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Performance analysis of an optimization management algorithm on a multi-generation small size power plant

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Abstract

In the last years, the carbon footprint reduction has gained great relevance in the energy industry. Thus, it is necessary to choose approaches that weight the results not only evaluating economic benefits but also emphasizing the environmental impact. In order to measure this impact, the key parameter is the CO_2 emission in the atmosphere.
The most powerful mean to satisfy this compromise between economic benefits and emission decrease is represented by the concept of Smart Grid.
A Smart Grid implies a joint participation between information network and electric grid. In order to acquire the data from the electric grid, transmit them through the IT network, compute and translate them into commands to the plant devices, an 'intelligent brain' is necessary.
In order to embed a small local network in the larger VPP a delocalized intelligent device is necessary, able to interface with the Smart Grid.
An optimization algorithm performs this function of intelligent delocalized brain by setting different set-points for the energy devices on field.
In this paper a purposefully developed optimization algorithm is described, with the aim of optimizing the operations of an existent trigeneration plant managing both RES and fossil energy sources. The plant analysed is a real plant located in central Italy, provided by several generators (PV, CHP, absorption chiller, electric chiller, gas boiler and a wind turbine).
The results are yielded by a MATLAB/Simulink simulation tool, where all plant devices are characterized by datasheet information and on-field measurements.
The benefits evaluation of the algorithm optimized management is obtained by embedding inside Simulink the optimization logic and executing it during the simulation runtime.
The performance is compared with conventional thermal led management operations simulated in the same platform.

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The comparison is mainly based on economic costs but also considers CO_2 emissions and primary energy consumption.
The analysis takes in account two particular load case whose data have been retrieved from two representative days during summer and winter season.

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Keywords: CHP; Optimization Algorithm, Genetic Algorithm, Thermal Led.

1. Introduction

The increase of global energy demand counterposed with the climate worsening is one of the most important tasks of the last years. According to this matter, the carbon footprint reduction became a key parameter in the energy industry. This is the reason why, when designing a control strategy for an energy plant, a proper evaluation has to balance the economic benefits with the CO_2 emissions in the atmosphere.

In order to keep the CO_2 factor under control, it is necessary to manage both renewable and fossil energy sources; the main problem introduced by RES is the unpredictable behaviour that struggle with the request of the national electric distributor.

Nowadays the approach that fits this compromise between economic benefits and emission decrease is represented by the concept of Smart Grid.

Smart Grids represent intelligent technologies able to manage the electric grid finding a trade off between the supplier needs and the consumer requests; furthermore they have to optimize the RES functioning analysing the energy cost and forecasting loads request. Indeed RESs, like sun and wind, can supply relevant power but with constraint of unpredictability: this negative feature imply the necessity of backup devices ready to work in case of lack of supply from RESs.

The concept of Smart Grid is strengthened by the contemporaneous use of an information network and an electric grid.

The main core that provide communication between data inputted by the electric grid, by means of the IT network, and the commanded energy devices will be a local supervisor that receive external drivers and after elaborating them it is in charge of sending power setpoints according to a precisely defined strategy.

Furthermore is important to underline that small size plants need a gathering unit able to communicate with the Smart Grid. The Smart Grid is not conceived to manage all the single small plants but an intermediate actor is needed.

In the following paragraphs, firstly few other strategies to face energy plants managing are collected, then the optimization algorithm used (in this study it is not actually communicating with a gathering unit even if it is designed to provide this feature) is presented. Then the case study will be briefly described, simulation environment needed will be presented and the results obtained will be evaluated.

2. State of the Art

Several authors developed optimization strategies dedicated to energy devices control and local system managing; a large amount of these included in their studies a powerful mean that the present technology make available for the Smart Grids: CHP. In order to manage CHPs functioning, a control strategy is needed: usually the strategies to control a CHP are Electric Load Following (ELF) and Thermal Load Following (TLF). In both cases generator has to follow the load needs and, in order to provide economic benefits, it must guarantee a great flexibility. This flexibility can be increased introducing a thermal storage capable to decouple electric and thermal energy.

The optimization of the CHP functioning and of the plant itself depends from the algorithm that is in charge of managing the several inputs coming from the devices and from the environmental and economic information.

Many types of optimization have been applied to this field; Seijo et al. in [1] introduce the optimization of a real Combined Heat and Power plant and a slurry drying process by means of Artificial Neural Networks and Adaptive