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Development and testing of a micro-grid excess power production forecasting algorithms

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Abstract

Traditional electricity grids lack flexibility in power generation and load operation in contrast to smart-micro grids that form semi-autonomous entities with energy management capabilities. Load forecasting is invaluable to smart micro-grids towards assisting the implementation of energy management schedules for cost-efficient and secure operation. In the present paper is examined the 24h forecasting of excess production in an existing micro-grid. Alternative input parameters are considered for achieving an accurate prediction. The prediction can be used for scheduling the charging process of a thermal storage during weekends based on excess power production levels.

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Keywords: micro-grid, forecasting, integration, artificial neural network

1. Introduction

The requirement for clean energy, energy efficiency and cost-efficient energy management has given rise to the investigation of transition from traditional energy distribution grids to smart micro-grids.

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In traditional electricity grids energy is produced centrally and distributed to the various energy consumers that are connected to the grid. Traditional grids lack flexibility in power generation and load operation [1]. A micro-grid comprises distributed energy sources, energy loads and storage components, thus forming a semi-autonomous entity with energy management capabilities. Moreover, a micro-grid can operate connected to the main grid or in island mode [2]. For the purpose of reliable and efficient operation the Energy Management System (EMS) has become an essential component of micro-grids [2, 3].

EMS assists in the optimization of power distribution within a micro-grid through the application of appropriate controls. Measuring and monitoring and control equipment connected through Information and Communication Technologies (ICT) are necessary for "building" an EMS. These assets combined with advanced energy management techniques make a micro-grid smart [1, 4-6]. A smart micro-grid communicates with its components and through the EMS controls its loads so as to achieve an efficient and cost-effective operation. In [7] an energy management algorithm is tested for optimum integration and operation of a PV array and a battery for serving a micro-grid's loads. In [8] two algorithms are proposed and tested on an existing micro-grid, one for energy scheduling and one for demand response. Increased efficiency and occupant satisfaction has been achieved by the EMS applied in a University Campus [5].

Load forecasting is invaluable to micro-grid energy management [5, 6, 8, 9]. Load forecasting for controlling charge and discharge of an electrical storage has been studied in [10] as well as in [11]. Depending on the forecasted period three types of forecasting are recognised [6, 9]:

- Short-term forecasting: 1h to 1week for optimum
- Medium-term forecasting: 1week to 1year
- Long-term forecasting: 1year to decades ahead

Two methods for load forecasting have been recognised in literature, statistic mathematical models and artificial intelligence models [6, 9]. Artificial Neural Networks (ANN) are artificial intelligence models widely used for forecasting providing high accuracy [6, 9]. ANN have been extensively used for short-term load prediction [9, 11]. In [12] a multi-layer perceptron neural network that uses load and weather data was applied in order to forecast the daily load of a suburban area. In [13] a feed forward artificial neural network for hourly demand prediction is tested and the proposed algorithm is able to achieve a high prediction accuracy.

In the present paper the 24h load forecasting of a micro-grid using artificial neural networks is examined. The purpose is to predict the day ahead excess production of the micro-grid so as to apply appropriate controls for its utilisation.

2. Case Study

The case study is the micro-grid of the Leaf Community, in Angeli di Rosora, Italy, Figure 1. The energy production sources connected to the grid are a micro-hydropower plant, of 48kWp, four rooftop PV installations of total 421.3kWp and a dual axis Solar Tracker of 18kWp. Five buildings are currently connected to the micro-grid, all equipped with ground water heat pumps (GWHP). A 224kWh electrical storage system and a thermal storage with heat capacity 523.25kWh/K are also part of the micro-grid. All the previously mentioned power loads, renewables and storage components are in parallel to one single Point of Delivery (POD). All nodes as well as the collective operation of the micro-grid is monitored and controlled via My Leaf web based platform.

The rooftop PVs are installed on four of the five interconnected buildings of the micro-grid. The production by each rooftop PV installation is consumed by the respective building first. If there is residual production, it is fed to the micro-grid. The production of the micro-hydropower plant is also fed to the micro-grid. When the production is not enough to cover the micro-grid's loads, energy is withdrawn from the main grid. Energy is also given to the main utility grid if the demand of the micro-grid has been fulfilled, storages are fully charged and there is excess production. Regarding the storages, both have been recently connected to the grid and their operation and integration are tested.