European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

Optimal Design of Trigeneration and District Energy in the Presence of Energy Storage

S. Bruno[1], S. Lamonaca[1], M. La Scala[1] and U. Stecchi[1]

[1] Dipartimento di Elettrotecnica ed Elettronica
Politecnico di Bari
via Re David 200, 70125, Bari, Italy
Phone/Fax number:+39 080 5963422(3658), e-mail: **bruno@deemail.poliba.it**, **lascala@poliba.it**

Key words
District heating and cooling, combined heat and power, thermal energy storage, chilled water storage, ice storage.

Abstract.
Combined Heat and Power (CHP), Combined Heat Cool and Power (CHCP) and District Heating and Cooling (DHC) are well known applications and represent the most effective (and efficient) solutions for the development of modern and sustainable urban settlements.
The technological and financial feasibility of investments in CHCP and DHC is not under discussion. Technologies for CHCP are in general mature and permit, thanks to their variety, efficient applications for any size or fuel. DHC systems are widely adopted and have been successfully implemented in different urban scenarios.
CHCP plants are usually designed for producing, at nominal value, less than the average thermal base-load. In this way the plant operates for the highest number of hours and wasted thermal energy is minimized.
In presence of Thermal Energy Storage (TES) it is possible to reduce the size of the plant or capital costs, maximize CHCP efficiency and shorten investment pay-back time.
The effect of TES systems is to decouple heat/cool generation from the provision of thermal energy during peak hours. This is particularly useful in DHC systems, since cooling loads tend to peak in those time of the day (or year) when high temperatures create maximum power demand.
The design of a CHCP/DHC plant is significantly affected, in both energetic and economical terms, by a great number of decision variables and by fluctuating parameters such as energy prices or load profiles. Further complexity is due to the fact that a CHCP plant design cannot be optimized without having performed an optimization of its operating conditions.
This paper is aimed at finding, given a set of future energy customers, the optimal size of a trigeneration plant and a TES unit for an on-going CHCP/DHC in the South of Italy.
This optimal solution is calculated by means of a two-step multiperiod algorithm that permit to solve concurrently the problems of designing and operating the CHCP/TES system according to a specific management.
The optimal solution can be considered as the one that maximises a specific financial performance index (for example Return Of Investment - ROI or the Internal Rate of Return - IRR) in the presence of equality and inequality constraints, that represent the chosen DHCP and TES management strategy.
In general, TES can be managed through full, near-full and partial storage. In the specific project under development, partial storage is adopted to co-generate electricity also during peaking hours of the day (and therefore when the maximum selling tariffs are available). At the same time, TES technology is adopted for following thermal demand when the production system operate constantly at nominal conditions.
Test results have been carried out considering four test cases. The first case is referred to a plant design without cool storage. The other three cases are referred to the employment of Chilled Water (CHW), external melt ice-on coil and ice harvest, respectively.
For each case the best TES design has been evaluated by fixing the electric power capacity of the gas turbine. For each options a full-space research on control variables has been performed.
Test results showed how through Chilled Water (CHW) TES it is possible to reduce capital costs and achieve better financial performances. Other technologies are not fit for this specific project and should be applied for smaller or different applications.