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Load and Renewable Energy Forecasting for a Microgrid using Persistence Technique

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Abstract

A microgrid system, be it connected to the utility grid or an independent system, usually consists of a mix of generation - renewable and non-renewable; loads - controllable or non-controllable and Energy Storage Systems (ESSs) such as batteries or flywheels. In order to determine how much power is utilized from the controllable resources such as ESS, diesel generators, micro-turbines or gas turbines, we first need to determine how much the demand is or how much the renewable energy sources are generating is which is accomplished using forecasting techniques.

Due to the intermittent nature of renewable resources such as wind energy or solar energy, it is difficult to forecast wind power or solar power accurately. These forecasts are highly dependent on weather forecasts. It is evident that forecast of any data based on forecast of other parameters would lead to further inaccuracy, even if the relation between the inputs and output maybe predetermined through regression methods. Therefore, this paper illustrates an approach to use historical power data instead of numerical weather predictions to produce short-term forecast results.

The concept is based on persistence method presented in [1]. This method uses the “today equals tomorrow” concept. From [2], we know that persistence technique produces results that are more accurate as compared to other forecasting techniques for a look-ahead time of 4-6 hours. Both [1] and [2] were based on wind power forecasting. In this paper, we investigate persistence method for short-term electrical demand, solar PV (Photovoltaic) power and wind power forecasting. Since the forecasts are dependent on historical averages of the data in the ‘near’ past, the accuracy is inversely proportional to the variation of power between the historical data and the actual data.

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1. Introduction to Power Forecasting in a microgrid Energy Management System (EMS)

The main function of a forecasting algorithm in a microgrid is to predict the demand of the loads in the microgrid network or the power generated by renewable energy connected to the network for the near future. This is necessary for determining how much power is utilized from the controllable resources such as Energy Storage Systems (ESS), diesel generators, micro-turbines or gas turbines. In other words, the optimization algorithm of the microgrid EMS utilizes the load and renewable energy forecasts to schedule in advance the power generated by distributed generators (DGs) or charged/discharged by storage devices, in an optimal manner.
Based on the design of the EMS, it may have other functions such as:

- predicting active and reactive power of PQ buses with loads or renewables to be used for power flow analysis
- acting as pseudo-measurements for bus with no measuring devices for calculation of distribution state estimation results
- determining user-defined constraints such as variable battery State-of-Charge (SOC) limits or distributed generation ON/OFF patterns.

Nomenclature

Distributed Generators	power generators at the point of consumption. E.g. diesel generators, micro-turbines or gas turbines
Power Flow	method for determining magnitude and phase angle of each bus voltage in the network
Pseudo-measurements	low accuracy bus generation and load measurements, required to complete the observability of the system in state estimation

2. Forecasting algorithms

For microgrid applications, the generation and load forecasts required are usually short-term forecasting. Any forecast performed in the order of hours or days in advance may be categorized as short term forecasting. Since the load and generation are dependent on several weather conditions, historical measurements, special events, time of the day, the inputs used for short-term load and generation data are Numerical Weather Prediction (NWP), past load or generation data and time-related data. Most forecast use NWP as the main input for generation forecast. The problem with this method is that the generation forecasts are based on weather forecasts, which may lead to further inaccuracy.

2.1. Review of other algorithms

Some of the popularly used methods for short-term power forecasting are:

- **Autoregressive Integrated Moving-Average (ARIMA)** is a stochastic method whose basic principle is that the forecasts for the later hours will be based on the forecasts for the previous ones [3]. Even though it is a simple model, it is based on approximation and the true model of the forecast is unknown.
- **Advanced Neural Network (ANN)** is a mathematical tool originally inspired by the way the human brain processes information [3]. The neuron receives information (weather, time, and historical data) through a number of input nodes, processes it internally, and puts out a response. The model is based on a black box