DISTRICT HEATING AND COOLING

EXPO'98

A CASE STUDY

by

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Promotion of CHP Systems to Major Energy Consumers
European Conference
Thessaloniki, Greece, 26 May 1995

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The aim of my contribution is to give all the participants in this European Conference information on some of the technical aspects being discussed of the plan to provide Lisbon's World Exhibition - EXPO'98 - with a district heating and cooling network.

Framework

As mentioned by my colleague Cancella de Abreu, it was decided to study the possibility of providing climate control in the various buildings to be constructed in the development area of EXPO'98 through a network of thermal fluids (chilled and hot water) which would supply the heating and cooling substations of the various consumers.

A study is therefore being carried out with the aim of determining the technical and economic viability of a district heating and cooling system, capable of satisfying the thermal energy requirements for heating and cooling, both during the period that EXPO'98 will run and subsequently for the medium and long-term, when the levels of use planned for the whole development area will have been reached.

The main objectives of a centralised system are as follows:

- To define an "efficient" system, from both the energy and the economic point of view, capable of supplying heating and cooling services to each building in the EXPO'98 Area;

- To find a definitive energy system that, apart from its high standards, would also be in accordance with the efficient use of natural resources, and the related need for sustainability in its development.

The possibility of an integrated solution, which is more efficient in energy terms, is put forward as an alternative to traditional solutions consisting of autonomous thermal production units for climate control installed in each building.

The production of the final energy (in the form of heat and cold) which will supply the urban network planned for the EXPO'98 area will be provided by a thermal production plant which, with a view to the optimisation of primary resources (natural gas), will be a Combined Heat and Power Station.
The capacities to be installed during the first stage will be of the following order:

- Heating Capacity 13 MW
- Cooling Capacity 30 MW
- Electricity Capacity 10 MW

In the long term, it is anticipated that they would be increased to the following:

- Heating Capacity 26 MW
- Cooling Capacity 50 MW
- Electricity Capacity 15 MW

If this project comes into being, it will represent the first experiment in district heating and cooling in Portugal. EXPO'98 will thus be a very important step towards the wider use in Portugal of integrated energy systems in urban networks.

Heat, Cold and Electricity Production Plant

I will present two possible technical solutions which could be adopted for the Energy Production Plant which will serve the heating and cooling urban network for EXPO'98.

Both solutions are based on a mixed system of traditional thermal production and cogeneration.

Solution A

In this solution, a plant consisting of the following main equipment is planned for the first stage of the project:

- 2 generating units driven by natural gas alternative engines, with an electrical capacity of 5 MW per unit

- 2 heat recovery boilers of exhaust gases, with a thermal capacity of 2.6 MW per boiler. These boilers will produce saturated steam at a pressure of 8 bar

- 2 absorption chillers, with a unit capacity of 2.6 MW

- 5 compression chillers, (centrifugal compressors), with a unit capacity of 4.65 MW

- 2 auxiliary boilers with a unit capacity of 3.8 MW, producing saturated steam at a pressure of 8 bar.

As can be seen on the slide, electricity is produced through the gas engines, which powers the compressors of the chillers, excess electricity being sold to the regional electricity network (LTE - EDP). The exhaust gases of these engines are recovered allowing the production of steam for the absorption cycle and for the heating network. The refrigeration energy of the engines is also recovered for the heating network.

The **plant** will therefore supply the chilled water network at a temperature of 6°C and the hot water network at temperatures of 75°C in summer and 90°C in winter.

Solution B

In this solution, a plant comprising the following main equipment is planned during the first stage of the project:

- 1 generating unit operated by a natural gas turbine, with an electrical capacity of 1.1 MW. This unit will be directly coupled to the compressor of a chiller with a capacity of 5 MW.

- 3 generating units driven by natural gas alternative engines, with an electrical capacity of 1.3 MW per unit.

- 1 heat recovery boiler of exhaust gases from the gas turbine, with a thermal capacity of 2.2 MW, which produces saturated steam at a pressure of 8 bar.

- 3 heat recovery boilers of exhaust gases from the gas engines, each with a thermal capacity of 2 MW, which produce hot water at 110°C

- 2 absorption chillers, with capacities of 2.6 MW and 1.6 MW

- 4 compression chillers, (centrifugal compressors), one of 5 MW and three of 3.5 MW each.

- 1 auxiliary boiler with a thermal capacity of 8 MW, producing hot water at 110°C.

- 1 storage system for thermal energy (chilled water) consisting of a 15,000 m^3 tank, for the storage of cold. This storage system has one equivalent cooling capacity of 11,5 MW.

As can be seen, there are some significant differences between Solution B and Solution A. The former also provides for the combined generation of heat and power (with gas turbines and gas engines), with thermal recovery being used for the production of cold (through absorption cycles) and for the hot water network. However, this solution also provides for:

- The direct coupling of a compression unit to a gas turbine, which permits the operation of this unit either for the turbine or for the regional electricity grid. Moreover, during periods in which the demand for cold is less, the turbine could supply electricity to the grid, via a hyper-synchronous generator which is also coupled to it.

- The storage of cold, allowing chilled water to be produced during those periods in which electricity is cheaper, and thereby reducing the capacity required in the cold production system.

In this solution, the **plant** supplies the chilled water network at a temperature of 4°C and the hot water network at a temperature of 95°C.

Urban Heating and Cooling Network

The Urban Heating and Cooling Network will be installed in underground service galleries, specifically designed to house the various technical infrastructures of EXPO'98. The network will have 4 pipes, 2 for the circulation of chilled water and 2 for the circulation of hot water.

The material to be used for such pipes will be carbon steel, duly thermally insulated, except for the chilled water return pipe which will not be insulated.

According to the proposals, diameters of the pipes from the plant will be of the order of 300 or 550 mm for the primary hot water network, and 800 mm for the primary chilled water network.

Substations

The consumers will be connected to the network via heat exchangers for both heating and cooling, in order to make the distribution circuits independent of the consumer circuits. The substations installed in each building will include, as well as the heat exchangers, all regulation, control and metering systems for the energy supplied.

Tariff and Price Structure

As far as the costs of providing a centralised supply service for heating and cooling are concerned, both proposals provide for the payment of an initial sum corresponding to the "right of connection to the network", in addition to a further sum called "advance on consumption" in the one case, and "deposit" in the other.

While differing somewhat in the calculation formulas and parameters applied, the tariff structure will be basically of a binomial type, consisting of a fixed amount, corresponding to the capacity contracted for, and a variable amount which corresponds to the energy consumed. However, an accurate comparative evaluation of the advantages and economic viability of the proposals cannot be based on the presupposition of different tariff structures. It was therefore decided to opt for a simulation of its application to already known typical consumers, adjusting the investment and operating costs of the different solutions to 1995 values. The results of the simulation will be available soon.

As can be foreseen, as well as the macro-economic advantages brought about by the optimum use of primary resources, the integrated solution of an urban distribution network also could represent advantages in terms of end users' energy bills; its implementation is therefore advantageous and desirable.

The proposals are still in the process of being evaluated, given the complexity of the installations and associated operating contracts. It has first to be decided, on the basis of tariff levels and the viability of the project, whether to go ahead with the system or not.

Hoping that this very short summary is sufficient to arouse your interest in energy systems integrated into urban networks, I thank you for your attention and remain at your disposal for any further clarifications that may be required.

Many thanks.