Final Report for

Grid ED: Building Power Consumption Prediction

Sponsored By

New York Independent System Operator (NYISO)

Electric Power Research Institute (EPRI)

Rensselaer Polytechnic Institute (Design Lab)

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Executive Summary

New York Independent System Operator (NYISO) schedules power generation and distribution through the power grid using a day-ahead forecast model. The NYISO model does not include domestic solar panel power generation because it occurs behind-the-meter. This leads to increased cost of energy per-unit as well as increased risk of blackouts. The objective of the Grid Ed project is to incorporate domestic solar panel power generation into the NYISO forecast model. The Grid Ed project is attempting to meet this objective in the Spring 2018 Semester by forecasting meter power from a load with a connected solar panel (East Campus Athletic Village (ECAV) building). This project is also of interest to the Electric Power Research Institute (EPRI) for further research and implementation. The project has the potential of reducing costs for NYISO as well as improving power grid safety, system efficiency, and reliability.

The previous semester team identified several significant weather variables for solar panel power generation and created a solar panel power generation model. The Spring 2018 team revised this model and found that the ECAV solar generation is very small compared with the total power consumption of ECAV. Consequently, the 2018 Spring Semester team recommends future semester teams to magnify the power generation of the solar panels by 1000 to make this generation statistically significant on the ECAV meter data. The Spring 2018 team also created a time series forecast model for the active (real) power consumed by the ECAV building. The team also identified several apparent anomalies such as irregular dates in the historical power data and recommends the next semester team to investigate the discovered anomalies and to create a time series forecast model for reactive power.

The previous semester team created an Artificial Neural Network (ANN) forecast model for solar panel power generation. The Spring 2018 team created a separate ANN forecast model for ECAV power consumption. The 2018 Spring semester team recommends the future semester team improve the accuracy of these models and integrate them into a forecast model of the NYISO meter power.

The Fall 2017 team designed and built the Weather Data Collection System. The Spring 2018 team implemented wireless communication and partial cloudiness analysis as well as conceptually developed upgrades to the battery, battery storage, and battery monitoring. The Spring 2018 team recommends future teams replace the existing camera and fix the corruption issue. The team also recommends the future teams analyze and improve the flexibility of the partial cloudiness code to incorporate additional factors such as time of day and season. Lastly, the team recommends the future teams implement the battery upgrade plan created by the Spring 2018 team once all other hardware components are finalized.

1. Introduction

1.1 Background and motivation

Grid Ed is a multi-semester project sponsored by New York Independent System Operator (NYISO), Electric Power Research Institute (EPRI), and Rensselaer Polytechnic Institute (RPI) Design Lab. The two direct customers for this project are NYISO and EPRI.

NYISO schedules power generation and distribution in New York State. Each day, NYISO creates a day-ahead load forecast for the next day's expected energy needs of New York State. This load forecast is created using measurement data collected at meters (individual building meters as well as substation meters). The day ahead load forecast is then used to schedule the most cost-effective power generation and distribution. From the perspective of NYISO, domestic solar panels reduce the power demand (load) of the connected buildings because a portion of the building's power needs is being supplied by the solar panels.

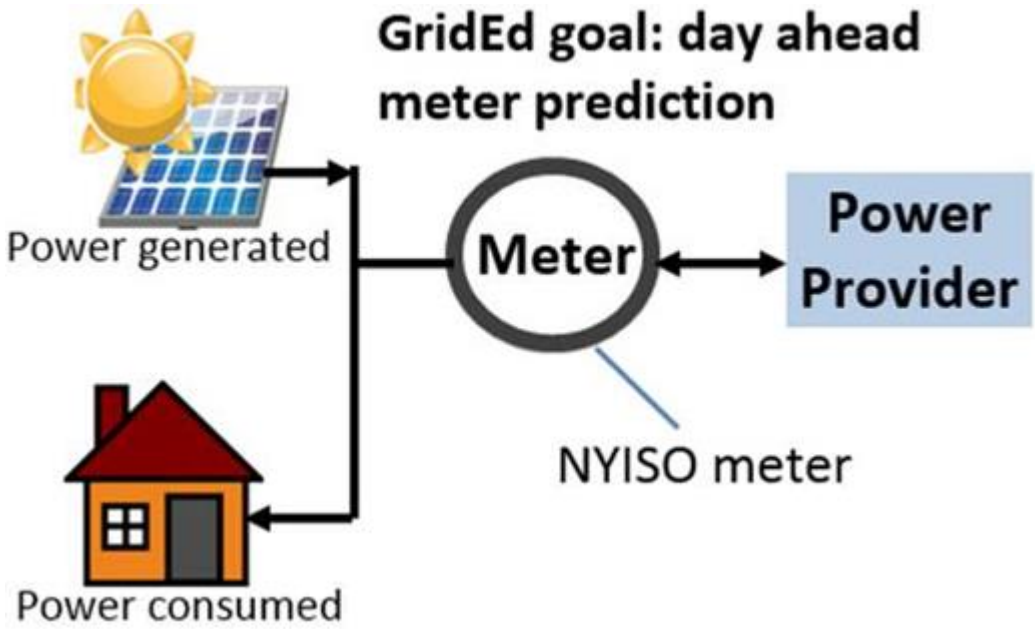

Figure 1.1.1: Diagram of connections between solar panels, buildings, and the power grid

NYISO cannot currently account for domestic solar panel generation in its day-ahead load forecast. Figure 1.1.1 shows a diagram of how a domestic solar panel interacts with the power grid. As can be seen in the figure, solar panel generation occurs and is consumed after the measurement instrumentation located at the meters. Domestic solar panels do not have to be reported to NYISO and the power generated by these panels can vary widely depending on the weather. As a result, NYISO cannot predict how power generation from these domestic solar panels will affect the load in its day-ahead load forecasting.

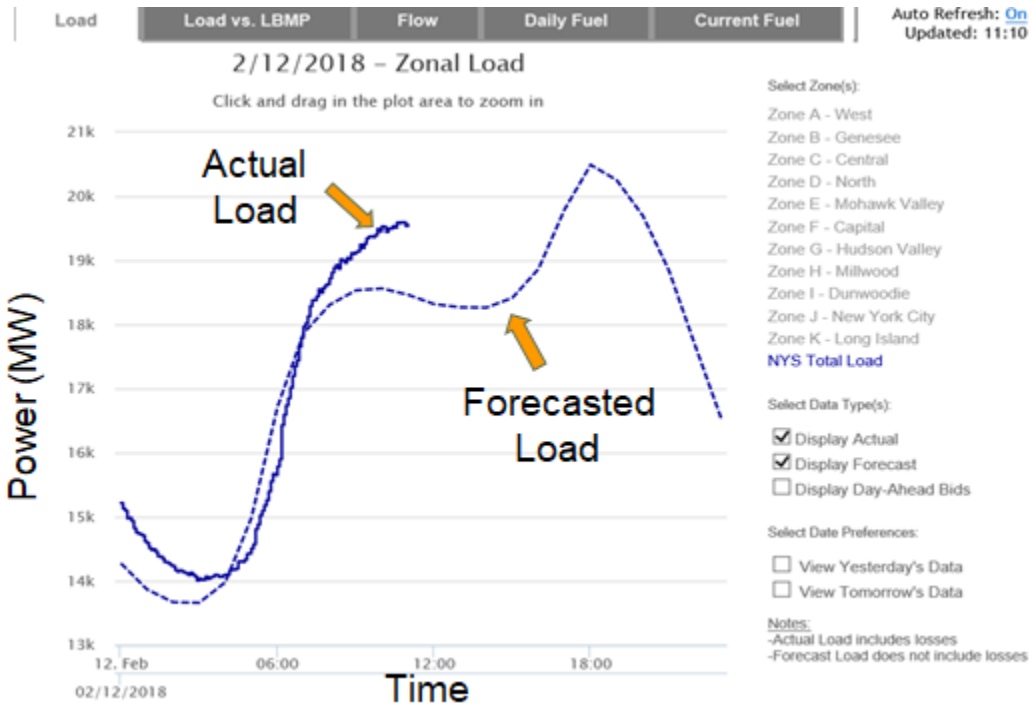

Figure 1.1.2: NYISO Load forecast (dotted) and actual load graph (solid) for 2/12/18. [1]

A mismatch between actual load and forecasted load creates a mismatch between the scheduled generation and actual load. Figure 1.1.2 is a graph of forecasted load and actual load for New York State publicly provided by NYISO. Looking at the graph, the actual load (solid blue) is significantly different than the forecasted load (dotted blue). If actual load exceeds scheduled load, then not enough power is being generated. This can cause power blackouts. To increase generation and avoid blackouts, NYISO must use fast response fossil fuel generation to quickly

supply needed demand. NYISO must pay a higher rate for this generation than scheduled generation, leading to higher overall costs for NYISO. If scheduled load exceeds actual load, more power is generated than required. This results in increased frequency which must be appropriately managed and similarly results in increased costs for NYISO.

EPRI conducts extensive research on power grid systems. As a result, the research EPRI performs is closely related to this project. The goal of the Grid Ed project is to apply behind-the-meter modeling and forecasting of loads with solar panel generation. This cannot be done without EPRI because the research and results found by the Grid Ed team are specific to one location (the ECAV building). As a result, factors such as location (Upstate New York versus New York City) and load type (industrial versus commercial versus domestic) cannot be incorporated into the Grid Ed team's research. These factors must be accounted for to implement behind-the-meter modeling and forecasting throughout New York State. As a customer, EPRI will expand on the research of the Grid Ed team to determine if the Grid Ed team's modeling and forecasting techniques can be applied to achieve similar results throughout New York State.

1.2 Customer Needs and Project Benefits

NYISO needs a way to incorporate domestic solar panel generation into its day ahead load forecasting model. To do this, the models created by the Grid Ed team must be reliable and adaptable to allow EPRI to expand the team's research to be applied across New York State. Behind-the-meter monitoring of the power generation of domestic solar panels would allow NYISO to account for the reduced load demand caused by domestic solar panel generation. This will reduce the mismatches between actual load and forecasted load. A reduction in the difference between actual load and forecasted load will have several benefits.

With reduced instances of under-generation and over-generation of power, NYISO will have reduced costs. This will reduce the cost per unit of power in New York State and save individual power users money. Similarly, NYISO forecasts to slightly over generate power to avoid power blackouts, but with more accurate information, this safety margin can be decreased. This will also improve system efficiency (average load divided by peak load) as the peak load would

be reduced. The department of public service estimates that a 1% increase in system efficiency can save New York State power users $221 -$330 million annually [2]. This savings comes directly from the reduced energy costs experienced by NYISO.

With more accurate meter data, NYISO will also have more accurate information about the power flow throughout the New York State Power grid. This will reduce the chances of distributing too much power through individual power lines, improving power grid safety and reliability.