Solar Assisted CHP Refrigeration System

S. M. Ezzahiri and C.A. Infante Ferreira [C, S]
Delft University of Technology, Delft, The Netherlands

J. Krieg
Unilever Food & Health Research Institute, Vlaardingen, The Netherlands

R. van Gerwen
Unilever Engineering Excellence Team EET, Vlaardingen, The Netherlands

This paper presents a study of the possibility to reduce the consumption of fossil fuel energy and related CO_2 emissions in industrial refrigeration processes by integrating solar energy systems as resources. A typical foods factory with ca. 3 MW refrigeration capacity requirements at two temperature levels (-23 and -10°C) has been selected for reference. A gas turbine CHP system drives both an electrically driven two-stage ammonia compression cycle and a thermally driven ammonia-water absorption refrigeration cycle. The electrical and thermal energy requirements are balanced. This reference system has a high primary energy ratio (1.63) and emits 3.2 Mton CO_2 per year. For the solar driven alternative systems, solar thermal and photovoltaic panels, and also a combination of both have been considered for use on the available roof area of the factory. Five solar assisted alternatives have been considered: one in which thermal and photovoltaic panels deliver (part of) the balanced electrical and thermal energy requirements of the existing plant; two electrically driven options (vapor compression and Stirling cycle); and two thermally driven options (absorption and adsorption refrigeration systems). The yearly solar radiation distributions for two locations in Europe (Rotterdam and Barcelona) have been taken into account to predict the yearly fossil fuel and related CO_2 emissions savings for the five alternative systems. For both locations the largest savings for both fuel consumption and related CO_2 emissions are obtained for the system that combines the use of thermal and photovoltaic panels with the existing system (ca. 16% for Barcelona and 8% for Rotterdam). The second best option is the system that combines solar thermal panels with absorption refrigeration only (ca. 10% for Barcelona and 4% for Rotterdam). Unfortunately the required investment in solar panels is quite large, leading, for Barcelona and considering future energy prices, to an unacceptable simple pay-back time of 26 years for the combined thermal and photovoltaic panels, and 10 years for the option with solar thermal panels and absorption refrigeration only.