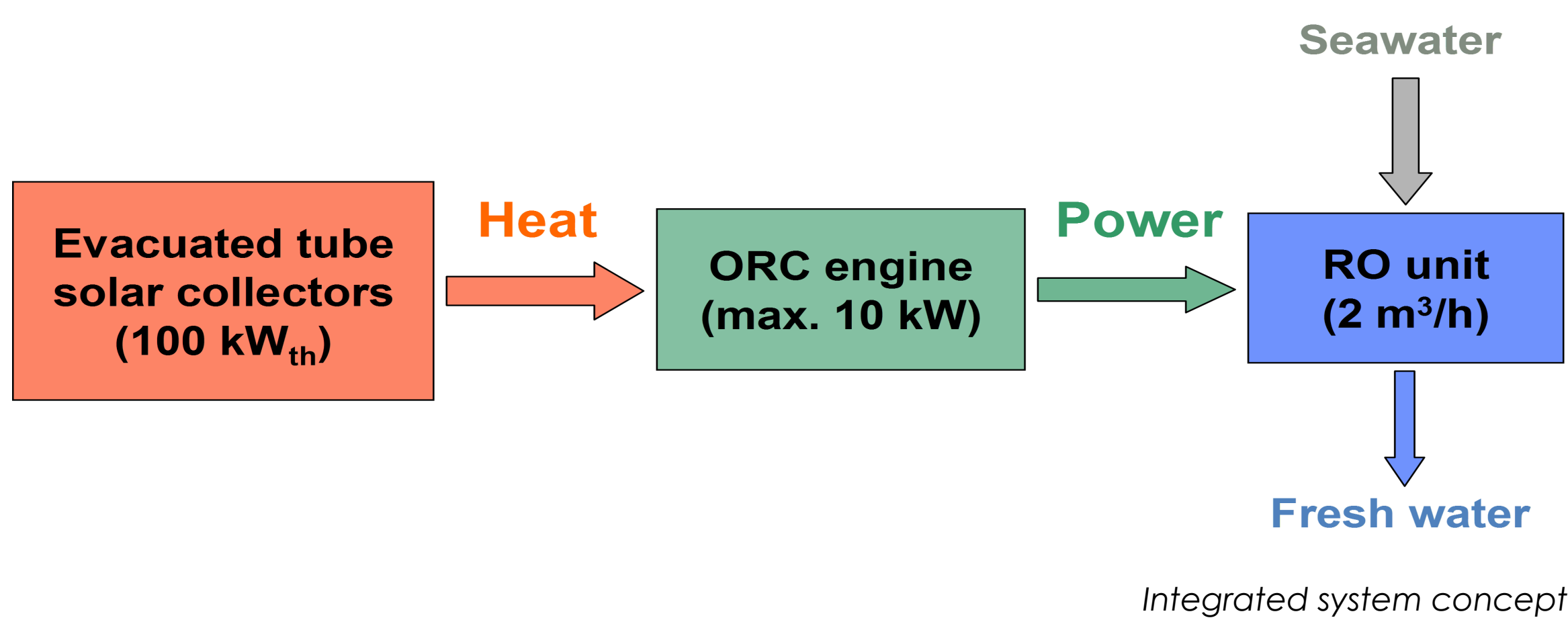


Development and experimental evaluation of two-stage solar organic Rankine cycle system for RO desalination [Two-stage RO-Rankine]

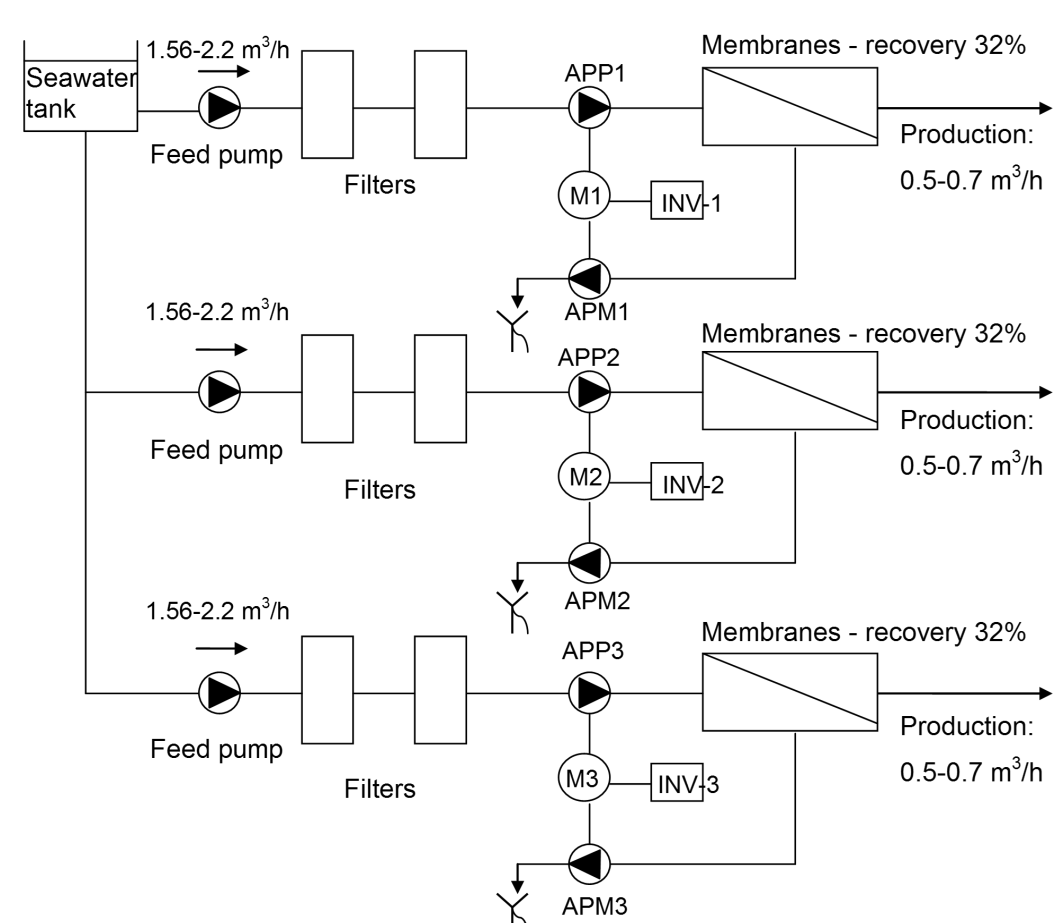
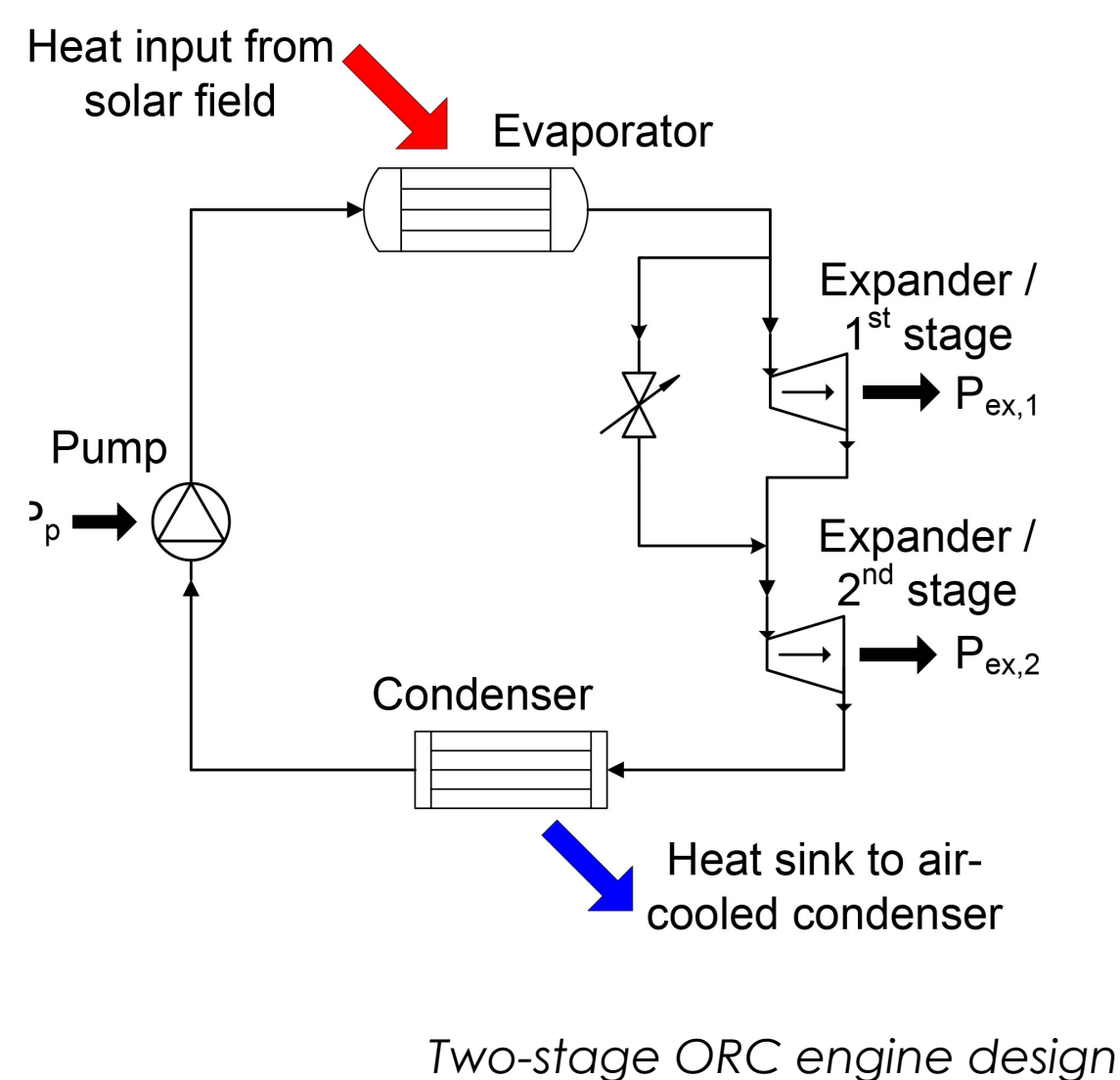
Concept

This project deals with the theoretical and experimental investigation of a solar two-stage organic Rankine cycle (ORC) system for reverse osmosis (RO) desalination with maximum fresh water production of 2 m³/h. The main objective regards the design and optimization of such combined system. The heat produced from the solar field feeds a subcritical ORC engine with maximum net power production of 9-10 kW. The power produced drives a RO unit for seawater desalination.



Solar field: high-performance evacuated tube solar collectors are used, having maximum thermal capacity of 100 kW_{th}, while operating at medium temperature range (around 120-140°C), providing heat to the ORC engine.

ORC engine: the main innovative aspect of the ORC engine is the use of two expanders installed in series, in order to operate efficiently at the whole range of solar irradiation. At low loads, when the total pressure ratio is decreased (~3), the first expander is totally by-passed and only the second one operates, ensuring a high system efficiency. The organic fluid selected is R-245fa, fulfilling all environmental criteria.



RO unit: the RO unit is composed of three identical sub-units, which can be switched on/off, according to the power availability. This design aspect is used, in order to keep an almost constant membrane pressure and acceptable water quality. Each sub-unit is equipped with an energy recovery device (APM type) for decreasing the specific energy consumption (kWh/m³).

RO unit with three identical sub-units

Main objectives and work implemented

The main objective of the project is to develop, optimize, construct and test a small-scale solar two-stage ORC engine for RO desalination with a maximum fresh water production of 2 m³/h. The expected end result is to produce fresh water with a reduced specific cost.

During 2011 there was a detailed investigation of each process (solar collectors circuit, ORC engine, RO unit), in order to simulate their operation under different conditions. Their design has been optimized, while the combined system simulation has been also implemented, which revealed the system's performance during the whole year under the weather conditions of Athens, Greece.

The design phase ended at the beginning of 2012, when the manufacture of the ORC engine was initiated. This involved at first the adaptation of the two scroll expanders (hermetic scroll compressors in reverse operation, see photo 1)

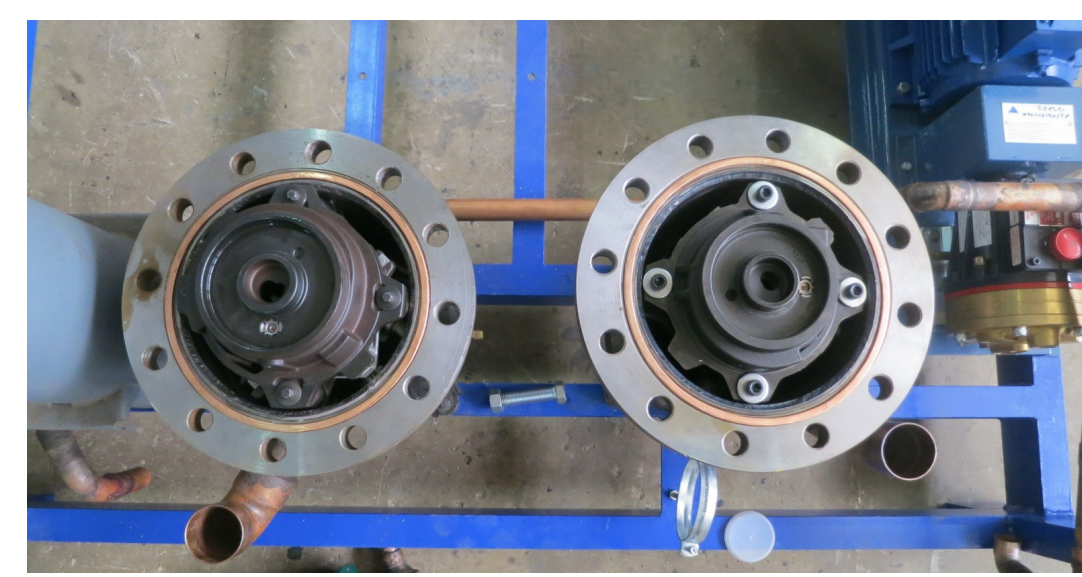


Photo 1: Hermetic scroll expanders



Photo 2: ORC engine

Then, the assembly of all components into a common basis was implemented, with the appropriate piping circuit and measurement instruments (see photo 2).

The manufacture of the three RO sub-units has been also implemented, which will be coupled to the two-stage ORC engine (one sub-unit is shown in photo 3).

It is expected during mid/end 2013 to test the two-stage ORC engine in the laboratory using an electric heater, before connecting it to the solar field (see photo 4) for further testing under real conditions.



Photo 3: RO sub-unit



Photo 4: Solar field

Duration and Funding

The project duration is 36 months (start: December 2010) and is receiving funding by the Greek General Secretary of Research and Technology (GSRT), under the program "SYNERGASIA 2009" with grant agreement n° 09SYN-32-982 [Two-stage RO-Rankine].



Consortium:



Agricultural University of Athens
Coordinator
www.aua.gr,
www.renewables.aua.gr



Hellas Energy
www.hellasenergy.gr



National Technical University
of Athens
www.mech.ntua.gr



TEMAK SA
www.temak.gr



University of Patras
www.physics.upatras.gr

Contact

If you need additional information about the project, please contact us:



Agricultural University of Athens
Iera Odos 75, Athens 11855, Greece

Project coordinator:

Dr. George Papadakis, Professor
+30 210 5294209, +30 6945707083
gppap@aua.gr

Contact Person:

Dr. Dimitris Manolakos, Lecturer
+30 210 5294036, +30 6948595967
dman@aua.gr

www.solar-orc-ro.aua.gr