2006-344: A DESCRIPTION OF A CAPSTONE PROJECT TO DEVELOP A WEB BASED ENERGY CENTER FOR MONITORING ALTERNATIVE AND RENEWABLE ENERGY SITES

Francis Di Bella, Northeastern University

Ryan Healey, Northeastern University

Mr.Healey is an ElectricalEngineering Technology student;Class of 2006. He is extremely versatil in electrical and computer engineering technology. He has authored the description of the web site engine. He expects to attend graduate school after graduation

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The Description of a Capstone Project to Develop a Web-Based Energy Center for Monitoring Alternative Power Generation Systems for Thermodynamics Laboratory Experiments

Francis A. Di Bella, PE Director, School of Engineering Technology
Ryan E. Healey, Electrical Engineering Technology (Cl. of 2006)
Northeastern University, Boston, MA

ABSTRACT

The recent extreme hurricane damage to the Gulf coast states and the consequential disruption of oil refinement emphasized the delicate balance that the United States is in with regards to energy consumption and supply. The future of the United States or any developed nation lies in a reliable and plentiful energy resource. Certainly there are renewable energy technologies that have been deployed throughout the United States. In order to bring these developments to the awareness of current engineering and engineering technology students it is necessary to develop a state-of-the-art curriculum that the students can use to learn the necessary thermodynamics. A Capstone project by a team of electrical and computer engineering technology students has begun to develop a means of acquiring web-based data from energy sites that have alternative and renewable energy systems in operation. This paper will describe the progress made to date along with the future experiments designed to be used in conjunction with the database.

Introduction and Background

The disasters that were witnessed in the United States during 2005 initially brought fear and surprise to the citizenry that was most directly affected. Soon after, the consequential damages were also felt by citizens across the country when oil prices continued to rise as before but now were exacerbated by the shut-down of the oil refineries and oil platforms that were in the path of the storm. The uncertainty of how long it would take to recover from these storms, forced the prices of gasoline to go as high as almost $4.00 per gallon in many parts of the country. The prices eventually abated but not before the typical consumer was awakened to the reality that what required millions of years to produce, was now literally within 40 to 50 years from depletion. Fuel costs of $3.00 per gallon or more may soon be the norm and not the temporary consequences of nature; the cost of petroleum in Europe is already over $4.00 per gallon.

A United Nations Committee on Third World developing nations has determined that a major requirement but also a major obstacle for developing nations, is the need for more efficient and innovative energy and power generation and delivery.[1] It is clear that the

[1] United Nations report on the 2001 Millennium Project (http://millennium-project.org) found that the leading response to the question: "What challenges can science pursue whose resolution would significantly improve the human condition?" was the answer: "Commercial availability of a cheap,

turmoil in the Middle East has threatened the stability of energy supplied to the United States. The debate continues in the United States regarding the development of energy reserves in Alaska with many advocates indicating that development of these oil fields is critical to the future independence of energy production in the United States. Certainly no one would argue that energy production is the "life blood" of the United States' industry-based economy.

This realization has never been far from the thoughts of most experienced engineers. When those engineers serve on the Industrial Advisory Boards (IAB) of engineering colleges it is not surprising that the advice many of the IAB members are giving to their constituents is to prepare the latest graduates to understand the economic and social impact that energy has on all people. IAB members further recommend that colleges adequately prepare students to be able to increase the energy efficiency of engineered systems including the use of renewable energy. This provides justification for why engineering and engineering technology students should be made more cognizant of the need for energy conservation, improved energy efficiency, and the increased use of renewable energy resources.

In response, several Capstone Senior Design projects over the last several years have chosen renewable energy as their theme. This paper describes the work that is being performed by several electrical and computer engineering technology students to develop a database that stores data from any number of renewable energy sites from around the nation in order to enable data to be used by engineering students who are studying courses in thermodynamic and renewable energy.

The Capstone Project:

The study of renewable energy resources[2] for the generation of electric power or thermal energy can best be fostered in engineering students if they are exposed to these technologies as undergraduates. Universities across the country have severe restrictions on their capital with the consequence that their investment in the initial cost as well as the maintenance of renewable energy systems. As a "next best substitute" to actually owning and operating many renewable energy systems on university property, it may be financially more prudent to create an "Energy Center" at a university where data can be continuously recorded. Through the Energy Center it would be possible to "call up" any available renewable energy site throughout the world and examine their data that has been transmitted through the web. The data collected can be stored on the university's server to be eventually used by students as well as faculty researchers; particularly those who are interested in the thermodynamics of in-use, applied energy systems.

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efficient, environmentally benign non-nuclear fission and non-fossil fuel means of generating base-load electricity, competitive in price with today's fossil fuels"

[2] A renewable energy is defined as an energy source that continues to be replenished at an equal or greater rate than its rate of use and without adverse effects on the environment. Solar, wind, tidal, wave, geothermal, hydroelectric are examples of such renewable energy resources. Although not renewable in the strictest sense, for the purpose of the capstone project the use of bio-fuels including anaerobic, aerobic digester, landfill gas, and municipal waste may be considered as a viable alternative fuel that can be recorded in the database for later analysis by the students assuming that these sites are already streaming this data to the World Wide Web.

For example, a wind turbine renewable energy site is likely to already have an anemometer and turbine-generator power (kw) transducers installed on their systems. Even if this limited data were collected via the Internet, stored on the university server and analyzed by the student/researcher, the following thermodynamic results could be obtained with only two data inputs:[3]

1. Power (kw) generated vs. time (minutes, hours, days, etc.)
2. Wind speed (ft./sec.) vs. time (minutes, hours, days, etc.)
3. Wind turbine efficiency vs. time (minutes, hours, days, etc.)
4. Wind turbine availability vs. time (minutes, hours, days, etc.)
5. Instantaneous available energy (kWh) vs. time (minutes, hours, days, etc.)
6. Off-set cost of the power generated vs. time (minutes, hours, days, etc.)
7. The Maintenance cost vs. time (minutes, hours, days, etc.)
8. Instantaneous R.O.I. vs. time (minutes, hours, days, etc.)
9. Wind turbine blade feathered time vs. time (minutes, hours, days, etc.)

Detailed Description of the Database Design

The purpose of the Energy Center site

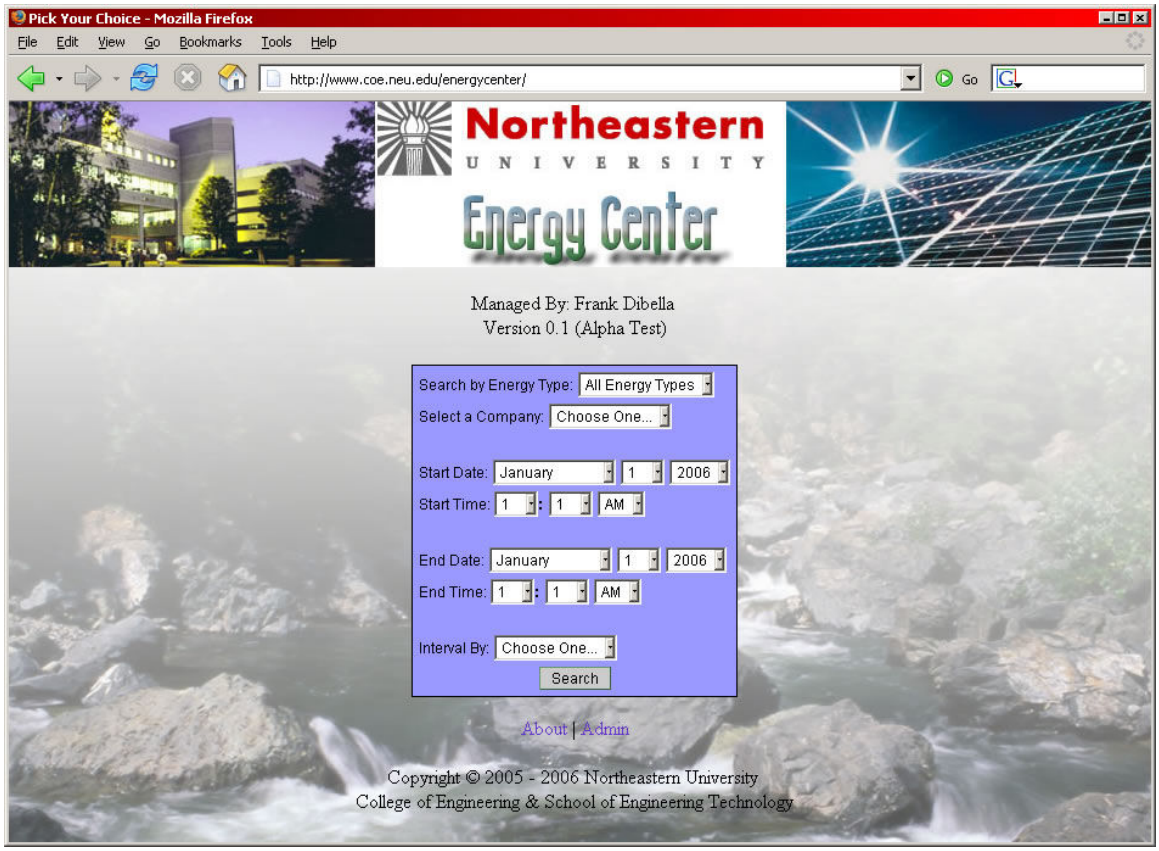
There is a demand for innovative technologies that provide renewable energy. The purpose of our website is to supply a means by which students and professors (researchers) are able to collect data at relative intervals from various renewable energy centers so analysis can be performed.

We designed a computer-based program that will collect data from various renewable energy centers from around the world/nationally to be sorted and stored within a database. A front end user interface was designed so that it would be easy to use. The original design was to create a central local area network that would run off of a main server. The students would login to the computer and start a session. They would then record data from a start to a finish time and then perform analysis of the data acquired. Our group decided to alter this design to create a web-based front end so students and researchers would not be confined to the lab. We also decided to constantly record the data to relieve the researchers of the task of recording the data themselves, managing accounts, and limiting this data accessibility only to students at the university or in a particular class.

The User Interface

Below, (in Figure 1) is a screen shot of the main page using Mozilla Firefox Web Browser. Here an individual has the opportunity to select different types of search options.

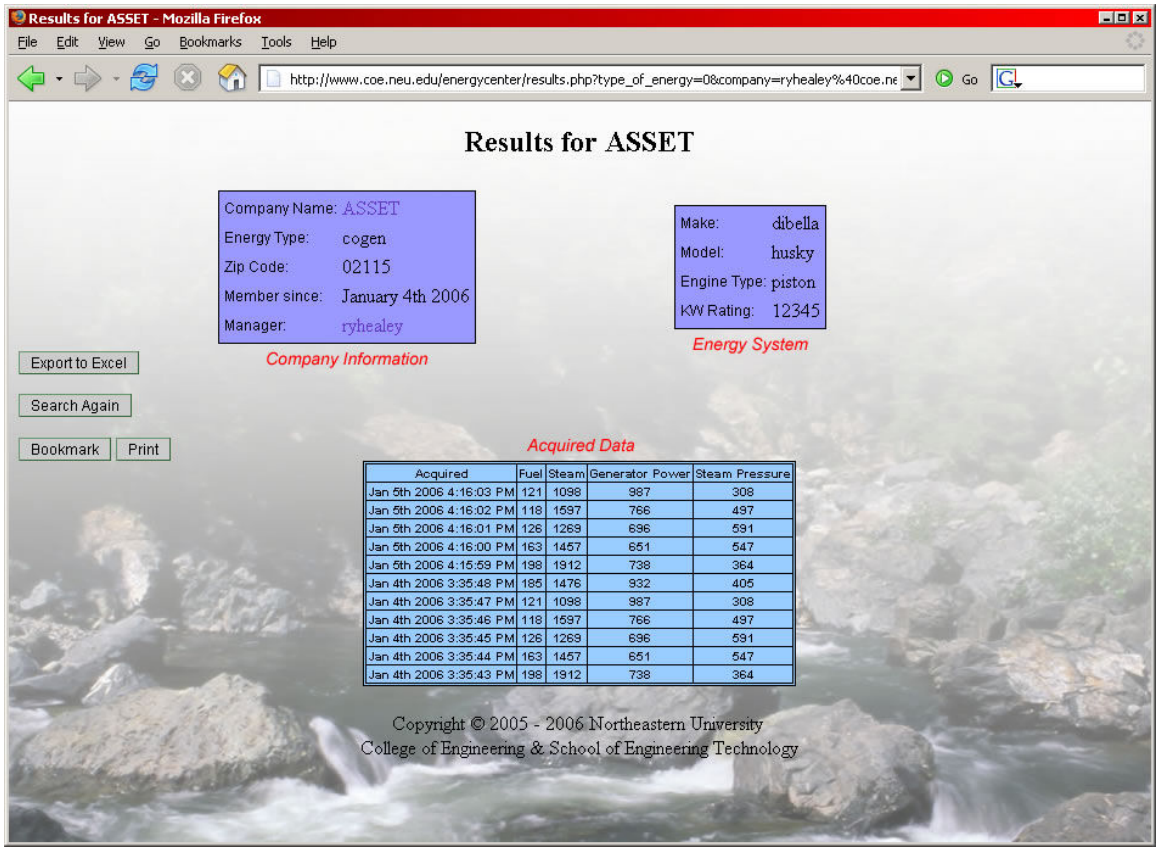
[3] It is assumed that the site's prime mover information has been acquired. This includes such data as: model number, blade diameter, pedestal height, design power rating, max. tip speed, and manufacturer's location and contact numbers.



The researcher is able to search by different Energy Types such as Cogen, Solar Light, Solar Hot water, Tidal, Hydroelectric, Wind, or a search of All Energy Types. Based on which "Energy Type" is selected, the page will limit the choices in the "Select a Company" box to only the companies providing that Energy Type.

The next step is to choose a "Start Date" and a "Start Time" followed by an "End Date" and an "End Time". The page is designed to only allow inputs of valid dates and times. This is sufficient to display all records between the "Start Date & Time" and the "End Date & Time" however an individual has the option of selecting the intervals at which the records are displayed. For example, if an individual selects a "Start Date" and an "End Date" that is a year apart and those records are recorded every minute, the results would include every minute recorded within that year, which may be more records than necessary. The "Interval By" box allows the researcher to limit his results to the interval of his choice such as per day or per month.

When the researcher has selected his options, he clicks "Search" to bring up a results page. (displayed in figure 2 below)

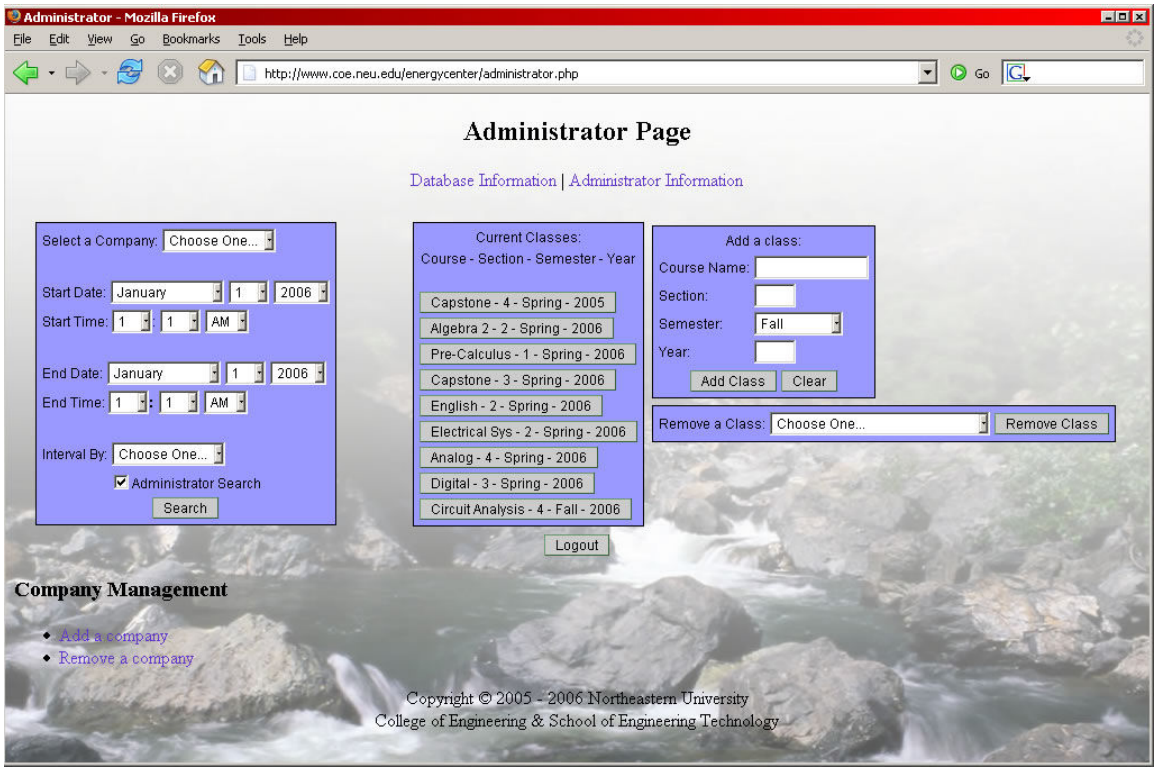


The results page displays the company information. Clicking on the company name will take the researcher to the website of that company. Clicking on the Manager's name will conveniently generate an email automatically addressed to the company's contact person should further information be needed. The energy system utilized will also be displayed along with information pertinent to that system. The acquired data can be exported into Microsoft Excel and saved to your computer with the click of a button. The results page can also be bookmarked and referred to at another time. The "Search Again" button on the left will bring you back to the main page.

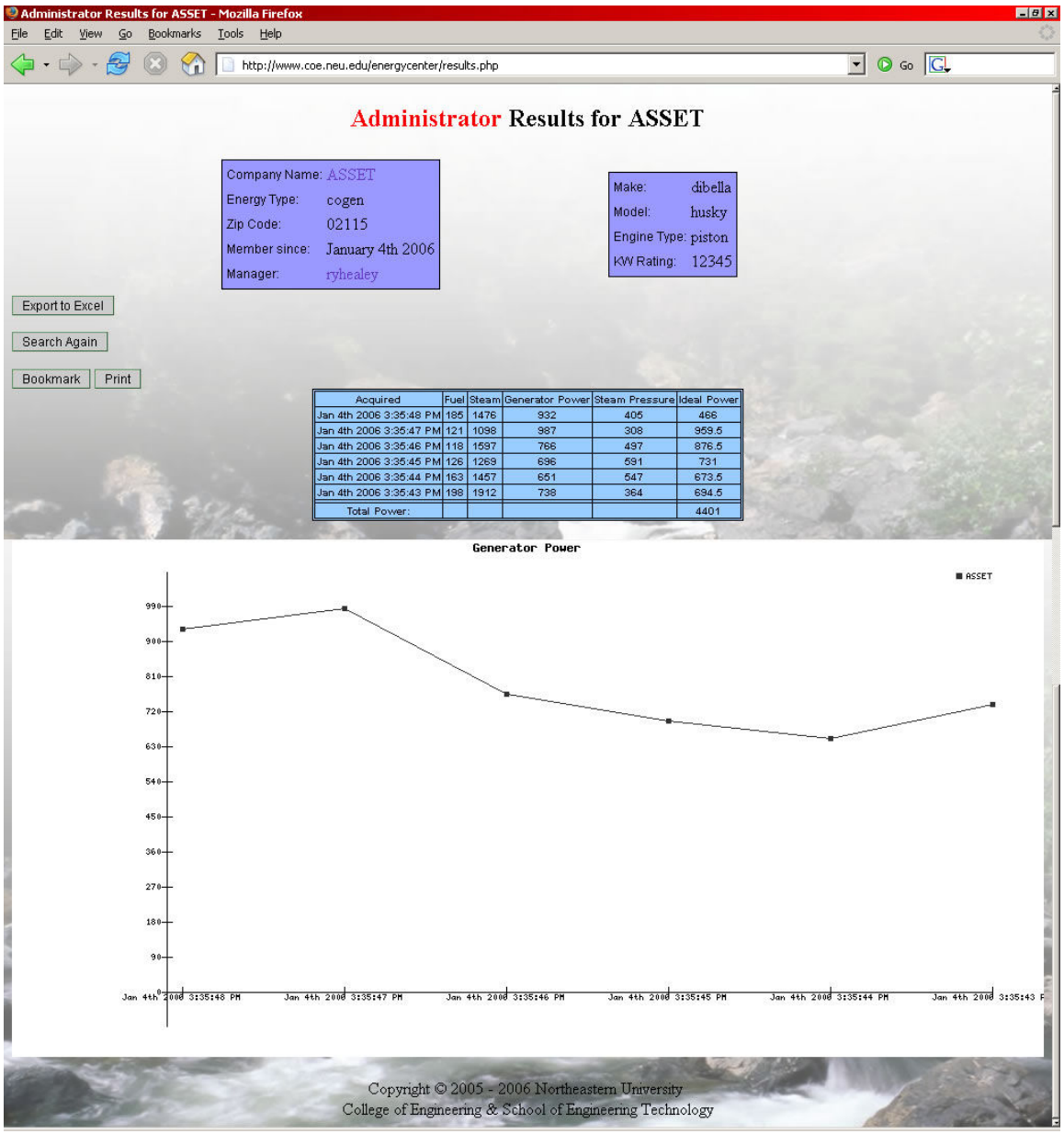
On the main page you will notice an "About" link that will bring up the page that provides detailed information about our Website Requirements with links to where you can download free programs or purchase others. The languages and software used to create this site are also listed along with the authors and additional detailed documentation.

The Administrator Page

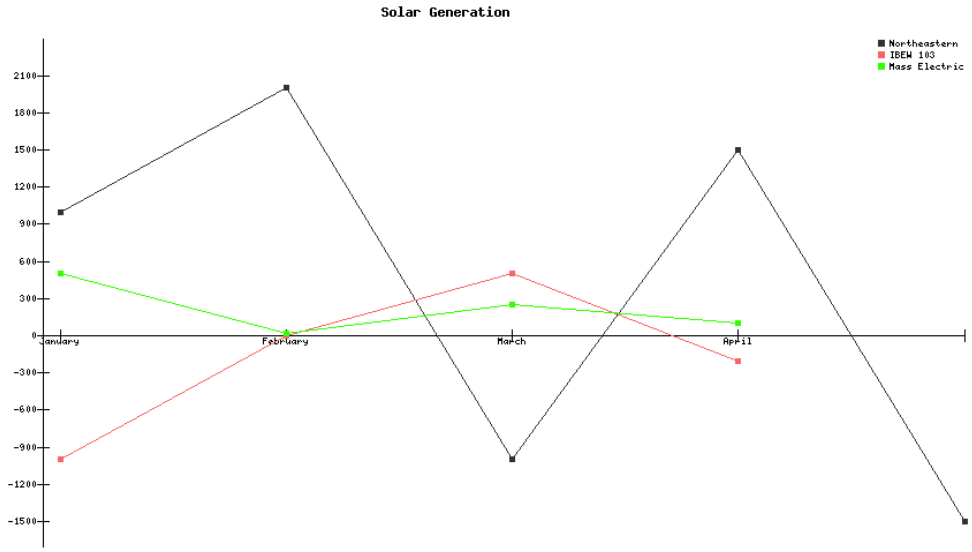
The Administrator of our site uses the "Admin" link to take him to his "Login" page. Currently the Administrator Page provides Database and Server Information that allows the administrator to monitor real-time connections to the database along with total network traffic. The administrator has the ability to change his password and add/remove companies. Included is a feature that allows him to keep an electronic Rolodex of the students in his individual classes enabling him to easily email or contact his students telephonically. This is one of many convenient tools currently under development.



Another feature provided to the Administrator is the "Administrator Search" check box. Unchecked, the administrator is able to access the search afforded by the main page without logging out. When the "Administrator Search" is checked, a secure page is displayed to provide him with instantaneous calculations and a graph of the results.

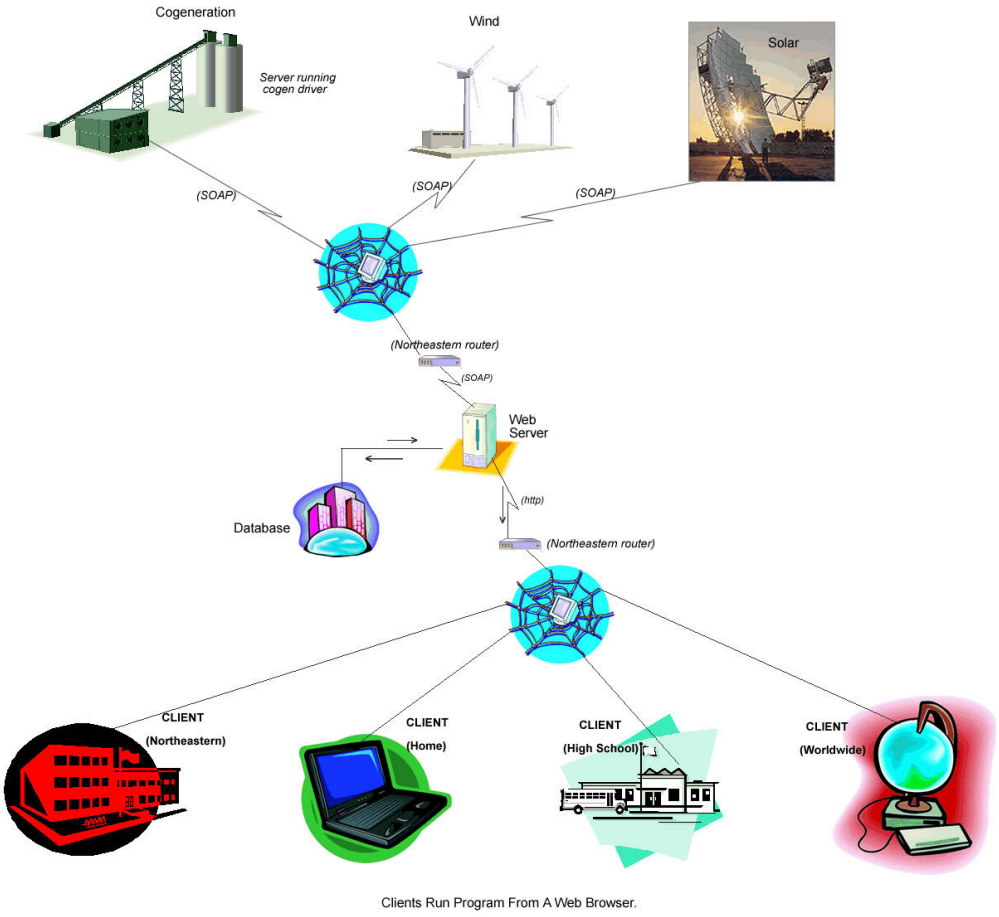


These calculations include for example, the area under the curve and ideal power, along with a graph that can be either printed or saved as an image to be emailed or inserted into a report. Comparative records can easily be displayed.



Laboratory Design

We have a central web server in which the program is located along with the database. Companies (or in networking terms "Clients") would transmit their data to our server via the internet. This data will be sent out at preset intervals. The design of our network is described below.



Clients Run Program From A Web Browser.

The companies transmit their data to our server using a small program that we developed. This small program, commonly referred to as a driver, is non-invasive and runs quietly in the background. The driver is packaged with three files, and when compiled consists of only two files. The packaged driver will consist a precompiled .dll (Dynamic Link Library) and an un-compiled source and header file. The source file will have a skeleton of six functions calls that the company's programmer can use. The functions are defined in the .dll. The company's programmer would then add the code necessary to collect data from their site and pass the data to our functions. When the programmer has finished, he will compile the source file, which will create an .exe (executable). The .exe will be placed together with the .dll and will run quietly in the background sending us data. The purpose for this design is to give each individual company complete control over their .exe; our functions will remain separate and therefore protected within our .dll. In summary, the driver translates the data into an expected readable form and also sends the data to our server.

The reason the source code to the .exe will be provided is each company's data acquisition system is unique therefore; the driver would need to be unique. This design is intended to provide the company with the level of security necessary to run the program since they have total control over it. Programs only do what they are coded to do. From our perspective, all we are getting is the data; we have no idea of how the .exe is running.

Progress to date

The work to complete the web site and to provide a first host site continues. It has been found that data acquisition systems that can communicate with a PC is not uncommon but that a common protocol "handshake" that is programmed by all of the reputable data acquisition manufacturers is not available. The student steam has focused on one supplier and the team is in the process of installing this system into a volunteer (first) host site.

A summary of the comparisons between the Energy Center hardware and software and "other systems" that are commercially available is shown in the table below.

Comparisons

Other Products | Energy Center

• Telephone	• Internet
• Dialup Modem	• Ethernet/Wireless
• Analog	• Digital
• Non-Standard	• Standard
• Unique Program	• Common Program
• Collecting data once a day	• Collecting data every minute.
• No Visual Diagram	• Visual Graph
• Campbell CR10 (Analog/Dialup) $800-$3,000	• ONEMeter - Brand Electronics $250-$450
• -	• Free monitoring
• -	• Free Bug/Security Patches

Conclusion:
This Capstone project, which is in progress as of this writing, will have accomplished two major objectives. The first is the fact that the prototype program will provide the School of Engineering Technology curriculum with a means of monitoring data from any number of sites throughout the country and the world. This data will serve to provide the thermodynamics student as well as the serious researcher with real data as to how a specific renewable energy system is performing; its efficiency, availability, power output per area, etc. The second major objective that has been achieved is no less important: a team of computer and electrical engineering technology students have confidently responded to and committed themselves to the challenge of creatively produce a "real-world" programming tool that meets a customer's (i.e. the instructor and future thermodynamics student's) specification while requiring the team to communicate the results via written and verbal communications.

Summary of Features

1. System can be used as an educational tool in thermodynamics and renewable energy.
2. Provides a search engine where a user can:
   - Search by an Energy Type.
   - Search a company name.
   - Search a specific Date and Time.
3. The searched results can be exported and saved into Excel with a click of a button.
4. The administrator has a list of additional features:
   - A secure login that provides access to an administrator search. The search will produce the same results as the normal search but will perform additional calculations. (Such as area under a curve).
   - Plots a graph of results.
   - Add or remove company information.
   - An optional categorized address book.
   - Create a database backup.