ECE 493

Senior Engineering Design

Final Report

Design Team No.	ECE-01	Advisor: Dr. Chikaodinaka Nwankpa
Submitted to:	Dr. Leonid Hrebien	

AND THE

SENIOR DESIGN COMMITTEE OF DREXEL UNIVERSITY ECE DEPARTMENT

ENTITLED: **LOAD LEVELING BATTERY ENERGY STORAGE SYSTEM**

TEAM MEMBERS

ISAAC CYRIL	ic77@drexel.edu
ABIN PRASAD	abin22us@gmail.com
PIERRE SIMO	pf78@drexel.edu
PRANEETH REDDY	pbr29@drexel.edu

Submitted in partial fulfillment of the requirements for Senior Engineering Design Project: ECE 493.

Submitted on: May 23, 2013

Abstract

In the power industry one of the main issues that utility companies face is how to effectively meet load demand. This proves to be extremely challenging, especially during peak hours of the day when power consumption is maximum. Load leveling is one of the methods being used in this time period to solve this issue. The objective of this project is to achieve load leveling using a battery energy storage system (BESS). The specific system of choice may consist of lithium ion or lead acid batteries. For this project, both batteries will be evaluated. In addition to the BESS, a utility and local load consumption connection is provided through an AC/DC power conversion system with associated monitoring and control equipment. The developed monitoring and control system evaluates and implements charging and discharging periods for the BESS while effectively leveling the load. Load leveling by this BESS will help not only to improve the reliability of the grid, but will also eliminate the need for expensive peaking power plants and help amortize cost of generators over more hours of operation.

Table of Contents

Problem Description

Figure 1 represents the load of the Regional Transmission Organization PJM on March the 13th 2013. It shows four different load curves: forecast, day ahead, instantaneous and original. The forecasted load curve is developed using historical load data by refering to various days in the past which had the same climatic conditions. The day ahead load curve is a prediction of load which is required for efficient performance of various energy management system functions such as unit commitment, economic dispatch, fuel scheduling, and unit maintenance for the next day. The instantaneous load curve represents the load data collected in real time. It can be seen that the instantaneous/actual load (blue curve) exceeds the forecasted load (green curve) by as much as 1,500 MW during peak hours, conversely, the forecasted load slightly exceeds the instantaneous/actual load during off-peak hours. This shows that electricity is being overproduced and hence wasted during off-peak hours while there is not enough generating units available during peak hours due to the inability of utility and grid operators to balance the supply and demand of electricity in real time. Moreover, when the forecasted load is lower than the actual load, high cost peaking are dispatched.

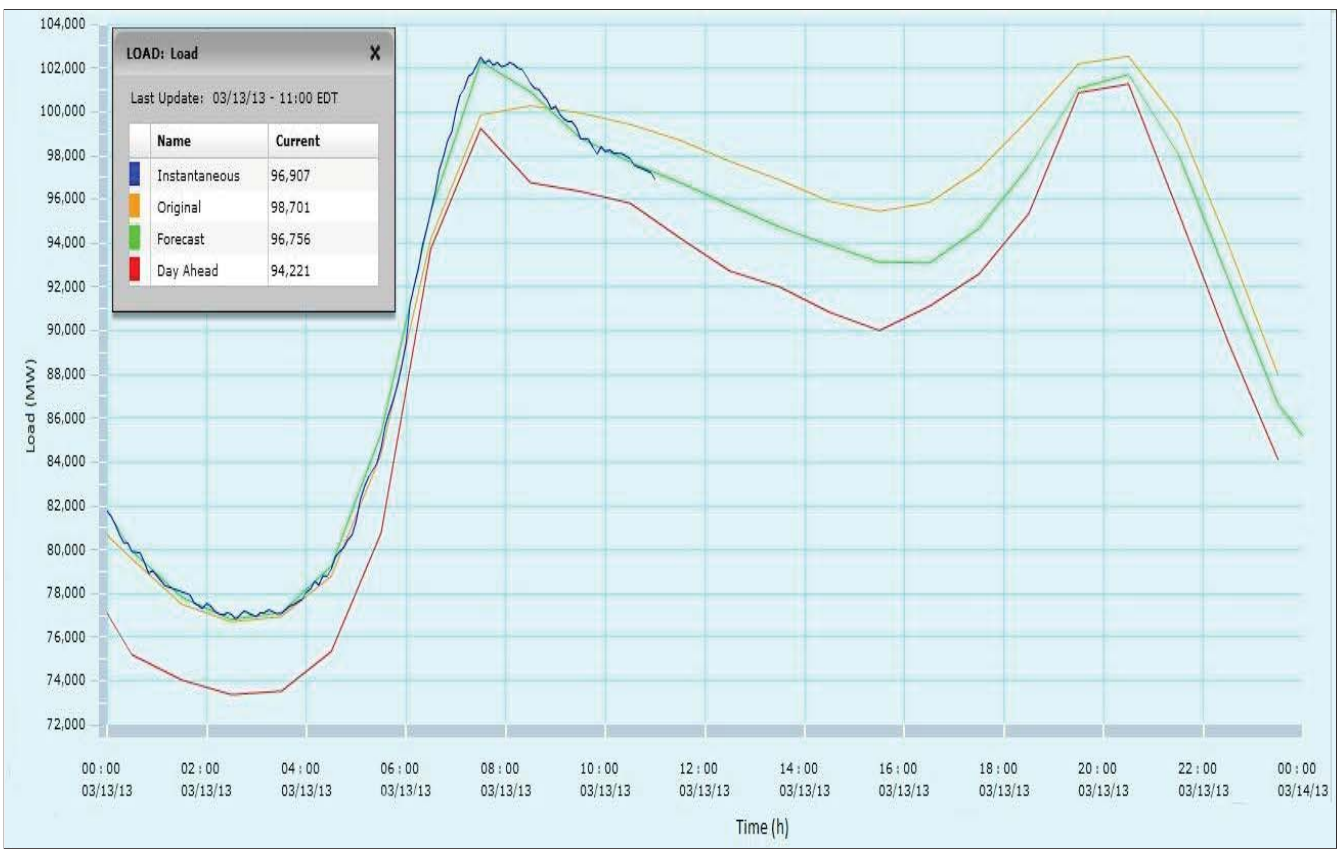

Figure 1: Original, Forecasted, Day-Ahead and Instantaneous Load Curves **[1]**

Since effective energy storages can precisely match total generation to total load on a second by second basis, they can load-follow by automatically adjusting to changing load conditions over short or long time spans, as well as compensating for long-term changes [2]. Accordingly, a solution to meet the discrepancy between supply and demand is to design a power controller system that can vary in real time the rates of the charge and discharge of a Battery Energy Storage System (BESS) depending on the load profile. The load curve can subsequently be smoothed out by utilizing battery storage. This can be done by charging the battery at night or during off peak times and thus fill in the valley of the load curve. During peak hours, the battery can be discharged to shave peaks and smoothen out the curve. For our design, the rate of charge and discharge will be triggered using a pre-defined algorithm that uses both forecasted and real time load data. It must be noted that, although the goal of the design is to achieve real time control of the BESS, the present work concentrates on providing a day ahead dispatch for the battery system. This will form the basis of an eventual real time control system. This BESS will not only benefit society by reducing power energy costs, but it will also benefit the grid by improving grid reliability by contributing to power factor and voltage correction as well as reducing peak load and spinning reserve requirements.

Progress towards the Solution

Load leveling was implemented by modeling optimal energy storage dispatch schedules for net load management in a grid connected battery storage system. This is achieved in the laboratory using Figure 2 that shows a schematic of the system diagram in which a computer is monitoring and controlling a battery array and a load, both connected to the utility electric grid. The following procedure was used to perform load leveling. A software algorithm uses daily forecasted load schedules obtained from PJM Interconnection to calculate the daily battery dispatch schedule. This battery dispatch schedule is input in a network computer and then used to notify the battery when to discharge/charge and how much to discharge/charge. The computer and the system are connected using the MATE 3 USB card and an interface called RealTerm. This enables the system to take ASCI commands that can modify parameters such as rates of the charge and discharge of the battery. When a command is sent from the computer, the battery's inverter and charger parameters are changed, allowing optimal control over the charging/discharging response of the battery. Since those commands are practically instantaneous, load leveling is achieved by dispatching energy from the battery "on demand".