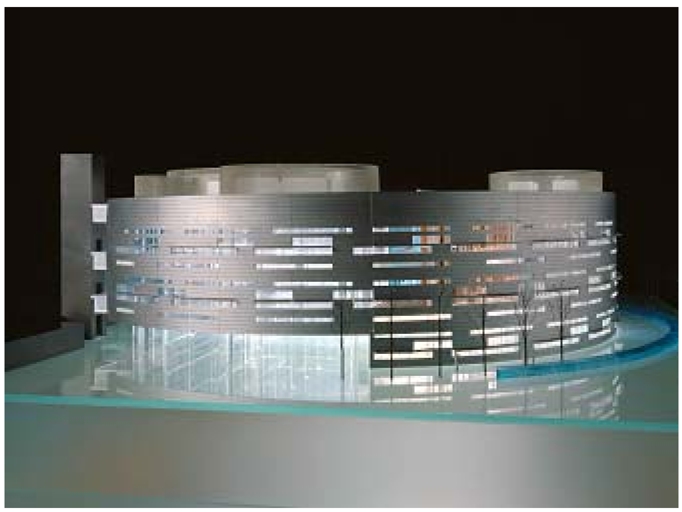
AE 482 Project Proposal

Building Mechanical & Energy Systems Option



Hauptman-Woodward Medical Research Institute
Buffalo, New York

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Mechanical Option

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Executive Summary

The Hauptman-Woodward Medical Research Institute is a 3 story, 73,000 square foot building which provides a full service biomedical research lab as well as supporting office and classroom spaces to the Buffalo-Niagara Medical Campus in Buffalo, New York. This report first discusses the design objectives and requirements to gain a better understanding of what dictated the current mechanical system design. At the Hauptman-Woodward Medical Research Institute, there were many factors which influenced building design. Energy sources and rates, mechanical equipment first costs, and maintenance costs were all considered in the design.

Once the design objectives were clearly stated, the report details the proposed ideas for the redesign of the mechanical system at the Hauptman-Woodward Medical Research Institute. After several alternatives were discussed, the proposed redesign, consisting of the implementation of a Dedicated Outdoor Air System is discussed. In addition, the feasibility of implementing a Water-Source Heat Pump System will also be determined. The primary reasons for implementing these systems were improved humidity control and decrease in energy consumption.

In addition to the depth portion of the thesis proposal, two breadth areas were also discussed. The first area to be discussed is the large lighting power density and the alternative light fixtures that can be implemented that will improve power density while preserving the architectural aesthetics and lighting levels required to suit the building function. This will have an effect on the electrical system and mechanical system due to reduced energy load. The second breadth topic is the feasibility of wind power to supplement the electrical grid. Although it would not be sufficient to power the building on its own, it would certainly be able to supplement the electrical system and cut down on energy costs. The location of Buffalo, New York between the Great Lakes makes it a prime area for wind power.

Finally, the solution methods, tools and preliminary research for the AE 482 Thesis project is discussed in detail for the depth and breadth areas. Trane Trace-700 and Carrier HAP will be used extensively for the redesign, in particular to determine operation costs and comparisons to the original design. In addition, lighting software such as AGI may have to be used to model indoor light scenarios to determine if particular lighting schemes will be better over others. At the conclusion of the report, a tentative schedule is provided for the duration of the spring semester, when the mechanical redesign will take place.

Design Objectives and Requirements

Project Information:

The Hauptman-Woodward Medical Research Institute is a 3 story, 73,000 square foot building which provides a full service biomedical research lab as well as supporting office and classroom spaces to the Buffalo-Niagara Medical Campus in Buffalo, New York. Not only does it serve as a center for research and development, the large atrium and classroom spaces make the Hauptman-Woodward Institute a prime gathering place for seminars and gatherings, as shown here in Figure I.

Figure I: Atrium at the Hauptman-Woodward Medical Research Institute

The Ellicott street entrance leads visitors to the grand atrium, where they can observe the scientific working environment as well as easily navigate to all areas of the facility. On the first floor, executive offices and the Board Room are found to the south. To the north is the main lecture/assembly hall, followed by several specialized laboratories, storage rooms and shipping and receiving for the facility.

Housed in the second floor atrium are the employee's lunchroom and kitchen, plus a large central area furnished with chairs and other seating for informal meetings. To the south are offices for scientists and study tables for students. To the north are the Crystal Growth Lab, a number of individual labs and central shared equipment and research support rooms.

The third floor atrium houses research library at HWI. To the north are additional cold rooms, laboratories, and shared research and support facilities. To the south are more offices for research scientists and technicians as well as additional areas for student research.

Basis of Design:

The main design objective at the Hauptman-Woodward Medical Research Institute is to provide a safe, accommodating atmosphere for improving human health through molecular studies of the causes and potential cures of many diseases. In contrast to clinical research, the focus of Hauptman-Woodward's basic research is to determine the structures of individual substances such as proteins that play a role in the development of specific diseases. In order to achieve this task, the Institute required a biomolecular research lab that would minimize outside contamination, in addition to office, library and classroom space that would support the program faculty, staff and students who frequent the facility on a daily basis. In addition to these strict requirements, the not-for-profit organization wanted to make an architectural design statement in the heart of downtown Buffalo, while at the same time reducing total building cost so that the focus of their efforts could be on research. One of the typical laboratory spaces within the finished building are shown in Figure II, below. As you can see, the laboratory overlooks the glass atrium, giving visitors a prime view of what's happening at the Institute.

Figure II: Typical Laboratory Space at HWI

Existing Mechanical Systems

Air Handling Units (AHU-1,2) with VAV Control

This 100% outdoor air system is by far the most complex system at the Hauptman-Woodward Medical Research Institute, consisting of 2 air handlers, each with pre and final filters, chilled water cooling coil, glycol preheat coil, glycol heat recovery coil, supply fans, and variable speed VAV control. The primary purpose of this system is to provide 58,000 cfm of conditioned air to the laboratory space. The system operates continuously to serve HVAC requirements at each individual zone. Scheduling is programmed on a zone by zone basis. The two units operate in parallel and serve a common supply duct. The units operate together, simultaneously varying temperature and airflow to meet SA requirements. The Supply air temperature is adjustable between 55^{O}F and 60^{O}F, however design dictates that 55^{O}F is the standard for sequence with the VAV terminals. Low temperature controllers provide freeze protection to the supply air fan when the air temperature drops before 53^{O}F. The SA fan is equipped with variable air volume control, which requires static pressure sensors to keep the flow rate at 1 inch WC.

Laboratory Heat Recovery Exhaust System

The laboratory general exhaust system consists of three exhaust fans that share a common intake plenum, and together provide 81,000 cfm removal of exhaust air. Velocity Sensors modulate air dampers in order to maintain 4,000 FPM velocity though the exhaust stack. The heat recovery system recovers heat from the general exhaust to preheat or pre-cool the incoming supply air. The system uses a single pump to circulate a 40% glycol solution between coils located in the exhaust and supply air streams. The pump is controlled via temperature sensor to operate continuously when the outside air is below 55^{O}F or above 80^{O}F. The system is equipped with a bypass in the event that the temperature drops below 10^{O}F to prevent freezing of the system.

Cooling Chilled Water System

As shown in Figure III, the chilled water system consists of an 300-ton air cooled water chiller and chilled water pumping system. The system supplies chilled water to the building in addition to serving the cooling coils located in AHU-1 and AHU-2. The system operates when the air outside is above 55°F and is monitored by temperature sensors. The chiller is set to maintain a constant 44°F chilled water supply. The pumping system is staged to run continuously when chilled water is needed. The system consists of 2 pumps, of which only one is needed. They are controlled automatically to alternate to maintain equal run time.

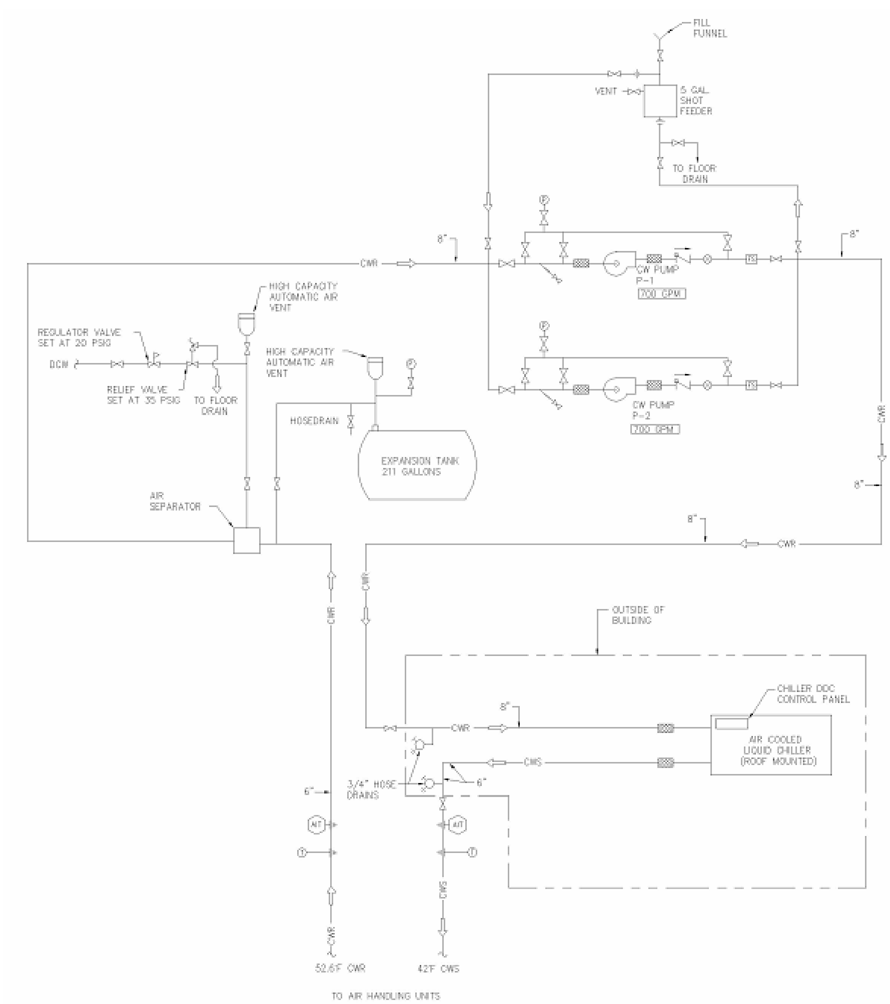

Figure III: Chiller Water System Loop

Hot Water Boiler Systems

The hot water and glycol heating systems each consist of three hot water boilers with dedicated hot water pumps, and a secondary pumping system, as shown in Figure IV. The system is DDC controlled and utilized electric actuation. Boilers are sequenced to equalize equipment runtime. Selection of the lead boiler will be evaluated on a weekly basis, with the boiler having the least runtime becoming the lead boiler.

For the hot water boiler system, the lead boiler shall start when the outdoor temperature drops below 65^{O}F. The lead boiler is sequenced to maintain the loop temperature at 190^{O}F. Should additional heating be required to maintain this temperature, the lag boilers will come online. Temperature sensors monitor loop temperature and dictate system operation.

The glycol hot water system operates in much the same way. When the outdoor air temperature drops below 55^{O}F, the lead boiler shall start. The lead boiler is sequenced to maintain the loop temperature at 190^{O}F. Again, should additional heating be required to maintain loop temperature, the lag boilers will be automatically enabled.

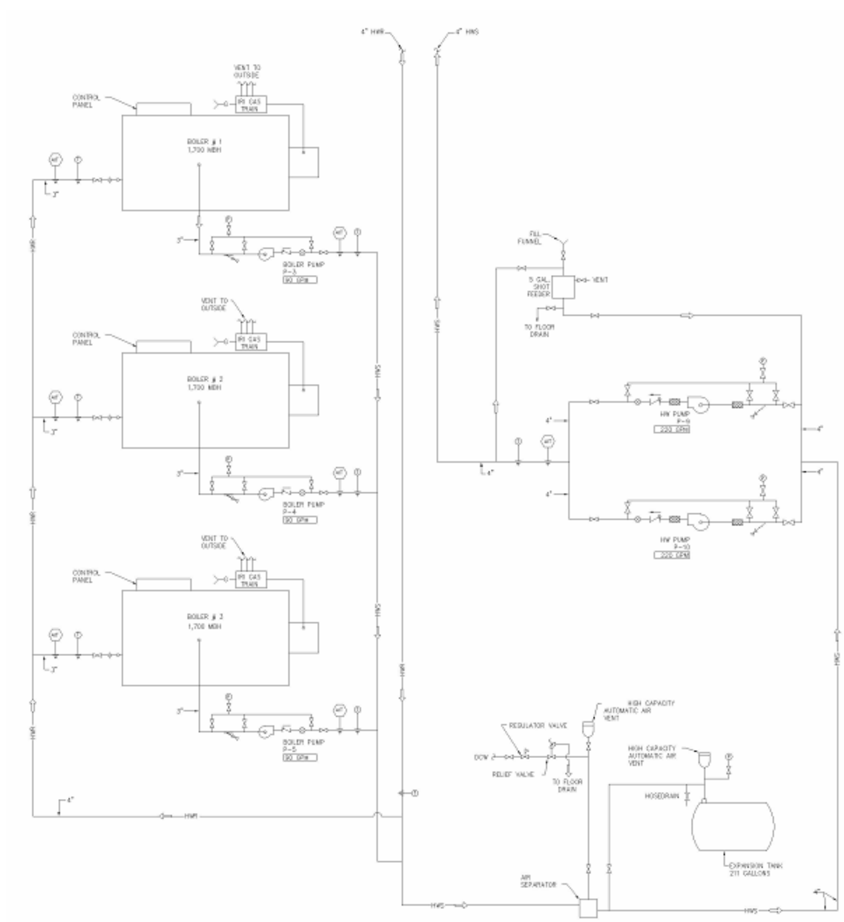

Figure IV: Hot Water System Loop

Rooftop Units (RTU-1,2) w/ VAV Control

The Hauptman-Woodward Medical Research Institute is equipped with two rooftop air handling units to supply conditioned air to the remaining areas of the building with the exception of the laboratory. Although they are significantly different in size, each provides operate under the same conditions, and are equipped with variable air volume control which are monitored by traverse fan inlet probes and static pressure sensors at supply and return fans. Heating is provided by natural gas and cooling is provided by DX cooling units, which maintain 55^{O}F supply air to each zone. VAV terminal reheat boxes are installed in each zone and space temperature sensors modulate the terminal unit supply air damper in sequence with the reheat coil to maintain space temperature. During occupied periods, the space shall be maintained at 72^{O}F, and when it is unoccupied, the system shall automatically maintain a minimum temperature of 55^{O}F. Each zone is supplied with a manual thermostat to adjust the temperature for comfort.

Penthouse Air Handling Unit (AHU-3)

The boiler make-up air unit is set up to run continuously and provide fresh air to the mechanical penthouse. The unit provides 3000 cfm of outside air to the space and a space temperature sensor modulates outdoor air dampers to maintain space conditions at 70^{O}F. Controls will override space sensor and open outdoor air dampers when boilers are started, allowing for additional make-up air to the penthouse and removal of excess boiler exhaust gases.

Atrium Smoke Control Ventilation System

The atrium smoke control system consists of four exhaust fans (E/F-6,7,8,9), make-up air from RTU-2, and two supply fans (SF-1,2). The system is designed to exhaust smoke from the atrium in order to keep smoke above an interface level of 42ft. Upon signal from the fire alarm, the system will open exhaust fan dampers and OA dampers from the air handling units, in addition to automatically opening all atrium entry doors. The rooftop unit return fan shall shut down and associated smoke dampers will shut. Once these procedures have been initiated, the four exhaust fans shall exhaust the required 160,000 cfm of air until deactivated at the firefighter control center (FCC).

Mechanical Redesign Alternatives

There are many ideas that were considered for the redesign of the Hauptman-Woodward Medical Research Institute, and could still be deemed as feasible alternatives to the existing mechanical systems within the building. The reason that these alternatives were ultimately not considered for the AE 482 project is due to the practicality and economical concerns they would create. Although there is no budget for this proposed redesign, it is important to note that the owner is a not-for-profit organization, and all funds that could be saved on the building would ultimately be used for research purposes. In this respect, there should be a careful balance between the proposed redesign and an economical standpoint.

Ground Source Heat Pumps

The first consideration for the thesis report was implementing a Ground Source Heat Pump (GSHP) system. GSHP's use geothermal sources, such as groundwater, surface water or other water mass as a heat source. Most have a reverse refrigeration cycle and either an open or closed geothermal loop. They are preferred over Air-Source Heat Pumps due to the fact that the ground water temperature is nearly constant and shallow depths. Although GSHP's have good response times in terms of allowing a switch between heating and cooling, they require large tracts of land for boring holes into the earth. The Hauptman-Woodward Medical Research Institute does not have a large lot, and there is most likely not enough space to layout the ground loops. In addition, the first costs of drilling the bore holes and laying out the piping loops would be much higher than the current system that is in place, giving it a very poor payback time. For these reasons, this option will not be considered for the project.

Laboratory Enthalpy Wheel

Another alternative was addressing the heat recovery system in the laboratory space. Currently, there is a glycol heat transfer coil loop between the exhaust air and the supply for the laboratory space. An enthalpy wheel was considered, although ruled out due to sensitive nature of the space. Although enthalpy wheels are in production that can contain contaminants, it is probably in the best interest of the program not to explore this route. These enthalpy wheels require a great deal of additional space as compared to their non-sensitive counterparts, and although we have a separate mechanical penthouse, it most likely would not fit in the space allotted.

Mechanical Redesign Proposal

After consideration of the proposed alternatives for redesign at the Hauptman-Woodward Medical Research Institute, the following scope seems to be the most appropriate for the AE 482 Thesis Project.

Scope:

This study will focus on optimizing the heating and cooling systems at the Hauptman-Woodward Medical Research Institute. The primary redesign is the installation of a dedicated outdoor air system (DOAS) and supplemented with radiant ceiling panels throughout the portions of the building not in the laboratory core. The primary concern was controlling humidity within the building due to the variable seasonal temperatures in Buffalo, New York. Utilizing a DOAS system will increase humidity control in addition to reducing energy, ductwork and equipment size. The system is able to meet the latent load of the building at lower temperatures by utilizing the cool, dry outdoor air. The implementation of radiant panels will then provide the required sensible load within the space. It is the intent that the implementation of a DOAS system will greatly improve humidity control at the Hauptman-Woodward Medical Research Institute.

The second redesign will focus on the implementation of water-source heat pumps (WSHP's) with radiant panels to the space. The challenge of this will be the addition of a cooling tower to provide the condenser water required for the WSHP's, and providing locations for each heat pump unit.

Justification of Proposed Work

The proposed work will ultimately reduce utility rates and energy consumption at the Hauptman – Woodward Medical Research Institute. By incorporating a DOAS System with Water Source Heat Pumps (WSHP's) the building electrical load will be decreased and thus decrease the life-cycle cost of the building as well. Although the use of Dedicated Outdoor Air Systems is not widely used, it is very beneficial in buildings with large cooling loads, such as HWI. Therefore, it seems appropriate to implement this design for the AE482 Thesis Project.

Integration and Coordination

The integration and coordination of this system within the building is going to be a difficult task. Water source heat pumps take up additional space that was not accounted for in the design, however due to an unusually large floor-to-floor height and plenum height; I believe that it will be feasible to hang the WSHP's from the structural grid above the finish ceiling. Placement of the Cooling Tower and other equipment will pose the same problem, since the mechanical room on the roof still has plenty of space. Structurally, members may have to be strengthened on the roof to accommodate a heavy cooling tower. Other building systems will have to be addressed as well, as discussed in the Breadth proposal.

Breadth Proposal

The mechanical redesign at the Hauptman-Woodward Medical Research Institute will likely have effects on the other systems within the building. Furthermore, it is likely that improving some of the other systems in the building will have a direct effect on the mechanical system of the building. The two breadth areas under consideration will likely have a major impact on the mechanical system. First, altering the lighting systems will ultimately decrease the cooling load of the mechanical equipment. Second, the incorporation of wind power will alter the electrical load and reduce the amount of electrical consumption from the city electric grid, and require a redesign of the electrical switchgear and generator systems.

Lighting

In the first technical assignment, it was found that the lighting system provided an unusually high amount of watts per square foot. The cause for this may be due to the incorporation of indirect lighting within the office spaces. Although the precise fixture type is unknown, a visit to the site over the holiday break may provide clues as to why there is such an unusually high watt output. Once the precise fixtures of the current system are analyzed, it will be easier to discuss alternative schemes that will provide lower watt output while keeping the architectural integrity of the space intact.

Wind Power

The fact that Buffalo, New York resides on the Great Lakes makes it a prime area for wind power. It is my intent to analyze wind power alternatives in this region and the feasibility of such a system at the Hauptman-Woodward Medical Research Institute. Additionally, the implementation of such a system would require minor redesign to the electrical system so that the wind turbine can first, provide alternative power to the space and secondly, supply energy to the grid in the event of a surplus. The major benefit to this system is a reduction in energy costs from the city, especially during a time when electric and gas rates are on the rise.

Project Tools and Methods

The mechanical systems at the Hauptman-Woodward Medical Research Institute were analyzed in Technical Report #2 using the Trane TRACE-700 program. Although this program provided adequate results, I intend to model my building again using Carrier's Hourly Analysis Program. Since utility bills were not available for the project, providing an accurate energy model is very important to determine whether the alternatives discussed are feasible. HAP seems to be much more user-friendly in regards to the energy modeling and cost estimation as compared to the Trane TRACE-700 program.

For the breadth lighting redesign, lamps, ballasts, luminaires, and luminaire distribution approximations will be utilized within computer modeling programs such as AGI to determine appropriate light levels for office spaces and other areas.

Preliminary Research

The following sources were consulted while putting together this thesis proposal for the redesign of the Hauptman-Woodward Medical Research Institute. As research progresses over the next semester, an updated list of sources and research will be posted directly to the CPEP site.

"Energy Efficiency and Renewable Energy." *U.S. Department of Energy*. December 9, 2006. <http://www.eere.energy.gov/>.

"Energy Recovery: Energy Efficiency and Energy Recovery." *Applications Team, Lawrence Berkeley National Laboratory*. December 9, 2006. <http://ateam.lbl.gov/>.

Mechanical Cost Data. R.S. Means, Co. 29th edition. 2006.

"Wind and Hydropower Technologies Program." *U.S. Department of Energy*. December 9, 2006. <http://www1.eere.energy.gov/windandhydro/.>

AE 482 Project Schedule

This section provides a tentative schedule for the spring semester to ensure that my redesign project will be completed on time and of the highest quality possible. The information provided in no way is concrete, and dates are subject to change as needed to suit the needs of the project throughout the duration of the semester.

Week			Tentative Task Schedule
1	14-Jan-07	20-Jan-07	Humidification/Dehumidification Research
2	21-Jan-07	27-Jan-07	Implement Dehumidication Design, ASHRAE Winter Meeting
3	28-Jan-07	3-Feb-07	Wind Analysis of Buffalo, NY and subsequent electrical work
4	4-Feb-07	10-Feb-07	Electrical power redesign to implement wind energy. Cost energy model
5	11-Feb-07	17-Feb-07	Radiant cooling/heating system design
6	18-Feb-07	24-Feb-07	Radiant cooling/heating system design
7	25-Feb-07	3-Mar-07	Structural Analysis, Research
8	4-Mar-07	10-Mar-07	Structural Analysis
9	11-Mar-07	17-Mar-07	Spring Break
10	18-Mar-07	24-Mar-07	Wrap up research, solve unresolved issues. Work on final report
11	25-Mar-07	31-Mar-07	Write Final Report
12	1-Apr-07	7-Apr-07	Thesis Report due April 5, Work on thesis presentation
13	8-Apr-07	14-Apr-07	Work on thesis presentation
14	15-Apr-07	21-Apr-07	Senior Thesis Presentation week

Conclusions

The Hauptman-Woodward Medical Research Institute has many possibilities for mechanical system redesign, due to the complex nature of the building. There are a variety of systems that are already in place that serve the different space functions of the building. After several alternatives were discussed, the proposed redesign, consisting of the implementation of a Dedicated Outdoor Air System was determined. In addition, the feasibility of implementing a Water-Source Heat Pump System will also be determined. The primary reasons for implementing these systems were improved humidity control and decrease in energy consumption.

In addition to the depth topics, two breadth areas were also discussed. The first area is the large lighting power density and the alternative light fixtures that can be implemented that will improve power density while preserving the architectural aesthetics and lighting levels required to suit the building function. This will have an effect on the electrical system and mechanical system due to reduced energy load. The second breadth topic is the feasibility of wind power to supplement the electrical grid. Although it would not be sufficient to power the building on its own, it would certainly be able to supplement the electrical system and cut down on energy costs.

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"LEED for New Construction." U.S. Green Building Council. October 19, 2006. <https://www.usgbc.org/Docs/LEEDdocs/LEEDNC_ checklist-v2.1.xls>.

Schultz, Justin. Building Statistics. December 9, 2006.

Schultz, Justin. *Technical Assignment #1: ASHRAE Std 62.1-2004 Ventilation Compliance Evaluation Report*. October 4, 2006.

Schultz, Justin. *Technical Assignment #2: Building and Plant Energy Analysis Report*. October 31, 2006.

Schultz, Justin. *Technical Assignment #3: Mechanical Systems Existing Conditions Evaluation Report*. November 21, 2006.

"TRANE TRACE 700 v 4.1.1." The Trane Corporation. 2001.