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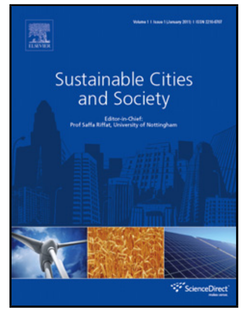

Title: A rule-based strategy to the predictive management of a grid-connected residential building in southern France

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A rule-based strategy to the predictive management of a grid-connected residential building in southern France

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Abstract

In this paper is presented a rule-based strategy to the predictive management of the energy resources in a residential building one can equip with power generators (i.e. photovoltaic solar panels and a vertical-axis wind turbine) and batteries for electricity storage. The strategy takes the status of the electricity grid into consideration (via grid thresholds) and aims at both favouring self-consumption of the electricity produced from renewables and minimizing the negative impact of local power generation on the grid operation. It is based on anticipating the total-occupant load of the building, the grid load as well as the variable power that comes from renewables, using a rolling forecast horizon. Note that we have previously proposed a non-predictive strategy and pointed out possible improvements, in particular regarding the management of the batteries [1]. So, a grid-connected residential building located in Perpignan (southern France) has been modelled using the TRNSYS software. Performance has been evaluated thanks to energy and economic criteria. Taking a look at the results we have obtained in simulation, one can highlight configurations that offer a good compromise between self-consumption of electricity and the renewable energy coverage rate. The combination of photovoltaic solar panels and a vertical-axis wind turbine has been highlighted as a viable energy mix option for residential buildings in southern France. Clearly, optimally designing and managing the power generators and batteries added to the building using the predictive strategy improve the way that building and the electricity grid interact. In particular, the batteries are better handled, allowing electricity to be injected to the grid and extracted from the grid at more favourable times.

Keywords: residential building, grid-connected mode, distributed generation, electricity storage, predictive strategy.

1. Introduction

In many countries, including France, the current model for electricity generation is dominated by centralized power plants. Typically, the power is combustion or nuclear generated. This model has many drawbacks, in particular transmission distance (e.g. power loss) and security related issues. Centralized power plants also contribute to greenhouse gas emissions and the production of nuclear waste. In addition, traditional electricity grids were originally designed for regional self-sufficiency whereas interconnections were developed for mutual support between regions [2, 3]. Many of these issues can be overcome through Distributed Generation (DG). DG refers to using small-scale technologies to produce renewable energy close to the end users of power and is related to the concept of microgrid. As defined by the U.S. Department of Energy Microgrid Exchange Group (MEG), a microgrid is “a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode” [4]. According to the MEG, the benefits of microgrids include “enhancing the integration of distributed and renewable energy sources that help to reduce peak load and reduce losses by locating generation near demand” as well as “meeting end-user needs by ensuring energy supply for critical loads, controlling power quality and reliability at the local level, and promoting customer participation through demand-side management and community involvement in electricity supply”. Distributed Generators (DGs) include a wide range of technologies, such as wind power, photovoltaics, micro turbines, fuel cells and storage systems. As highlighted by the United Nations Framework Convention on Climate Change and its Kyoto protocol [5, 6, 7], DG is one of the keys to energy independence and security and is currently leading the way to fight global warming and promote energy efficiency. However, a high penetration of sources of renewable energy impacts on transient and voltage stability, electromagnetic transients, power levelling, energy balancing, and power quality [8, 9, 10, 11]. So, controlling a huge number of DGs and operating the electricity grid in a safe and efficient way is a big challenge. It can be addressed, at least partially, by the proper design (sizing) and control of these technologies. Moreover, DG requires dramatic changes in planning practices, as well as an increased flexibility, because it affects the physical operation of the grid [12].

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