

ORC power systems and
Renewable energy engineering



ORC TECHNOLOGY : A CONVENIENT SOLUTION FOR POWER OR CHCP (COMBINED HEAT, COLD AND POWER) IN ISLANDS AT MW SCALE

ORGANIC RANKINE CYCLE – ORC

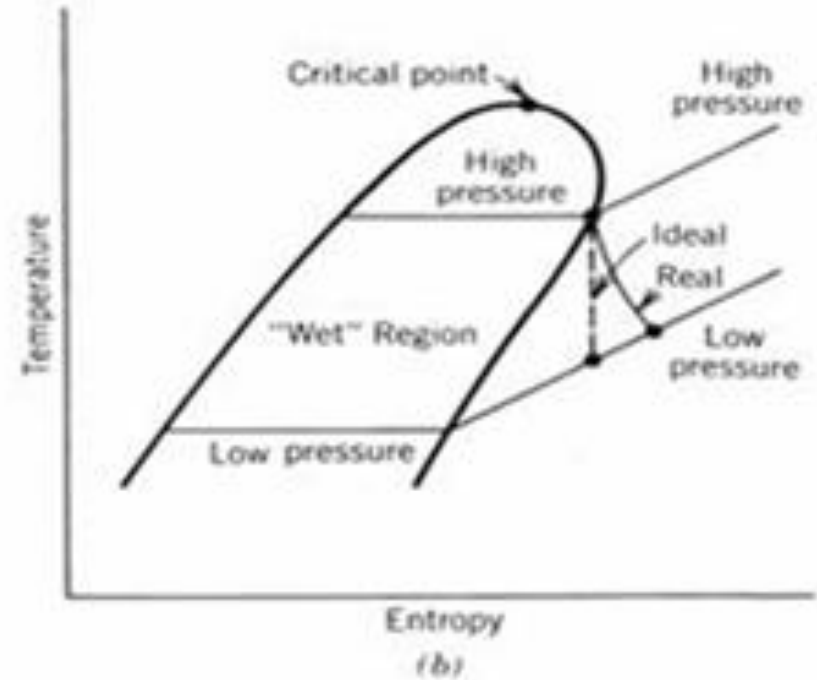
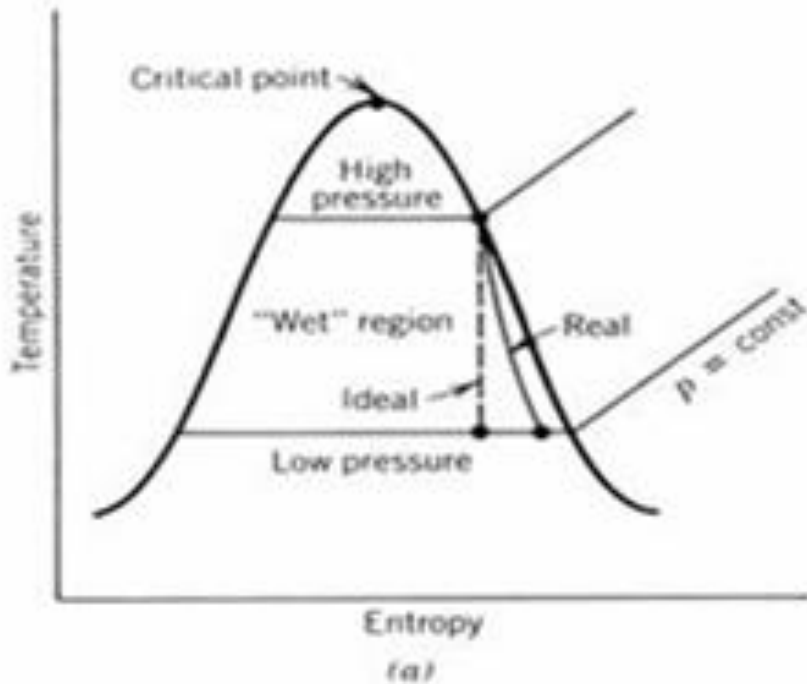
- thermodynamic cycle deriving from the basic water steam cycle described by Rankine a XIXth century Scottish Scholar.
- Addresses the shortcomings of the water steam cycle when temperature is low ($< 300^{\circ}\text{C}$) or power moderate ($< 20\text{MWth}$)
- Hence a perfect solution for distributed power in islands



WATER STEAM CYCLE vs ORC

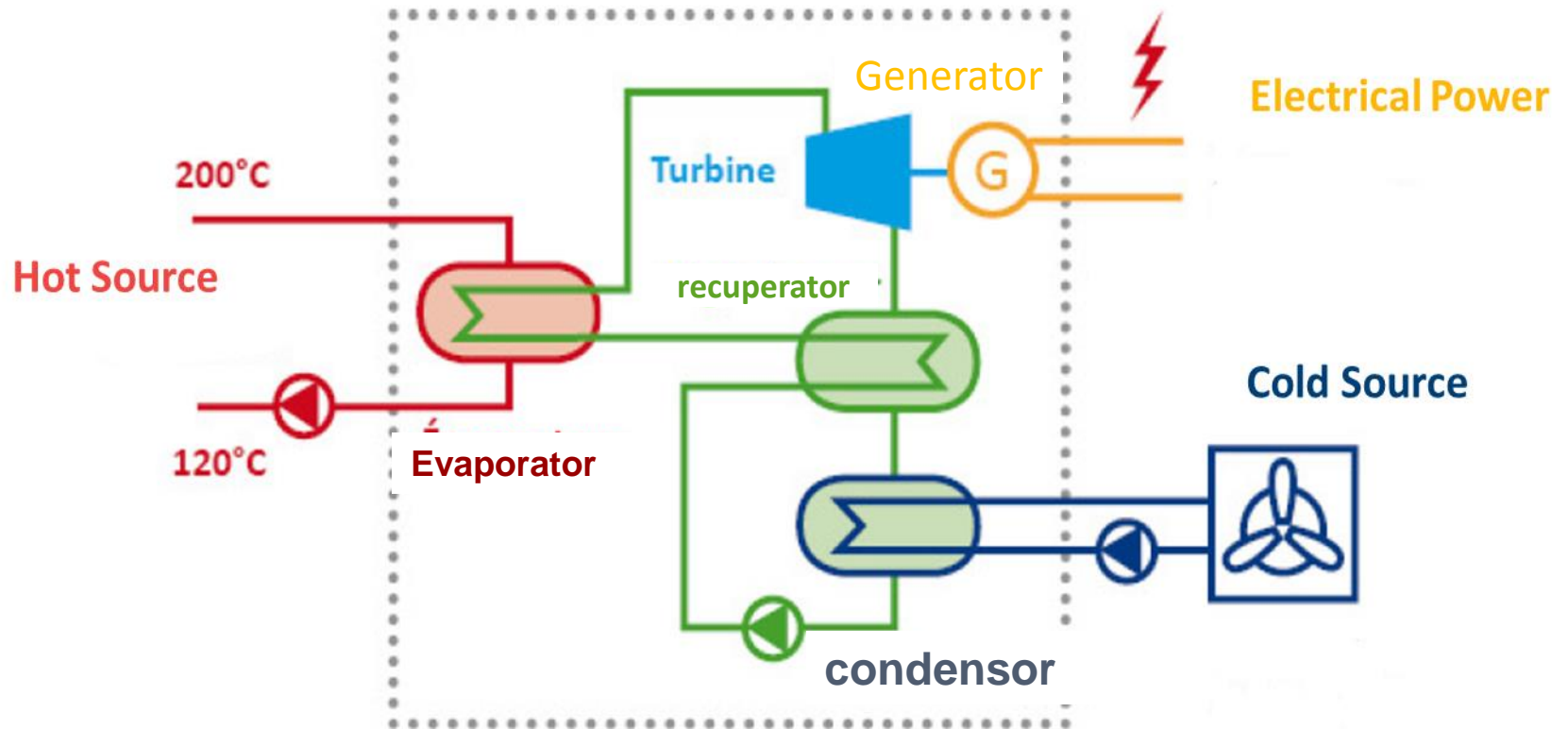
TEMPERATURE-ENTROPY WATER STEAM

TEMPERATURE — ENTROPY CHART
ORGANIC FLUID



ORC TECHNOLOGY

Thermodynamic Cycle Chart—Orchid module



THREE WAYS TO RECOVER/CONVERT HEAT WITH ORCs

- ❑ Power generation only (cycle designed to maximize electrical power output)
- ❑ Combined HEAT and POWER = CHP or co-generation
- ❑ Combined HEAT, POWER and COLD production with absorption chillers.

ORC FOR POWER PRODUCTION WITH A.C.CONDENSER.

ORCHID©



POWER. : 1MWe

Heat power input ... :

5,6 MWth

Cycle operating temp :

200°C

Net efficiency at 15°C :

15,4%

Direct Air cooling or water cooling

Working fluid : non flammable, non toxic refrigerant (HFC class).

ORC FOR CHP



ORCHID© COGEN

Electrical power	: 500 kWe
Thermal power	: 5000 kWth
Water temp. out/in	: 90°C/ 60°C

Input	: 5800 kWth
Hot source	: 200°C

High efficiency
Non toxic — non flammable fluid.



Système de cogénération

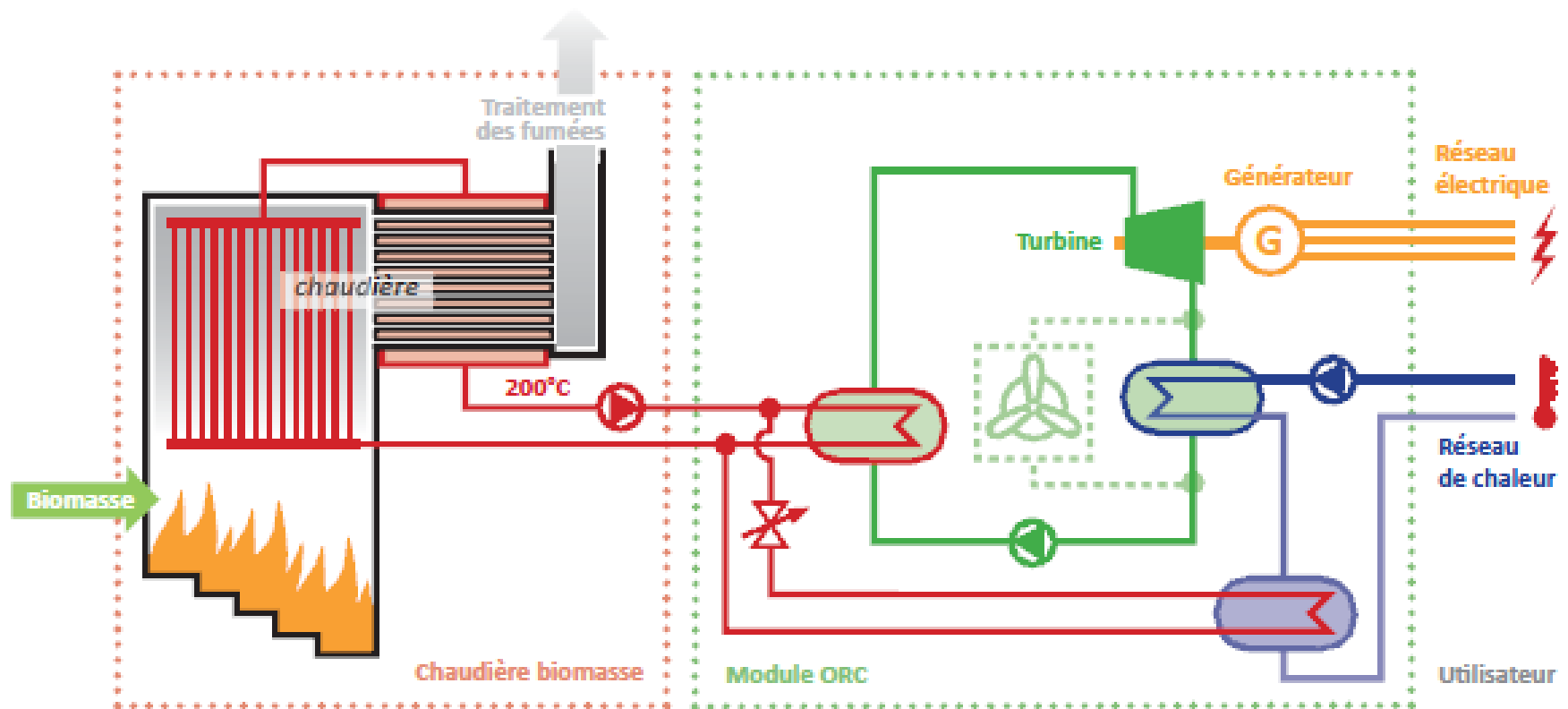
TRI-GEN ENERTIME ORC MODULE DELIVERED TO MONTPELLIER CITY POWER, HEAT AND COLD.



Water heated at 90°C at the ORC condenser feeds absorption chillers enabling cold production with an efficiency of about to 70%. With 5,5 MW thermal => 0,5MW of power and 3,4 MW of cold.

AND MANY DISTRIBUTED ENERGY APPLICATIONS RELEVANT FOR ISLANDS

BIOMASS BASED CHPC — BOILER +ORC SYSTEM



500KWe — 5MWth – for heat or for cold with and absorption system.

Green waste (trimmings) often a problem on mountaineous Islands — a biomass plant can dispose of them safely with high efficiency if CHPC can be applied

BIOMASS BASED COGENERATION — (MONTPELLIER – CASE)

15 000 tons/year of woodchips



- Energy: 40 000 MWh of primary energy equal to 5 000 t of coal
- Volume 600 truck loads of 90 m3 of woodchips/year
- Jobs 8 — 10 jobs created (ratio ADEME)

Energy distribution:

- Heating and hot water for 300000 sqm, or cooling for 900 homes
3400kW or 900TR
- Power production for 300 homes



FROM HOT TO COLD WITH ABSORPTION CHILLERS



Hot Water Driven Chillers

Operating Range

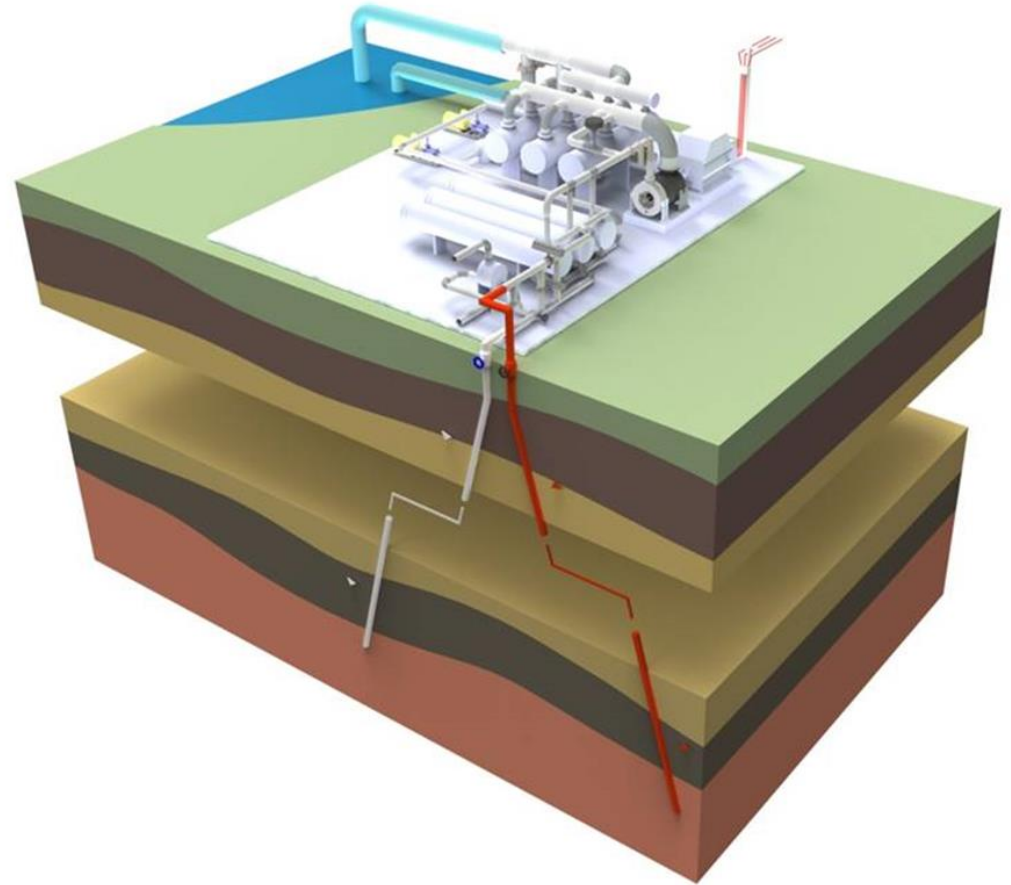
- **Capacities:** From 200 to 1380USRT (700 to 4850 kW)
- **Chilled water temperature:** Up to 0°C (34°F)
- **Hot Water temperature:** From 75°C(167°F) to 120°C (248°F)
- **COP:** 0.75 – 0.8



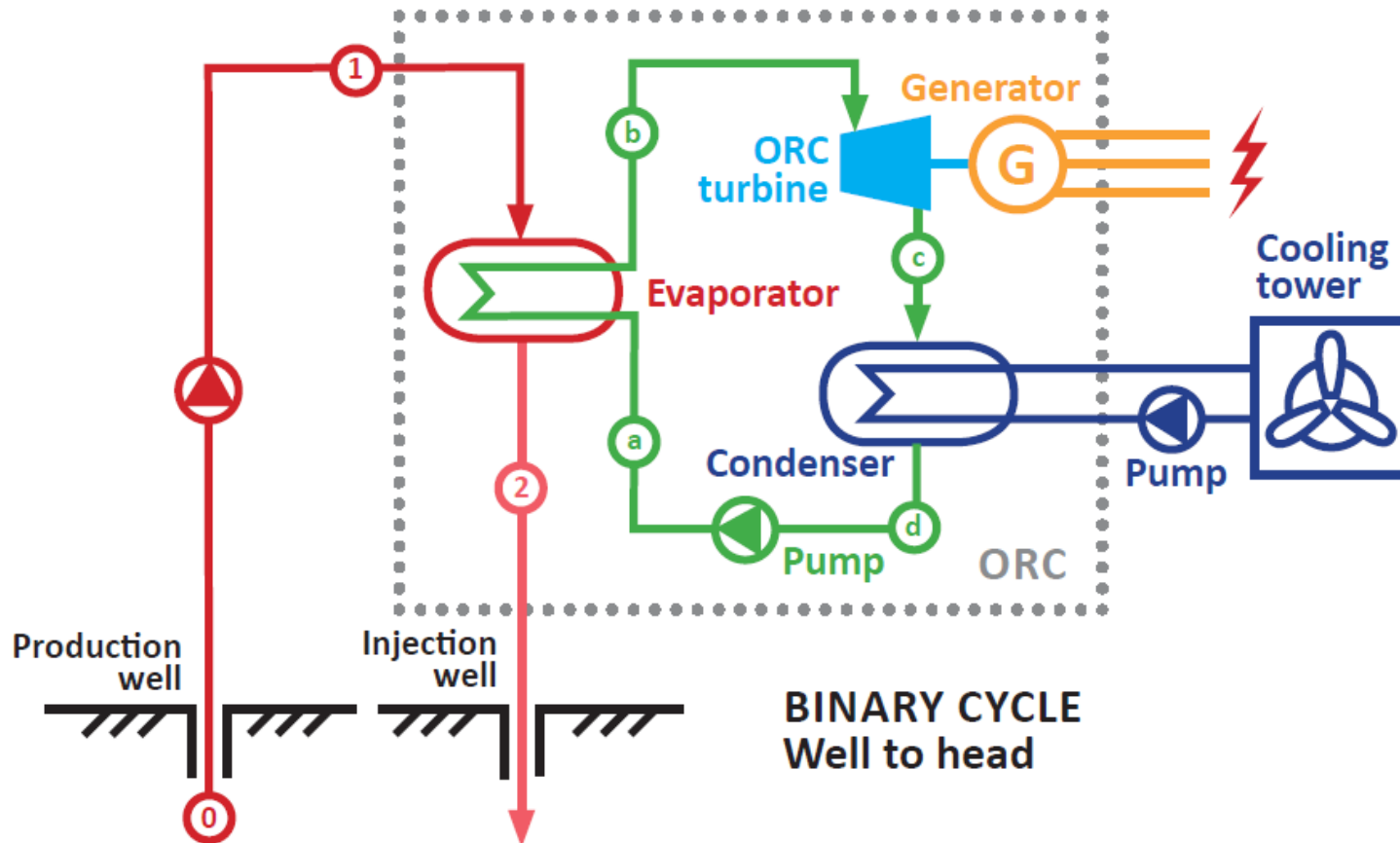
Medium enthalpy geothermal plant : power on demand day and night !



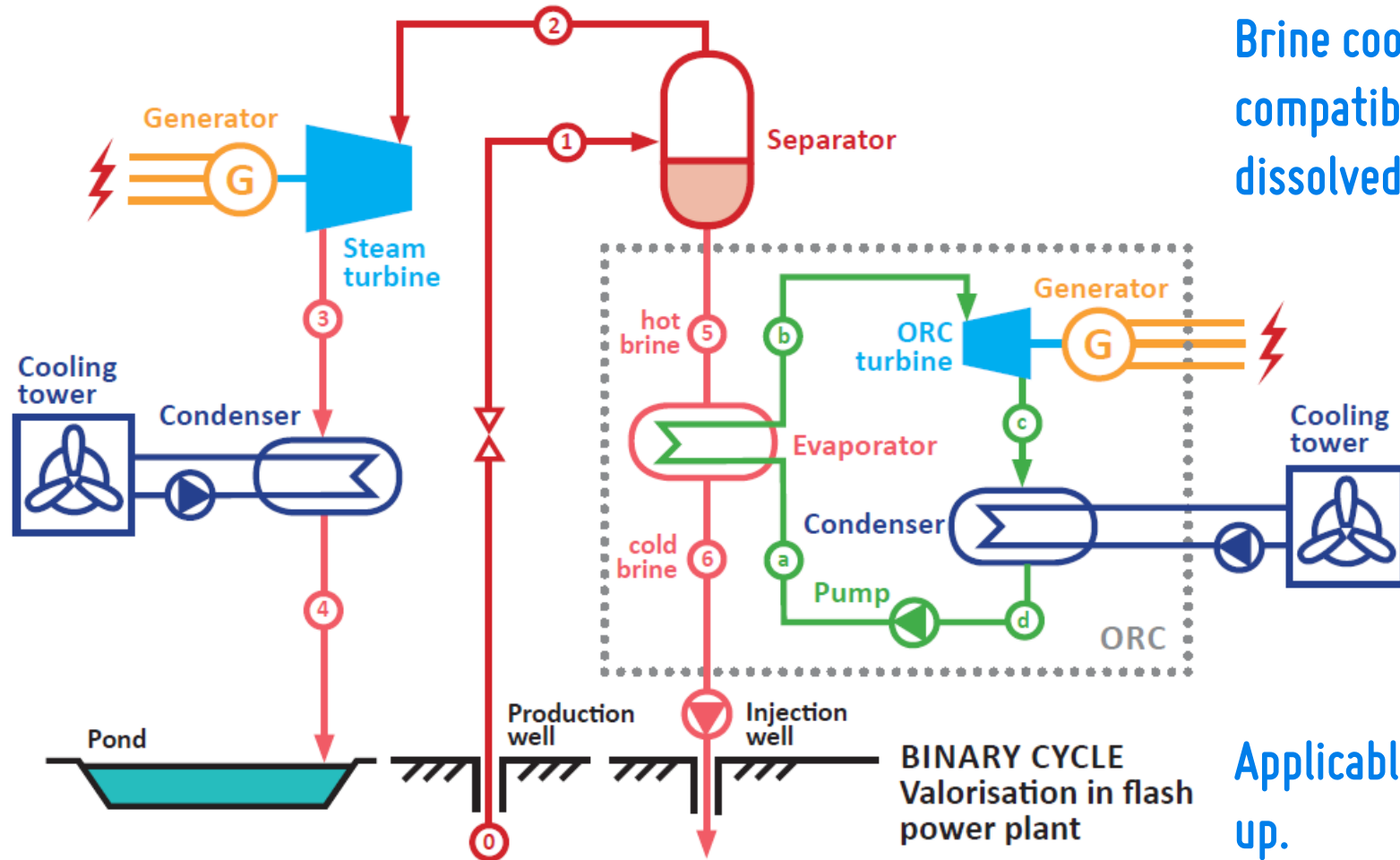
- Existing flash geothermal power plant or new medium enthalpy project
- Typical 145°C to 180°C geothermal heat source
- Net power from 700 kW to 5 MW per unit
- Can also work in CHPC mode with heat produced at condenser side.



WELL HEAD SYSTEM OPERATING PRINCIPLES



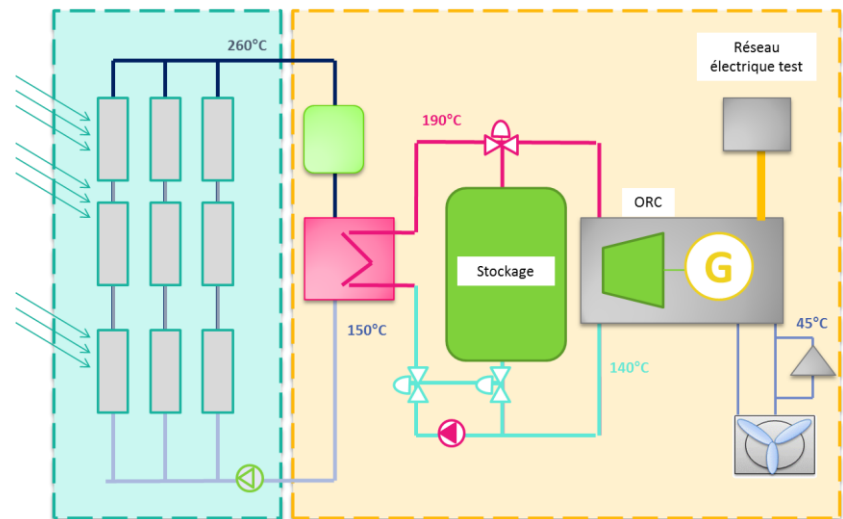
PRODUCTION ENHANCEMENT ON EXISTING PLANT WITH ORC



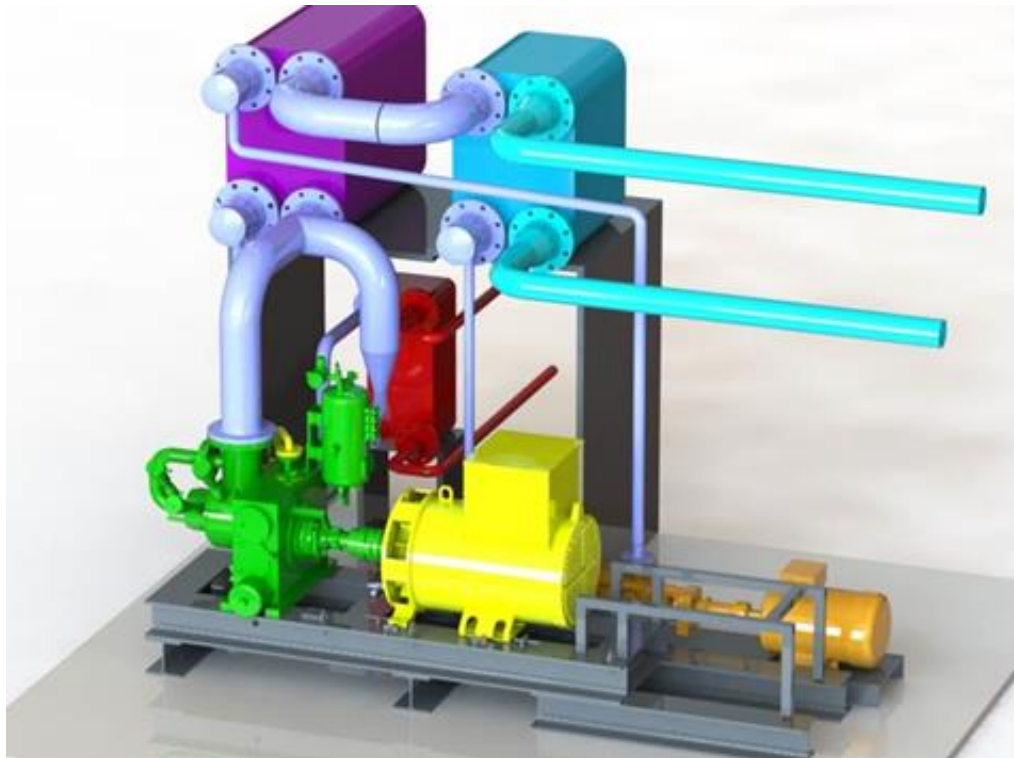
Concentrated Solar or biomass+solar power plant



- 200°C module fed by Solar Concentrators and/or small biomass boiler
- Simple thermal storage capacity
- Enertime develops a “low cost solution” of 100 kWe solution due for trials in India in 2015
- Possibility to work at 50kWe in CHPC mode with 350kW of cold (100TR)
- Various cooperations with parabolic troughs manufacturers
- Offering clean cost-effective rural electrification solution vs diesel power plants



100kWe MODULE UNDER DEVELOPMENT FOR RURAL ELECTRIFICATION AND SMALL CHP



200°C heat input (thermal oil, steam or water)

16 to 18% gross efficiency

Fully automated.

Made in India (except turbine)

Also available as co-gen Unit (50kWe + 500 KWthermal)



AND WASTE HEAT RECOVERY APPLICATIONS TOO !



WASTE HEAT, WHERE ?

- INDUSTRY : METALS AND MATERIALS
- METALS
- CEMENT
- GLASS
- POWER STATIONS

Direct heat usage is the optimal choice... but when there is no customer for the heat the ORC provides the best alternative : **electricity** (or electricity + low temp heat / CHP)

METALS AND MATERIALS

Waste heat Recovery



Reduce electricity bills

INDUSTRIAL REFERENCE : WHR WITH ORC ON A 25TPD



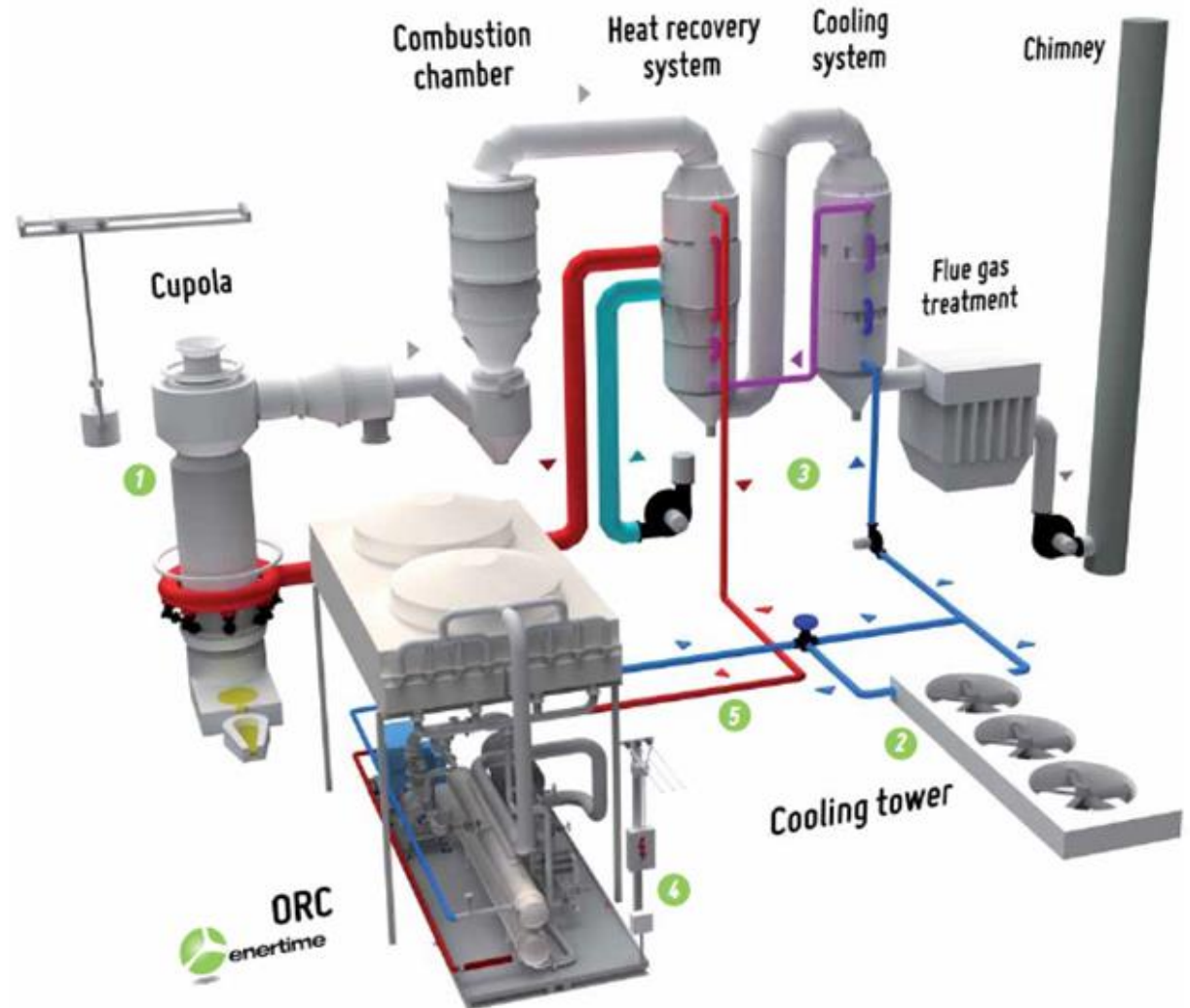
CUPOLA FURNACE



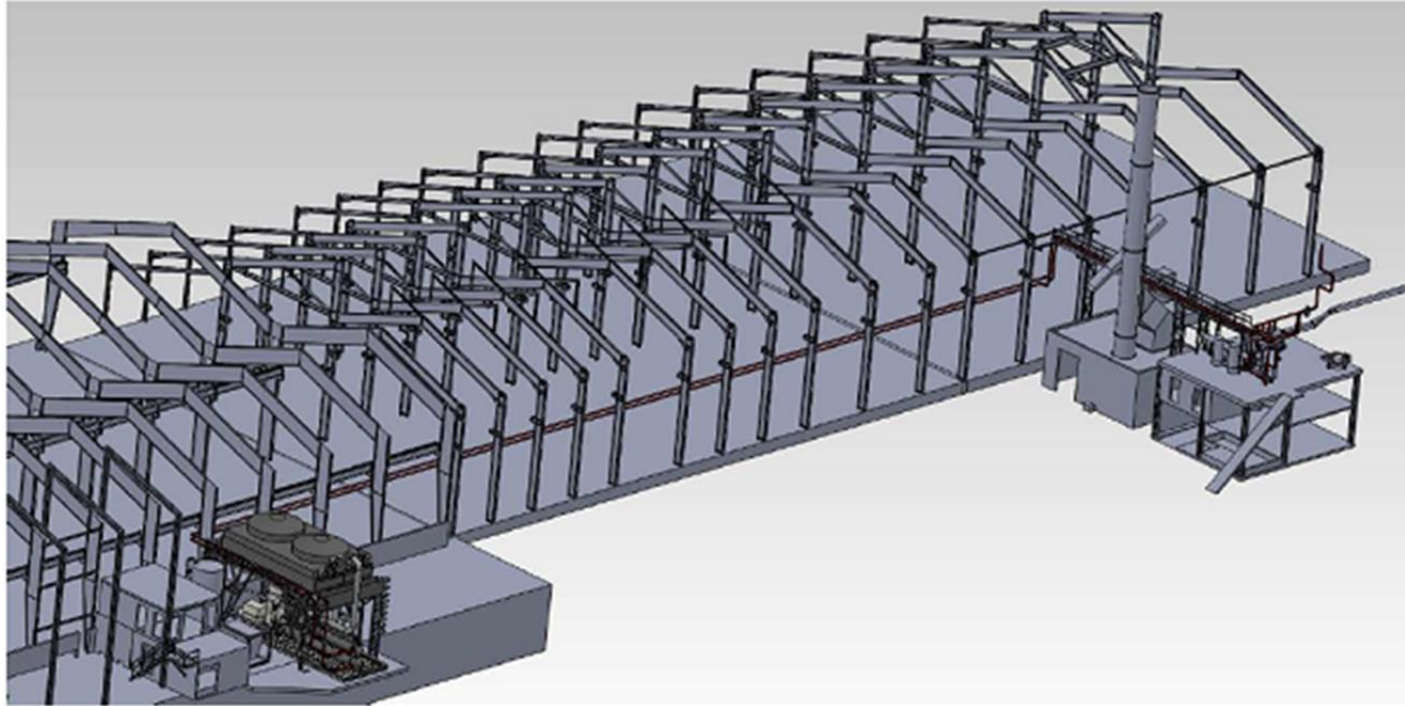
commissioning : Oct 2012

Châteaubriant (44), FRA

ORCHID© - 1MWe brut



FOUNDRY CUPOLAS / ROCKWOOL OR GLASSWOOL



Investment :
1,9M€.

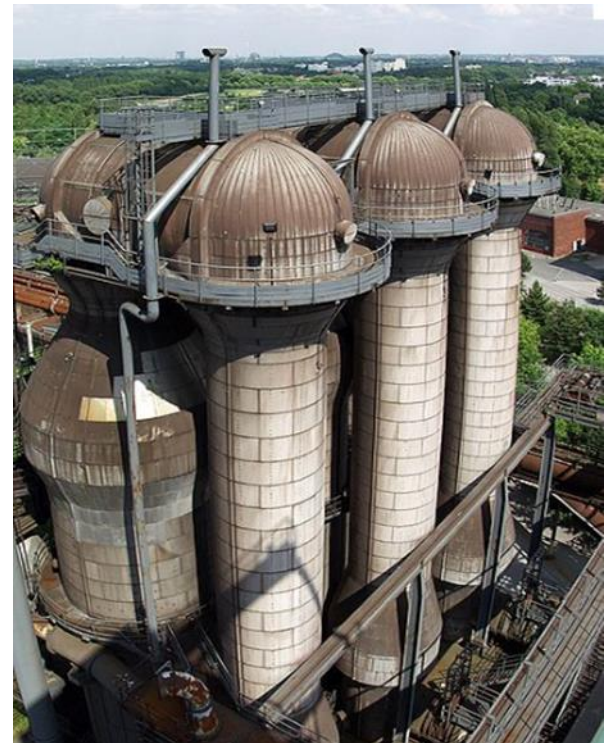
Production: 5-
6000 h x
850kW net =>
4 to 5 GWh/yr

- Production of 5 GWh/y => T/O @80€/MWh = 400 k€
- @ 80€/MWh Payback time \leq 5 years .

STEEL MILLS HEAT RECOVERY OPPORTUNITIES



- DRI plants (Midrex, and rotating kilns...)
- Sinter plants
- EAFs (Heat storage reqd)
- Cowpers exhausts
- Slag cooling systems.
- WBF/Reheating furnaces.
- Heat treatment furnaces.



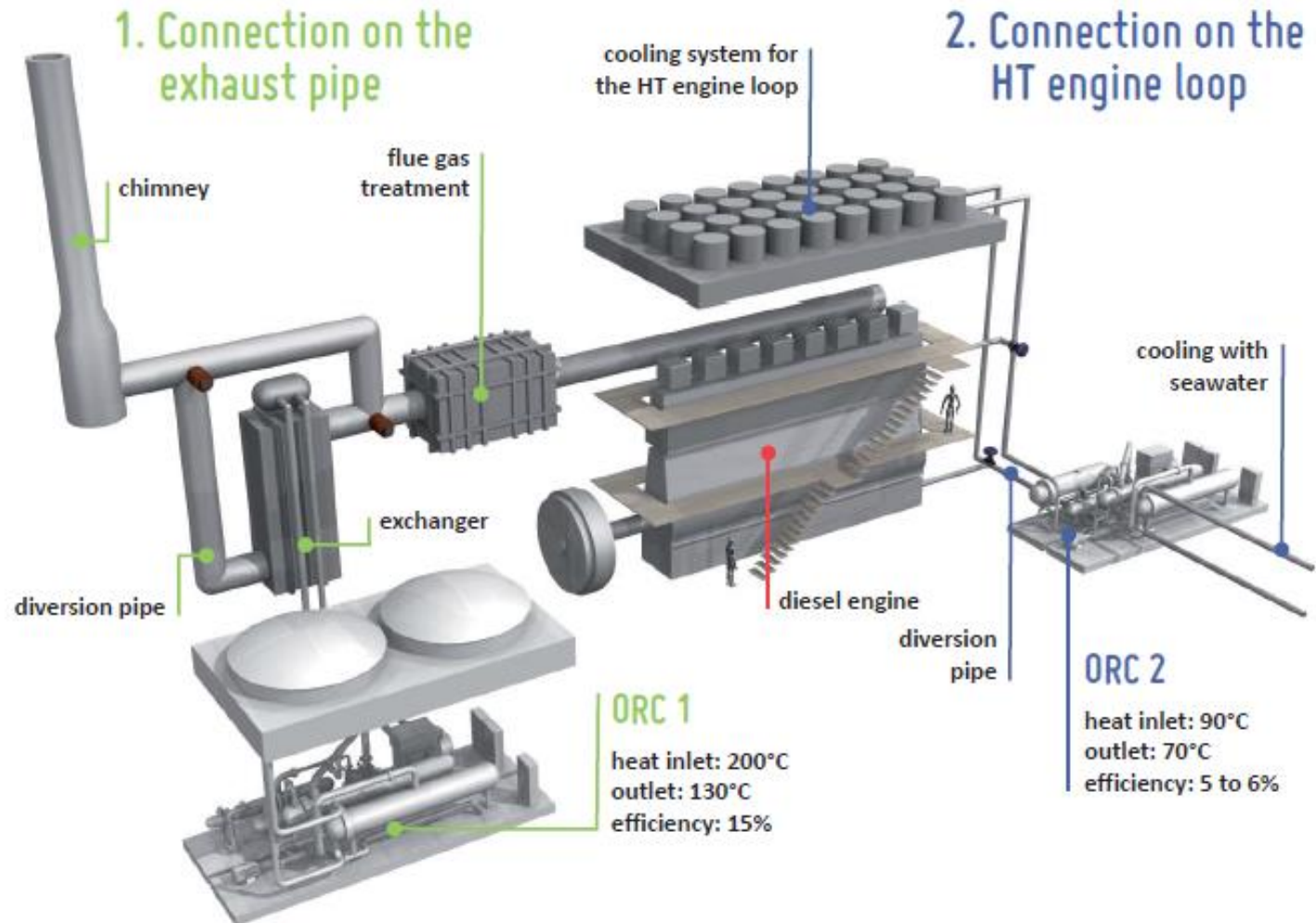
CEMENT FACTORIES : TWO PLACES FOR RECOVERY



DIESEL POWER PLANTS – A COMPELLING BUSINESS



CASE



10% LESS FUEL FOR THE SAME OUTPUT



1MWe for 18MWe of base load.

Investment 3-4M€/MWe

6000 MWh/year

@170€/MWh = 1M€ income
yearly. => 3-4 year payback on a
plant running with HFO

@240€/MWh (LFO) => 1,4M€
income...

KEY SUCCESS FACTORS

- Operating hours > 6000 hours
- heat power resource > 5MWth
- Heat and Power prices
- Investment cost

CHALLENGES

- In CHPC: Availability of a heat/cold network that can be fed by 90°C water (via absorption chillers for cold delivery)
- Connection to Heat source / Primary HX for some off-gases types (not an issue for solar).

WHY AN ORC

- Flexible (can operate even at 15% load)
- Simple to operate and built-in reliability (no operator)
- Non flammable working fluid (Enertime)
- Easy and cheap to maintain (no permanent staff req.)
- Can work with a primary water loop (Enertime)
- Low price per MWh produced (long life+low oper. costs)
- Skid mounted (can be moved)

ENERTIME...

Enertime: Innovator in turbomachines and power plants

- French share Cy incorporated in 2008 by former ALSTOM/AREVA Bio-energy division head.
- Head Office in Courbevoie close to Paris La Défense business district
- Offices in Lyons, Reunion island and the Philippines
- Subsidiary in India under formation
- 20 employees, including 15 engineers or PHD. Average age is 32 years
- 7 FTE engineers in R&D with an R&D annual budget of 1 M€
- Scientific partners



- International/ Overseas presence: Philippines, India, Reunion island, New-Caledonia

Manufacturing thermodynamic plants and associated turbo machines / power systems

Two activities in synergy:

- Design and manufacturing of turbo machines: for gas expansion and compression
- Design and manufacturing of industrial size thermodynamic power plants:
 - ORC (Organic Rankine Cycle) modules,
 - High temperature heat pump for energy efficiency and renewable energy production.

5 years vision:

- International leadership in innovative thermodynamics for energy efficiency and renewables



Biomass



Solar CSP



Geothermal



Waste treatment



Waste Heat
Recovery



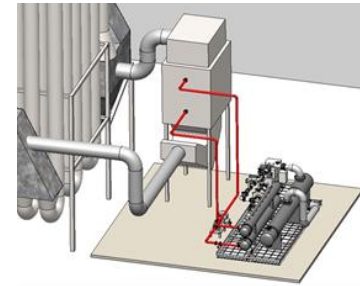
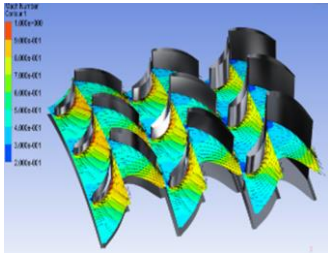
engine
efficiency



District heating



Operating along the entire value chain



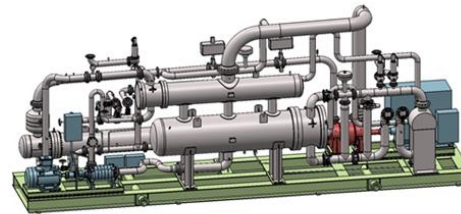
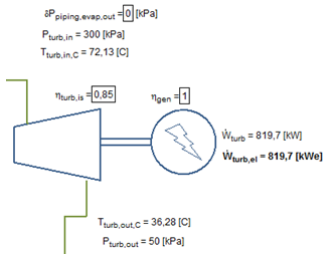
Design of cycles
and associated
turbo machines

Manufacturing
turbo machines

Construction of
skid-mounted
module

Module
integration into
the process

Financing,
maintenance
and operation



Thank you for listening

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REFERENCES (CONSULTING & ENGINEERING)

Industries



Investors



Development agencies



Cities

