Executive Summary

Throughout the 2013-2014 school year, a comprehensive study of the Aria Health Emergency Department Expansion project located in Philadelphia, Pennsylvania was performed. Detailed reports of the building systems, project cost and schedule, site logistics, and project delivery method were compiled after months of examination during the fall semester. After which, a final proposal was written to portray the changes that could have been implemented on the project for improvement. During the spring semester, four separate depth analyses were performed, including the implementation of a rainwater collection system for gray water reuse, the addition of 180 photovoltaic modules for self-production of electricity, an energy analysis due to the addition of operable solar shading devices, as well as a research study on the modularization of 42 patient treatment rooms.

Analysis 1 – Rainwater Collection

After calculating the total amount of rainfall per year based on historical weather data for Philadelphia, the building rainwater conductor riser diagram was used to find the total possible rainwater collection. The total gray water usage for sewage conveyance was then calculated based the flow rates for each of the specified water closets and urinals and an assumed value for flushes per day. It was found that total of 82,162.5 gallons of water was used monthly for flushing, which was below the monthly rainfall value of 93,792.09 gallons. A rainwater harvesting system was then designed around a 20,000 gallon storage tank, where all the associated piping, booster pumps, filters, valves, and hydropneumatic tanks were designed. The piping was then laid out within the building framework, along with specified manufacturers for each of the system components. After layout, two different detailed cost estimates were performed, to show the difference in cost between a copper and steel arrangement versus a PVC arrangement. The direct costs for the PVC piping system, including each of the required system components, was found to be $146,680.40. After finding an initial cost for the system, a comprehensive economic analysis was performed to depict the amount of time the system would take to pay for itself, along with the cumulative income produced over time. The payback period for the system as designed was found to be 12.18 years, while the cumulative income over a 25 year period was found to be $281,105.50.

Analysis 2 – Photovoltaic Array

Before performing the analysis for the addition of a photovoltaic array, a solar study was first conducted to determine where each of the modules should be located on the roof of the building. This was done in order to show the shading due to the parapet wall, as well as the modules themselves. After the solar study was done, the system had to be designed. The Sharp ND-F4Q300 300 watt solar panel was chosen as the basis of design, around which the entire system was formulated. It was decided that 180 photovoltaic modules would be added for a total of 54,000 kilowatts DC, or 44.3 kilowatts AC, all wired into five different groupings. Each of the five groupings consisted of six modules in series strings, with six of those series strings wired in parallel. Each of the conductors were sized accordingly, after which a wiring layout was performed in order to perform quantity take-offs. The entire system was designed, including the panels themselves, inverters, circuit breakers, disconnects, conductors, and racking system with specified manufacturers. A cost estimate was performed, where a grand total price was found to be $211,958.98, or $4.78 per usable watt. After the initial cost was found, an in-depth economic analysis was performed after finding the system capacity for electricity production. It was found that the system could

potentially save $6,949.60 in utility costs annually. Taking several different factors into account, a payback period of 19.52 years was determined, with a cumulative tax exempt income of $94,467.20 over a 25 year period.

Analysis 3 – Operable Solar Shading

With the vast majority of the building curtain wall system facing southeast, operable solar shading devices were decided as a viable option to combat solar gain during the peak load times of the year. Colt Shadoglass, a product specifically designed for the intent stated above, was analyzed as an addition to the existing building façade. The system employs glass blades that allow natural light into the building almost exclusively, while simultaneously rejecting solar radiation back into the atmosphere. A conceptual cost estimate was performed, where the initial cost of the system was found to be $442,533.33. A site logistics plan, schedule, and installation phasing plan were included to show how the system would be constructed. The addition of the Colt Shadoglass was found not to affect the existing critical path of the project. In order to quantify cooling cost saving due to the Colt Shadoglass, an energy model was produced using IES Virtual Environment. After performing the energy model, it was found that an annual reduction of 46,220.7 BTU/h, or 20% reduction from the baseline data was possible, which equates to a $935.97 savings in cooling costs yearly. In addition to energy savings, it was found that a total of 12,856 lbs of greenhouse gas emissions could be kept from entering the earth's atmosphere. This 20% reduction in cooling load was then used to resize a section of ductwork present in the space that was modeled in IES.

Analysis 4 – Modularization of Patient Treatment Rooms

For the purpose of schedule reduction, modular construction techniques were researched and implemented into the Aria Health ED Expansion project. 42 patient treatment rooms were broken out into individual modules to be prefabricated in an off-site facility located 1.1 miles from the actual project site. Several different media were utilized during research, including online articles, peer reviewed journals, and interviews held with industry professionals experienced in modular construction. Off-site locations and shipping procedures were investigated, after which a site logistics plan was produced to show truck traffic on-site and how the modules would be set into place. A schedule was produced in order to quantify a savings of 15 days from the project critical path.

In conclusion, it was decided that only two of the four aforementioned analyses are recommended for implementation into the existing project. With only a 12.18 year payback and a cumulative income of $281,105.50, the rainwater collection system would serve as a valuable resource conservation technique and is recommended due to its income generation. The integration of a photovoltaic array, however, is not recommended due to its high initial investment and 19.52 year payback. The cumulative income is also not worth the upfront cost. The addition of the Colt Shadoglass system onto the façade is also not recommended, as the savings in cooling costs are not substantial enough to rectify a $442,533.33 investment. Lastly, modularization of the 42 patient treatment rooms is recommended for its critical path duration savings of 15 days.