Lucerne University of Applied Sciences and Arts

Research, Development & Commercialization of ORC modules in Swithzerland

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Research, Development & Commercialization of ORC modules in Swithzerland

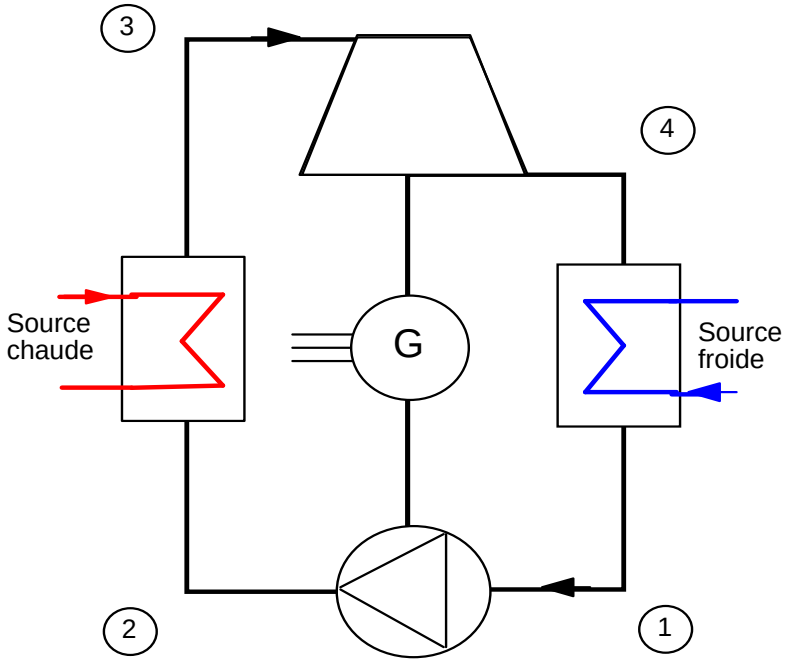
Presentation:

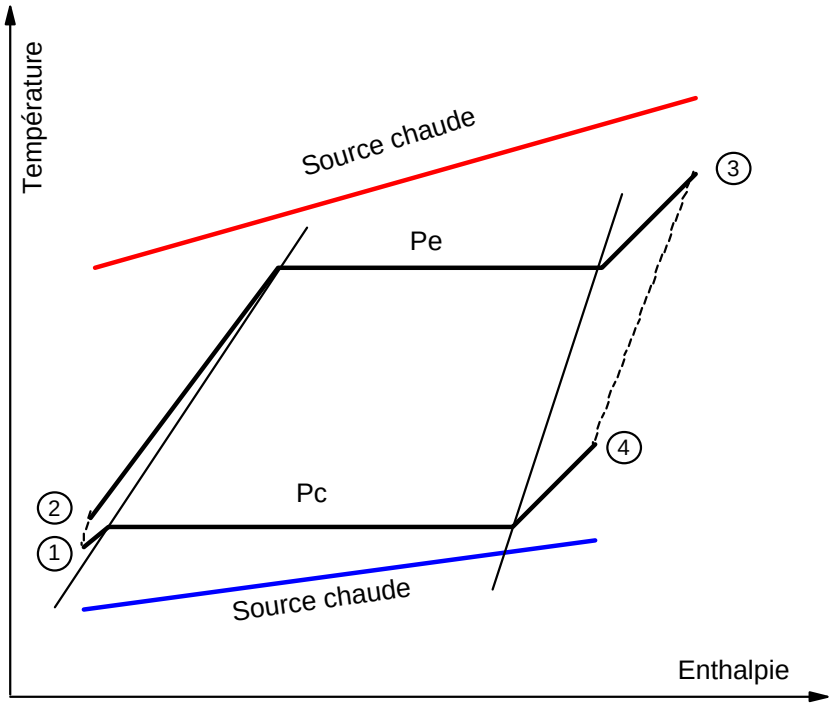
- Research, Development & Demonstration
- ORC modules development & field testing
- ORC Modules for commercial applications

Research Development & Demonstration (EPFL)

Organic Ranking Cycle principle

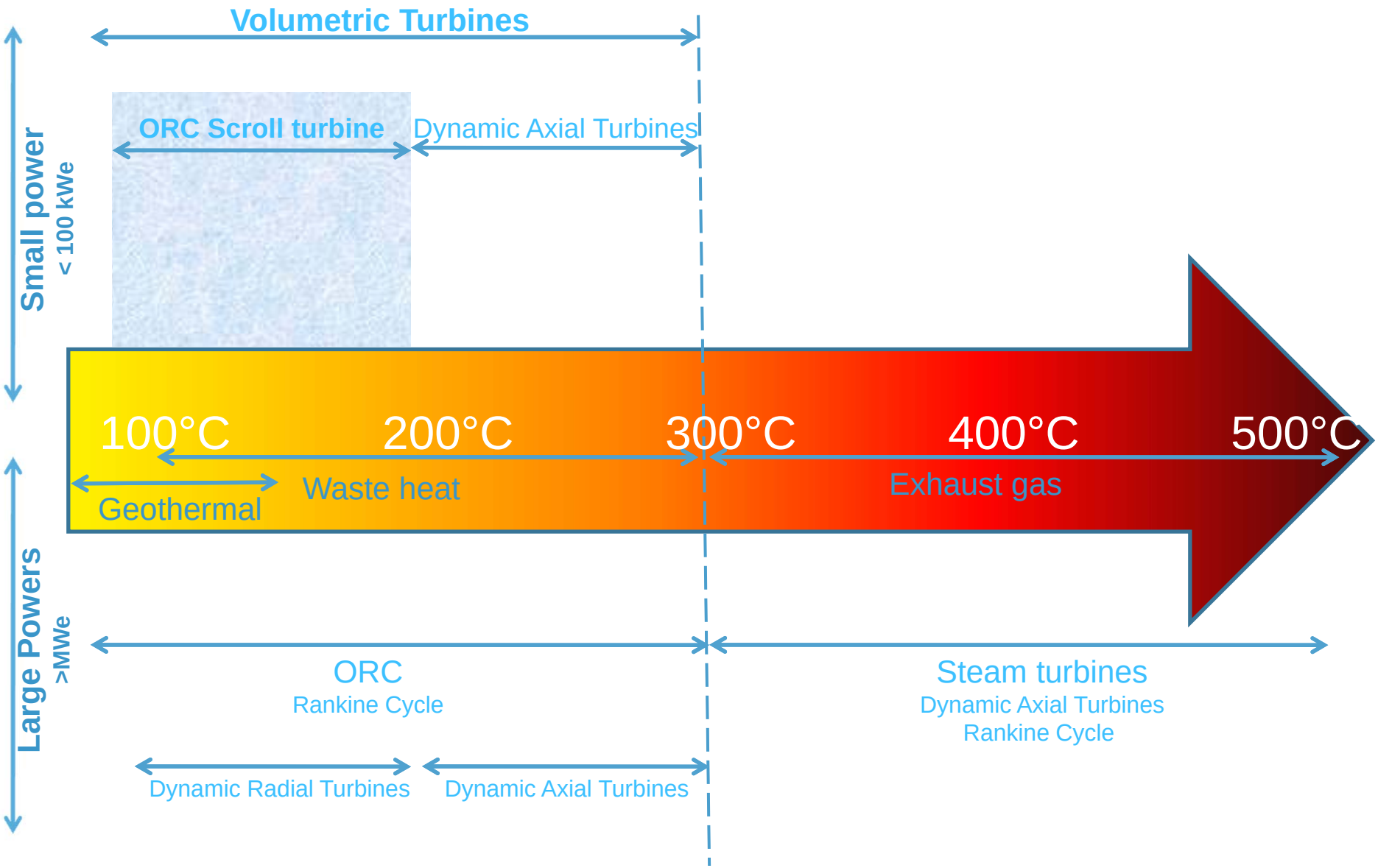
- Concept using organic fluid, working in Steam Rankine Cycle principle (low Tº app, < 200ºC)
- Main application: solar, biomass, geothermal power plants, size > 400kW



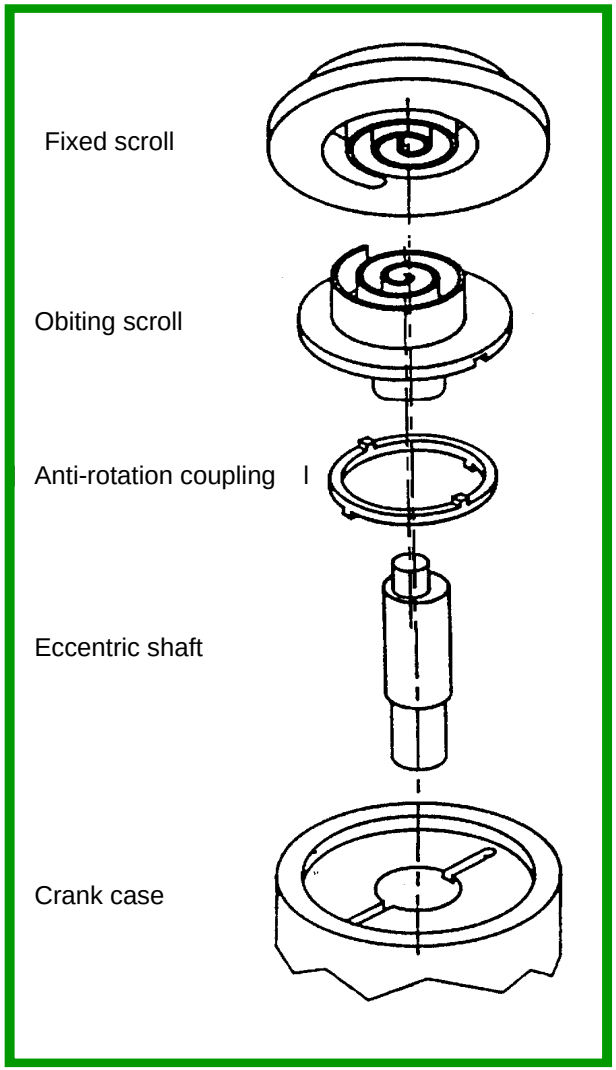


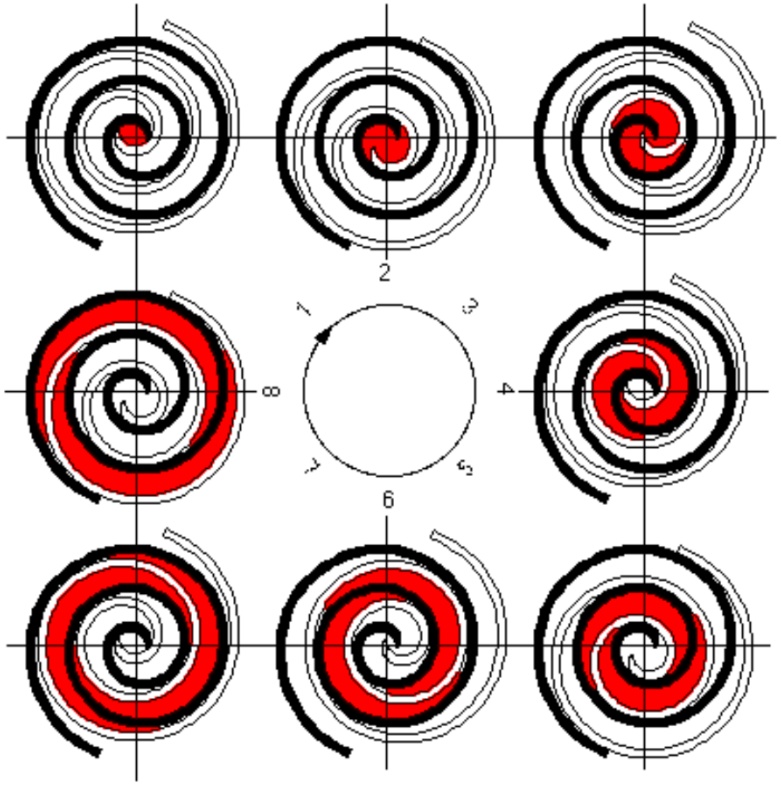
Organic fluids :

- Adequate thermodyn. properties
- Low specific volume
- High molar mass
- Positive saturated vapour slope


Volumetric Turbines
ORC Scroll turbine
Dynamic Axial Turbines
Small power
< 100 kWe
100°C
200°C
300°C
400°C
500°C
Geothermal
Waste heat
Exhaust gas
Large Powers
>MWe
ORC
Rankine Cycle
Steam turbines
Dynamic Axial Turbines
Rankine Cycle
Dynamic Radial Turbines
Dynamic Axial Turbines

New innovative concept of using scroll turbine

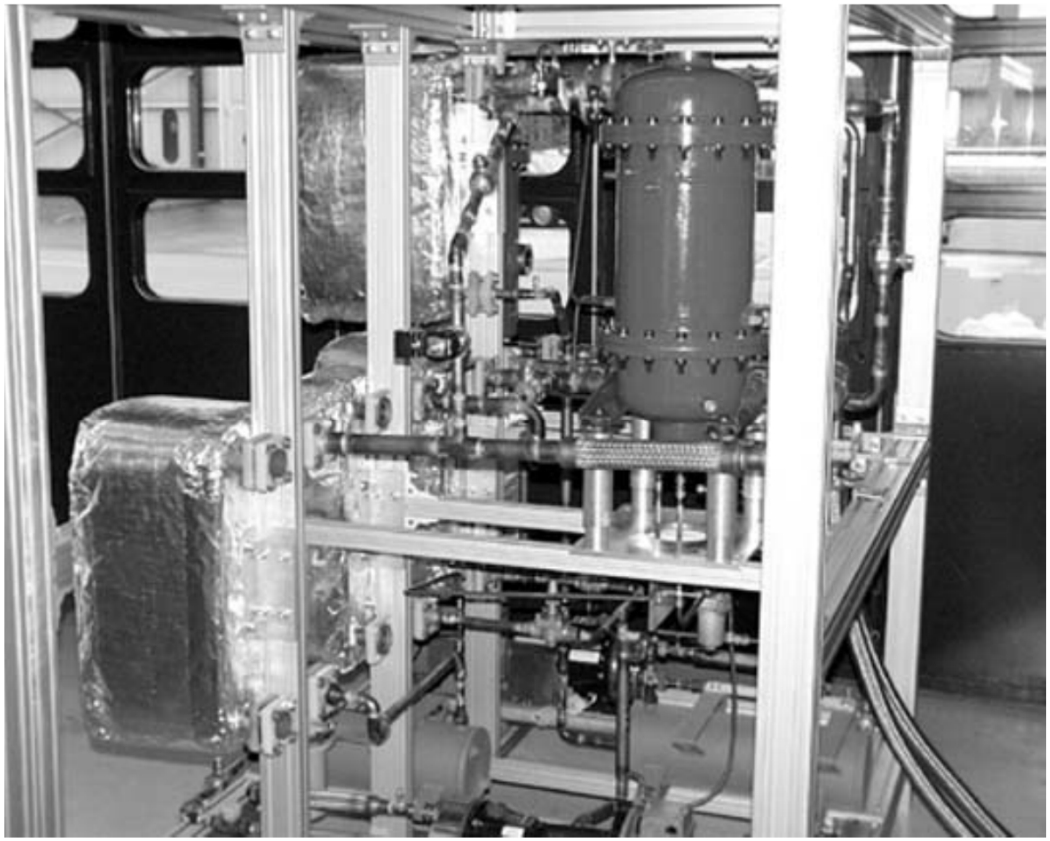




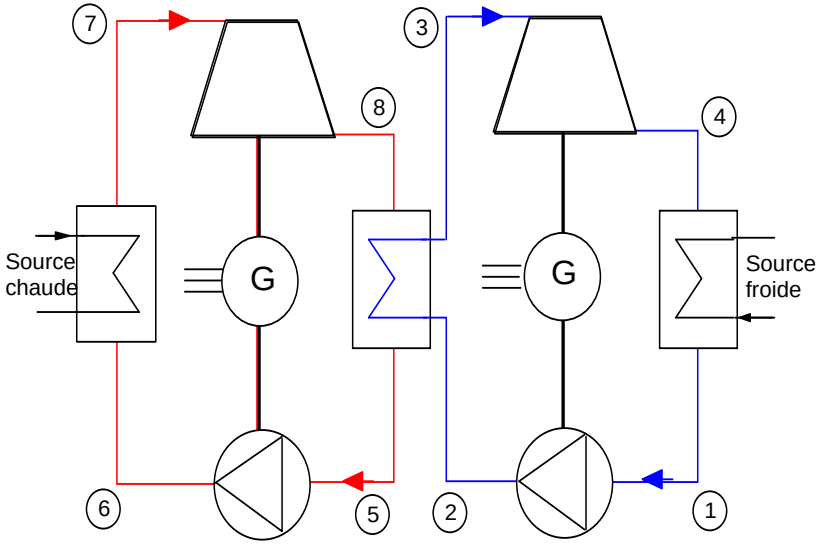
Technology : **ORC using hermetic scroll expander-generators witch based on the conversion of conventional scroll compressors**

ORC scroll turbines prototype

Technology : 12 kW prototype unit using superposed ORC cycles



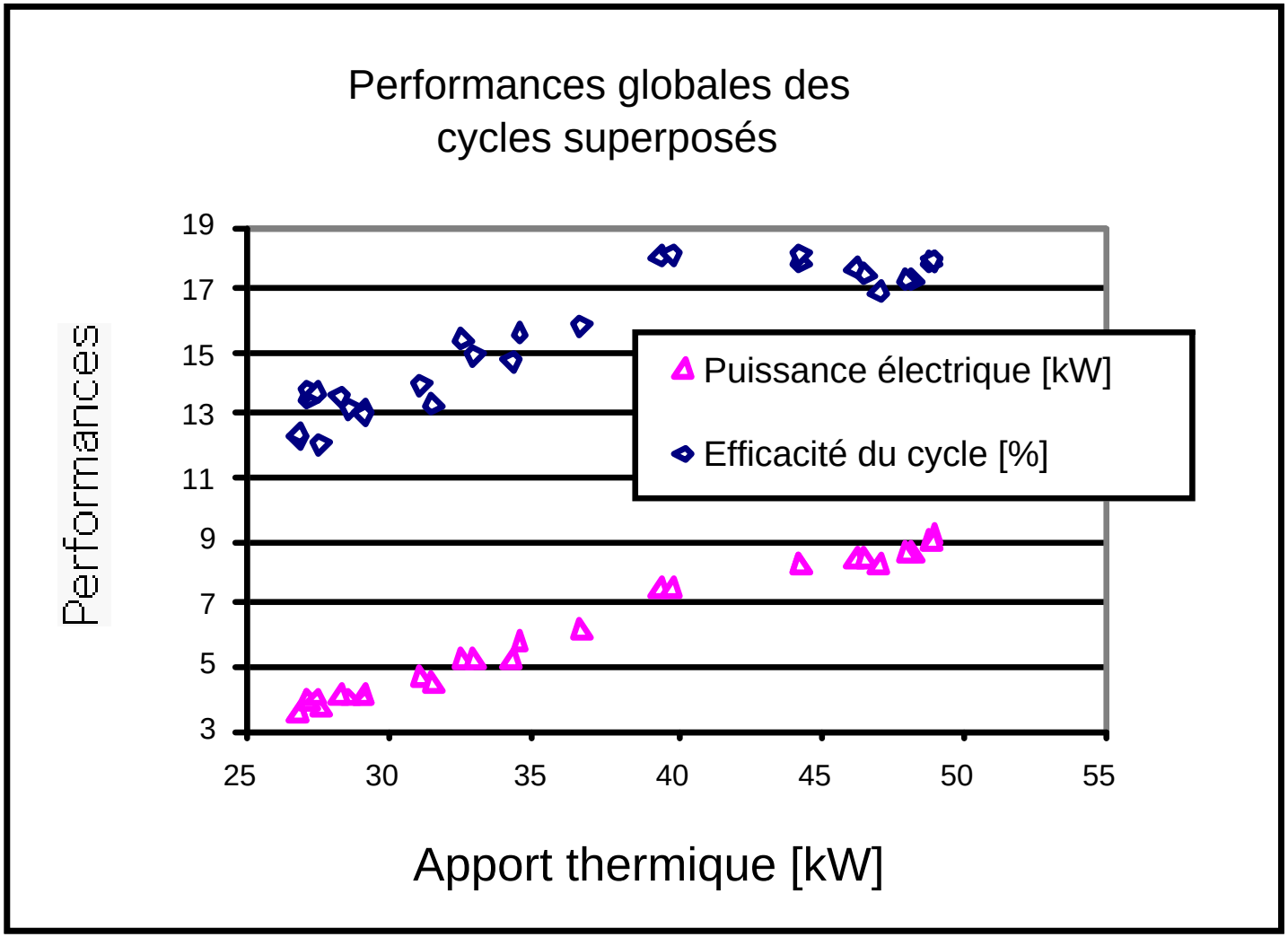
EPFL-LENI, Lab testing, 1999



- **Topping ORC (HCFC123):**
  - **5kWe-scroll expander-generator**
  - **Evaporator temperature of 120 to 150 °C**
- **Bottoming ORC (HFC134a):**
  - **7kWe-scroll expander-generator**
  - **Evaporator temperature of 60 to 80 °C**

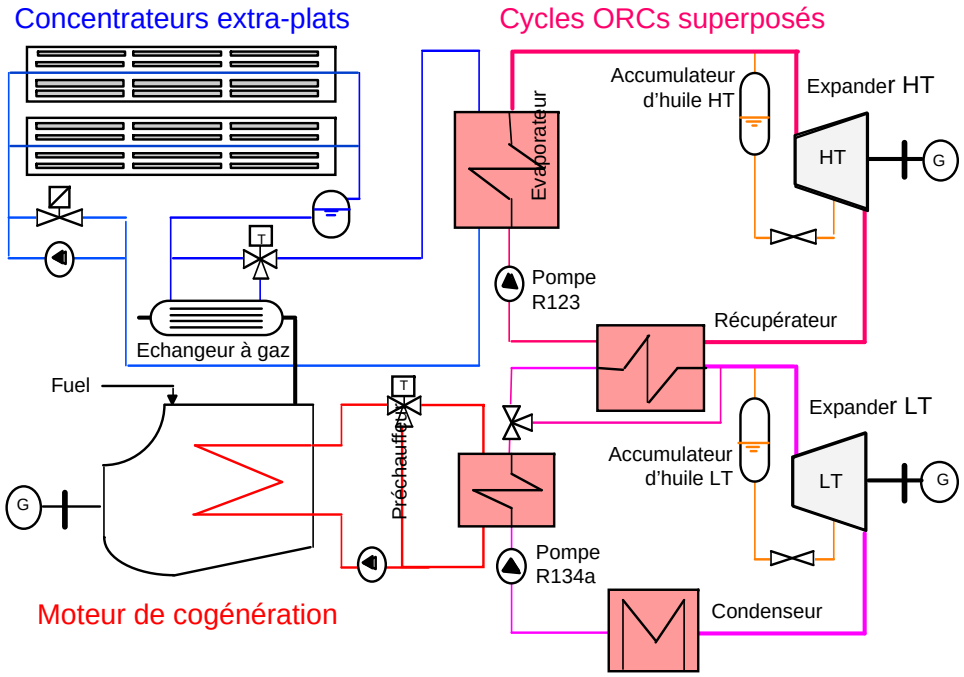
ORC cycle performances

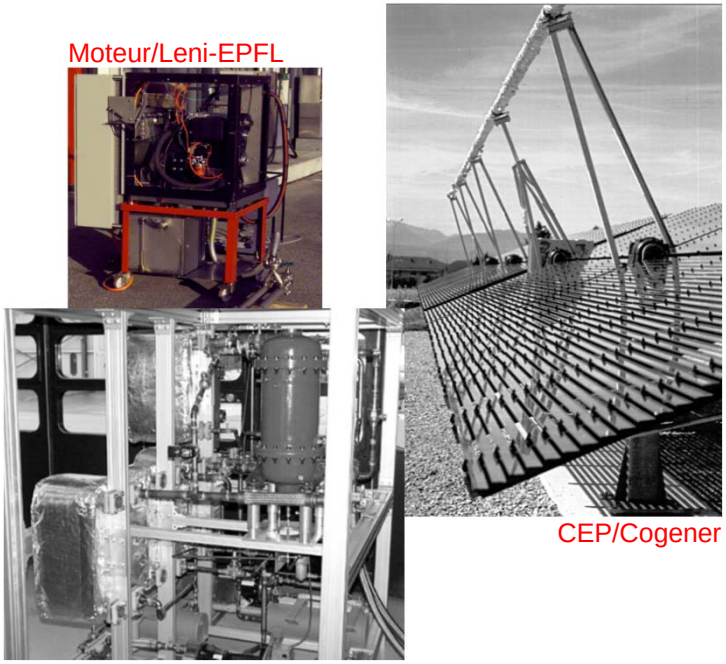
15%-overall electric efficiency with 165ºC of hot source



ORC scroll turbine

- **HSPS application : Integrated solar-fuel small power system using hermetic scroll turbines**
- **SPS project 25 kWe (EPFL-PSE-Lausanne)**





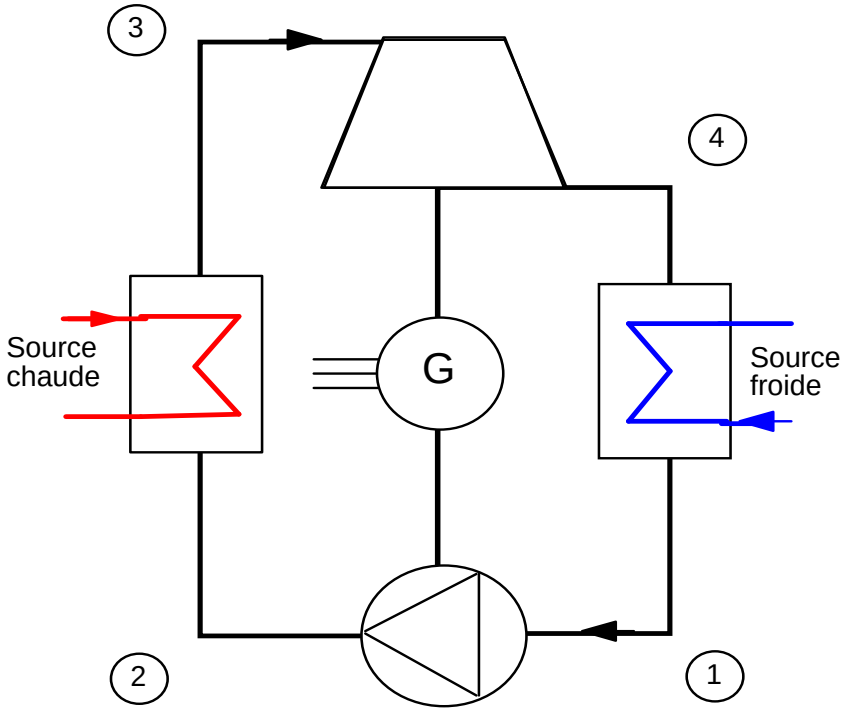
System and results :

- Flat reflector concentrators
- 13kW-27% diesel engine
- Hermetic scroll turbines
- Fuel electric efficiency, 38%
- Solar electric efficiency, 8%

On site demonstration project

- Bottoming cycle based on Scroll turbine Organic Rankine Cycle (ORC) technology boost of a biogas engine

- Site of Nant-de-Châtillon (Genève, Switzerland)



ORCNC – Photo LENI Genève, 2001

Test results for a ORC-7kW :

- Hot inlet temperature: 95°C
- Evaporation pressure: 18-22 bars
- Condensation pressure: 7-8 bars
- Electric power measured, 5-6kW
- Net exergetic efficiency: 40%

eneftech
Generate your Heat & Power

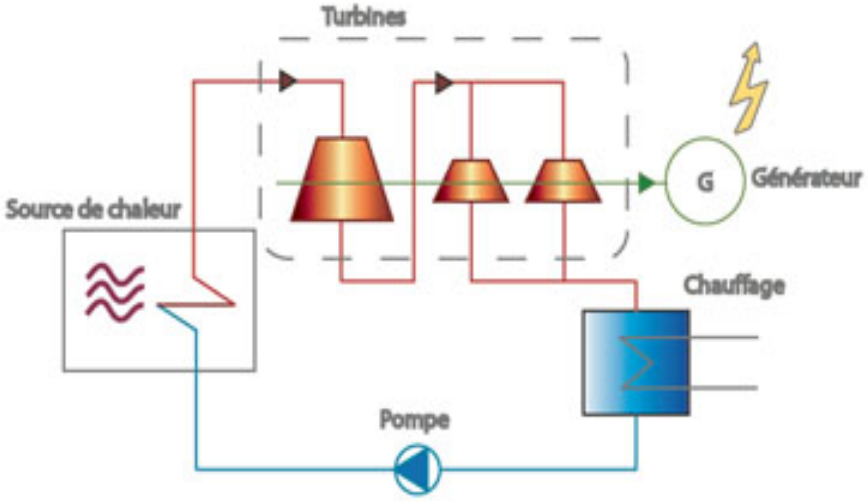
ORC modules:
Development & commercialization
(Eneftech)

Main development for industrial application

Bi-stage cycle (one fluid):

- *Low temperature waste heat recovery system or cogeneration*
- *Compact, modular design and easy to use*
- *Hermetic components with high reliability*

Eneftech 2005 @ PSE



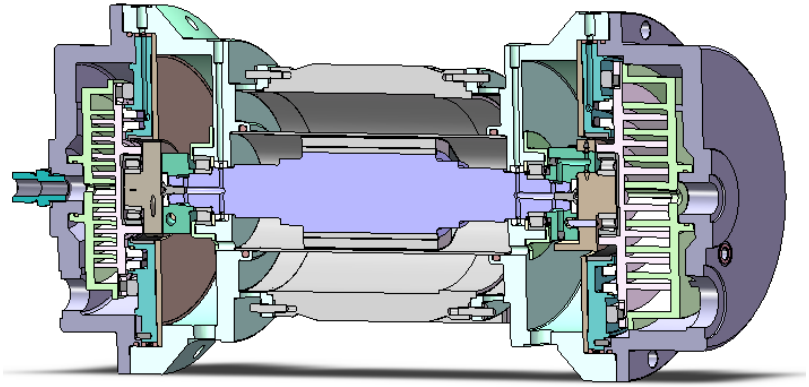
Characteristic :

- Electrical capacity – 30 KW
- Hot source – 160°C / 200 kW
- Cold source – 30°C / 170 kW
- Dimensions (HxLxW) – 1.8x2.3x1
- Weight – 1500 Kg

Main development for residential application

Bi-stage cycle (one fluid):

- ✓ *Combined heat and power using renewable energy from biomass boiler and two stage scroll turbine*
- ✓ *Highly CHP efficient unit, 90%*
- ✓ *Compact & reliable - low maintenance and low capital cost*



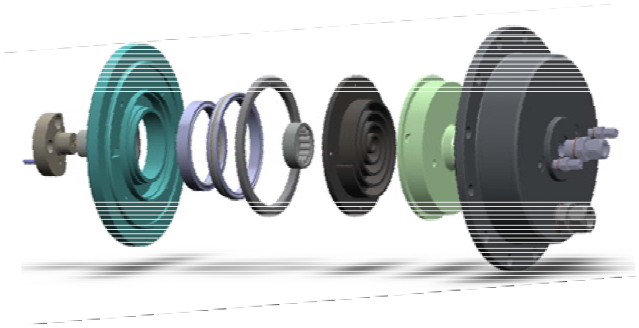
Eneftech 2006 @ PSE

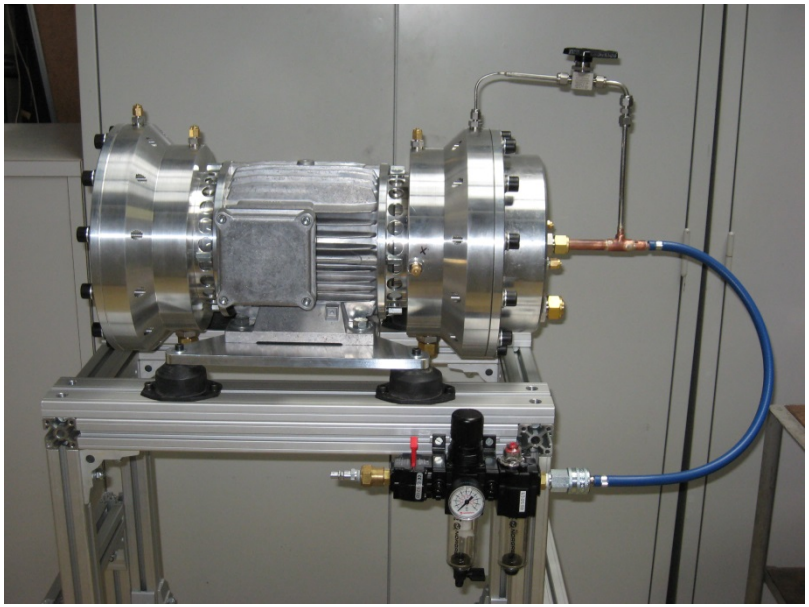
Eneftech facility testing, 2009

Characteristics :

- Electrical capacity – 5 KW
- Heating capacity – 25 kW @ 60°C
- Renewable heat input – 30 kW / 200°C
- Dimensions (HxLxW) – 1.2x0.9x0.6
- Weight – 300 Kg

High temperature scoll turbine





Eneftech 2006 @ PSE

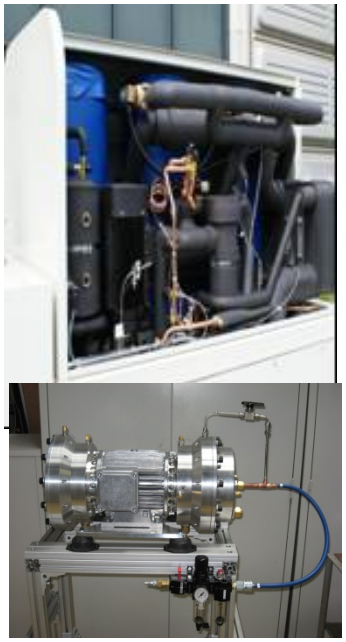
Main advantages:

- Capacity of the generator: 5 kWe
- Scroll member maximum temperature : 250°C
- Multi working fluid system
  - Synthetic refrigerants
  - natural refrigerants
- Hermetic design
- Variable speed (Max. rotational speed of 6000 rpm)
- Compliant positionning system
  - reducing internal losses
  - increasing efficiency
- Modular construction,
  - Single or double stage

ORC modules development

Alpha-phase

Functional alpha tested units



Beta-Phase

Advanced Enefcogen unit

Goals
- End-user **field trials** with several key customers
- Industrial processes and marketing activities

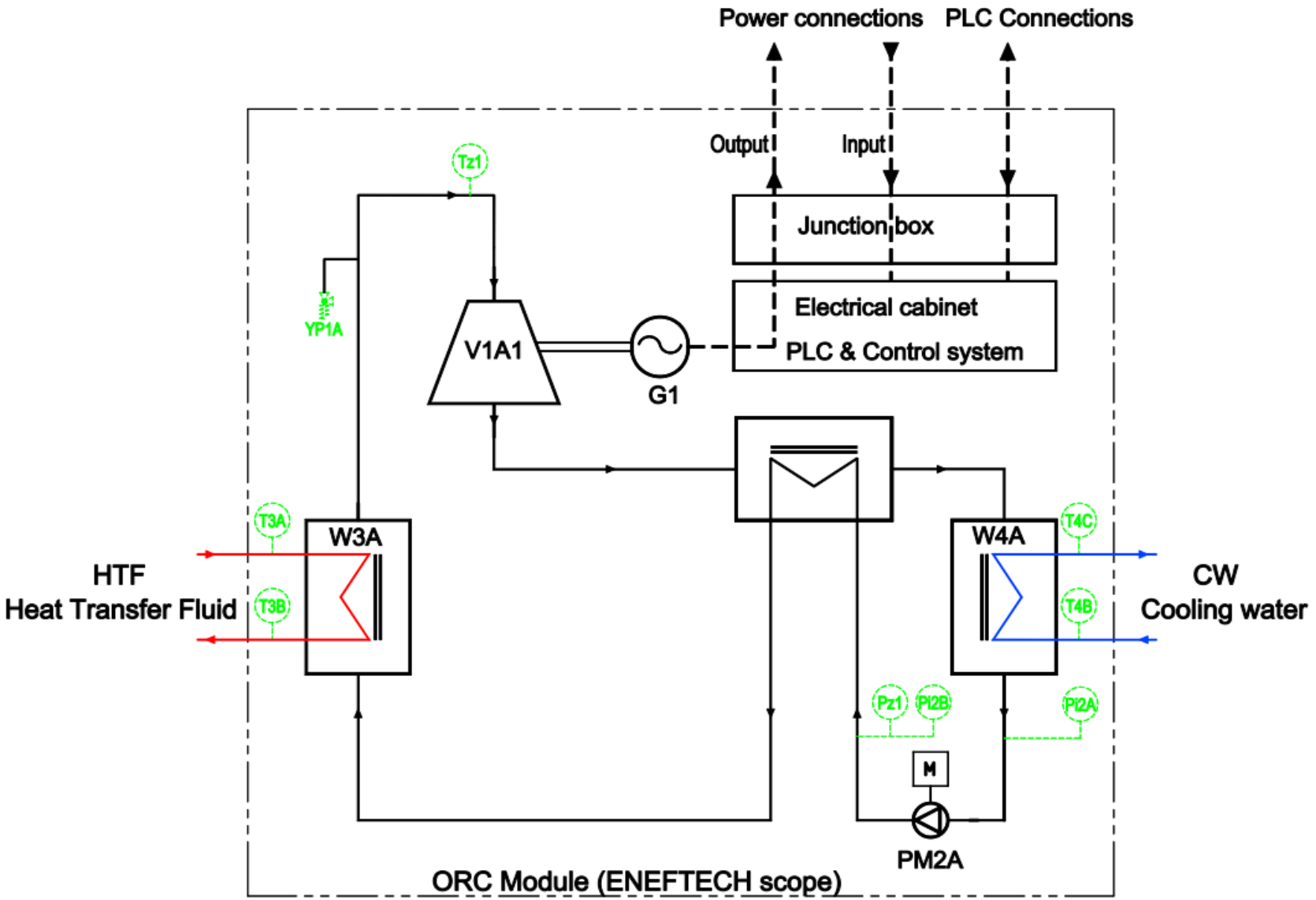
Industrialization phase

Commercial Enefcogen unit

Goals
- **Introduction** of commercial units to the market
- Sales and marketing

Alpha development	Fiel trials - Industrialization	Introduction & commercialization
2006 - 2008	2009 - 2010	2011 - Ongoing

ORC CYCLE MODULE



FLUIDS FOR SMALL SCALE ORC SYSTEMS

Recommandations:

- Typical applications of the product are located in the residential sector where flammable fluids are highly restrictive
- machinery with 70kg of flammable fluid can be installed only in rooms with a restrictive access to authorized and trained personal (Class C)
- Operators need special training
- The technology used for the very small range of power relies on standard equipments in order to keep the prices as low as possible
- Machine room needs special requirements (size and design of air extraction, elevation of machinery, …)

WORKING FLUID

Replacement Fluid HFC - R245 fa:

HFC 245 fa : Pentafluoropropane

Formula : CF3CH2CHF2

Boiling point : 14,90°C Critical point : 154°C (36.4bar)

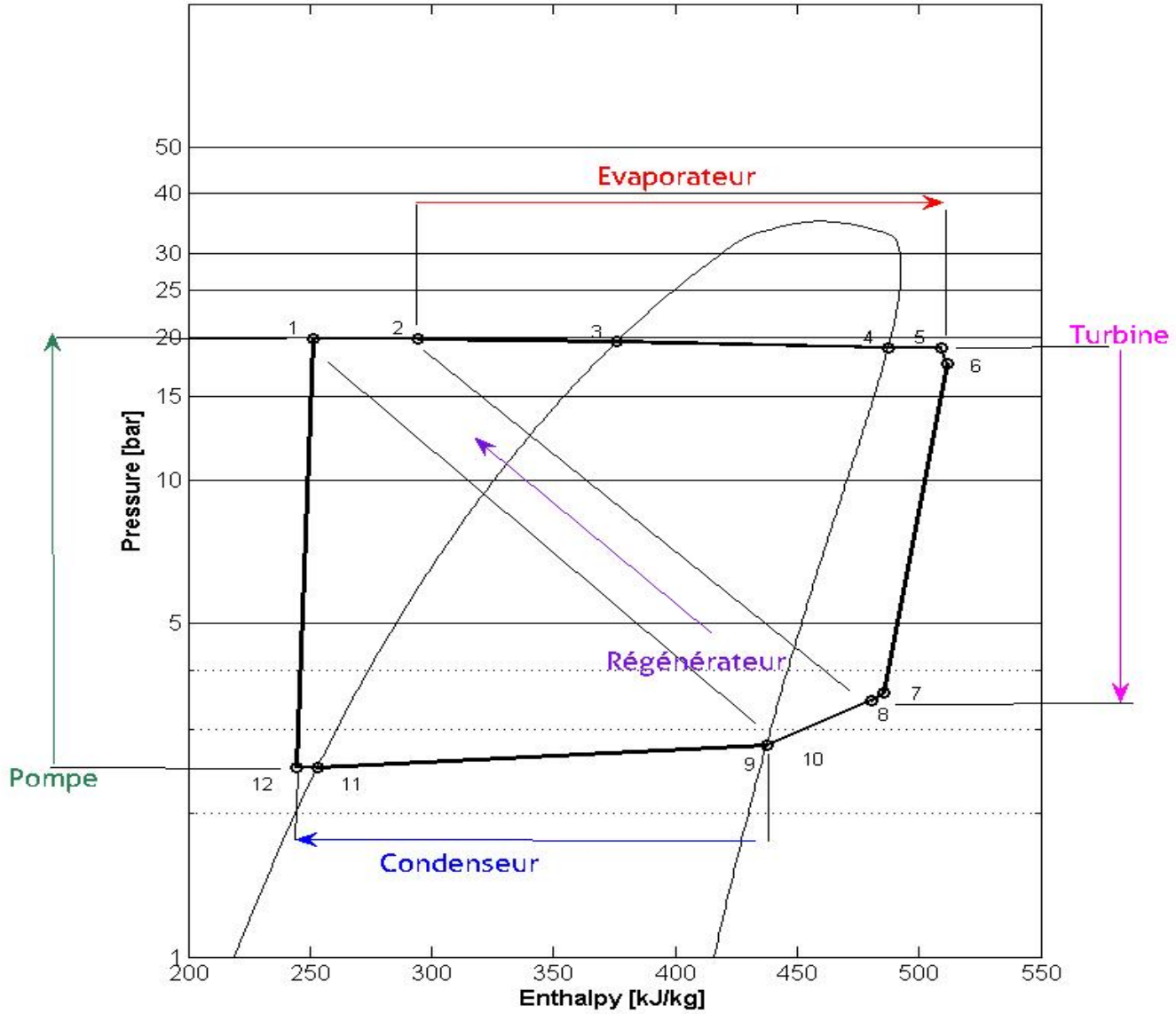
Mass : 134,05 g/mol Thermal stability : > 200°C

Ozone depletion : non (ODP=0)

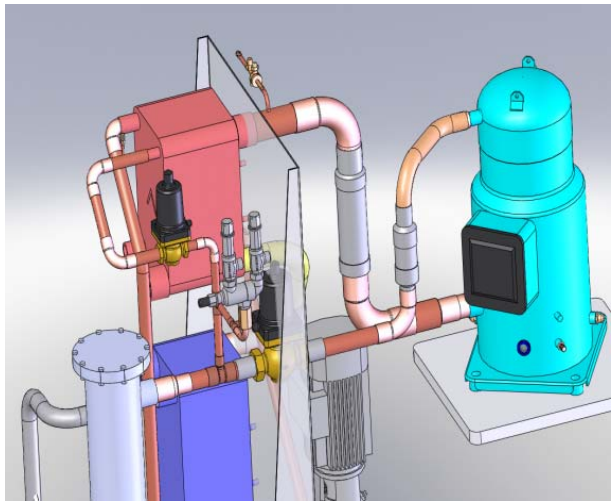
Global Warming Potential : low to medium (GWP 1020)

Classe B1: Toxic, Non-flammable

THERMODYNAMIC DIGRAM



ORC SUBSYSTEM DESIGN



Including :

- Turbine V1A1
- Asynchronous electric generator
- Heat exchangers with Evaporator, Condenser and Regenerator
- Feeding pump with electric motor, PM2A
- Oil Lubrication system and circuits
- Piping including valves, instrumentation and security devices
- Electrical cabinet including electrical devices and PLC control system

ORC scroll turbines

Key characteristics
of the ORC Scroll turbine

- Well suited in smaller capacity range < 100 kWe
- Fully closed system
  - Reliable system

    -> very low maintenance
- Well proven technology (used before in compressors)
  - 60.000 hours design life

ORC units for cogeneration

Cogeneration of power and heat

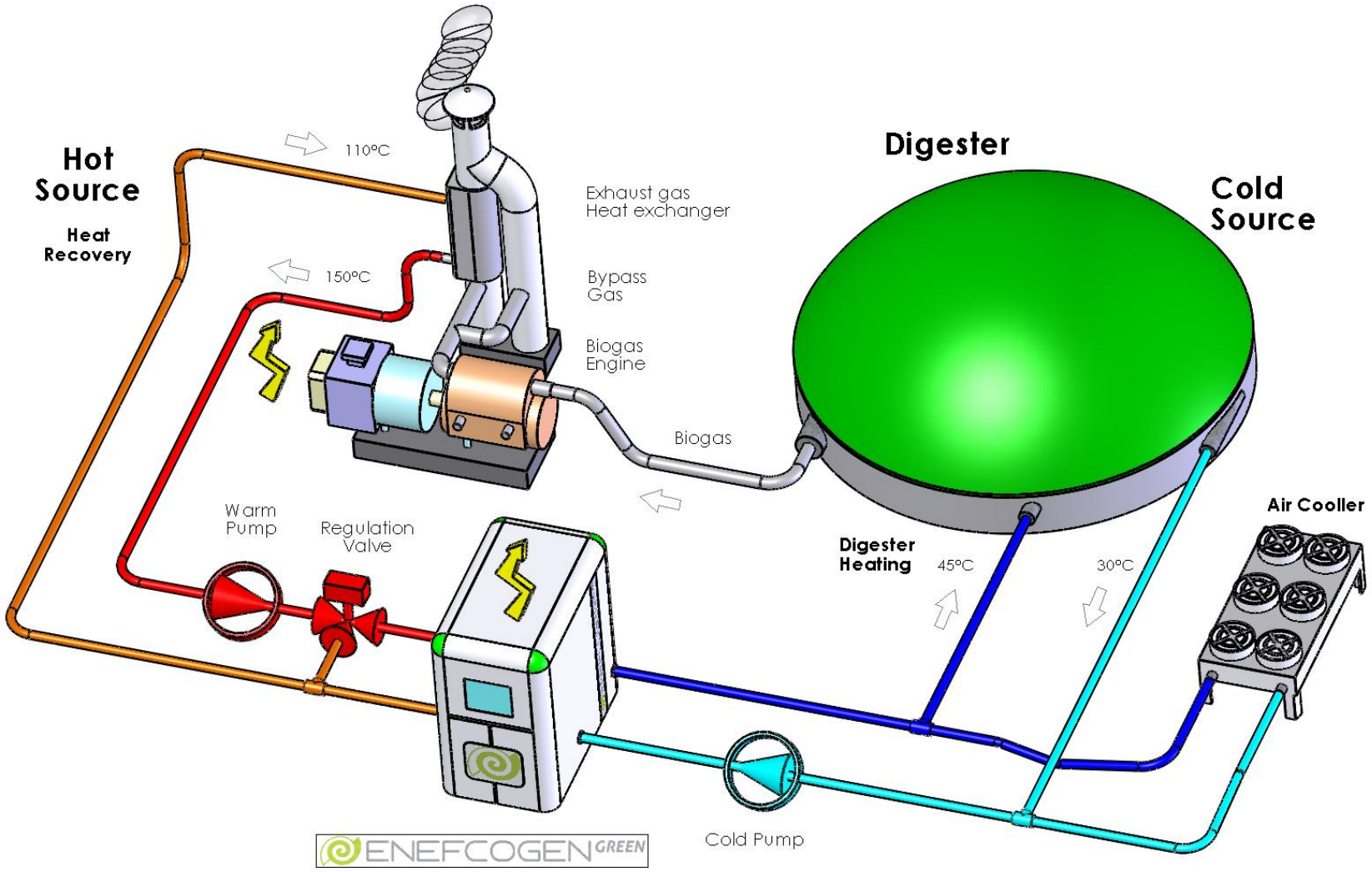
Required heat input:

- > 100 kWth (any hot source)
- Temperature from 120°C – 150°C

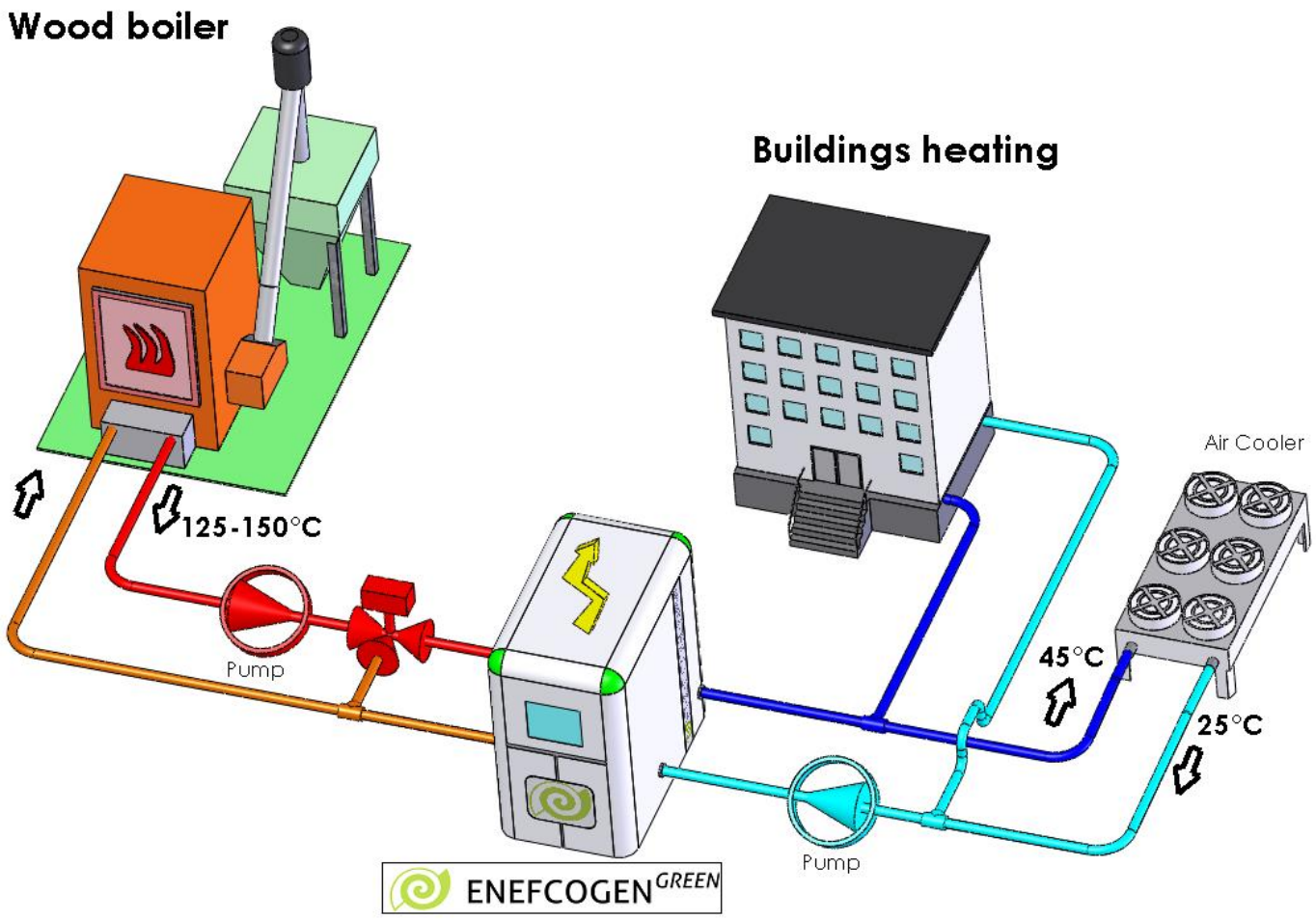
Output:

- Electric capacity – 10, 20, 30 kWe.
- Efficiency - electric ≈ 10%.
- Cogeneration efficiency – 95% (heat and power)

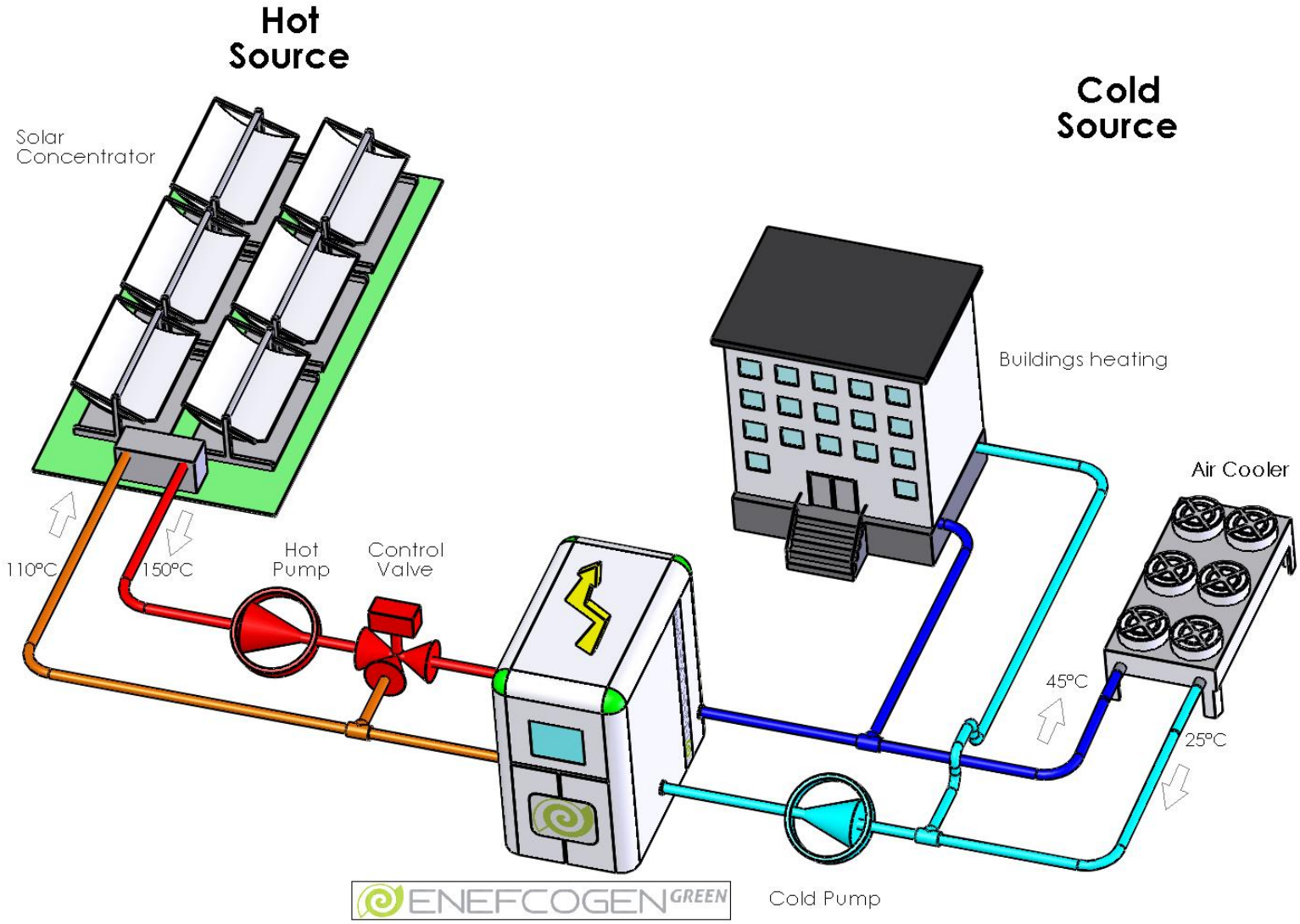
Electricity & heat from waste heat of biogas motor



Heat & electricitv generation from biomass



Cogeneration from solar thermal collectors



Heating of swimming pool & electricity generation

Projects & Partners

Installation d'un cogénérateur ORC dans le cadre d'un projet qui porte sur la réalisation d'une centrale biomasse sur le domaine agricole de la famille Petermann, à Lignerolle (VD). La société Agrogaz Lignerolle SA est détenue à 40% par Romande Energie.

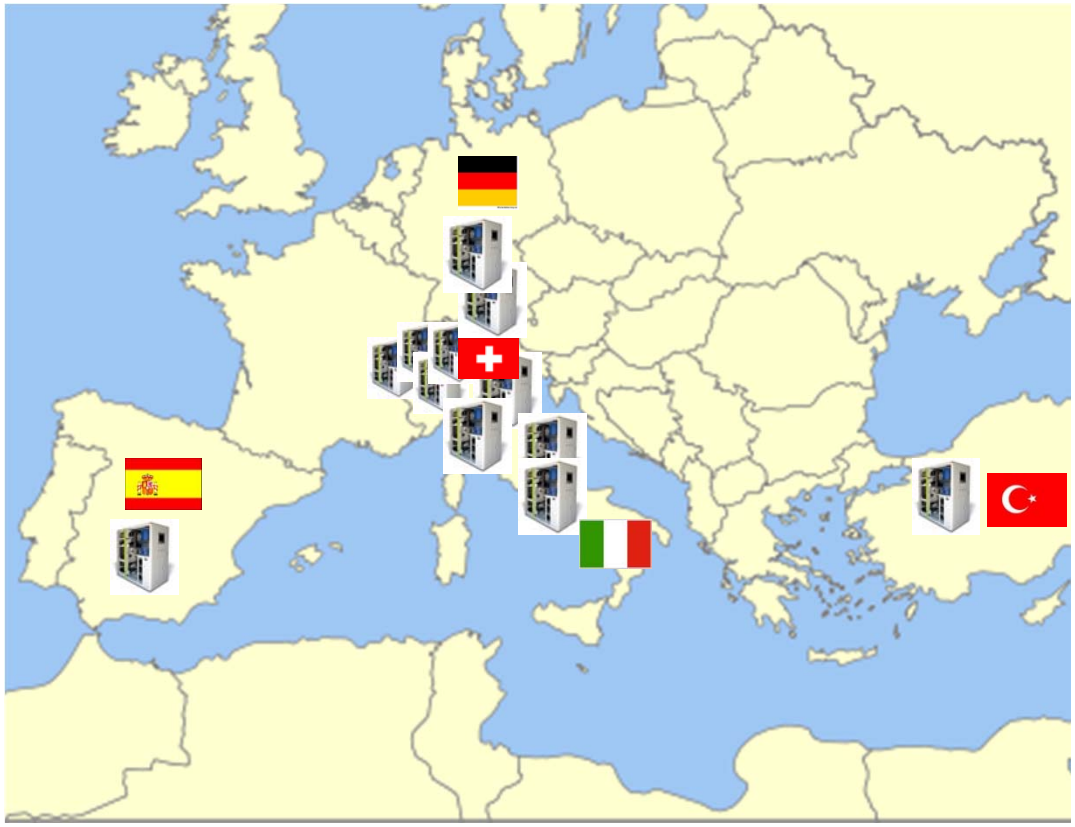
Installation d'un cogénérateur ORC sur le site de Kompogas Plant à Klingnau, canton d'Argovie.

Installation d'un cogénérateur ORC à la piscine de Mon-Repos à Lausanne.

Collaboration entre l'Ecole Polytechnique de Lausanne, l'Haute Ecole d'Ingénierie et de Gestion de Canton de Vaud et Eneftech Innovation SA afin de développer un cogénérateur 5 kWe.

Cette liste n'est pas exhaustive.

Other projects & applications



Applications:

- 6 units for heat valorization from the exhaust gas of biogas/vegetable oil motor

-2 units to heat swimming pools & generate electricity

- 2 units in connection with solar thermal collectors

-1 unit in connection with biomass boiler

Projects & applications

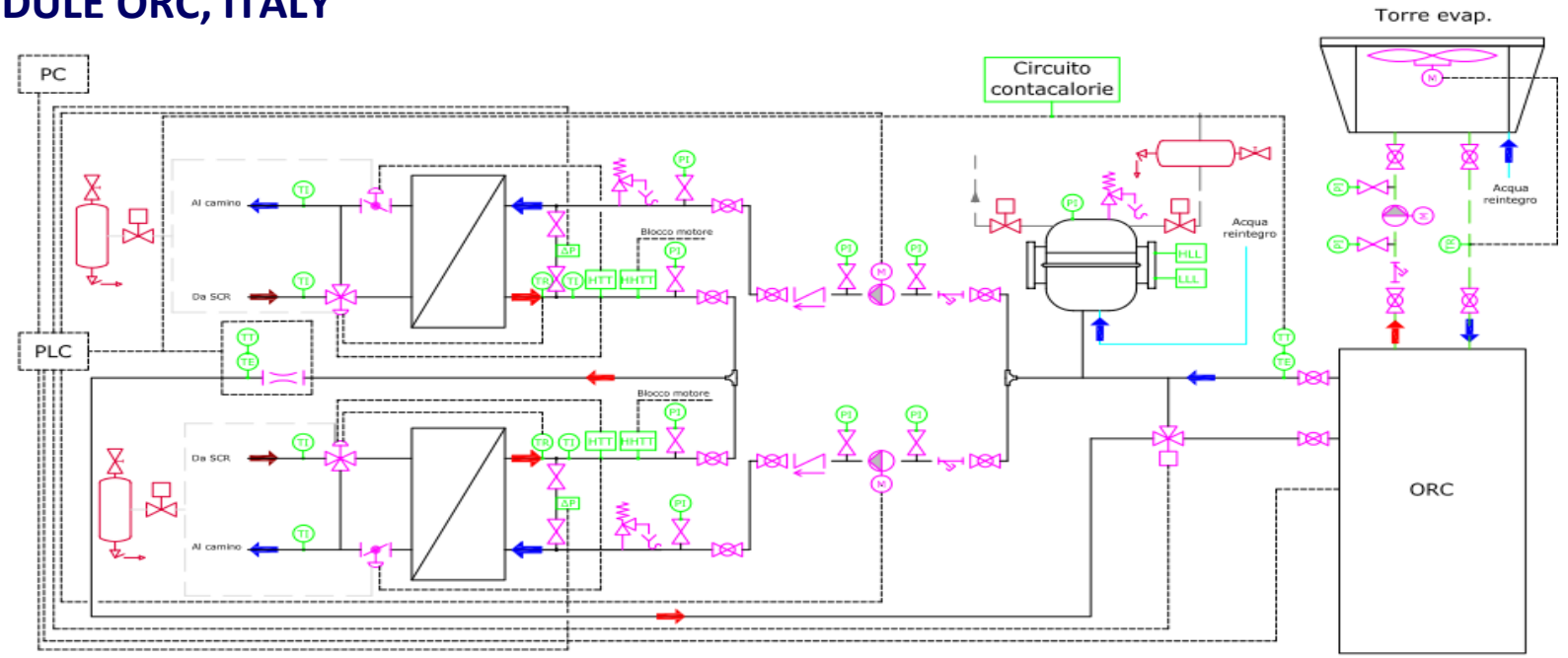
	ORC Application	Eneftech's ORC unit	Heat source	Project scope
University of Technology of Sydney, Australia	Electricity generation from solar collectors via ORC unit	Enefcogen GREEN 10 kWe	Parabolic Solar collector	Delivery of Enefcogen GREEN 10 kWe ORC Module
Klingnau, Switzerland	Electricity generation from biogas engine exhaust gas via ORC unit	Enefcogen GREEN 30 kWe	Exhaust gas	Turn key solution in a container with Enefcogen GREEN 30 kWe
Padova, Italy	Co-generation of electricity and heat via ORC unit	Enefcogen GREEN 30 kWe	Biomass boiler	Turn key solution with Enefcogen GREEN 30 kWe ORC unit
Istanbul, Turkey	Electricity generation from solar thermal installation via ORC unit	Enefcogen GREEN 30 kWe	Solar heated thermal oil	Delivery of Enefcogen GREEN 30 kWe ORC Module
Bassin, Switzerland	Co-generation of electricity and heat via ORC unit	Enefcogen GREEN 10 kWe - electricity production & swimming pool	Biomass boiler	Delivery of Enefcogen GREEN 10 kWe ORC Module
Lausanne, Switzerland	Co-generation of electricity and heat via ORC unit	Enefcogen GREEN 15 kWe - electricity & heating of 3 swimming pools	District heating with overheated hot water at 150°C	Turn key solution with Enefcogen GREEN 15kWe ORC Module
Schwindegg, Germany	Electricity generation from biogas engine exhaust via ORC unit	Enefcogen GREEN 30 kWe	Exhaust gas	Delivery of Enefcogen GREEN 30 kWe ORC Module
Grimma, Germany	Co-generation of electricity and heat via ORC unit	Enefcogen GREEN 30kWe	Exhaust gas	Delivery of Enefcogen GREEN 30kWe ORC Module
Ravina, Italy	Electricity generation from engine exhaust via ORC unit	Enefcogen GREEN 30 kWe	Exhaust gas	Delivery of Enefcogen GREEN 30 kWe ORC Module
Ravina, Italy	Electricity generation from engine exhaust via ORC unit	Enefcogen GREEN 30 kWe	Exhaust gas	Delivery of Enefcogen GREEN 30 kWe ORC Module
Winterthur, Switzerland	Co-generation of electricity and heat via ORC unit	Enefcogen GREEN 15 kWe	Waste heat recovery	Delivery of Enefcogen GREEN 15 kWe ORC Module
Almeria, Spain	Electricity generation in an experimental solar thermal installation via ORC unit	Enefcogen 5 kWe- especially produced prototype	Solar heated thermal oil	Delivery of Enefcogen GREEN 5 kWe ORC module
Volvo Power train, France	Electricity generation in an experimental setting via ORC unit	Especially produced turbine - 5 kWe	Exhaust gas	Delivery of 5 kWe turbine
PSA Peugeot Citroën, France	Electricity generation in an experimental setting via ORC unit	Especially produced turbine - 3 kWe	Exhaust gas	Delivery of 3 kWe turbine

MODULE ORC LAUSANNE, SWITZERLAND

Characteristics of the module :

- Electrical power – 15 KW
- Heat power – 150 kW
- Rendement de cogénération – 95%
- Modulation de la puissance, 50-100%
- Net weight of the module – 1700 Kg
- Dimensions (HxLxW) – 1.8x2.1x1

MODULE ORC, ITALY



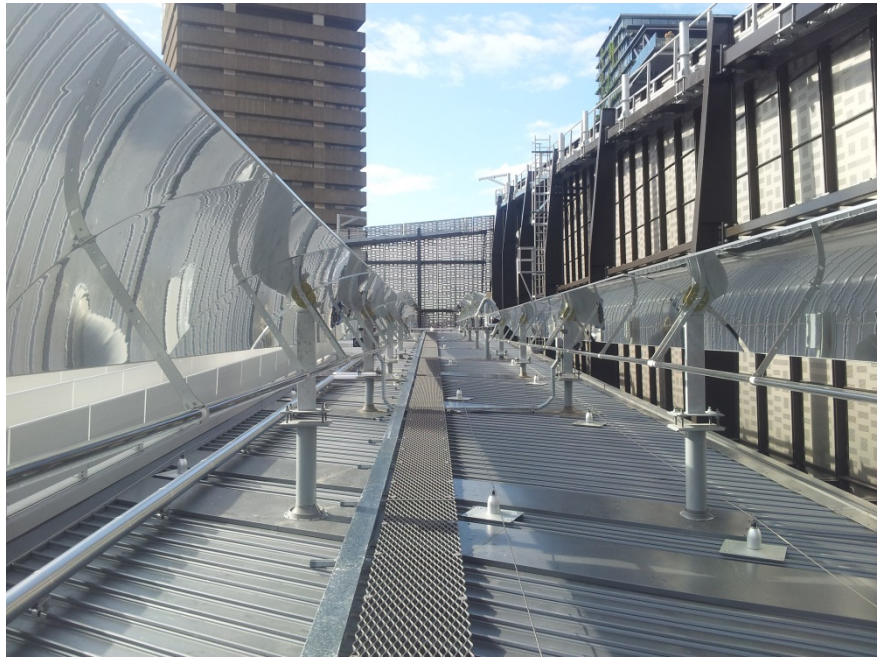
Italia, Partner: Icenova

MODULE ORC, GERMANY

MODULE ORC KLINGNAU, SWITZERLAND

500kW biogas engine, 30kWe ORC unit in Klingnau, Eneftech 2013

MODULE ORC SYDNEY, AUSTRALIA, UNIVERSITY OF TECHNOLOGY SYDNEY



UNIVERSITY OF TECHNOLOGY SYDNEY

Projects & sponsoring

Cette liste n'est pas exhaustive.