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DHC load management using demand forecast

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Abstract

The optimal management of a district heating addresses problems such as the optimization of the pumping in supply energy and minimization of heat losses. Demand forecasts are based on historical data and heat losses are generally calculated developing a model based on the topology of the district network. The variability of the users' load brings situations where predicted information becomes very useful while managing different possibilities in supplying that energy.
Once the different possibilities for energy generation and the forecasted energy demand are known it is required to develop a model to calculate the future associated heat losses in the district network according with the expected demand.
A network operator that dispose information about the future behavior in the DHC would be able to manage and optimize the energy generation of the power plant as much as minimize the cost of the pumping station and the heat losses without reduction in service quality.

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1. Introduction

The District Heating and Cooling under analysis in this study provides heating and cooling to the Balearic Islands University (UIB) and the Balearic Islands Innovation Park "Parc Bit" (PB), located in Palma de Mallorca, Spain. The district network was built in 2000 and connected the tri-generation plant to Parc Bit office buildings using 3 branches. In 2002 the network was extended connecting another branch to the university facilities, including the student house and the sports center. Currently it provides heating and/or cooling to 25 different customers. For district networks located in Mediterranean climates and particularly for this one the cooling demand may be as important as heating demands.

The whole network comprises 4 branches of pre-isolated steel pipes, each branch has two pairs of pipes: flow and return for heating and cooling. The total length in single direction of the District Heating and Cooling network

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(DHC) is 4.6 km. A noteworthy feature of this district network is the fact that some of the branches provide, at the same time, heating and cooling to certain users, nevertheless most of the users are seasonal users (heating demand in winter, cooling demand in summer). Moreover, according with the customer's energy profile they can be split in three categories: office buildings, educational and specific usages (residential, swimming pool and IT room). These profiles are also differentiable between workdays and weekends.

The power plant generating the thermal energy to cover the demand is placed at the beginning of the branches and it is run by Sampol Ingeniería y Obras. This power plant is composed by 2 Combined Heat and Power (CHP) engines of 1.36MW, 700kW of solar collectors, 1MW biomass and 2 diesel burners of 2MW total on the heating side and 2 absorption chillers of 2MW total and 2 electric chillers of 2.5MW total on the cooling side.

The heated or cooled water to be pumped to the branches is taken from a water storage tanks used as energy buffer, there are four tanks of $100m^3$, two for cooling and two for heating. The thermal energy generation from the power plant is delivered to an equilibrium collector and then to straight to the tanks. The return flow is directed to the generation plant to be heated again.

The power plant is providing heated water which flow temperature is at maximum 95ºC and the return temperature is fixed on 65ºC. For the chilled water the minimum flow temperature is 6ºC in the flow and the return is fixed on 12ºC. Both of the returns are fixed on a temperature due to load side design and it is achieved through the use of variable pump flow in the pumping station.

The management in the flow from the power plant is achieved using Variable Frequency Drives (VFD) which provides the power to the pump to propel the requested flow. The VFD adjusts to a linear relation the pump power consumption and the fluid flow, and thus optimizes the electric consumption of the pump for variable flows [1].

The relationship between the flow impulsion and the related pump energy consumption suggest an energy optimization way in the DHC adjusting the tandem temperature-flow. This optimization must take into account the variability of the Heat Losses (HL) with the temperature difference between flow and return.

From the Energy Services Company (ESCo) point of view, it is very important to have certain knowledge of the cost in supplying the demanded energy; such cost comes from the pumping electric cost plus the thermal HL in the distribution. Once the energy values are known, an economic value is associated to the used energy, that value is minimized by finding the optimum supply flow-temperature tandem to deliver the requested energy.

Nomenclature

ANN	Artificial Neural Network
ARIMA	Auto Regressive Integrated Moving Average
CHP	Combined Heat and Power
c_p	Specific heat capacity of water [$J\cdot Kg^{-1}\cdot K^{-1}$]
D0	Current day
D1	Next day
DHC	District Heating and Cooling
ESCo	Energy Services Company
HL, $\hat{E}$	Heat Loss [W]
MAE	Mean Average Error
MAPE	Mean Average Percentage Error
m	Mass flow [$Kg\cdot s^{-1}$]
PB	Parc Bit
SCADA	Supervisory Control and Data Acquisition
U	Heat Loss coefficient [$W\cdot K^{-1}$]
UIB	University of Balearic Islands
VFD	Variable Frequency Drives