January 16, 2015

THESIS PROJECT PROPOSAL: INTRODUCTION TO DESIGN AND DELIVERY ALTERNATIVES

PSUAE

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Executive Summary

This report is an updated version of a proposal for altering the design and project delivery characteristics of the NEOMED Research and Graduate Education building and Comparative Medical Unit expansion. These changes are intended to illustrate potential benefits to the owner as well as provide educational value. While the project team had to work with real-world limits on time, money, and design options, here we will have a broader choice to exercise other options in order to emphasize potential improvements in long-term energy savings, reliability, and construction cost and schedule.

The project is a very technically challenging one, and the design must perform to a stringent set of code and programming requirements. However, the application of certain choices that were not available or were not considered have potential for both upfront and long-term savings and benefit to the campus as a whole. Here, several choices will be examined and applied in an educational capacity to demonstrate their feasibility and practicality.

The core of this proposal is the implementation of a combined heat and power plant where the existing plant is located in the basement of the RGE building. Rather than simply serving the RGE, this plant will also serve the Vivarium addition to the CMU building and another new project, the Education and Wellness Center. Accompanying this new system will be an effort to alter equipment, construction materials, and feedback systems all in an effort to create an efficient, effective, reliable building infrastructure. Subject breadths include the implementation of a single-prime project delivery in place of the multiple prime delivery used. Also electrical work coinciding with CHP application will be carried out consisting of addressing grid interconnection and the implementation of black start capability.

Building Overview

The project is comprised of three additions to the NEOMED campus. The main addition is the Research and Graduate Education Center, a four-story 63,000 square foot biomedical research building. The first three floors are fully built out with laboratories, support rooms, and offices, while the top floor is shelled in and will be built out as the research program grows. There is a 6,000 square foot basement to house stand-alone utilities.

The second component is a 14,500 square foot addition to the Comparable Medical Unit, which provides animal care services. Lastly, several existing laboratories in Building D were renovated.

Existing Systems Overview

The project has utilities independent of the campus infrastructure. Contained within the RGE basement are four 3MMBTU natural gas-powered condensing boilers for heating, two 300-ton electric centrifugal chillers for cooling, and three 1000lb/hr. medium pressure vertical steam boilers for humidifiers and laboratory process equipment.

Most air handling units on the project were custom made by Air Enterprises. Two 100% Outdoor Air AHU's, sized at 37,500 CFM each, serve the lab areas to the west in the RGE. Serving the offices on the east is a smaller AHU at 25,000 CFM and 30% outdoor air. A small constant-volume 4,500 CFM air handler is located in the RGE basement to provide ventilation and space conditioning. The CMU expansion has a new 85,000 unit with 100% outdoor air similar to the two serving the RGE labs.

Running water for the project is provided by a new 6-inch water service. Domestic hot water is provided via duplex 250-gallon gas-fired condensing water heaters located in the RGE basement. The building is designed as a single zone with full recirculation back to the water heaters. A separate supply and return branch provides hot water for the lab equipment and is outfitted with local backflow preventers. The plumbing system is equipped with a duplex water booster to assist in serving the upper floors.

The RGE has a new main electrical service with a single-ended normal power switchboard rated at 480V 3000A. A pad-mounted distribution stepdown transformer takes the 480V down to 208/120V. This transformer is rated at 1500 kVA and is three-phase, four-wire. Power is then circuited throughout the building via double-throw branch automatic transfer switches. A 400kW/500kVA diesel emergency generator sits outside to provide power to the 225A emergency branch serving emergency light and power fixtures. The generator also is connected to a 300A circuit legally required for the fire pump, and an optional 800A standby circuit for HVAC components and select lab equipment.

Lighting in the RGE is mostly fluorescent. All lighting fixtures are suspended from the building structure rather than the ceiling system. Sensors and controls are provided to perform daylight dimming in perimeter areas and zero-occupancy shutoff. Existing Telecommunications system in the Comparative Medical Unit are extended to the expansion and the new RGE Building. 120V power sources, obtained from the emergency/standby system, provide power for alarms and access control system.

Proposed Alternatives

Depth Analysis: Combined Heat and Power Implementation

After the various analyses performed over the course of the fall semester, the NEOMED Research and Graduate Education and Comparative Medical Unit Expansion has shown to be a feasible candidate for the implementation of co-generation, or combined heat and power, utilities. Many qualities of the project are conducive to combined heat and power. As a laboratory the RGE building has substantial electric demand, and the animal-holding areas in the CMU have a constant thermal demand. In addition, the CMU has significant use of hi-pressure steam for washing, sterilizing, and humidifying; the RGE was also designed to have humidifiers in its air-handling units. The RGE facility already has an independent plant, and has provisions made for future expansion. In addition, power reliability is absolutely essential for both the animal care areas in the CMU and the research functions of the RGE. Having on-site power generation could save energy and provide an extra measure of reliability.

The base of the mechanical alternate system will be a new configuration of the RGE basement plant to provide heat, chilled water, steam, electric, and compressed air, all generated on-site via natural gas combustion. This plant will serve both the RGE and the CMU, as well as a more recent project in the campus expansion plan, the NEOMED Education and Wellness center. The NEW center has several areas with year-round heating demands including a lap pool and a hydrotherapy pool that lend themselves well to CHP implementation. Ancillary components of the redesign will include a closer examination of vivarium HVAC requirements to see if any equipment can be downsized or eliminated, as well as a general resizing and reconfiguring of systems and equipment coinciding with the implementation of CHP. Also, potential changes to secondary equipment selection and façade choice will be considered in order to maximize effectiveness of a CHP strategy. In an additional move to reinforce long-term benefits, more robust feedback mechanisms will be implemented to construct a continuous feedback loop and apply inverse modeling techniques.

The intended goal of the redesign with a combined heat and power plant will be to provide long-term cost and operation benefits, all while providing dependable utilities and maintaining a top level of operability.

The other major depth analysis considered was the implementation of chilled beam systems in place of the current VAV system. This idea had some potential, but also had serious complications attached due to the stringent ACH, humidity, and pressure relationships demanded by the project. The use of chilled beams in a vivarium may not even be allowed via code. While they have been successfully utilized in lab applications, there are a litany of precautions to be taken, and normally are only beneficial in labs where the HVAC system is sized largely based on equipment loads and less making up exhaust from fume hoods. While

there is some potential for the implementation of chilled beams to result in less energy waste and smaller airside equipment, there is too much risk associated on this particular project. The airside components of the project's mechanical system will remain largely unaltered.

Construction Management Breadth Analysis: Alternative Procurement Process

At the time of bidding in 2011, the state of Ohio mandated that all building projects funded with state money were to be awarded as competitive multiple-prime contracts. As a higher education project, the NEOMED RGE + CMU fell under this ruling and was multiple prime. Since early 2012, Ohio has changed their stance and now allows single-prime contracting for state funded building. The considered construction management breadth would be to consider the potential benefits of using a single-prime delivery on the project. The project experienced notable over-runs due to weather and contractor delays; creating mock schedules of single-vs-multiple prime delivery and comparing the two could shine light on potential savings of both money and time.

One alternative construction management breadth considered was the implementation of prefabricated core MEP shafts. The procurement option was chosen instead because it appears to have more potential for overall time and money saved. In addition, given the complex nature of the building systems implementing a core philosophy could result in serious and time-consuming architectural layout changes

Electrical Breadth: Power Interconnect and Black Start Capability

Coinciding with the inclusion of a combined heat and power system will be the need for properly designed power interconnection with the existing grid. In addition, the new CHP plant will have provisions made to provide black start capabilities, allowing the plant to restart in the event of a blackout.

Another electrical breadth briefly considered was the potential for daylight harvesting from a different building orientation. This option was not chosen due to the aforementioned electrical redesign's tie-in with the mechanical breadth.

Analysis Tools and Methods

Load and energy simulation software will be used extensively to perform the mechanical depth of the redesign. In order to properly design the new plant, it is essential to first obtain real utility data from the existing project. From that data, specifically designed spreadsheets will be used as calculation tools for proper selection of equipment. Other programs such as Equest and IES may potentially be utilized as well.

To execute the construction management breadth, a recreation of the real project schedule will be made as accurately as possible. Then, a mock schedule of construction events will be developed for a single-prime delivery for comparison to the first schedule. By using cost data gathered from RS Means and from existing project estimate documentation, cost information will also be correlated to each respective delivery method. Microsoft Project will likely be the scheduling software of choice, and with excel a tie in with cost will be made.

In addition to program usage, extensive building code and guideline research will be performed. NIH guidelines will be examined pertaining to the CMU vivarium, and ASHRAE Lab design guides as well. Early in the work process, it will be crucial to examine a number of CHP case studies to glean lessons learned and practical wisdom.

References

Design Documents:

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Bard, Rao + Athanas Consulting Engineers, LLC. MEP Schematic Narratives. BR+A, Boston, MA

Ellenzweig Architects. Architectural Construction Documents. Ellenzweig, Boston, MA

TC Architects Inc. Architectural Construction Documents. TC Architects, Akron, Ohio

Research:

"Construction Contracting Rules To Take Effect Amid Concern For In-State Firms." *AIA Ohio News*. AIA Ohio, 17 Jan. 2012. Web. 10 Dec. 2014. <http%3A%2F%2Fwww.aiaohio.org%2Fthe-news%2F38-legislative-issues%2F463-construction-contracting-rules-to-take-effect-amid-concern-for-in-state-firms>.

"Is My Facility a Good Candidate for CHP?" *Combined Heat and Power Partnership*. United States Environmental Protection Agency, n.d. Web. <http%3A%2F%2Fwww.epa.gov%2Fchp%2Fproject-development%2Fqualifier_form.html>.

McMahon, PE, LEED AP, Geoffrey P. "Chilled Beams: The Science of Lab Cooling." *Engineered Systems Magazine* (January 2009): n. pag. Web. 8 Dec. 2014.

Appendix A:

Spring Work Schedule

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		Initial Research	15 days	Mon 12/29/14	Fri 1/16/15	
2		Flesh Out Work Schedule and Thesis Scope	10 days	Mon 12/29/14	Fri 1/9/15	
3		Review and Revise Thesis with Advisor	5 days	Mon 1/12/15	Fri 1/16/15	2
4		Clean Up Old Trace Model	10 days	Mon 1/12/15	Fri 1/23/15	
5		Add Alternative System to Trace Model	10 days	Mon 1/26/15	Fri 2/6/15	3,4
6		Run Trace Model	5 days	Mon 2/9/15	Fri 2/13/15	5
7		Plant Equipment Selection and configuration	10 days	Mon 1/19/15	Fri 1/30/15	1
8		Secondary Equipment	10 days	Mon 2/2/15	Fri 2/13/15	7
9		CM Breadth Scheduling	10 days	Mon 1/26/15	Fri 2/6/15	
10		CM Breadth Cost Estimating	10 days	Mon 2/9/15	Fri 2/20/15	9
11		Electrical Redesign	10 days	Mon 2/2/15	Fri 2/13/15	7
12		Controls Redesign	10 days	Mon 2/16/15	Fri 2/27/15	11
13		Develop Continuous Feedback Loop	10 days	Mon 3/2/15	Fri 3/20/15	6,12,8
14		Create Presentation	15 days	Mon 3/16/15	Fri 4/3/15	
15		Write Final Report	15 days	Mon 3/16/15	Fri 4/3/15	
16		Milestone #1	0 days	Fri 1/23/15	Fri 1/23/15	
17		Milestone #2	0 days	Fri 2/13/15	Fri 2/13/15