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Effects of the load forecasts mismatch on the optimized schedule of a real small-size smart prosumer

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Abstract

The increasing need for reducing the costs and the environmental impact of the energy supply renewed the interest on distributed generation, also favoured by the recent EU directives. Anyway, the solely installation of efficient small- and medium-size pieces of equipment is not sufficient to achieve the expected targets, being their proper scheduling and management, of course based on the fluctuations of both the loads pattern and the energy prices, the fundamental issue determining their effectiveness. In recent times, several techniques have been proposed with the purpose of optimizing the operation of the installed generators on the basis of load predictions; even if these latter ones heavily affect the performance of the plant management, especially when considering a single prosumer whose behaviour is scarcely predictable with a good accuracy, often this aspect is neglected. The present study aims to analyse how inaccurate load predictions affect the performance of an energy plant whose generators are scheduled by an optimization tool working considering a time span of one day. Different "structures" of error will be modelled and analysed, taking as benchmark load profiles the acquired data for different periods of the year from an office building plant, equipped with a PV plant, two micro-CHP system combined with an absorption chiller, an electric chiller, a gas boiler and a reversible electric heat pump, with thermal storages. The focus will be on the comparison of both the economic and CO_2 emission impact, by considering on one side the loads prediction as perfect and on the other side with different entity of errors, with the target to stress the importance of the correct loads prediction issue.

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1. Introduction

Nowadays the global energy demand is driven mostly by three key factors: the increase of the population, the economic growth, and cheap energy supply. In order to balance the population increase and economic growth with the reduction of the Green House Gas emission, one of the most fruitful strategies is to focus on the energy efficiency. This concept, enhanced by greater and greater attention to environmental impact and to cost reduction, can be partially translated into an emphasized importance of algorithms for the optimized management of energy production plants, not only limited to large-size contexts but mostly in case of small-size prosumers, whose behavior is scarcely predictable.

Independently from the plant size, every optimization logic aims to control generators behavior by considering many inputs: among these, one of the most uncertain is undoubtedly the forecast of the loads. In advanced systems, the expected loads are often calculated by purposefully developed mathematical procedures, or they may be directly edited by the operator accordingly to his experience; as a consequence, the probability to face significant mismatch between real load patterns and their prediction is relatively large, with the detrimental effect of vanishing the advantages of the optimization of the generators schedule by the managing algorithms.

In technical literature the effect of the loads mismatching on the performance of energy plant optimization algorithms is barely unexplored, on the contrary several studies approaching the accuracy of the automatic load forecasting are becoming more and more popular: Buhari et al. in [1] approach this problem by using an Artificial Neural Network (ANN) technique, while Kwok et al. in [2] design a Probabilistic Entropy-based Neural Network (PENN) model to predict the cooling loads of a building and in [3] apply a Multi-Layer Perceptron (MLP) model for load prediction widely adopted in engineering applications to estimate the cooling load of a building. Summarizing the results got by the cited papers and by other works on the same issue, a load forecast mismatching compared to the actual data laying in the range between -15% and +15% is achieved in most of the cases.

Starting from this point, an analysis of the loads forecast error on the performance of an optimization algorithm managing a small-size office building will be carried out. In the following, at first the plant layout taken into account will be introduced, describing the controllable generators and their sizing. As a second step, the case study will be presented and in particular the thermal and electric load pattern will be shown in two representative days for summer and winter season. As a conclusion, several load forecast mismatch structures will be hypothesized and the optimization method will be run taking into account these perturbations compared to the predictions; all the generated results will be analyzed and compared both from an economical and environmental point of view.

Nomenclature

ANN	Artificial Neural Network
CAR	Cogenerazione ad Alto Rendimento
CCHP	Combined Cooling Heating and Power
CHP	Combined Heating and Power
COP	Coefficient-Of-Performance
EER	Energy Efficiency Ratio
EHP	Electric Heat Pump
GSE	Gestore Servizi Energetici
ICE	Internal Combustion Engine
MLP	Multi-Layer Perceptron
PENN	Probabilistic Entropy-based Neural Network
PES	Primary Energy Saving
PV	Photo-Voltaic
SMR	Summer season
WNT	Winter season