Boston University
Electrical & Computer Engineering
EC463 Capstone Senior Design Project

Project Description

Smart Grid Test Facility

Team #14
Power Pooches

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Project Summary

The objective of this project is to design and construct a Smart Grid test facility for classroom demonstrations and experiments in undergraduate and graduate settings. Students in power and electric energy courses can study their designed grid elements using this test bench. Smart Grid technologies refer to devices that make the electrical grid more efficient, economical, and reliable via communication systems and electronics. Teaching students about the electrical grid will encourage pursuit of new challenges associated with the aging grid infrastructure; the more that engineers focus on updating the electrical grid, the more improvements in Smart Grid technology and clean energy generation that will arise. This test bench will include a collection of fixed generators, variable loads, a transmission network, and sensors feeding into a visual display. This facility will also provide the infrastructure for integration of Smart Grid components. Ultimately, this project will help students learn about the power grid and how it reacts to various arrangements of generators, loads, wiring networks, and Smart Grid elements.

1 Need for this Project, Objectives

Our project is to provide a test bench that can act as a small, low-voltage surrogate for the United States Power Grid with the ability to connect small versions of renewable resources and perform key measurements. It will be used as an academic tool for various topics related to the general theory and methods behind power engineering, renewable energy sources, and electrical infrastructure. In addition, it will serve as a test bench for the development of Smart Grid technologies, such as Smart Meters.

Modern American society heavily relies on the functionality of electrical infrastructure with the average home consuming about 900 kilowatt-hours each month. From essential systems such as HVAC and water pumps to discrete devices such as computers, medical imaging systems, cell phones, and almost all devices we regularly interact with receive electrical power from the United States Power Grid. Unfortunately, current methods of using natural resources, such as gas or coal, are not sustainable in supplying power. However, the invention of renewable energy resources such as wind turbines and solar panels provides sustainable alternatives. The introduction of these sustainable, but highly variable, alternatives has produced the need for a self-correcting grid with an emphasis on efficiency and sustainability. This self-sensing system is the Smart Grid.

Formally, a Smart Grid is a modernized electrical grid that uses analog and digital measurements to gather information about the behaviors of the grid and regulate power flow based on those readings. Using Smart Grid devices improves the efficiency, reliability, economy, and sustainability electricity production and distribution. Mastering the theory of Smart Grid technology is essential to integrating sophisticated renewable energy resources and their requisite control systems into our power infrastructure. The ultimate goal regarding power grid efficiency is to reduce waste and emissions released by traditional power sources (such as coal and oil). The Smart Grid infrastructure supports integration of clean energy technologies and overall improved power distribution.

The objective of the Power Pooches team is to construct a fully functioning tabletop power grid test facility with sufficient hardware and software to simulate the behavior of the power grid. This test facility will include DC-powered prime movers and incorporate a lumped transmission structure with loadflow data acquisition. These features are required to be modular and the test bed is required to be self-contained. However, the system should be designed so that future contractors working for the customer can implement upgrades to the design and continue to add features such as Smart Grid technology. The primary implementation of this project will be as a teaching tool in BU courses EC583, Power Electronics, and EC417, Electric Energy Systems, so the system must be operable within a classroom setting and be safe for use by student operators.

2 Visualization

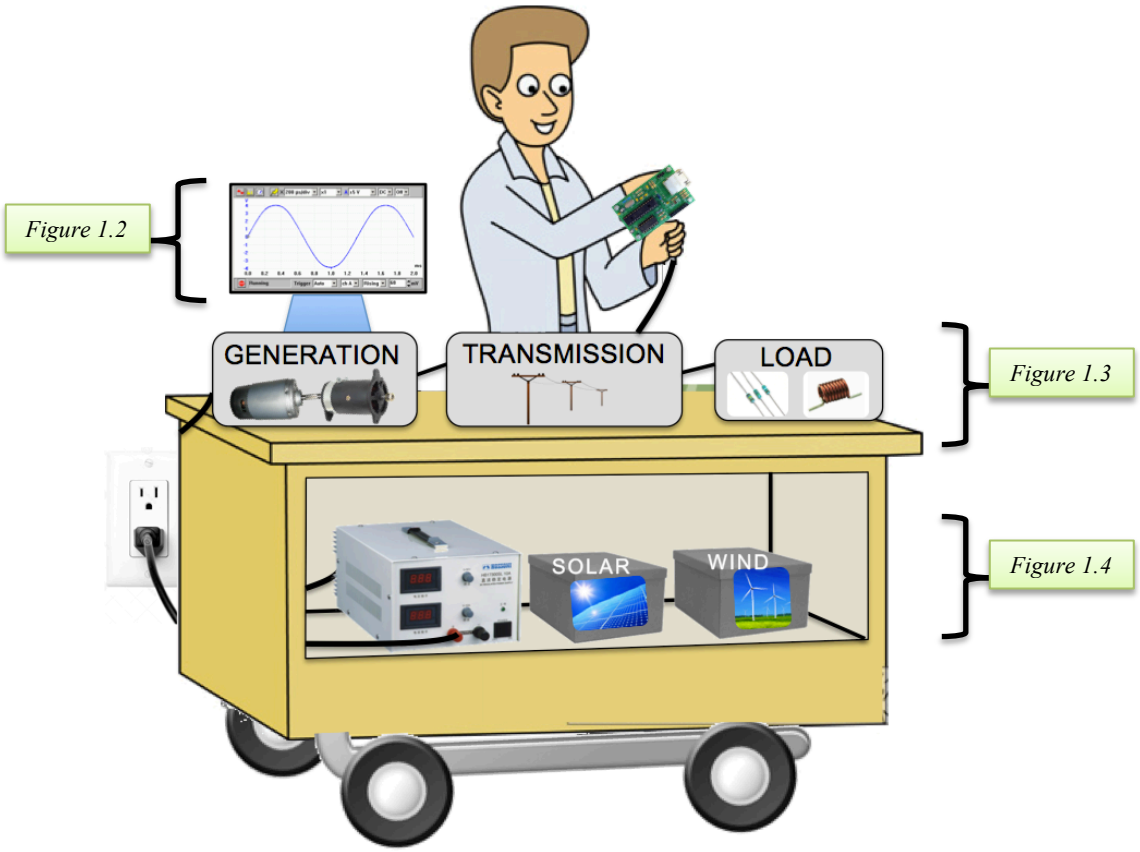

Figure 1.1 This image shows a basic representation of the project's final device system. A student has created a circuit (perhaps a load) that he wishes to test within an electrical grid. He connects his device to the test bed and can observe the grid's response on the monitor.

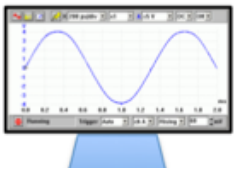

Figure 1.2 A key element of this project is providing students a way to analyze their circuits in the context of the simulated grid network. To do this, the test bed will have an incorporated sensor system that will monitor the current, voltage, and power flows.

Figure 1.3 The simulated grid is comprised of generators, transmission lines, and loads. The test bed will have a collection of several generators, various transmission lines, and variable resistive and reactive loads. Students will be able to adjust the loads in order to study the way the grid reacts to different levels of demand. Additionally, Smart Grid elements can be modeled as loads by their nature of consuming power.

Figure 1.4 A DC power supply (at left) will power the various generators for the grid. While the test bed will have ports for clean energy systems, we also strive to create these simulated clean energy technologies. Because some clean energy systems do not product power in the traditional steam turbine way (such as solar plants which produce DC voltage), additional design considerations will need to be taken in order to create simulated green energy systems. Nonetheless, these types of generators should be available for students to test within the test bed.