Mechanical Systems Proposal
Hydrogen Generation & Hydrogen Fueled Cogeneration

(Rendering Courtesy of Clark-Nexsen)

William & Mary
Virginia Institute of Marine Science
Marine Research Building Complex
Seawater Research Laboratory

Gloucester Point, VA

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Mechanical Option
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1.0 Executive Summary

This is a proposal for the redesign of the VIMS Seawater research Laboratory's mechanical systems. This proposal used the information about the existing mechanical system, which was presented in the previous technical reports as a basis for the redesign.

The proposed use of hydrogen generation to power and heat the VIMS Seawater Research Laboratory reduces the cost of the energy consumed with out redesigning a mechanical system or process that could affect the laboratory processes that occur within the building. Also the use of hydrogen generation reduces the emissions that are created by the consumption of energy to almost nothing.

This proposal does not imply that there are flaws and errors in the current building and building systems design. This proposal merely suggests improvements to better the building and its surroundings.

The process that is proposed is a prototype of how a building is powered and operated, and if proven functional and feasible it would soon become part of the DOE's Hydrogen Program's goal of a hydrogen economy. This redesign is involving new technologies that are currently being developed to eliminate the U.S. dependency on oil. Also, this redesign will add great educational value and allow me to increase my knowledge and understanding of mechanical systems and the new equipment that is being developed for these systems.

2.0 Overview of Existing Mechanical Systems

Heating System

The heating source of the VIMS Seawater Research Laboratory is tow propane gas-fired modular hot water boilers located in the mechanical room. Both boilers provide a 1760 MBtuH net IBR heating capacity for all space and ventilation air heating requirements, and to also raise seawater at 100 gpm by 10°F.

Cooling System

The VIMS Seawater Research Laboratory's cooling source is two 105 Ton air cooled screw compressor water chillers located outside the mechanical room. The chillers are sized to provide cooling to lower seawater at 100 gpm by 10°F, and to serve the cooling coils of AHU-1 and AHU-1.

Ventilation System

The VIMS Seawater Research Laboratory is ventilated with two variable air volume air handling units and four variable air volume make-up air units. All of the units are located on the roof. The two air handling units serve the administration and wet lab areas, and the four make-up air units serve the remaining lab spaces. AHU-1 utilizes an air to air coil energy recovery loop that extracts heat energy from the exhaust air stream of EF-4A and EF-4B to either preheat or precool the intake air. All of the units provide 100% outdoor air to all of the building spaces.

Exhaust System

The exhaust system of the VIMS Seawater Research Laboratory requires the use of eight exhaust fans and two fume hood exhaust fans, and five relief hoods, all of which are located on the roof. The two fume hood exhaust fans are staged so that one is operating and the other is on standby. The other exhaust fans and relief hoods are used to control the pressure of the spaces preventing any air transfer to another space.

3.0 Items of Redesign

The following are aspects of the VIMS Seawater Research Laboratory that are able to be improved upon justifying my proposed work of my thesis.

The VIMS Seawater Research Laboratory is ventilated with 100% outdoor air. Cooling and heating of 100% outdoor air requires more energy due to the fact that there is no energy retained, latent or sensible, from the building as there is with recirculated air systems.

There is an air to air coil energy recovery loop that is utilized by AHU-1, but that can only recover some of the sensible energy that is leaving the building in the exhaust air. An energy wheel cannot be used because of the quality of the exhaust air. The exhaust air contains potentially dangerous vapors so there can't be any possibility that the exhaust air can mike with the supply air.

The laboratory processes require more energy than that which is required by the mechanical systems. These laboratory processes require the use of seawater which is pumped up from the York River travel a distance over 600 feet, ozone to be generated to clean incoming water from the domestic service and then the ozone has to be destructed to prevent any danger to the environment. These are just a few of the process that are required for the laboratory spaces.

Another reason of wasted energy is that there cannot be any air transfer between any of the spaces of the VIMS Seawater Research Laboratory. This causes the use of more fans for both supply and exhaust to maintain the pressure level of each space. Although the fans utilize variable speed drives, the conditioned outdoor air is sometimes exhausted out before it is used to manage the thermal loads.

Exhaust fume hoods also require more energy to be consumed, because they need to exhaust large quantities of contaminated air. These exhaust fume hoods are necessary to maintain indoor air quality.

The projected annual cost of operation of the mechanical systems and the laboratory processes of the VIMS Seawater Research Laboratory as calculated by Carrier's HAPv4.2 and as stated in *Technical Report #2 Building & Energy Analysis Repor*t is $4.928 million, which is over half of the initial cost of the building itself. A reason for this high annual energy cost is that the laboratories use process heating and cooling.

Energy recovery is used in the VIMS Seawater Research Laboratory but, do to the nature of the building, sensible energy recovery has a limited effectiveness. Another potential solution is to use the York River as a heat sink for the cooling system and to utilize water source heat pumps for the heating system. This solution could potentially alter the environment of the York River and also the temperature of the seawater that is used in the experiments, also it still requires the majority of the energy to be purchased electricity and propane natural gas. Also the building will still have emissions that are harmful to the surrounding environment. Propane was selected as the fuel for the heating source because it burns cleaner than oil, its storage is safer than oil, and also it utilizes an existing propane delivery contract.

4.0 Proposed Redesign Solutions

The proposed redesign solutions are directly related to the items of redesign mentioned in the previous section. The main goals of this redesign solution are to provide the VIMS Seawater Research Laboratory with the cleanest and cheapest energy possible.

To improve, if not eliminate, the issues mentioned in the previous section, I propose to explore the applicability of generating hydrogen by the electrolysis of seawater that is powered by tidal generators located at the base of the piles supporting the pier that extends out into the York River, also being constructed during this project.

There are two applications for this proposed system. The first possible application is to use the generated hydrogen to fuel a cogeneration system. Some considerations that are involved with this system are electrical systems demand loads, generator type which will most likely be a gas turbine, noise generated by the generator, size of the generator both physical and output capacity, and amount of heat that is generated. The second possible application is to over size the tidal generators. By doing this the tidal generators will provide the VIMS Seawater Research Laboratory with electricity and to use the excess electricity to power the electrolysis reaction to generate hydrogen that will be burned either by itself or mixed with a low concentration of propane gas. Deciding on the choice to mix the hydrogen with propane gas or not will depend on the availability of the equipment that can handle hydrogen as a fuel source.

If the second application is chosen then there will need to be improvements on the energy consumption of the VIMS Seawater Research laboratory. One option that is available is to use the York River as a heat sink for the cooling systems and the use of water source heat pumps for the heating system. If this option is to be used then the environmental impact of the potential slight change in the water temperature of the York River will need to be explored.

Factors that are involved with the hydrogen generation process are the voltage and current that allows for the most efficient electrolysis reaction, the proper electrodes are used so that the electrolysis of the seawater doesn't produce chlorine or any other potentially dangerous gas, and that the electrodes will produce the most efficient electrolysis reaction. Currently the most efficient electrolysis reaction has an efficiency of 70%.

The application that is chosen is going to be driven by the depth and flow of the York River. This is what determines the size of the tidal generators, which determines the amount and rate at which the electricity will be generated. Another factor will be the amount of space that is available for the equipment that is required for the different applications.

This solution will greatly reduce the cost of the energy consumed and also practically eliminate the emissions that are generated by the VIMS Seawater Research laboratory.

5.0 Breath Topics

The proposed breadth redesign includes the acoustical analysis of the redesign process, the effects on the electrical system, as well as the cost of the additional equipment and the payback of the system from the savings of the purchased energy.

The use of a generator increases the amount of noise that is generated. An analysis will need to be doe to see if the surrounding neighborhood will be affected by the added noise, as well as, the potential treatments or solutions to the noise problem if it exists.

An analysis of the electrical system will need to be done to see if the demand loads can be reduced to allow for the use of a smaller generator and tidal generators. This is done to keep the overall cost of the additional equipment down.

A feasibility study will need to be done to validate the potential of using this system. The more efficient hydrogen generation technology is currently being developed, which cheap. However, the government through the Department of Energy's Hydrogen Program could potentially provide assistance in making the newer technologies affordable. Also, the payback period due to the savings in cost of the energy consumption of the initial cost would be needed.

This process is a prototype of how a building is powered and operated, and if proven functional and feasible it would soon become part of the DOE's Hydrogen Program's goal of a hydrogen economy.

6.0Tools and Methods to Be Used

Research will be done through various references to find available standards, calculation procedures, and possibly analysis software. Most references will be found through DOE's Hydrogen Program online. Other general references will be the ASHRAE Standards 62.1 and 90.1, NFPA, and IBC.

Excel spreadsheets will be used to calculate and size the generator and the tidal generators, as well as the electrolysis process. The Energy-10 program will be used to analyze and compare the different applications of the hydrogen generation process. The acoustic analysis will be done using Excel spreadsheets. The feasibility analysis will be done using Cost Works.

Other items that will be referenced are the comment and responses of the VE Study performed during the design, equipment catalogs, and actual building operating conditions once the building construction is completed which is projected to be in February.

7.0 Schedule

Task	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12	WEEK 13	WEEK 14
Organize and Confirm Schedule	■								Spring Break					
Faculty Consultantions	■	■	■	■	■	■	■	■		■	■	■	■	■
CPEP Maintenance	■	■	■	■	■	■	■	■		■	■	■	■	■
Research Characteristics of the York River	■	■												
Research Tidal Generators			■											
Research Hydrogen Generation				■	■									
Analysis of Energy Generated					■									
Analysis of the Electrical System						■								
Research of Equipment that will reduce electrical loads						■	■							
Research & Analysis on using the York River as heating cooling source	■													
Selection of Application								■						
Research Hydrogen Distribution								■						
Selection of Equipment for Process										■				
Acoustic Analysis of Equipment										■				
Calculation of Feasiblility of the Process											■	■		
Final Report												■		
Presentation Generation												■	■	
Presentation														■

8.0 References

Minerals Management Service Renewable Energy and Alternate Use Program "Generation of Hydrogen and Transportation and Transmission of Energy Generated on the U.S. Outer Continental Shelf to Offshore"

U.S. DOE Hydrogen Program online: http://www.hydrogen.energy.gov