Solar hybrid gas turbine electric power system

- Results from European project "SOLGATE"

Technology sheet

Technology

- Solar cogeneration

General information:

- Technology developer:
  - Solar Research, Institute of Technical Thermodynamics (Germany)
  - Research & Development Department, ORMAT Industries LTD. (Israel)
  - Renewable Energy Department, CIEMAT (Spain)
  - TURBOMACH SA (Switzerland)
  - SOLUCAR (Spain)
- Date of issue (year): 2004

Aims and Objectives (around 200 words):

The solar-hybrid power system has been developed within the European SOLGATE project (Contract No. ENK5-CT-2000-00333). The combination of high solar shares with high conversion efficiencies is one of the major advantages of solar gas turbine systems compared to other solar-fossil hybrid power plants.

The objective of the SOLGATE was aimed to:

- develop a solar-hybrid power system with direct solar heating of a gas turbine's pressurized air;
- prove its technical feasibility;
- verify the electricity cost reduction potential of such a system;
- develop software tools to simulate the system;
- Assess the system's market potential and identify initial niche applications for market introduction;
- Define a first industrial demonstration plant.

The obtained results demonstrate that significant cost reductions for solar electric power generation can be achieved by combining with highly efficient combing cycle systems or recuperated gas turbines; however, technological know-how of the components and the system as well as the operational experience are still required in order to initiate a demonstration project.

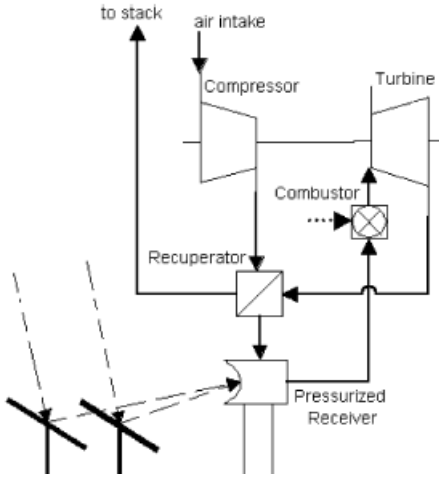
A Short Description of the Technology:

Solar gas turbine systems use concentrated solar power to heat the pressurized air in a gas turbine before entering the combustion chamber. The utilisation of highly concentrated solar energy permits the combustion chamber to closes the temperature gap between the receiver outlet temperature (800–1000 °C at design point) and the turbine inlet temperature (950–1300 °C) and therefore provides constant turbine inlet conditions despite fluctuating solar input.

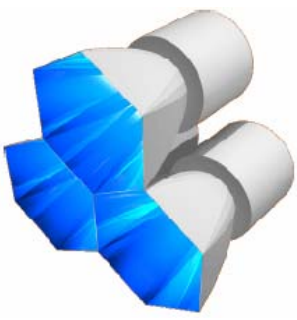
The solar power tower technology is used with concentration ratios up to 1000 suns to reach the high receiver temperatures.

The so-called REFOS receiver technology for air heating in gas turbine cycles has been adopted in the project, which was developed through several German national and international R&D projects.

For higher power levels the complete focal spot can be covered by a number of low, medium and high temperature modules that are interconnected in serial and parallel way. In fact, the complete Solgate receiver system consists of 3 modules (low temperature module, middle temperature module and high temperature module) arranged in a honeycomb-like arrangement in the focal spot; each receiver module was equipped with a hexagonal secondary concentrator to enable installation side by side in the aperture plane.



Solar gas turbine plant schematic



Honeycomb arrangement of receiver modules for high power level

Further, in order to develop the high temperature modules which have outlet temperature of 1000°C, the appropriate absorber together with absorber mounting and window cooling, has been utilised. In this way, the solarization adds a receiver cluster directly before each combustion chamber for solar preheating of the compressed air. As the receiver design temperature rules the maximum solar share, the maximum exit temperature of the receiver is designed to be 800 °C.

Moreover, regarding solar air heating, a new window cooling technology was developed to ensure operation of the quartz window below its temperature limit. Air jets are directed towards the window and are operated in a special way to ensure good and homogeneous cooling of the window surface.

So far as turbine, the solarized gas turbine was based on a helicopter engine, which was modified to enable external solar heating. Modifications included a combustor suitable for air inlet temperatures up to 800°C, addition of a generator connected via a reduction box to the gas turbine shaft, there are a new control system and an oil cooling system.

European Project "Eco-Building International Club for advanced European sustainable energy technology dissemination in Europe and China"

Project partners:

ENEA (IT), ISNOVA (IT), FINCO (IT), ADEME (FR), AIMCC (FR), DTI (DK), DI (DK), CRES (GR), EBHE(GR), GPREC (GR), SEC(B), ZERI (CN), CBEEA (CN)

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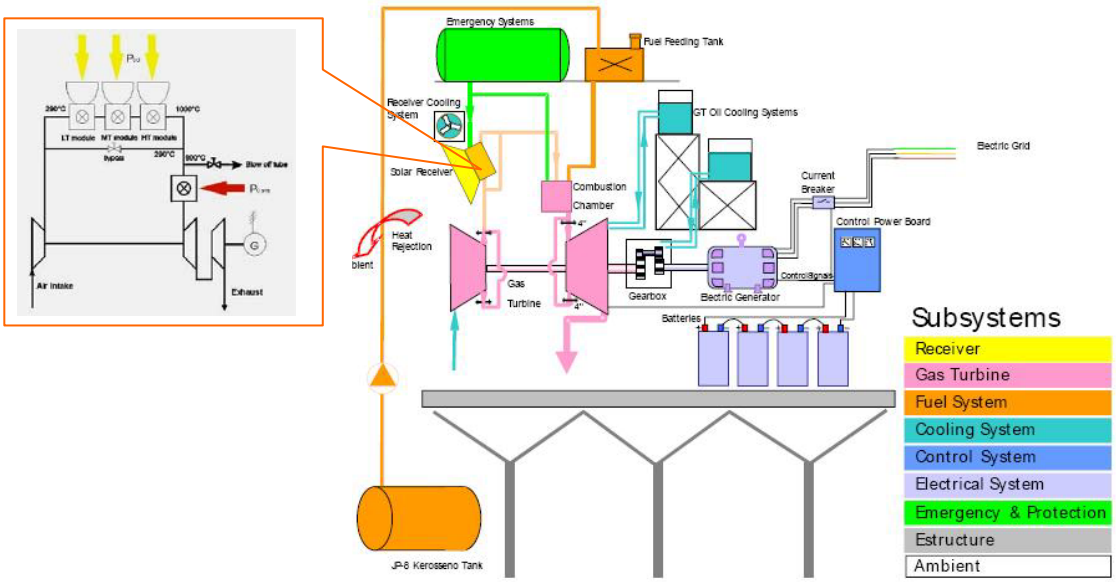
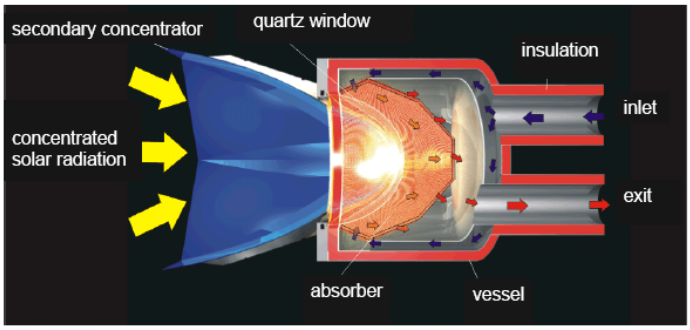


Layout of the SOLGATE solar hybrid gas turbine electric power system

Results and Achievements:

The project successfully demonstrated that the combination of pressurized volumetric solar receivers and a gas turbine really works. According to the estimation, an annual average solar to net electric efficiency of up to 19% would be obtained, amongst the highest conversion efficiencies for solar electric technologies. Solar shares above 50% are feasible, this leads to significant reductions in fuel consumption and CO2 emissions.



Scheme of a pressurized volumetric receiver

Further, the cost analysis showed total plant investment costs from 7000 €/kW down to below 1800 €/kW, depending on power level and solar share. In particular, the specific total investment costs vary between 1730 €/kW for the 16 MW hybrid combined cycle plant and about 7000 €/kW for the 1.4 MW gas turbine plant. The solar equipment costs vary between 20% and 40% of the total investment, according to the power block costs and the solar share.

Using the cost reduction potential that lies in combined design, construction and operation of multiple distributed plants leads to solar LEC (Levelized Electricity Cost) of below 10 €cent/kW h for an electric power level of 16.1 MW. In other words, the solar-hybrid gas turbine power technology shows interestingly low cost for solar produced bulk electricity at a moderate power level.

Possible application area:

Both industrial and tertiary areas.

Reference:

The research results have been obtained through the project SOLGATE (contract no. ENK5-CT-2000-00333), which was partly funded by the European Union within the framework of the 5th RTD Framework programme, Thematic Programme: Energy, Environment and Sustainable Development.

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- energy efficient building materials, components and systems not yet introduced into the building market or in their first market phase;
- innovative applications of heating/cooling and power supply technologies, combined with the use of renewable energy sources, in building sector;
- best EU demonstration eco-building projects.