ORGANIC RANKINE CYCLE, POWER GENERATION FROM WASTE HEAT

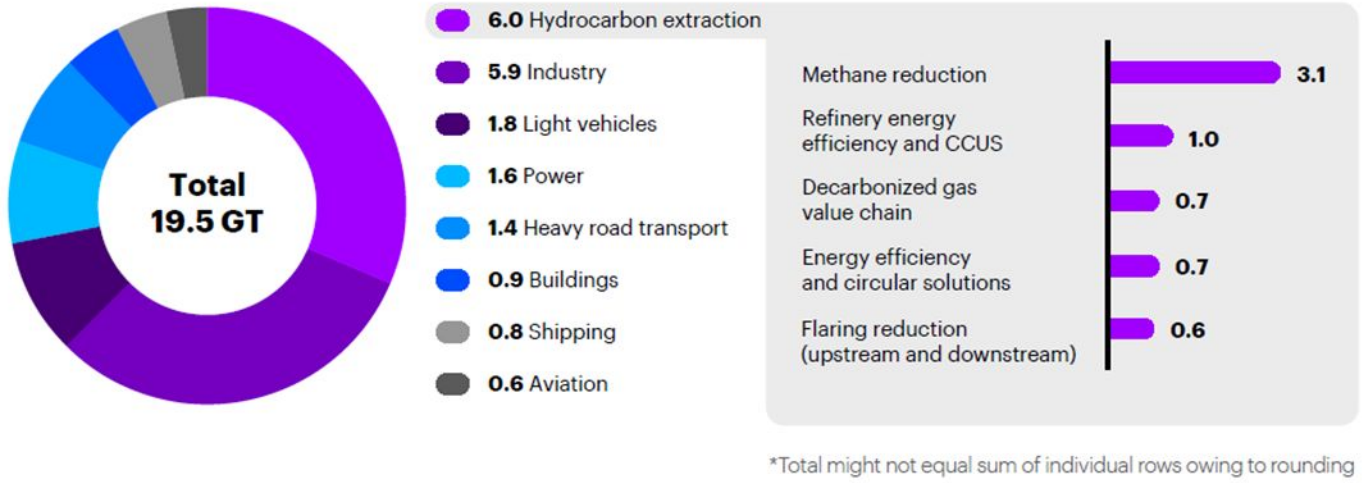
BE PETROTHAI GROUP

EXERGY

ENERGY Community of Practice TIChE

THE O&G MARKET NEEDS

- 5 gT of CO2/y are the emissions directly associated with extracting, transporting and processing hydrocarbons. These could rise to close to 7 gT by 2050
- Reduce or eliminate emissions using existing energy sources and technologies can lower global emissions by almost 20 gT by 2050



ORGANIC RANKINE CYCLE TECHNOLOGY

Advantages

- Competitive capital costs
- High efficiency at a variety of operating temperatures and loads
- Fast start up and shut down
- Automated operation, no dedicated personnel needed
- No water treatment or make up
- Flexible placement
- Reduction of the plant energy consumption and carbon footprint, in the case of industrial process

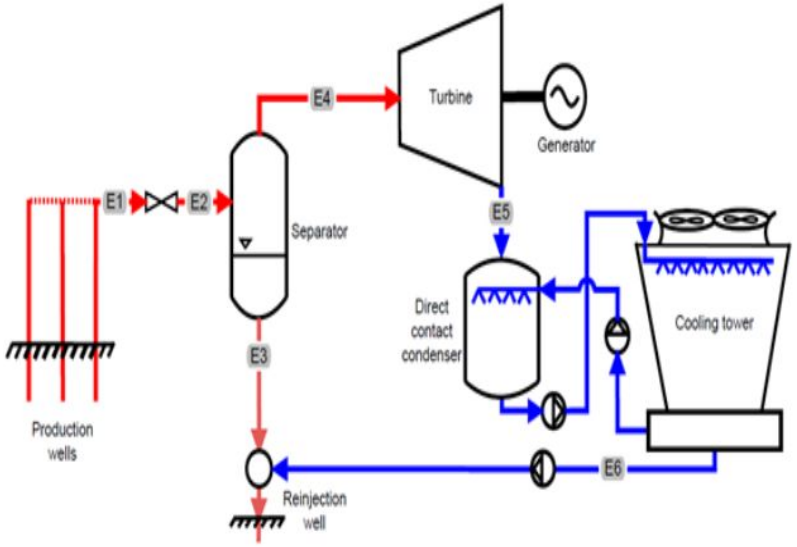
THE O&G MARKET NEEDS

Oil and Gas companies can achieve near net-zero direct emissions with technologies and processes readily available through:

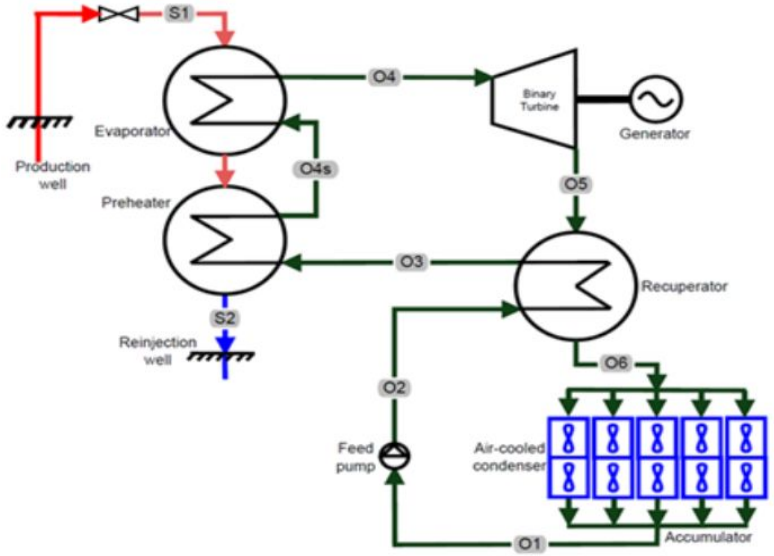
- energy efficiency of existing assets across the energy system
- capture vented, flared and fugitive gas emissions
- deploy circular solutions that reduce energy intensity and wasted energy from operations

SUCH ACTIONS CAN REDUCE AN OIL AND GAS COMPANY'S DIRECT EMISSIONS BY 80%

WHERE THE TECHNOLOGY COMES FROM



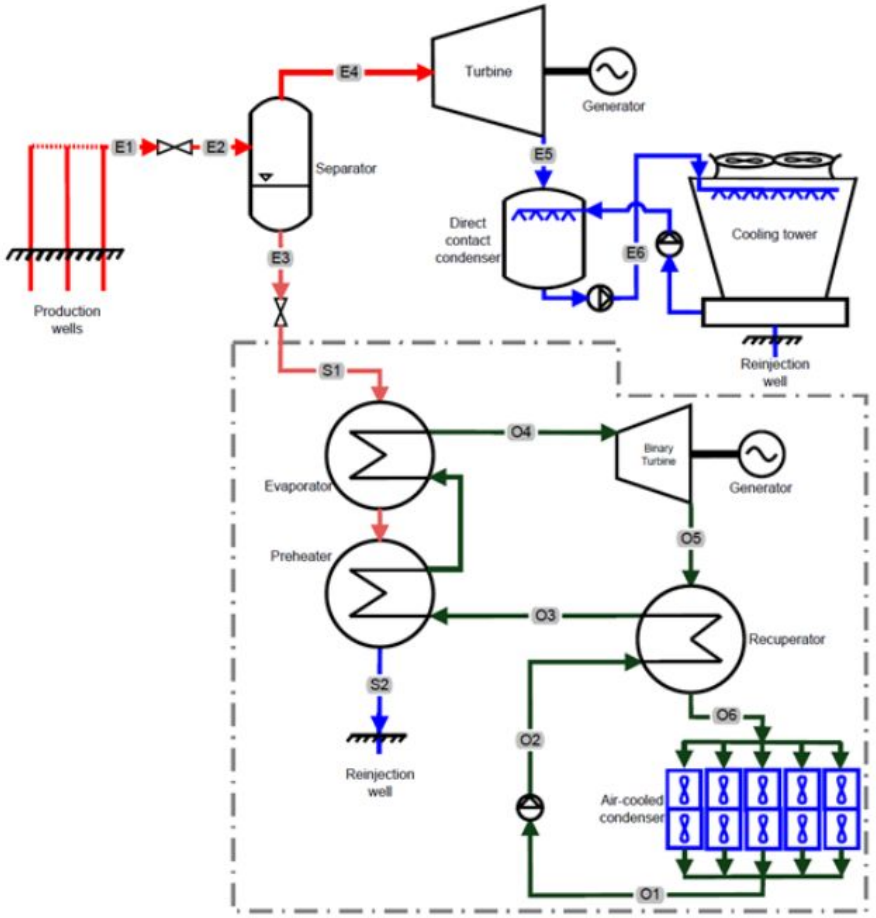
Flash steam Power plant



Binary Power plant

WHERE THE TECHNOLOGY COMES FROM

Combined cycle geothermal power plant



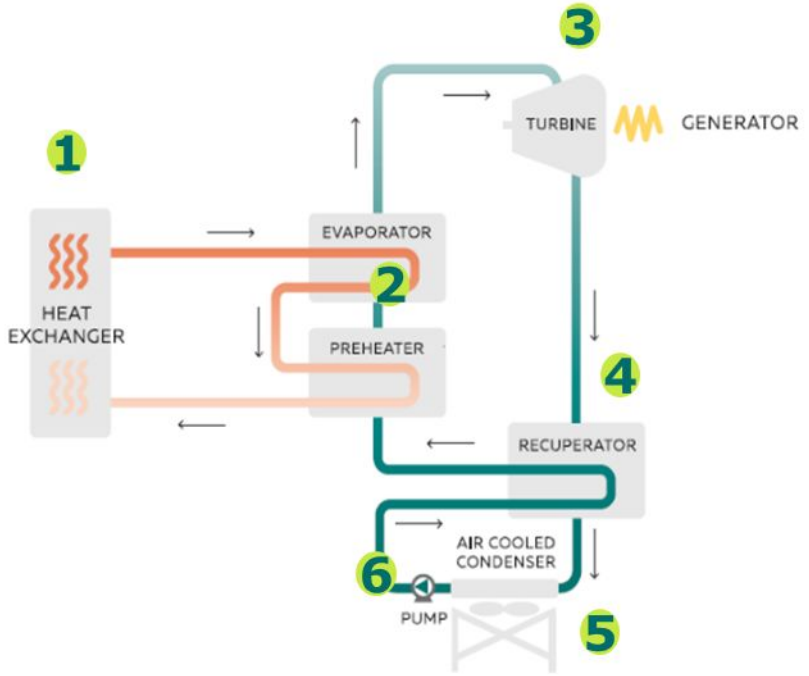
- **Extremely advantageous configuration**
- **Enhance** geothermal power production with **no additional drilling**
- **No risks** and **costs** of the **exploration phase**
- **No environmental impact**

HOW IT WORKS

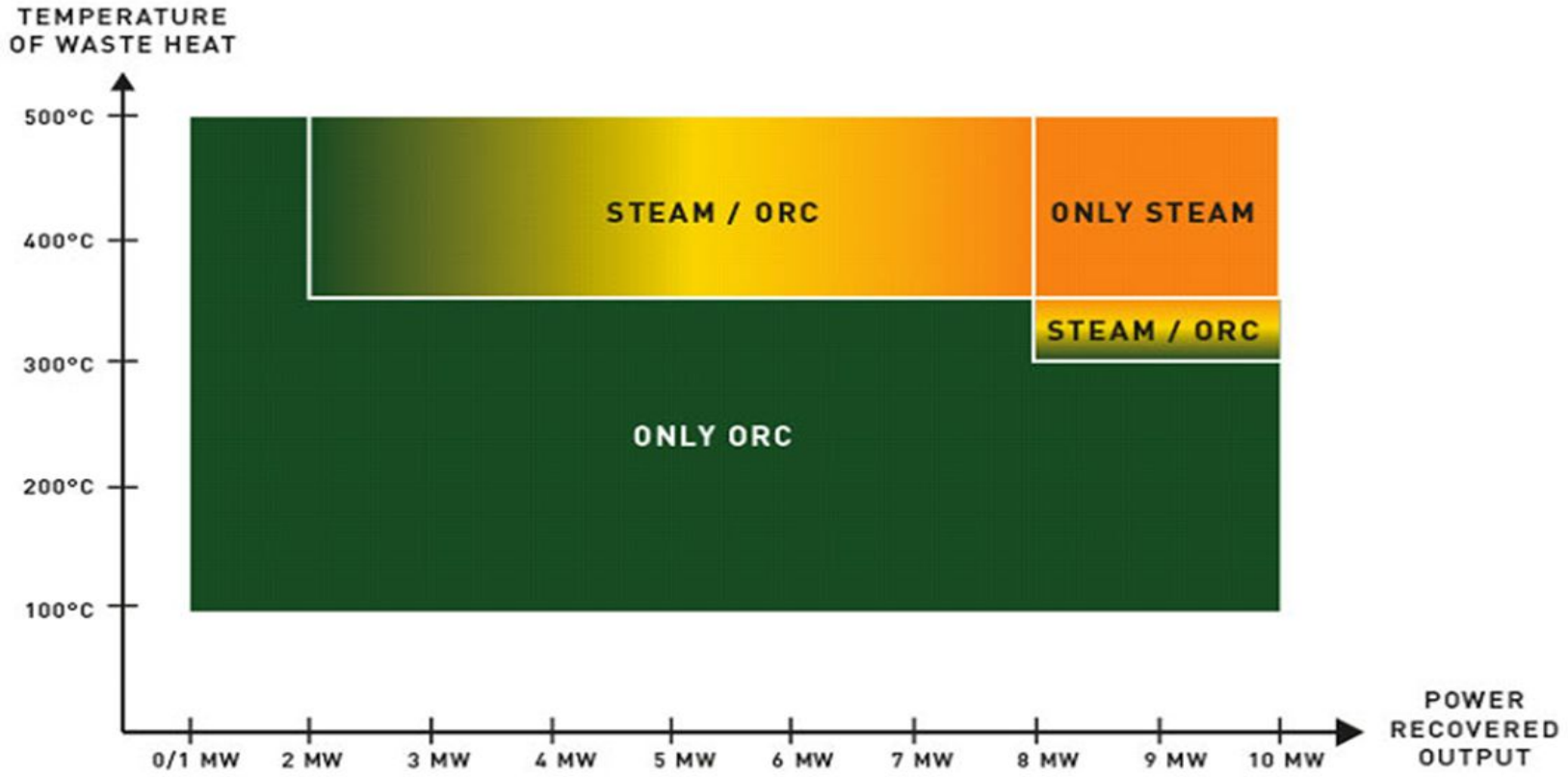
- ORCs allow **to convert heat energy** into **clean electricity** through a thermodynamic cycle
- ORCs are suitable for power generation from geothermal, biomass and solar resources and for waste heat produced in several industrial processes

HOW THE CYCLE WORKS

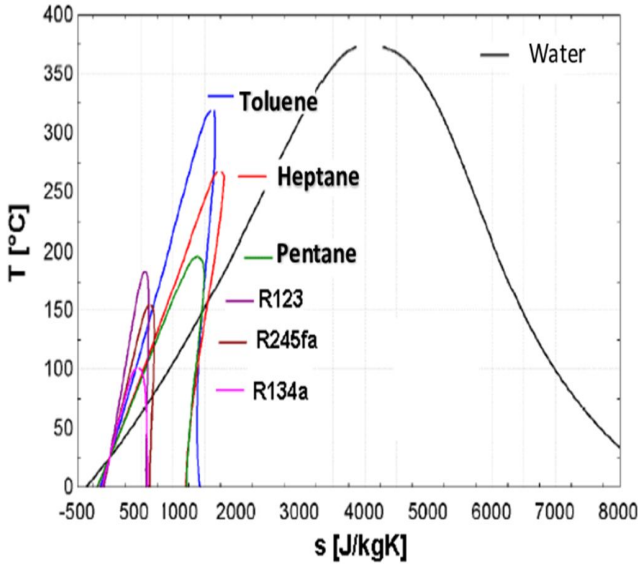
1. Heat exchanger recovers heat from the primary source transferring it to the intermediate fluid
2. Organic fluid warms up in the preheater and vaporizes in the evaporator
3. Vapor expands in the turbine producing power at the generator
4. Recuperator exchanges heat between the vapor to preheat the fluid
5. A condenser releases the waste heat and turns the organic fluid back into a liquid
6. The pump gives the pressure needed for the cycle

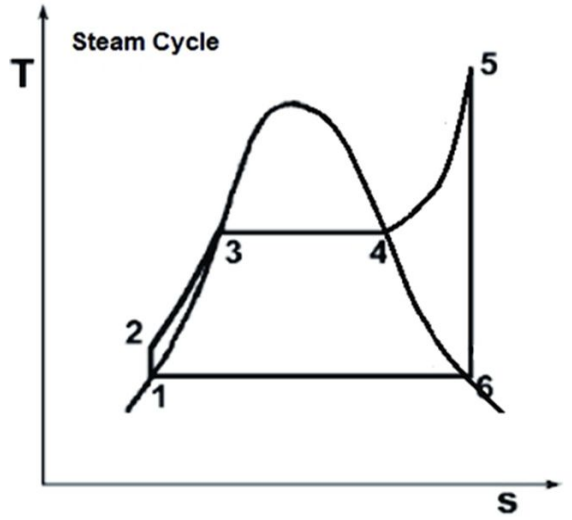


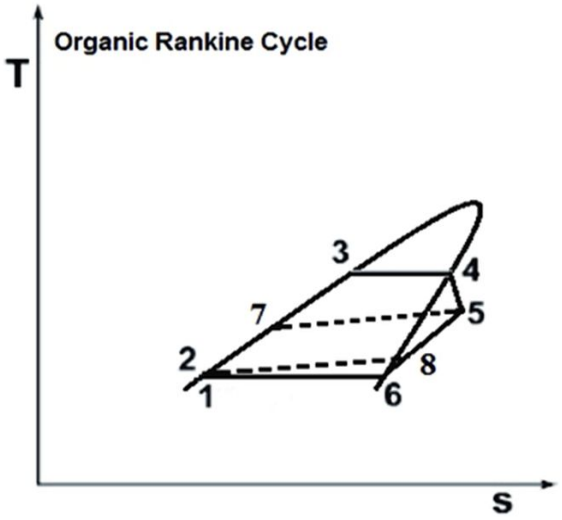
HOW IT WORKS


TEMPERATURE
OF WASTE HEAT
500°C
400°C
300°C
200°C
100°C
STEAM / ORC
ONLY STEAM
STEAM / ORC
ONLY ORC
0/1 MW
2 MW
3 MW
4 MW
5 MW
6 MW
7 MW
8 MW
9 MW
10 MW
POWER
RECOVERED
OUTPUT

HOW IT WORKS


Water
Toluene
Heptane
Pentane
R123
R245fa
R134a
T [°C]
s [J/kgK]
400
350
300
250
200
150
100
50
0
-500
500
1000
2000
3000
4000
5000
6000
7000
8000

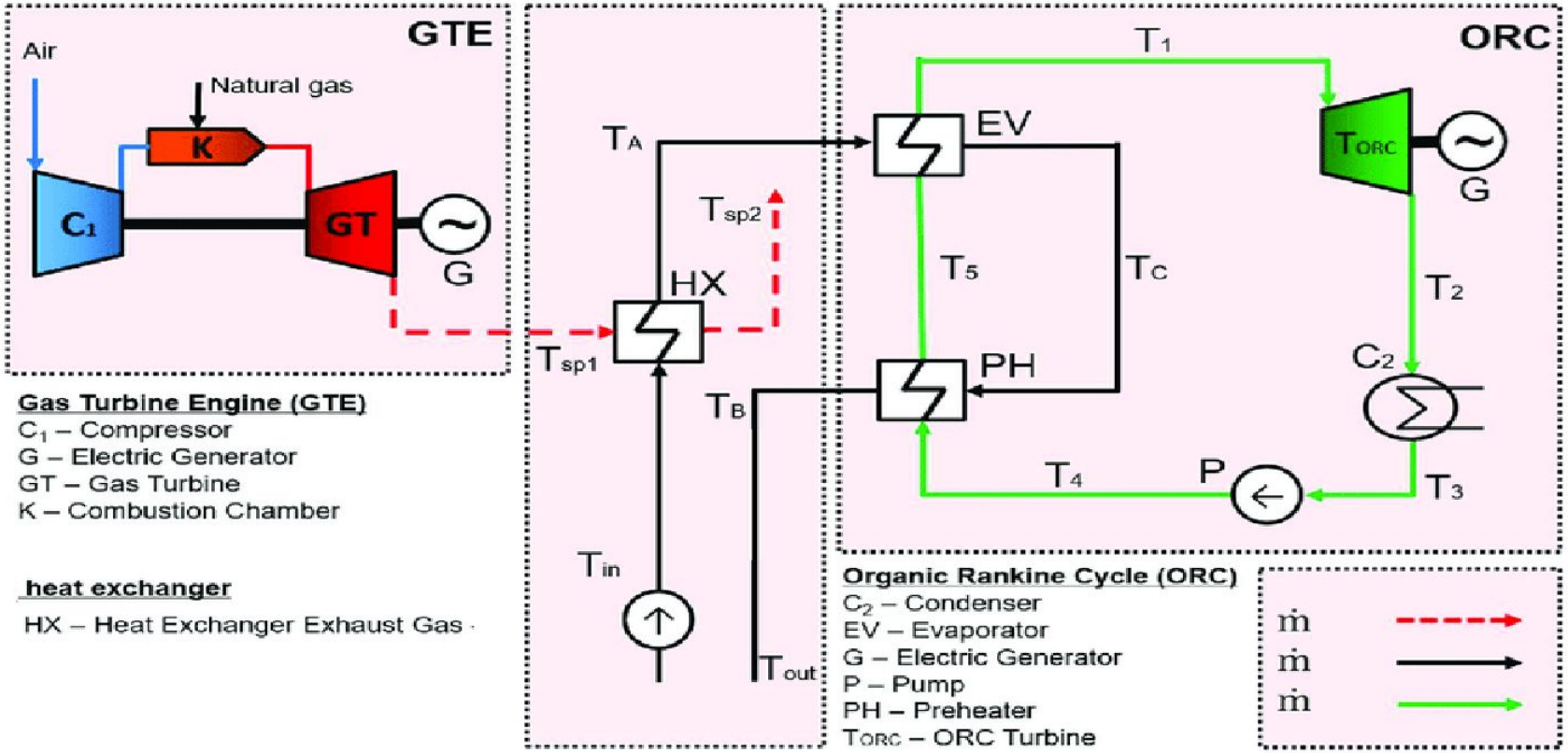

Steam Cycle
T
s
1
2
3
4
5
6


Organic Rankine Cycle
T
s
1
2
3
4
5
6
7
8

NEW SOLUTIONS FOR PROCESS PLANTS

- Certain areas with open cycle gas turbine do not have water in their process
- There are also process plants that are currently disposing their low enthalpy steam or hot water as they are no longer suitable for neither the current process nor into the steam turbine.
- Such conditions are very similar to geothermal resources.

HOW IT WORKS


GTE
Air
Natural gas
K
C1
GT
G
ORC
T1
EV
TORC
G
TA
Tsp2
T5
Tc
T2
HX
Tsp1
PH
C2
TB
T4
P
T3
Tin
Tout
Gas Turbine Engine (GTE)
C1 – Compressor
G – Electric Generator
GT – Gas Turbine
K – Combustion Chamber
heat exchanger
HX – Heat Exchanger Exhaust Gas
Organic Rankine Cycle (ORC)
C2 – Condenser
EV – Evaporator
G – Electric Generator
P – Pump
PH – Preheater
TORC – ORC Turbine
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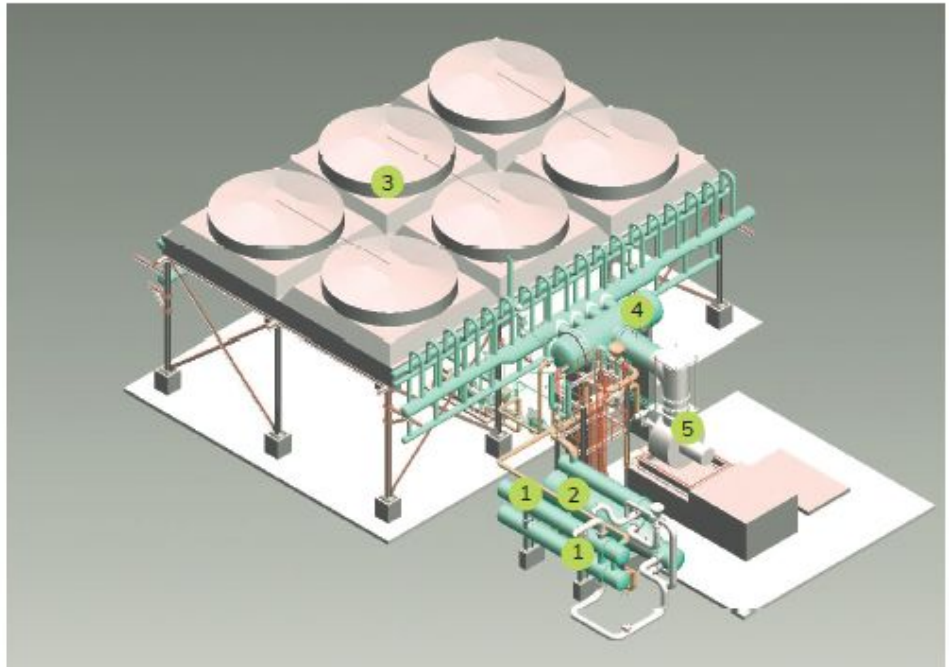
HOW IT WORKS

System components

1. Preheater
2. Evaporator
3. Air Cooled Condenser
4. Recuperator
5. Turbine



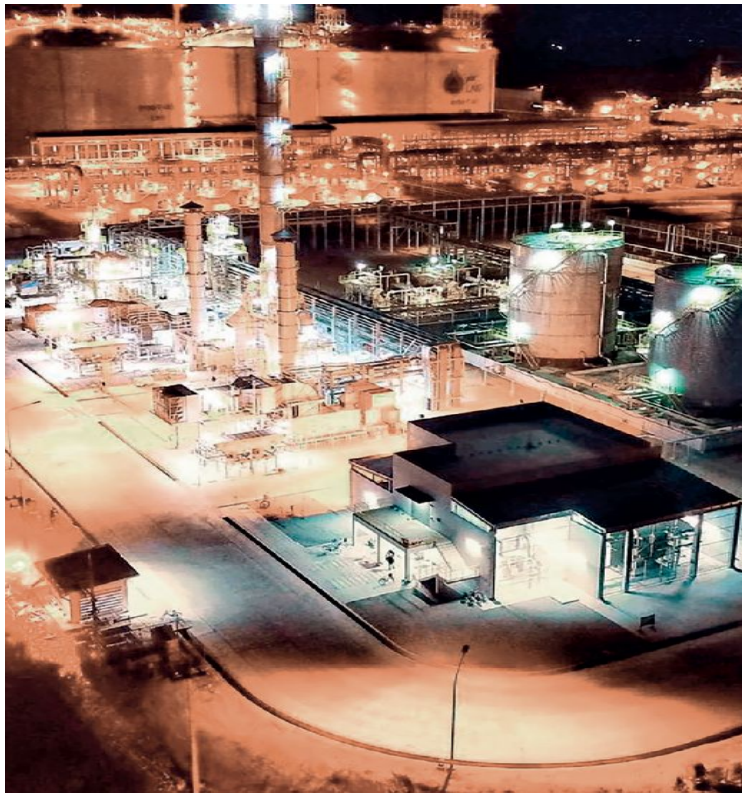
EXERGY'S RADIAL OUTFLOW TURBINE

- The Radial Outflow Turbine is an extremely highly efficient and reliable arrangement in ORC applications applied by Exergy to its ORC systems.

- **Radial development of the stages**
  - match between volumetric flow and cross section
- **Higher number of stages (7+)**
  - higher isentropic efficiency per stage
  - better off-design performance
- **Low speed (direct drive)**
  - low noise and vibrations
- **Single-disk, overhung configuration**
  - enhanced components accessibility
  - possibility for multiple admissions on one disk
- **Built-in mechanical group extraction slide**
  - reduced downtimes

ORC APPLICATION IN PROCESS PLANTS

- Gas compressor stations
- LNG regasification processes
- WHR from internal combustion engine/gas turbines
- Refining and petrochemical processes
- Low enthalpy steam
- Hot water



PTT LNG CASE STUDY

The customer need

PTT LNG wanted to increase the efficiency and the sustainability of its operations in its regasification terminal located in Rayong. The request was to recover the exhaust heat downstream generated from the two Solar Mars 100 open cycle gas turbines installed in the LNG plant, to generate additional power without extra fuel (carbon free electricity).

PTT LNG CASE STUDY

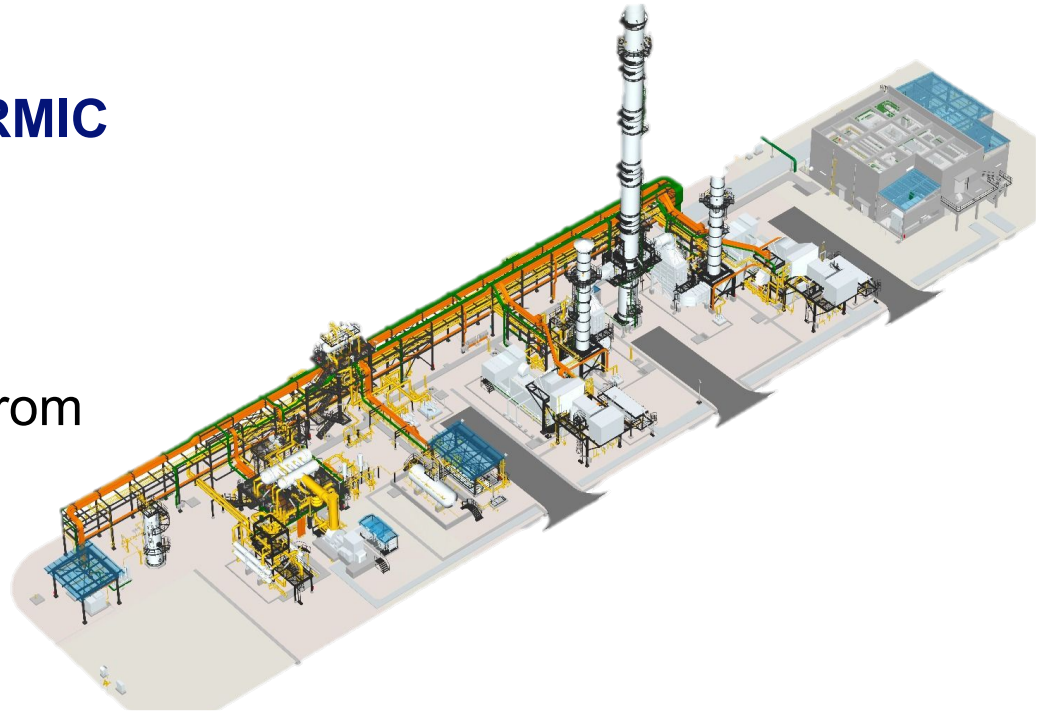
- The engineering was based on a feed performed by Technip and based on ORC technology
- Major overall project constrains have been defined at this stage
- , Exergy technology has been preferred for the execution of the project, through a technical due diligence proving its compliance with required standards and feed data
- The EPC contractor was **Samsung Engineering Thailand**

PTT LNG CASE STUDY

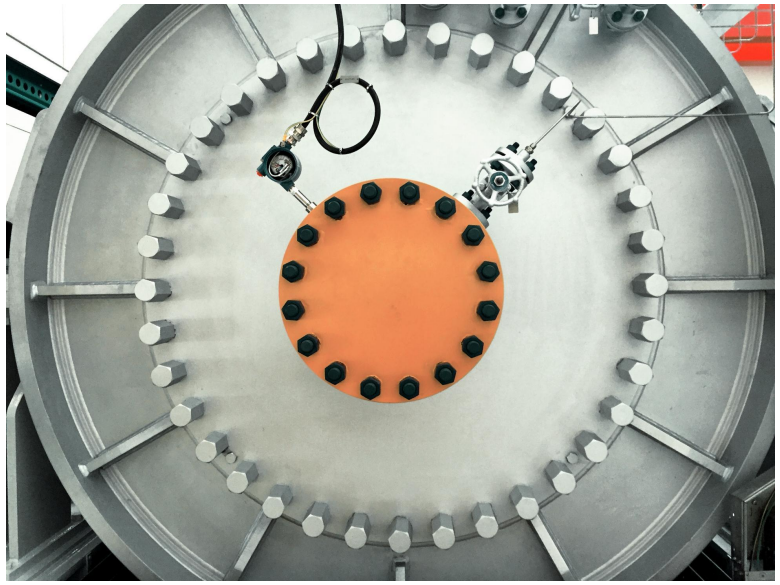
- **PLANT SIZE:** 5 MWe
- **APPLICATION:** Heat recovery gas turbines
- **GAS TURBINES:** 2x Solar Mars100
- **HEAT SOURCE TEMPERATURE (DIATHERMIC OIL):**

  294°C - 140.8°C
- **WATER OR COOLING AGENT:** cold water from

  LNG regasification cycle as heat sink
- **TEMPERATURE WATER:** 5-38°C
- **EFFICIENCY GROSS:** 23%
- **INSTALLATION:** Outdoor



PTT LNG CASE STUDY



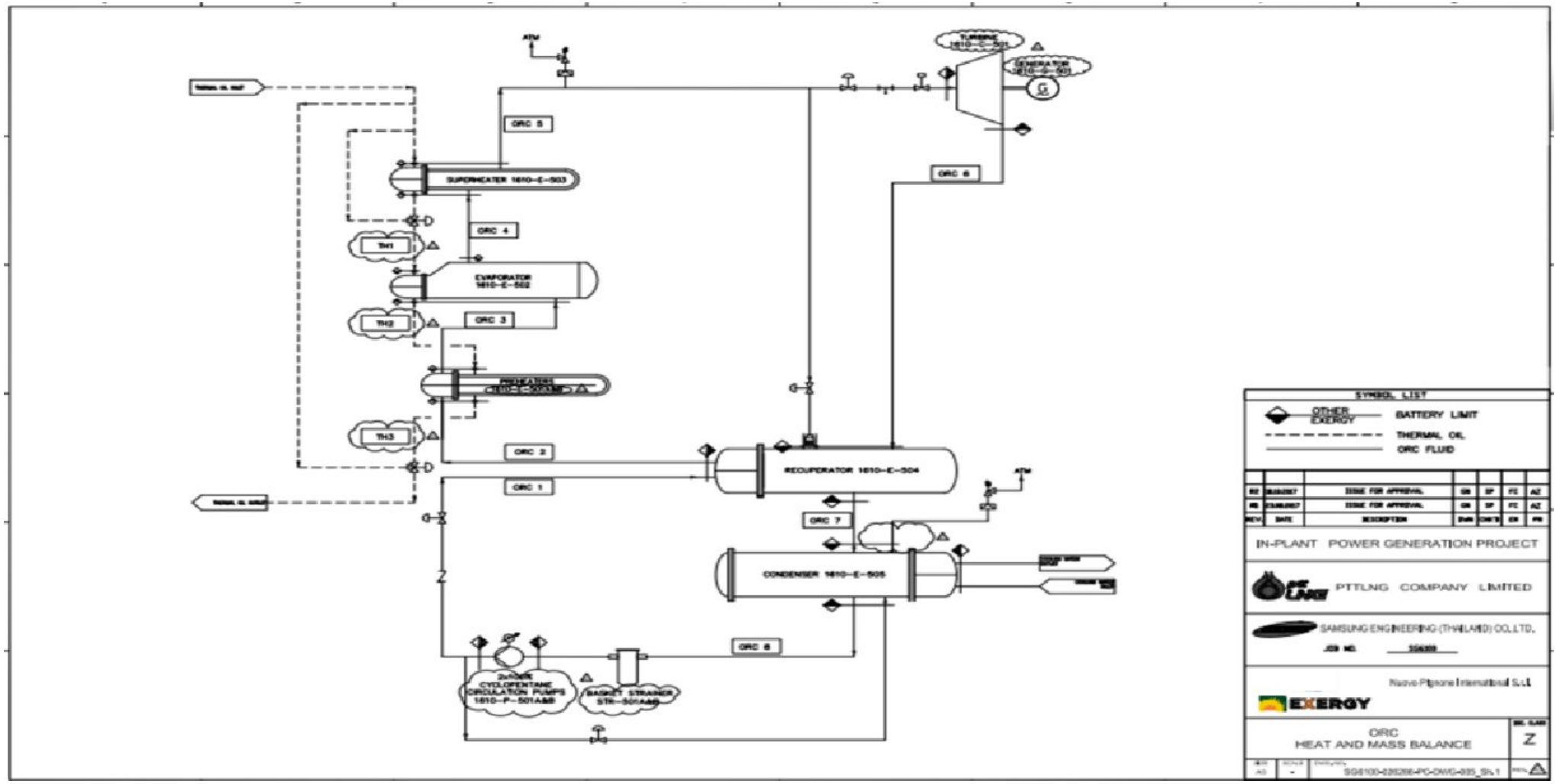
- All the components of the ORC system compliant with **API technical standards**

ENVIRONMENTAL SAVINGS

< 23,460 tCO_2/y

< 7,497 TOE/y

NEW SOLUTIONS FOR PROCESS



NEW SOLUTIONS FOR PROCESS PLANTS

Site conditions are:

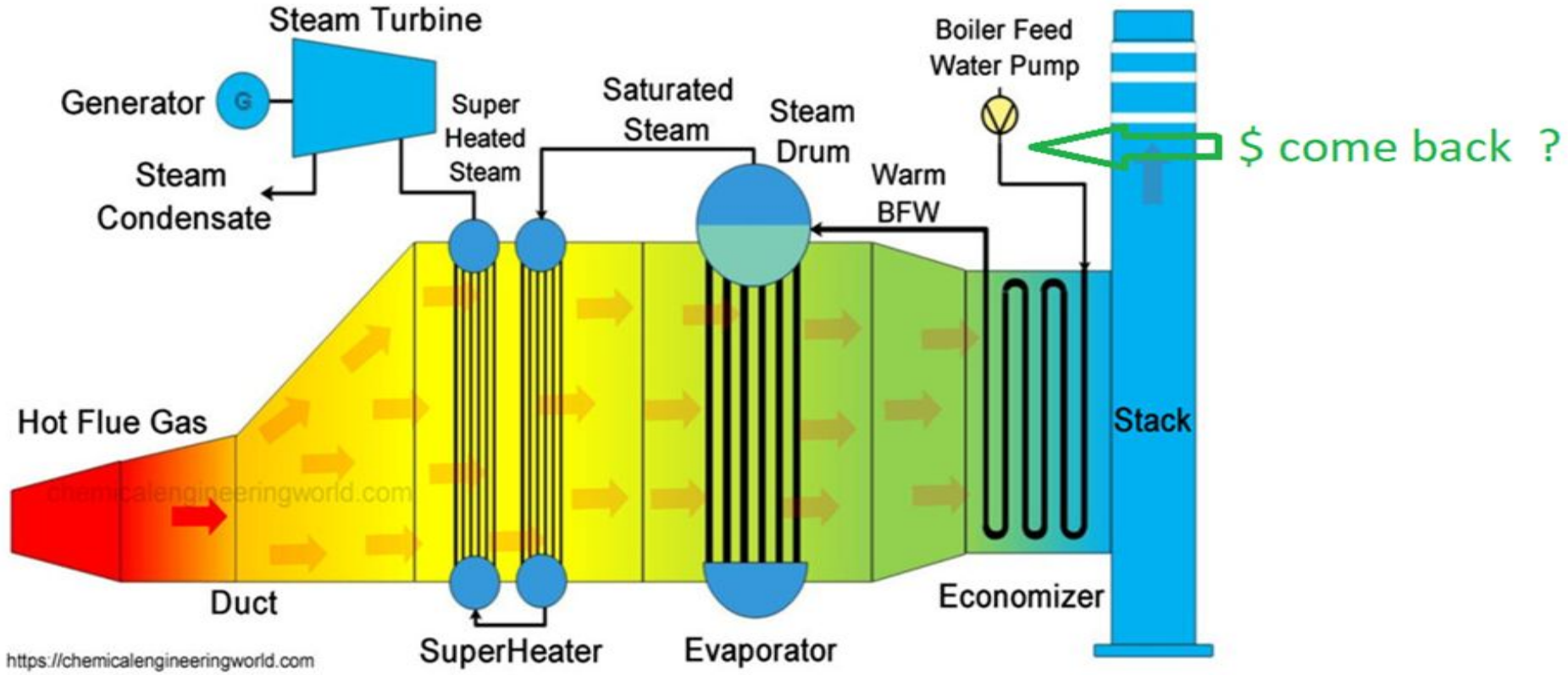
Location	Labuan, Malaysia	
Elevation	m a.s.l.	0
Reference dry bulb temperature	°C	32
Grid Frequency	Hz	50

Hot source (Steam) boundary conditions are:

Steam pressure at ORC inlet	bar a	4.5
Steam temperature at ORC inlet	°C	155
Steam flow at ORC inlet	ton/h	50

		NOMINAL
Gross Power at generator terminals	kW_e	4'985
ORC auxiliary consumption	kW_e	500
Net ORC Power	kW_e	4'485
Required thermal input	kW_{th}	33'410
Gross efficiency	%	14.9
Net efficiency	%	13.4
Condensate temperature at ORC outlet	°C	84.6
Condensate mass flow rate at ORC outlet	ton/h	50
Ambient air temperature at ACC inlet	°C	32

NEW SOLUTIONS FOR PROCESS



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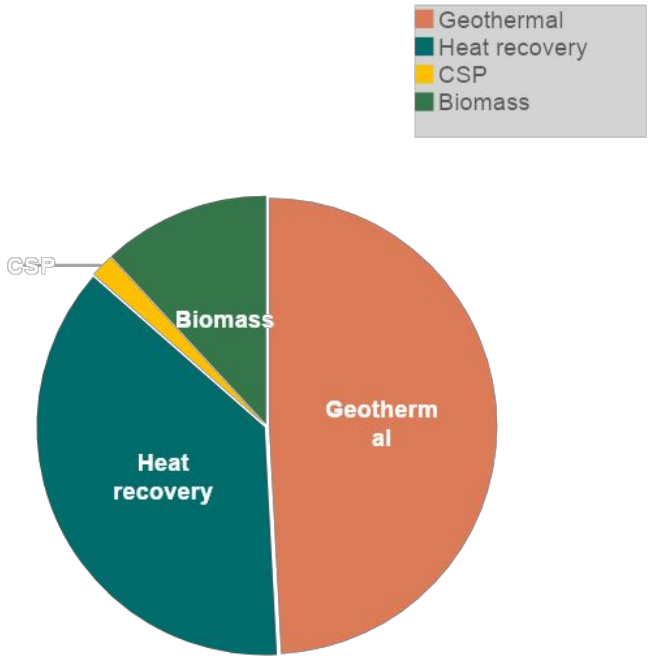
APPLICATION	PLANTS
GEOTHERMAL	29
HEAT RECOVERY	22
BIOMASS	6
CSP	1
TOTAL	58



PTT LNG/RAYONG, THAILAND/5 MWE/WHR O&G

CEMENTIROSSI /PEDEROBBA,ITALY/3,6 MWE/WHR CEMENT

SISECAM/TARGOVISHTE, BULGARIA/4 Mwe/WHR GLASS

ABS DANIELI/UDINE, ITALY/1 Mwe/WHR STEEL

EDC/MINDANAO 3,THE PHILIPPINES/3,6 MWe

KIPER ELEKTRIK/KIPER 1,TURKEY/12 MWe

GREENECO ENERJI/SARAYKÖY 6, TURKEY/28 MWe

BEŞTEPELER ENERJI/KUBILAY 1,TURKEY/24 MWe