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Wavelet-based Decomposition and Artificial Neural Networks for Short-Term Prediction of Power Demand in District Heating

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Objectives

The present work is directed towards improving the operation of multi-energy district boilers by adding to the plants optimally sized and controlled thermal storage tanks. The proposed strategy is based on a Model Predictive Controller (MPC).

Predictive Control of Thermal Storage Systems for Multi-energy District Boilers

Multi-energy district boilers

CASE STUDY

Component	Description
WB	Wood boiler [1050 ; 4200] kW
GB1	Gas boiler [140 ; 7000] kW
GB2	Gas boiler [180 ; 9000] kW

Why a predictive controller ?

Generate optimal command sequences to manage the amount of thermal energy to be stored or released by the hot water tank.

To implement such a controller, one needs to **forecast the heat network power demand.**

Structure of the proposed predictive controller

Forecast methodology

A model is developed to forecast the power demand as follows:

1 Discrete wavelet transform

Seq {1,...,M} (original signal) → **Decomposition at level N** → Dc {1,...,N} (N detail coefficients) and Ac (Approximation coefficient at level N)

2 Multi-layer Perceptron (MLP) for forecasting future sequences

Dc {1,...,N} (Day, Hour) → MLP-Dc {1,...,N} → FDC {1, ..., n} (Forecasted detail coefficients)

Ac (Day, Hour) → MLP-Ac → FAc (Forecasted approximation coefficient)

FDC and FAc are combined to produce Seq-F (Forecasted sequence).

3 A parametric study is carried out to optimize the:

- Number of observation sequences (M)
- Decomposition level (N)
- MLP topology (number of hidden neurons)

Simulations Results

Hourly forecast model (April to September)

OPTIMAL CONFIGURATION

Parameter	Value
Wavelet decomposition level	1
Number of observation sequences	1
Number of hidden neurons	17
FIT (similarity criterion)	72.26
MAE (mean absolute error)	299.57 kW
MRE (mean relative error)	5.9%

- Results highlight the ability of such an approach to achieve the task of forecasting with high accuracy

Impact of the predictive controller

Increase in economic gain

Decrease in CO₂ emissions

- The proposed control scheme allows the fossil energy consumption to be significantly reduced
- The same remark applies to the functioning costs and CO₂ emissions