Senior Design Project 7

CAES – Combined Compresses Air Energy Storage and Electric Power Generation System for Wind Applications

Needs Assessment and Project Scope

September 22, 2010

Group Members

Bryan Campbell

Timothy Davis

Ramon Melendez

Needs Assessment

Renewable and sustainable energy sources have become a major topic of interest with the depletion of oil and natural gas supplies. In addition, the need for cleaner and more efficient energy processes are becoming increasingly apparent. Wind energy is an obvious choice when searching for sustainable and environmentally friendly energy sources. However, there currently lacks an efficient means of storing renewable wind energy for later use. Our project is to design a more efficient means of harnessing surplus wind energy by compressing air, storing it, and defining its later use.

Project Scope

Project Statement

The problem this project will address will be storing surplus wind energy by using wind turbines to compress air at the highest efficiency possible. The compressed air will be stored in a pressure vessel and its later use will be defined for the most efficient means achievable.

Objective

The focus of this project is to identify the need for coupling wind turbines with Combined Air Energy Storage (CAES) systems. We will construct and design a system driven by wind turbines and a power generation unit to convert energy to electric power. Analysis will be done on the system performance, efficiency and energy balance. This will be done while keeping the cost and scalability of the system at a minimum while keeping efficiency high.

Justification/Background

With the current energy crisis at hand there has been a lot of discussion on renewable energy and how to harvest energy efficiently. Among the most popular and most talked about forms of renewable energy are Solar and Wind Energy. Both have advantages and disadvantages that make harvesting their energy a hassle. Solar is often not reliable enough during daytime due to cloud cover and weather. The advantage is that solar panels can be placed almost anywhere there is sunlight without a dramatic effect on the aesthetics of the rest of the environment around it. Wind energy, on the other hand, produces more electricity which is better for production and, if conditions warrant, can run even when the sun is not shining. Wind energy does require more land usage, and often times a new structure in the environment must be created. Often when there is enough wind to be harvested for energy, the electricity produced is not needed due to off peak hours. This is where storing the energy becomes crucial.

There are various forms of storing energy which include, but not limited to, batteries, flywheels, capacitors, springs, and compressed air. This project is focused on compressed air. Compressed air has a very broad range of uses where the other storage types are seemingly limited. Compressed air is used in machine shops, chemical plants, power plants, paper mills, pharmaceuticals, drilling and construction as well as many more industries. There is surely a reliable and continuous market for compressed air.

This is where the Compressed Air Energy Storage (CAES) system has attained most of its attention. However, compressing air to a higher pressure is often times one of the least efficient processes in engineering. The efficiency can be made better or worse by scaling the dimensions of the compressor and pressure vessel. CAES can be used for power plants to increase the efficiency of existing gas turbines by supplying the compressed air. Or CAES can be used by a company that is currently using electricity to compress its air and use wind turbines to compress the air instead. This in turn will reduce the company's power usage.

Current CAES systems use abandoned salt mines or natural caverns to store the compressed air. This is done at the only CAES plant in the United States. The methods of compression vary. In the Alabama plant, they use gas turbines to compress the air into the cavern during off peak hours. However, our system will be powered by wind turbines.

Methodology

In order to complete the project of creating and testing a compressed air energy storage system, an extensive amount of background research must first be completed. This research will cover several different topics, all of which are extremely important for understanding how this system will function. First, different types of compressors will have to be analyzed to determine which will provide the greatest efficiency within the system. Next storage devices such as pressure vessels will need to be researched to decide what size will be appropriate along with a review of how to calculate the pressure storage capabilities of a pressure vessel. Third, a study of wind energy systems will need to be completed to determine the amount of energy that will be available to power the compressor. Finally, research covering how the compressed air energy will be used. This will specifically cover the topics of creating electricity from compressed air through use of turbines and systems that currently use compressed air as their primary source of energy.

Once the background research process is completed, the system components will need to be ranked to determine which provides the attributes that are desired. The primary concern will be the efficiency of the entire system. Cost, scalability, and life expectancy are also important aspects that will be considered. Once each of the components has been ranked and the best solutions are determined, the design will need to be drafted with help from the

industry sponsors. Once the design has been decided upon it will be built on a small scale to allow testing of the efficiencies within the system. These efficiencies will then be analyzed to provide results on the systems relevancy as an energy storage device.

Expected Results

Upon completion of this project, a well designed working compressed air energy storage system should be created. This system will take mechanical energy created by a wind turbine, store the energy as compressed air, and then use the harnessed energy in an effective way. This system needs to be efficient in order to be effective so that as much energy as possible can be used.

Constraints

Creating and testing the compressed air energy storage system will require that several constraints are taken into account during the process. Time will be a consistent aspect that will require a rigorous time line for deliverables as there is less than a year to design, create, test, and analyze the product. The scalability of the system will be important as this device should be able to be sized up or down to allow it to be used in many different applications. Efficiency of the system is the most important constraint, as this system needs to be a viable option for renewable energy storage. Balancing efficiency with budget will be a huge constraint within this design as we have a fixed budget. Finally safety of the device will continuously be a concern, especially considering that air will be compressed to high pressures, stored, and used possibly in high speed gas turbines.