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A High-Temperature Pressurized Receiver for Solar-Driven Gas Turbines

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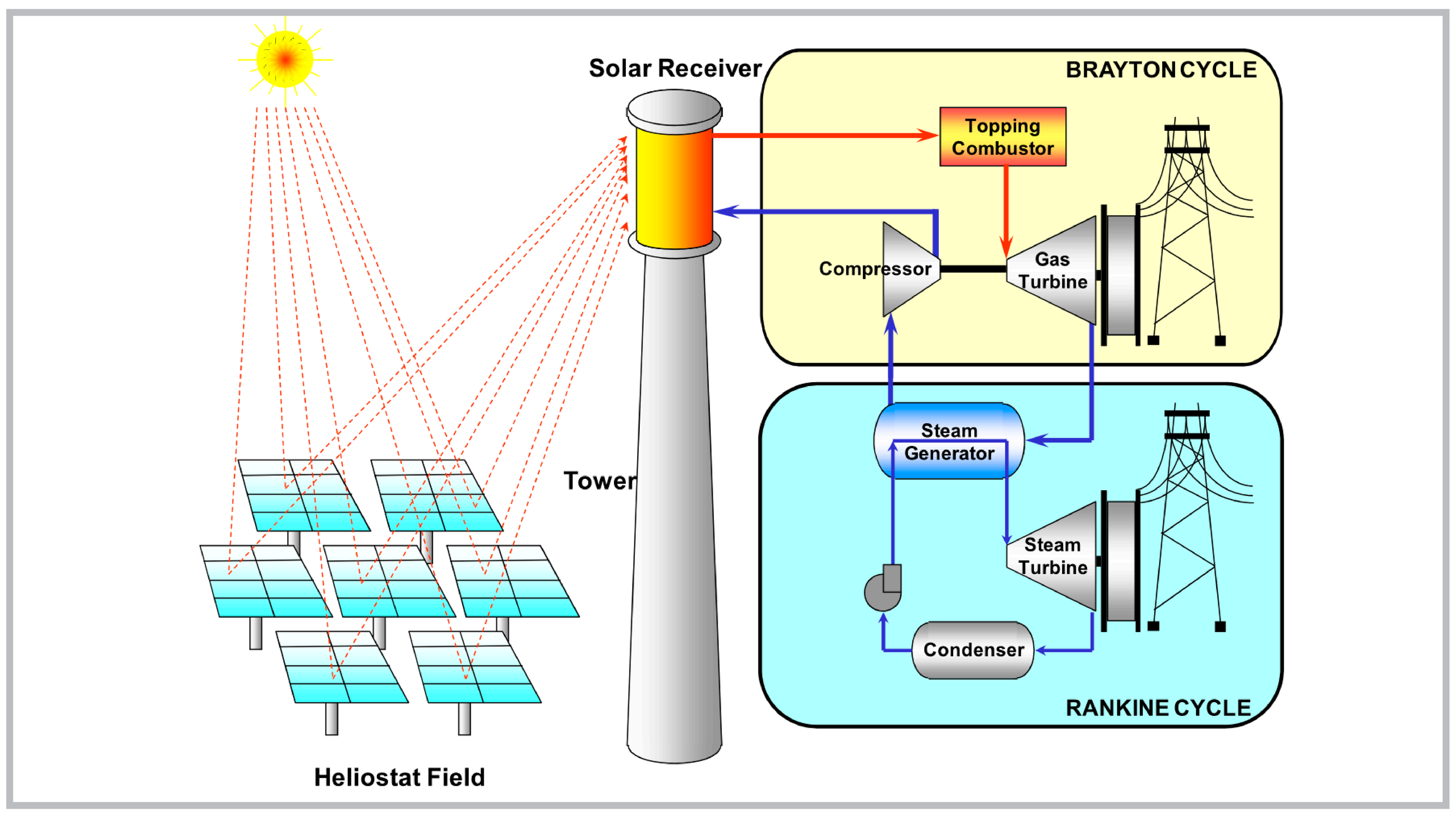
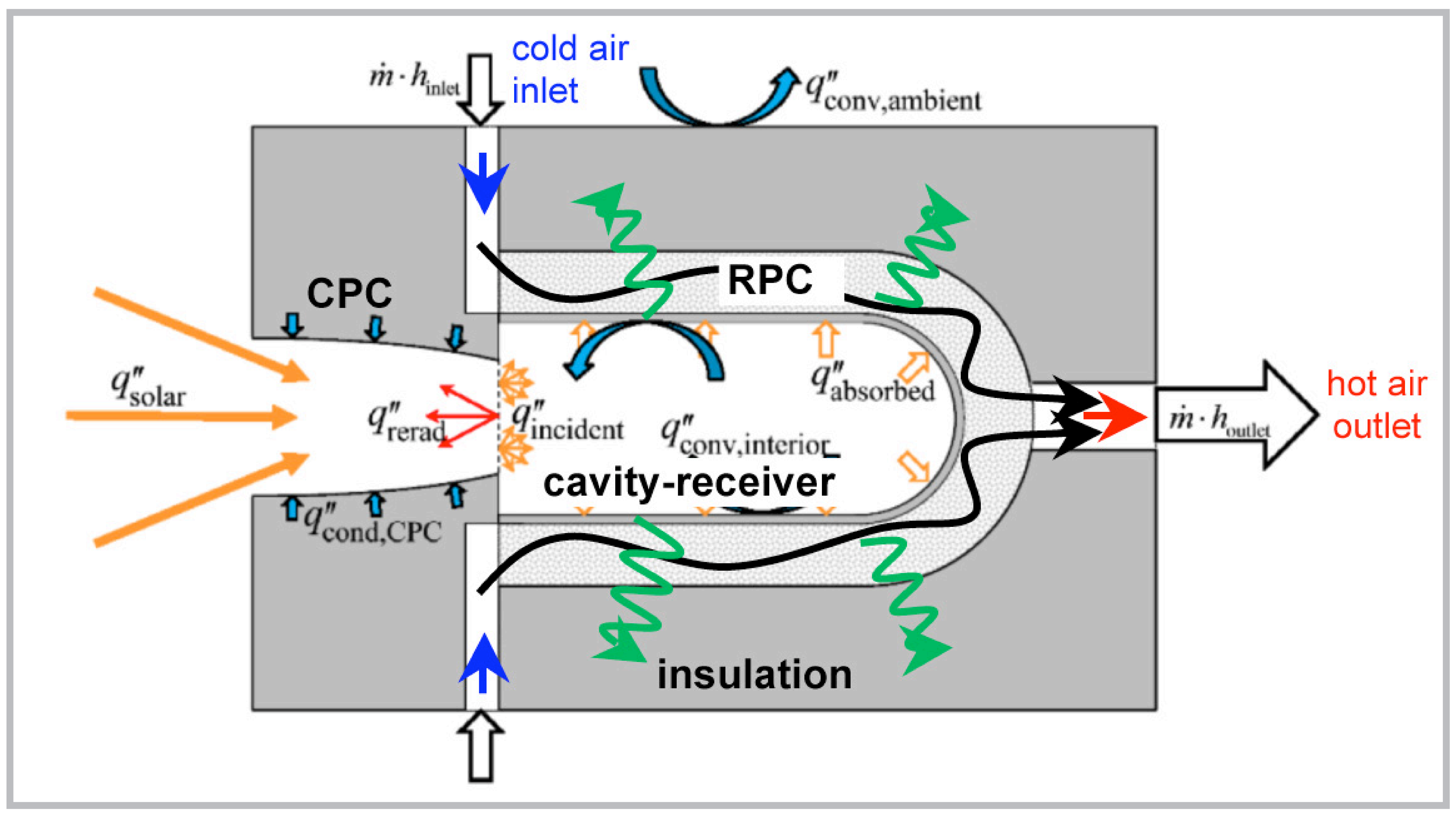


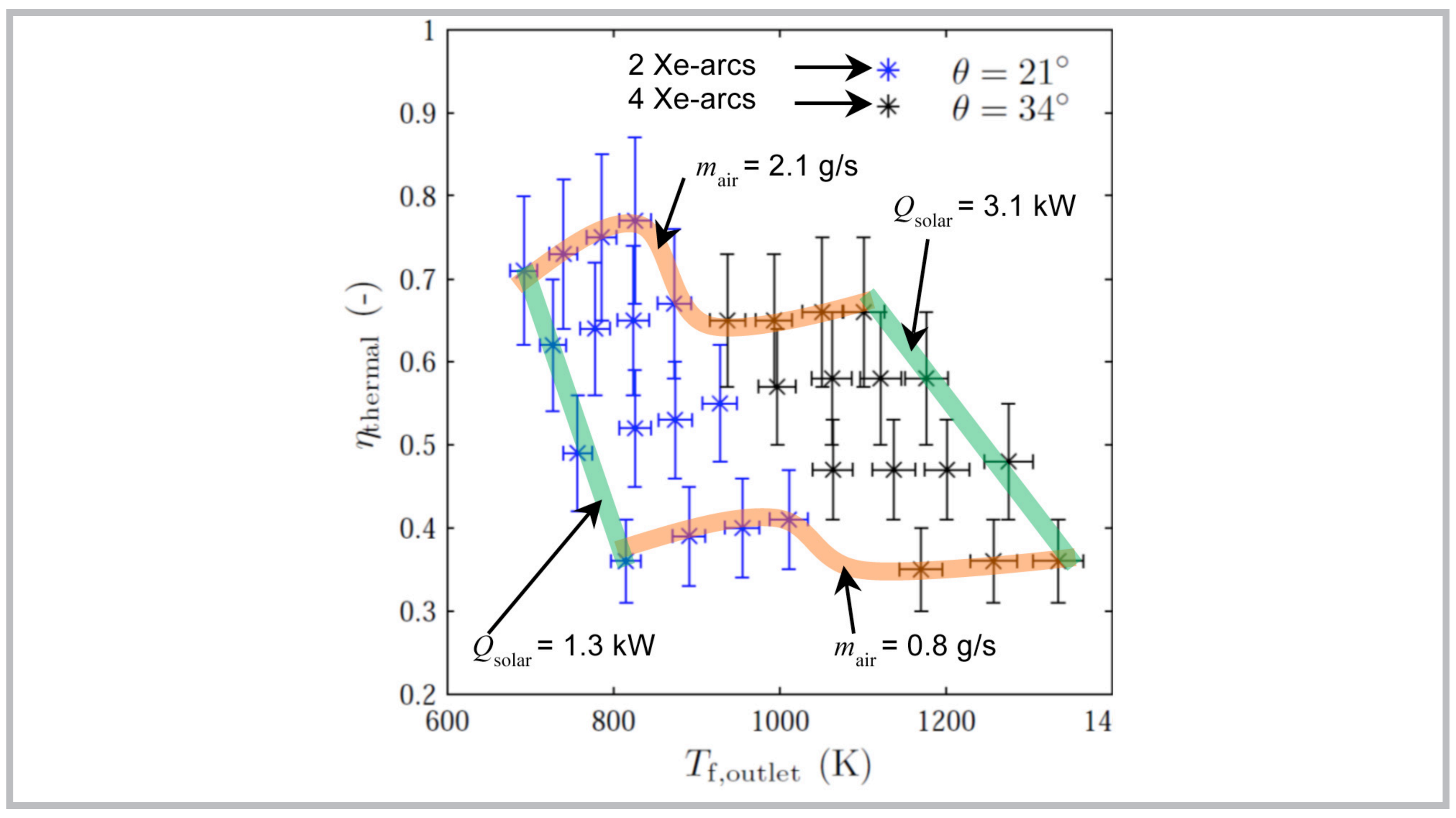
Principle of solar power generation via combined cycles

Direct solar irradiation is collected by a field of heliostats (two-axis tracking parabolic mirrors) that focus the sun rays onto a solar receiver mounted on top of a tower. Pressurized air flowing across the solar receiver is heated and used to drive a gas turbine (Brayton cycle). A combustor can be integrated for 24/7 hybrid operation. The heat content of the off-gas is employed to generate steam, which in turn drives a steam turbine (Rankine cycle). The combined Brayton-Rankine cycle converts heat to electricity with high efficiency.



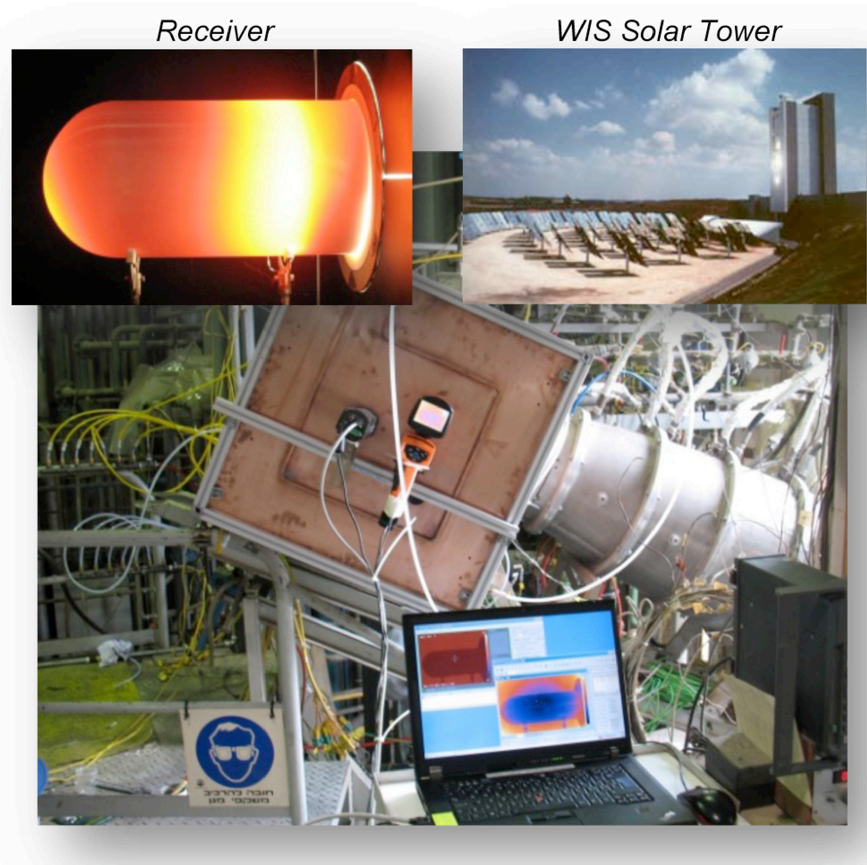
The novel solar receiver concept

It consists of an annular reticulate porous ceramic (RPC) bounded by two concentric cylinders. The inner cylinder, which serves as the solar absorber, has a cavity-type configuration with an aperture for the access of concentrated solar radiation. A compound parabolic concentrator (CPC) is incorporated at the aperture to further boost concentration. Absorbed solar radiative heat is transferred by conduction, radiation, and convection to the pressurized air flowing across the RPC.



Experimentation with a 3 kW prototype

A 3 kW solar receiver prototype was subjected to a peak solar concentration ratio of 4360 suns. Experimentation was carried out with air and helium as working fluids, heated from ambient temperature up to 1350 K at an absolute operating pressure of 5 bars. Maximum thermal efficiency, defined as the enthalpy change of air divided by solar radiative power input, was 78%.



Scale-up to a 35 kW cavity-receiver

A set of silicon carbide cavity-receivers attached to a CPC were tested on a solar tower at stagnation conditions for 35 kW solar radiative power input under mean solar concentration ratios of 2000 suns and nominal temperatures up to 1600 K. Experimentation was performed at the solar tower of the Weizmann Institute of Science, Israel.

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- Hischier I., Leumann P., Steinfeld A., Experimental and Numerical Analyses of a Pressurized Air Receiver for Solar-driven Gas Turbines. Proc. 2010 IMECE - ASME International Mechanical Engineering Congress & Exposition, Vancouver, Nov. 12-18, 2010.
- Hischier I., Poživil P., Steinfeld A., Experimental and Numerical Analyses of a Ceramic Cavity-Receiver for High-Temperature High-Concentration Solar Applications. ASME Journal of Solar Energy Engineering, in press 2011.