Optimal Design and Integration of Solar Thermal Collection, Storage and Dispatch With Process Cogeneration Systems

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1. Introduction This paper introduces an optimization approach to the design of process combined heat and power systems that integrate the thermal profile of the process, an external fossil fuel, and solar energy. A hierarchical design approach is proposed to stage the implementation of steady-state and dynamic calculations. Initially, energy integration is used to identify minimum heating and cooling utility targets. Next, a genetic algorithm approach is employed to optimize the external heating load and generated power of the cogeneration system that includes a steam Rankine cycle. Another loop is used to optimize the flowrate, temperature, and pressure of the steam entering and exiting the turbine. A multi period optimization approach is developed to account for the diurnal variability of solar energy. Direct usage of collected solar energy is considered along with the option of thermal storage and dispatch. The solution of this mixed integer nonlinear program determines the optimal mix of energy throughout the year. A case study for a petrochemical plant in Jeddah, Saudi Arabia was solved to illustrate the applicability of the devised approach.

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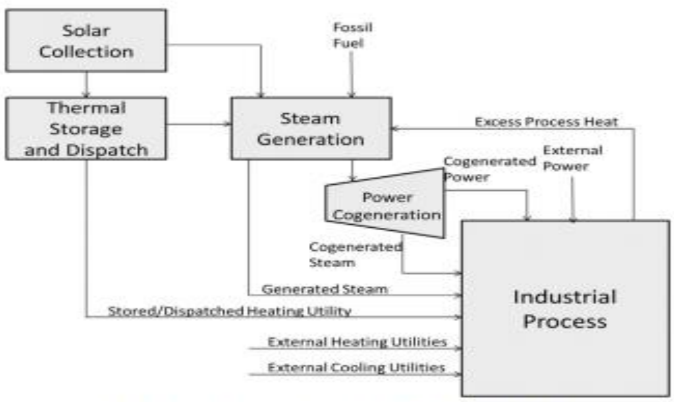

Fig. 1. Schematic representation of the problem statement.

— **2. Experimental -** The heating and cooling requirements for the process are to be integrated and the process is to be modified so as to minimize the external heating and cooling utility demands.

— The external utilities are to be provided by a combination of fossil fuels and solar energy.

— In spite of the diurnal variation of solar energy, it is necessary to provide a steady supply of energy to the process. This can be solved by using time-based solar-energy storage and dispatch

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— **3. Results and Discussion** - The solution identified a solar collector area of 3605 m2 and a thermal storage system with a maximum storing rate of 11,815 kW during a time period of one hour. The total annualized cost of the solar collector is $\$4095*10^3$ /yr

— The solution typically favors the use of fossil fuel in the early hours while favoring direct solar energy in the middle of the day.

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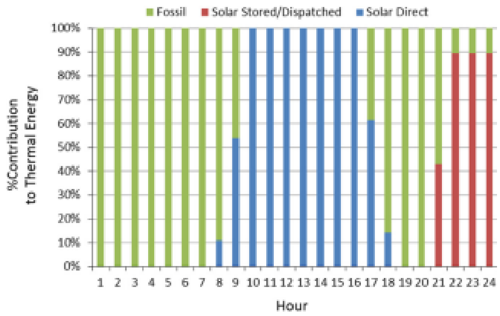

Fig. 8. Hourly distribution of energy mix during the month of January.

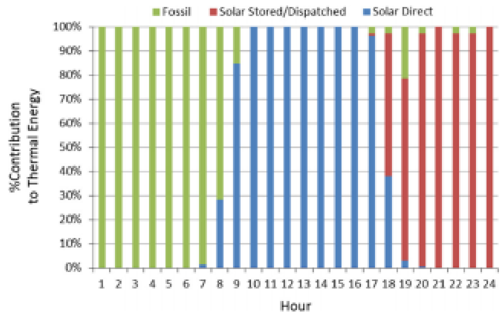

Fig. 10. Hourly distribution of energy mix during the month of March.

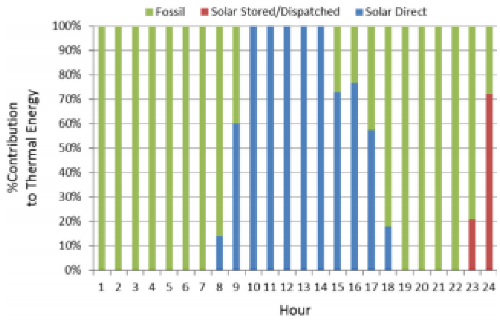

Fig. 9. Hourly distribution of energy mix during the month of February.

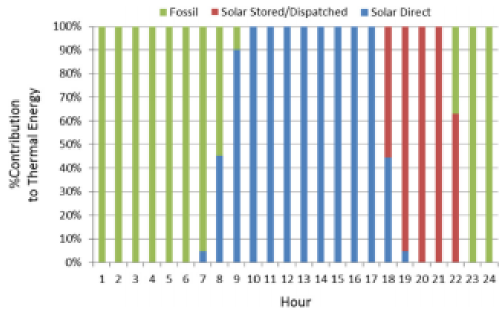

Fig. 11. Hourly distribution of energy mix during the month of April.

4. Conclusions - Stored solar energy is dispatched in the evening.

— The net reduction in GHG emissions associated with the substitution of natural gas with solar energy for power generation in this case study is 112.11 t CO_2-eq/yr.

5. References

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