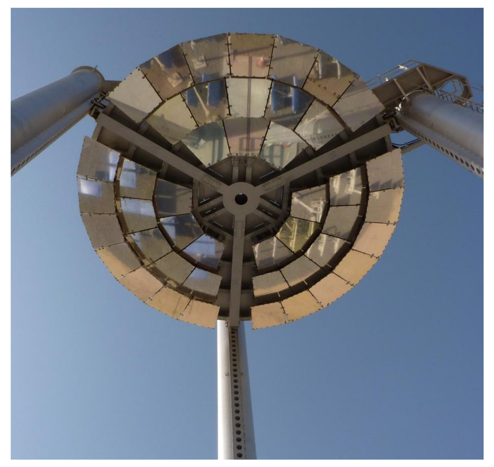

Combined Cycle Concentrated Solar Power with Energy Storage for 24 Hour Base Load Grid Availability

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Introduction

Current solar power plants can generate a reasonable amount of electricity during the daytime and some can store an excess of thermal energy for use during evening hours. These systems however, are not optimized with the objective of 24 hours of electricity generation. One of the prime research goals at the Masdar Institute is to model a solar thermal power plant which can deliver both demand and base load electricity for a complete 24 hour cycle.

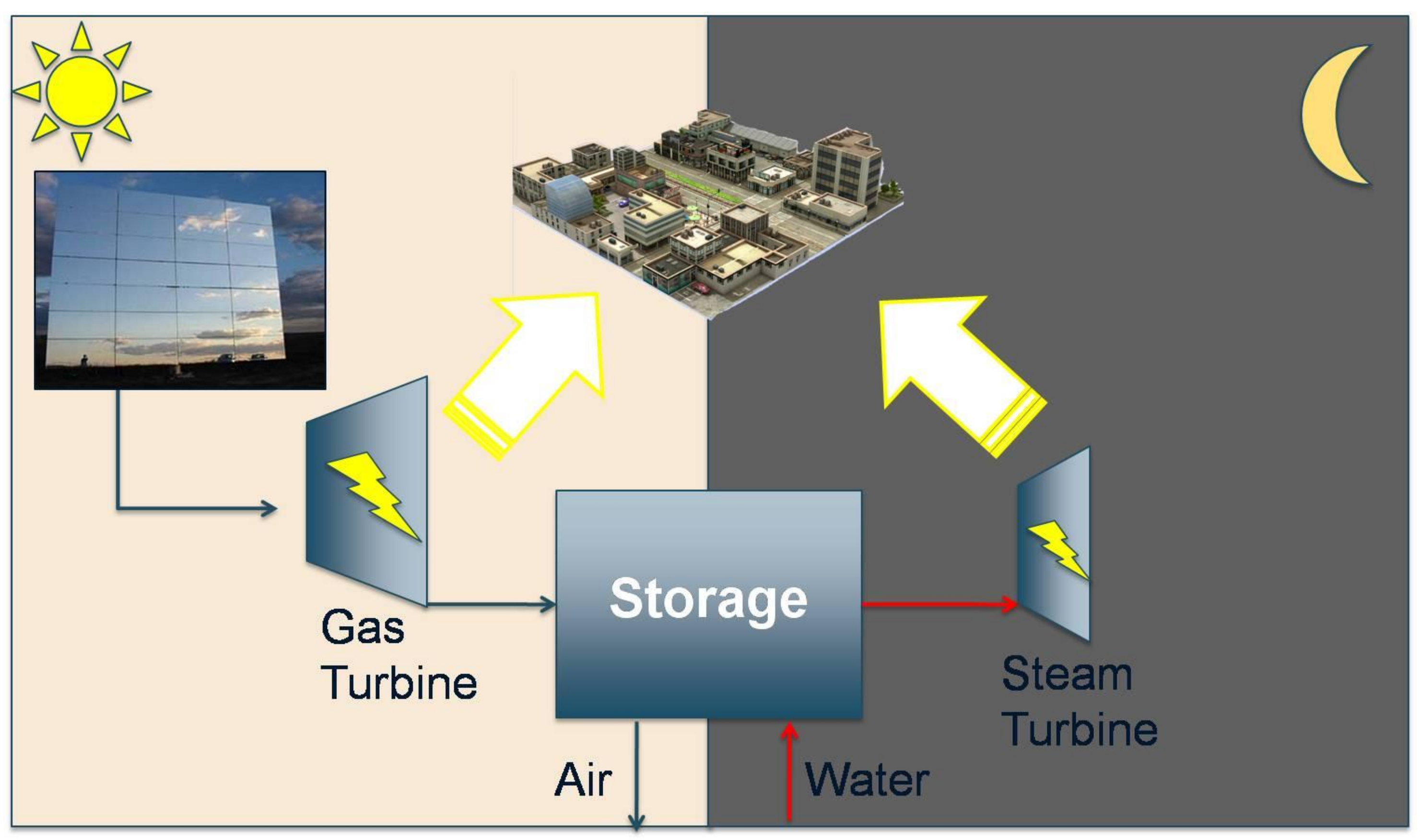

Figure 1 – Visualization of the *24h combined-cycle* solar power plant

Concept

The *24h combined-cycle* concept being developed at the Masdar Institute consists of two turbines, gas and steam, for electricity generation (Figure 1). Exhaust from the gas turbine is fed into the thermal storage system, which is a combination heat exchanger/thermal storage medium using a optimized configuration of both sensible and latent heat (Figure 2). The gas passes through three stages of thermal storage, each followed by a heat exchanger. The type of storage is based on the need of the Rankine cycle. For instance, the boiling phase implements latent heat storage, since a constant temperature process is needed.

Each turbine's use is determined by matching the demand and the base load of the grid. The gas turbine will provide peak load electricity during the daytime, whereas the steam turbine will operate 24 hours a day, providing base load electricity.

Model Analysis

The model consists of several basic parts. These components are currently being modeled in TRNSYS using the STEC[1]:

- Heliostat Field
- Air Receiver
- Solar Gas Turbine [2]– Brayton Cycle
- Three Tiered Sensible and Latent Heat Storage (Figure 2)
- Heat Exchangers
- Steam Turbine– Rankine Cycle

Proper optimization of turbine size, thermal storage components, heliostat field, and control systems will make this project technologically feasible.

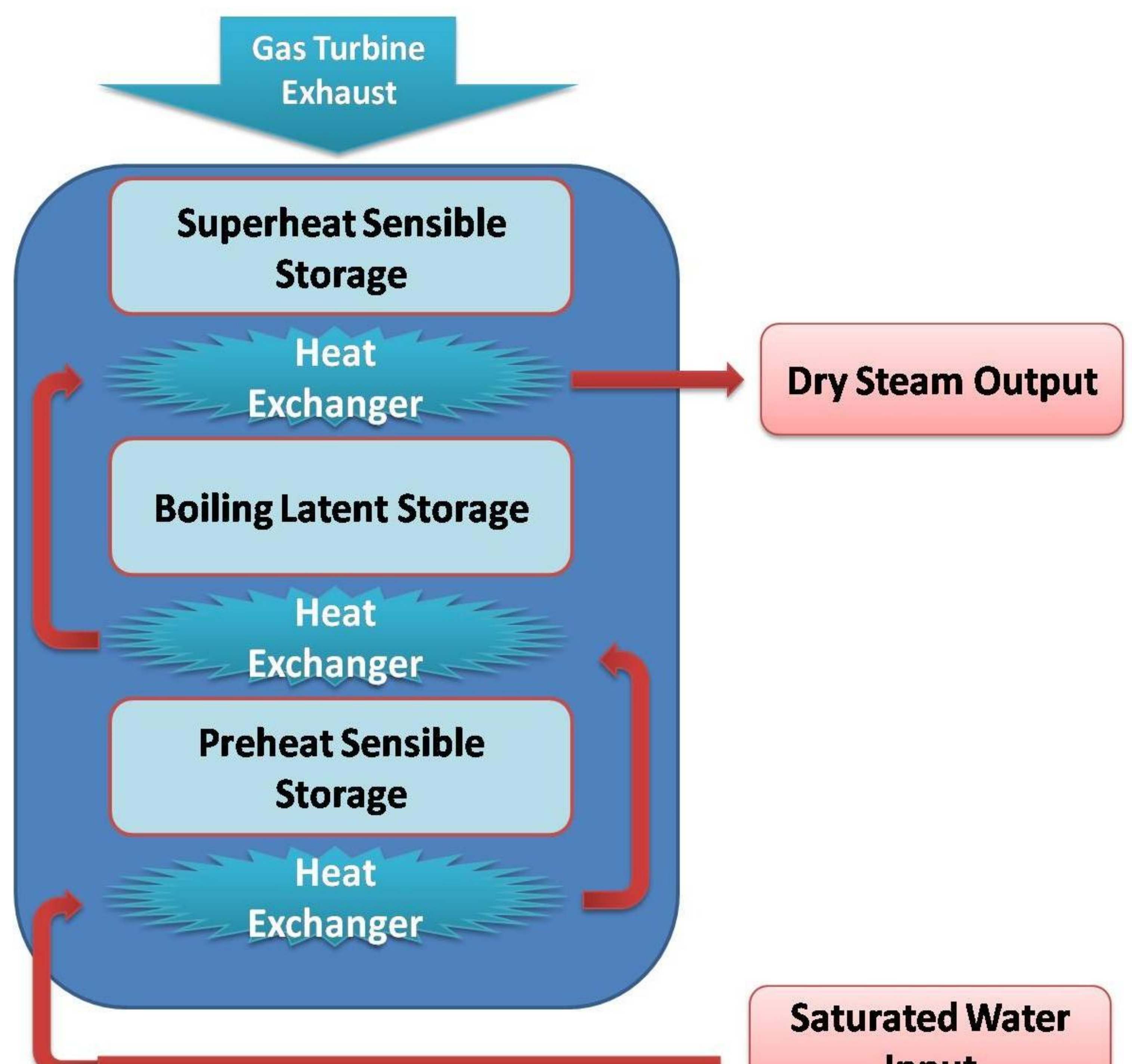

Figure 2 – Thermal Storage System with heat exchangers. The three tiered storage unit is meant to simulate the three phases of heating found in a normal steam power plant.

Model Implementation

After verifying the model, the *24h combined-cycle* configuration will be constructed at the Beam Down Solar Plant (Figure 3) located in Masdar City, UAE. The unique aspect of this facility allows for concentrated solar radiation to be collected at ground level, as opposed to the top of tall towers. This flexibility allows for many different experiments to be swapped out at any time, expanding the breadth of research projects at the Masdar Institute.

Figure 3 - The $100kW_t$ Beam Down Solar Plant at Masdar City

Conclusion

This novel *24h combined-cycle solar power plant* will attempt to solve the supply-demand balancing problem. By storing thermal energy during the day and using it to carry the base load demand at night, supply fluctuations are smoothed to improve grid integration. The two big challenges will be:

1) Interfacing the thermal storage effectively to both an air turbine exhaust and a water boiler/superheater

2) Keeping the plant operating at high thermodynamic efficiency while varying the fraction of energy diverted to storage over the day

References:

[1] Schwarzboezl P.: *A TRNSYS Model Library for Solar Thermal Electric Components (STEC). Reference Manual*. Release 3.0, November 2006

[2] Schwarzbozl, Buck, Sugarmen, Ring, Crespo, Altwegg, Enrile, Solar Gas Turbine Systems: Design, Cost and Perspectives, Solar Energy, Volume 80, Issue 10, Solar Power and Chemical Energy Systems (SolarPACES'04), October 2006

[3] Hasuike, Yoshizawa, Suzuki, Tamaura, Study on Design of Molten Salt Solar Receivers for Beam-Down Solar Concentrator, Solar Energy, Volume 80, Issue 10, Solar Power and Chemical Energy Systems (SolarPACES'04), October 2006,

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