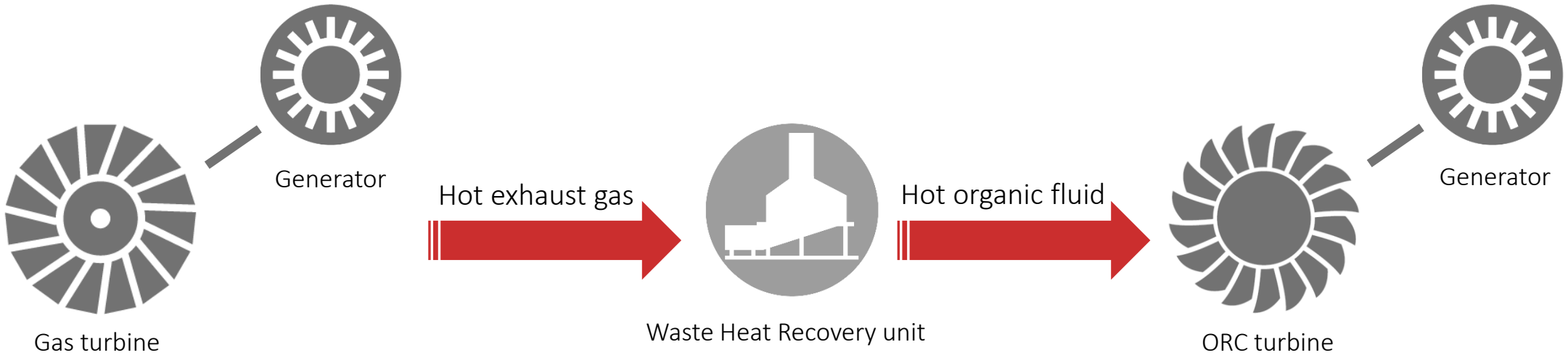


HEAT RECYCLE RESPONSE

- Producing power with lower emissions
- Providing lower cost of electricity
- Developing isolated and remote areas
- Offering a water-free solution

Heat ReCycle solutions
An alternative combined cycle power plant with ORC technology

Gas turbine + Organic Rankine Cycle



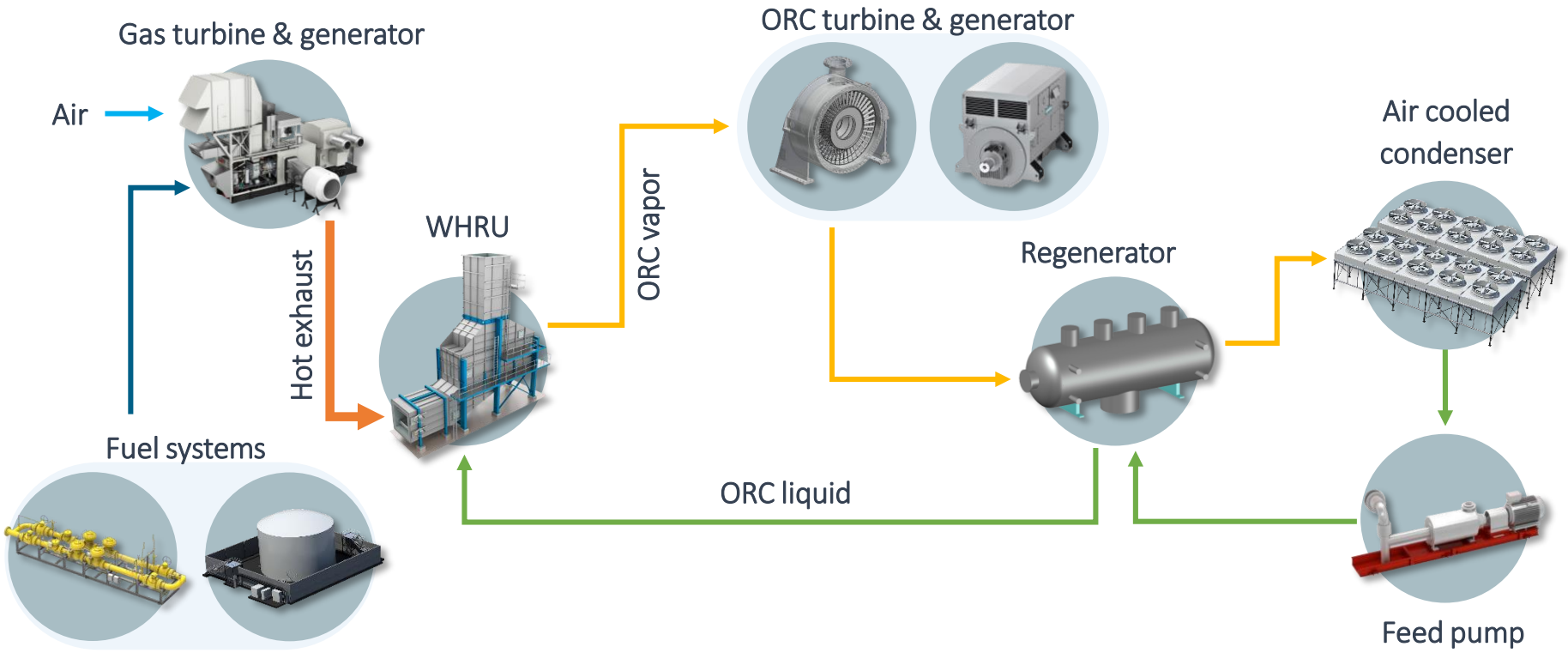
Designed to reduce CAPEX and OPEX providing affordable and reliable electricity generation

Heat ReCycle solutions
How does the power plant works?

Benefits to use ORC technology:

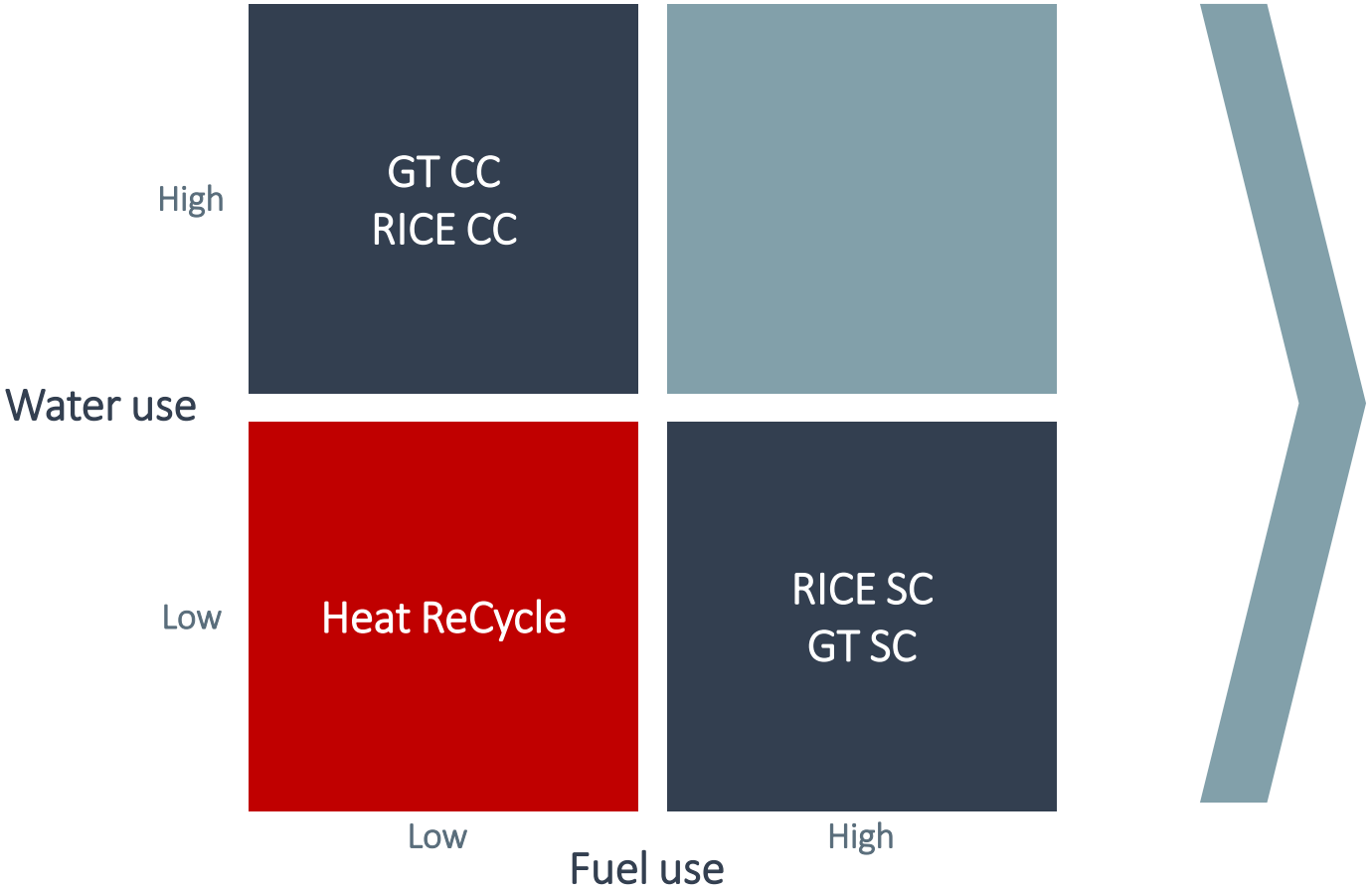
- ✓ No use of water
- ✓ Simple and compact design
- ✓ Fast start capability
- ✓ Hermetically closed cycle

Process flow scheme



Environmentally sound solution

Water and fuel use matrix



Cleaner and efficient

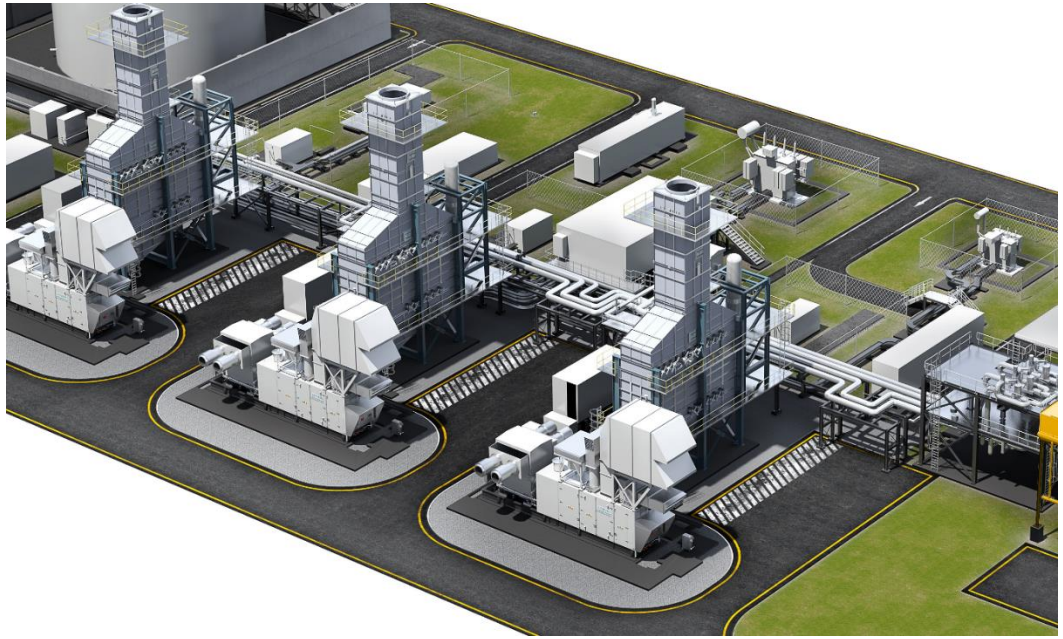
No water use

Low fuel use

Reliable technology

Abbreviations:
RICE = Reciprocating Engine
GT= Gas Turbine
CC = Combined Cycle
SC = Simple Cycle

Siemens Heat ReCycle solutions
Reliable power. Cleaner and efficient. Trusted technology.



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Siemens as integral solutions provider with Turboden ORC technology

Reliable & flexible power supply

- ✓ Full remote and unmanned capability
- ✓ High reliability and availability with proven technology
- ✓ Excellent part load efficiency over wide range

Cost-effective power generation

- ✓ Very attractive plant CAPEX
- ✓ Affordable electricity with the best LCoE
- ✓ Outstanding power density

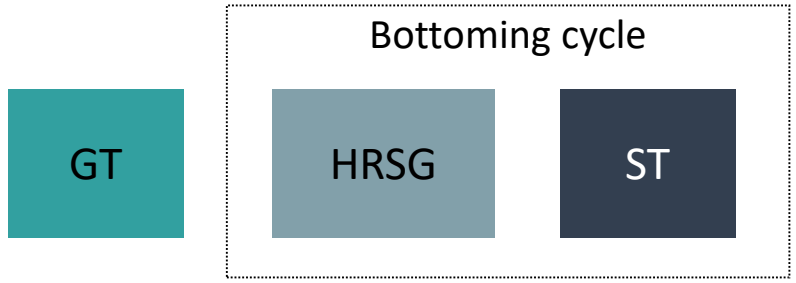
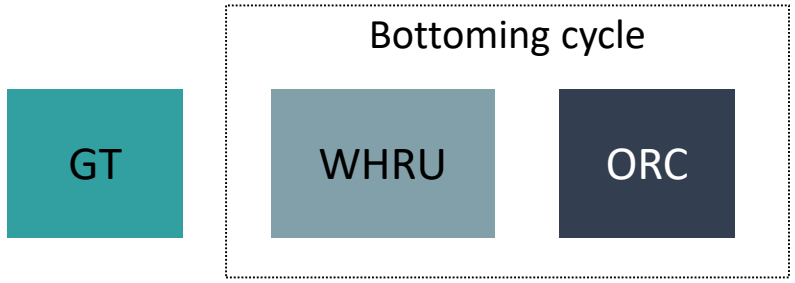
Superior value in operation

- ✓ OPEX savings with high fuel efficiency
- ✓ Liquid & gas fuel with same service interval for GT
- ✓ Quality turbomachinery for high performance

Cleaner and efficient technology

- ✓ Lower emissions
- ✓ Less noise pollution
- ✓ A water-free solution

Organic Rankine Cycle technology

	Traditional Rankine Cycle	Organic Rankine Cycle
Main components		
Common application	Conventional Gas Turbine Combined Cycle Power Plants (CCPP)	Organic Rankine Cycle (ORC) in waste heat applications as industrial gas turbines
Heat transfer medium	Water / Steam	Organic Fluid
Bottoming cycle characteristic	Makeup water required	Hermetically closed cycle – no fluid losses
Typical heat source temperature	~ 450 ºC – 700ºC	~100ºC – 550ºC
Key advantages	High efficiency in higher temperature range	Simple, compact design with lower CAPEX
Focus	Large frame GTs with high exhaust temp.	Industrial / aero GTs with lower exhaust temp.

Organic Rankine Cycle technology

	SGT-400 Heat ReCycle
Configuration	3 x SGT-400
Plant power output (ISO)	52 - 58 MW_e
Fuel	Natural gas / Liquid fuel / Dual fuel / Other
Frequency	50 / 60 Hz
Plant efficiency	~ 47 – 50 %
Bottoming cycle	Organic Rankine Cycle
Heat transfer medium	Thermal oil / Cyclopentane
NO_X emissions on fuel gas with DLE, 15% O2	≤ 15 ppmvd

Best in class equipment

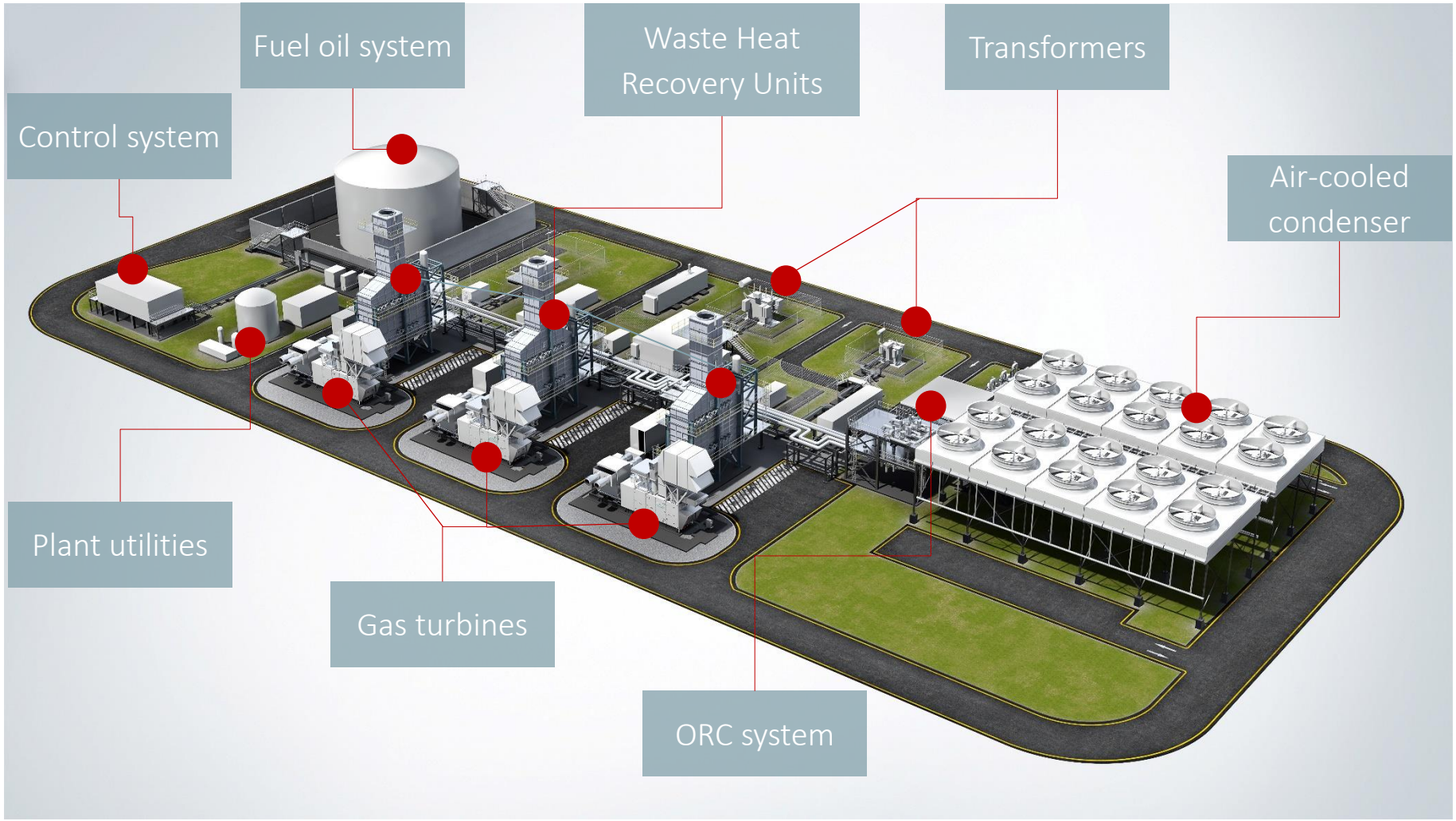
- Highest efficiency gas turbine core in its class
- Optimized GT-WHRU integration
- ORC technology based on > 370 references

Proven and efficient industrial design for reliable operation

3 x SGT-400 Heat ReCycle plant overview

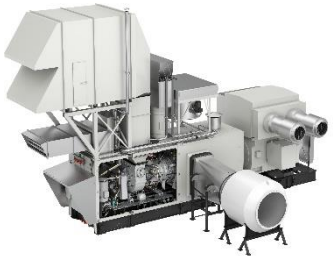
Client value

- Designed for reduced CAPEX and OPEX
- High power-density (MW/m2)
- Automated operation and high safety standards
- Proven and reliable power generation



Heat ReCycle main components
A best-in-class selection of equipment

SGT-400 Gas Turbine

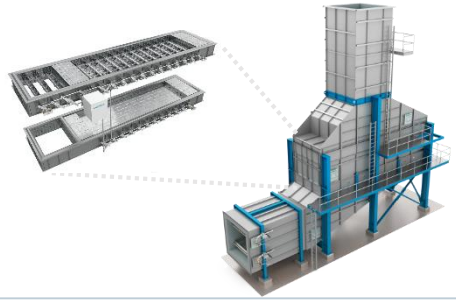


Global experience

- Over 390 SGT-400 gas turbines sold worldwide.
- More than 5 million actual operating hours of fleet experience.

- Superb availability
- Fuel flexibility
- Lower emissions
- Reliable Power supply

Waste Heat Recovery Unit (WHRU)



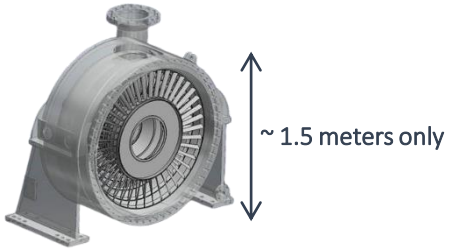
Feature
internal by-pass for continuous GT-operation

Global experience

- More than 45 units sold during last four years.
- Number 1 in the market for heat recovery <100 MW GT output (source: McCoy Power reports).

- Modular design
- Improved overall lead time
- High constructability
- Low total Installed cost

Organic Rankine Cycle (ORC)



Global experience

- Close to 400 ORC installations worldwide.
- Experience in various industries from gas turbine waste heat to geothermal power generation.

- Great part load performance
- Simplicity of design
- Long lifetime > 30 years
- Water-free

Bringing together the best of worlds

Turboden Organic Rankine Cycle
The ORC turbine & technology

Flexibility

- Different types of working fluids fit to purpose
- Excellent part load capability down to 10% GT load

Simplicity

- Modular solution
- Automated operation
- Minimal maintenance

Dependability

- High overall availability (> 98%)
- Long lifetime (> 30 years)

Sustainability

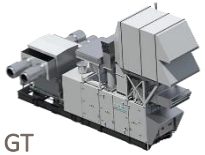
- No water use and treatment required
- Efficient recovery of GT waste heat

The ORC is a closed-loop thermodynamic cycle for efficient power generation

With tailored scopes and solutions we fit our customers needs

Scope of work

Components


GT


WHRU

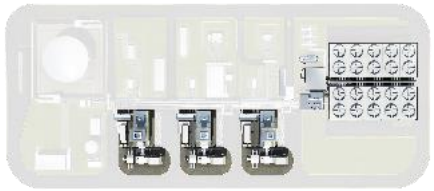
GT package including:

- Gas Turbine(s) including auxiliaries
- Technical Field Assistance (TFA) for installation and commissioning

WHRU package including:

- Waste Heat Recovery Unit(s)
- Technical Field Assistance (TFA) for installation and commissioning

Power island



GT package +

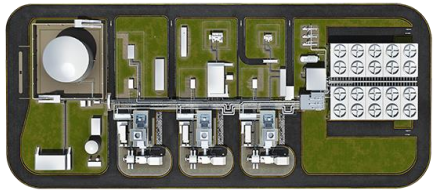
- WHRU(s)
- ORC turbine including auxiliaries
- ORC-system/-components
- ORC cooling system (ACC or WCC)
- GT- and ORC PCC container for electrical system of packages
- GT(s) and ORC control system
- Basic planning of complete power plant
- TFA for installation and commissioning

Power core

Power island +

- Cooling tower/system (if applicable)
- Auxiliary cooling system (if applicable)
- Fuel systems
- Piping system
- Electrical system for power plant (as PCC-container)
- Auxiliary transformers
- Emergency generator set (if applicable)
- Distributed control system (DCS)
- Plant commissioning
- Performance tests

Turnkey plant



Power core +

- Compressed air system
- Nitrogen system
- Fire fighting system
- Potable/rain/waste water system
- HV electrical system including main transformer
- Cabling
- Civil works and steel structures
- Installation

Customized scopes and solutions to fit all project needs

ACC: Air Cooled Condenser | **WHRU**: Waste Heat Recovery Unit | **PCC**: Power Control Container.

Heat ReCycle gas turbine portfolio

Industrial gas turbines

Aeroderivative gas turbines

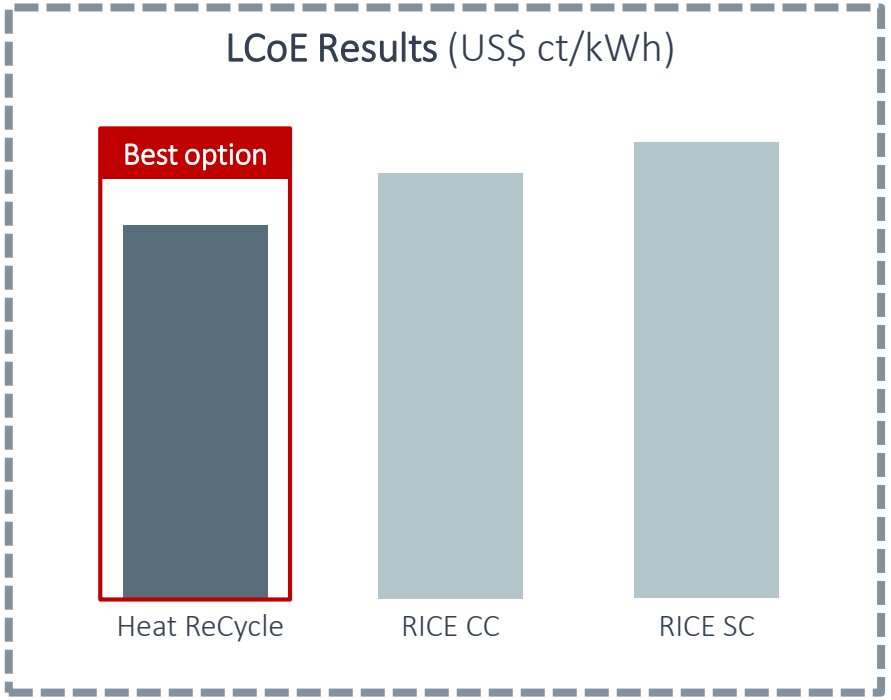
	SGT-300	SGT-400	SGT-600	SGT-700	SGT-750	SGT-A35 DLE	SGT-A65 DLE
							
Gas turbine (ISO output)	8 to 9 MW	13 to 15 MW	24 / 25 MW	33 / 34 MW	40 / 41 MW	27 to 38 MW	53 to 72 MW
Configurations	1 x 1 2 x 1 3 x 1 4 x 1	1 x 1 2 x 1 3 x 1 4 x 1	1 x 1 2 x 1	1 x 1	1 x 1	1 x 1	1 x 1
ORC ready	✓	✓	✓	✓	✓	✓	✓
Power range	~ 11–46 MW	~ 18–68 MW	~ 34–68 MW	~ 44 MW	~ 50 MW	~ 35–50 MW	~ 65–90 MW

The added value of Heat ReCycle
A cleaner and more efficient alternative to RICE

Economical Comparison of Heat ReCycle vs. RICE

	Reciprocating engine	Heat ReCycle
CAPEX	✓	
OPEX		✓
LCoE		✓
Efficiency		✓
Availability		✓
Reliability		✓
Noise		✓
Emissions		✓

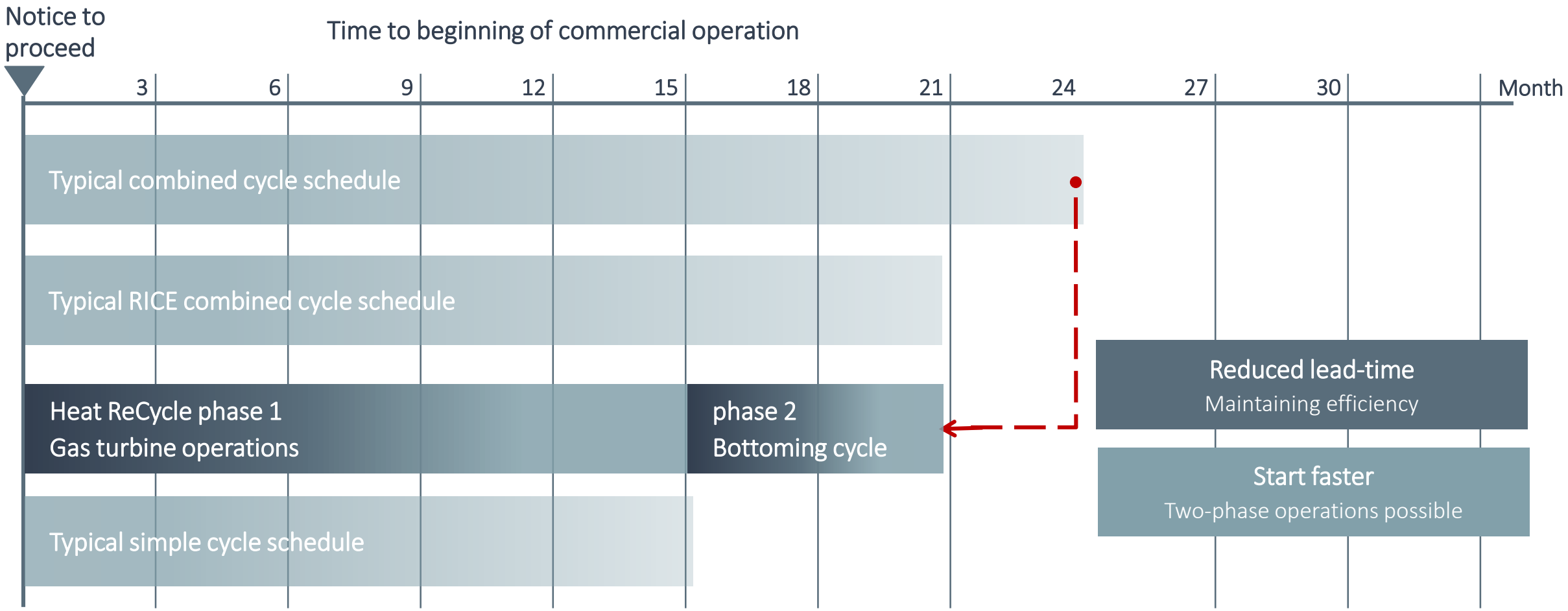
✓ better



Estimated comparison of 3 x SGT-400 Heat ReCycle solutions vs RICE.
Note: comparison for intermediate to base load power.

Achieving the lowest cost of electricity for intermediate to base load power

Power plant deployment is increasingly time-critical…



RICE refers to reciprocating engines in combined cycle.

Typical durations, subject to individual project conditions.

Heat ReCycle solutions
The cleaner and efficient alternative

Attractive CAPEX and low LCoE

Combining the simplicity of Organic Rankine Cycle (ORC) design and the proven performance of gas turbines result in a cost-effective alternative power plant.

Environmentally sound solution

No water usage, lower emissions and limited noise pollution support a better climate.

Future-proof design

State-of-the-art technology, providing remote and unmanned operations, ready for a new era.

The cleaner and efficient alternative: a reliable solution for environmentally sound, affordable electricity **Heat ReCycle™**

Heat ReCycle contact page

Heat ReCycle Solutions

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