NSF Community College Innovation Challenge: Innovations at the Nexus of Food, Energy and Water Systems

Palm Beach State College: The Renewable Energy Club: Team Florida Power Tech:

Water-Energy Nexus

Problem:

Water is an outstanding resource that is utilized by all live beings on Earth. Plants, animals and humans all share its needs of water for survival. Humans also use it for leisurely activities. It is also used in many industrial fields, and is an essential aspect of power production. Using primarily gas and steam cycles for power production, power industry is able to provide millions of homes with electricity, but it requires large amount of water for cooling part of the steam cycle. We conducted a case study of two local power plants, Martin County Power Plant (MCPP), located in Indiantown Florida, and West County Power Plant (WCPP), located in Loxahatchee Florida. MCPP is a hybrid of three different types of power generators: two single cycle steam turbines, eight combined cycle gas/steam turbines, and a field of solar thermal parabolic system. The power plant produces an estimated 28,000,000MWh per year, enough energy to provide for hundreds of thousands of homes. In order to provide enough water to cool each system, the power plant utilizes an artificial pond as a source of water. It withdraws 915 million gallons a day for once-through single cycle steam turbines cooling towers, and recirculates 280,000gpm for combined cycle turbines recirculating cooling towers. An estimated 75% of cooling water is lost to evaporation yearly and needs to be replenished. WCPP utilizes 3 combined cycle gas/steam turbines, producing 33,000,000MWh per year. It uses a similar cooling system as MCPP, withdrawing 13 million gallons a day from an underground aquifer.

Solution:

We propose two-step solution where the first step is immediately technically and economically feasible, while the second step requires technological breakthroughs. First step solves the sourcing of cooling water, reduces evaporation losses, and reduces cooling water needs. For this, rainfall, so plentiful in South Florida's wet climate, is collected and used as source of cooling water. The average rainfall is 53.45"/year, and with MCPP area being about 1.15 square miles, we would be able to collect over 1 billion gallons of water a year, and 300 million gallons at WCPP 220 acre area. To reduce evaporation from cooling pond at MCPP, we use pontoon system of floating solar panels. Covering the pond's surface will significantly reduce evaporation and conserve collected rainfall for cooling needs. Power generated by floating PV array will be used to power cooling fans as well as to power dry cooling tower inserted immediately after the turbine and before wet cooling tower. Dry cooling tower requires a lot of electricity for fans (solved by solar array), cools the steam, and therefore requires less heat exchange and less water in wet cooling tower. Hybrid cooling systems accomplishes all of our objectives. This first step would significantly improve energy-water efficiency at an acceptable cost. Second step requires new materials that would be used to construct very large, lightweight and wind resistant dome over cooling towers: it would allow air circulation for cooling but would condense evaporation and collect it at the bottom, thus further reducing water losses.

Impacts and benefits:

The main benefit of our proposed system is the reduction of a significant amount of water used by power plants. By implementing proposed solutions and developing new technologies, a great portion of water would serve other purposes, putting less strain on the local environment. The cooling pond used by the MCPP has an area of over 10 square miles. The power plant loses millions of gallons of this water every day due to evaporation. If the amount of water the power plant uses could be reduced, more water would be allowed to stay in the local environment and natural areas. The implementation of this product would also result in an increased availability of water for human consumption. Although South Florida does not currently have a shortage of water, it is possible that an increase in the region's population would put a larger amount of stress on our water supply. Decreasing the amount of water we use in today's power plants will ensure that Florida has a plentiful water supply for many years to come. The balance of this saved water could be used in restoration of South Florida's largest natural resource: Everglades National Park, allowing for improved conditions of native flora and fauna. Using solar array for power plant's own electricity needs uses clean, non-polluting and non-water requiring technology to solve this issue. All aspects of South Florida's society would benefit: improved natural areas bring more tourists, more water stays in aquifer for future population increases, and more electricity is produced with less impact on environment.

Involvement of Community Partner:

South Florida's coastal area is densely populated with high population growth, steadily increasing the demand on both water and energy resources. At the same time, the inland portions of South Florida are used either by agriculture industry or are protected nature reserves for wildlife. Both require steady supply of water. This varied overlapped community of population, industry, agriculture, utility and conservationist has one thing in common: ever increasing demands on water and energy that need to be satisfied by steady or shrinking resources. These conflicting constraints can only be satisfied by new approaches where we can lower our demands on water resources while maintaining our energy production. The utility company was our business partner identifying potential ways of looking at and solving the problems, providing detailed data on water usage and power production in their power plants. Our community, represented by general citizens, nature lovers, agricultural and industrial businesses, agrees on a need for a better-balanced ecosystem that ultimately benefits all the stakeholders. The water usage savings benefit utility through lower water cost and better community and social image; benefit existing and future population through higher existence of drinking water; benefit industry and agriculture through removal of competition for water with power utility; and finally benefit conservationist and nature lovers through allowing more water for the wetlands thus allowing more birds, mammals, and flora to thrive.

Name: Joshua Peralta

Major: Electrical Engineering

About: I am a second year student looking to transfer to FAU and the President of Palm Beach State's *Renewable Energy Club*. I have a strong background in physics, circuitry, and mathematics. I am also experienced in various instrumentation including DMM's and Oscilloscopes.

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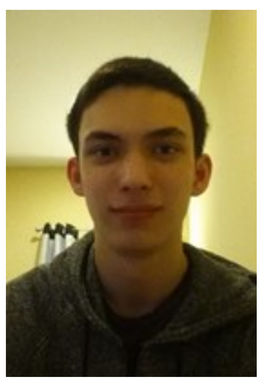

Name: Shawn Kasinger

Major: Electrical Power Technology

About: I'm a second year student in the Electrical Power Technology Program and Vice President of Palm Beach State's *Renewable Energy Club.* I have had hands-on experience working with circuits, microprocessors, and Programmable Logic Controllers. Some of my interests are electronics and digital circuits.

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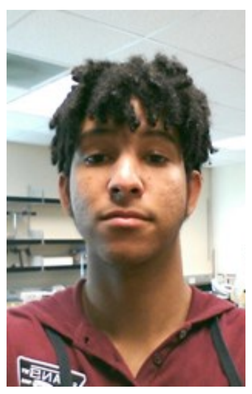

Name: Jhon-Paul Singh

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About: I am a student of in the Electrical Power Technology Program and Secretary of Palm Beach State's *Renewable Energy Club*. I have a large amount of experience working hands on with electronics, particularly in the field of alternative energy.

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