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Energy Engineering and Feasibility Studies

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1 Initial Feasibility Study for Absorption Chillers to Use Additional Waste Heat from New Cogeneration Unit

1.1 Summary

kW Engineering conducted a high-level feasibility analysis for potential uses of waste heat from the larger 4.4 MW cogeneration plant now under construction. Our analysis soon led us to investigate the possible use of absorption chillers in buildings with electric chillers.

Based on our study and cost analysis, we recommend the installation of one 100-ton absorption chiller in the Jack Baskin Engineering building, and one 150-ton absorption chiller in the Engineering II building. These units will cost-effectively take advantage of available waste heat to generate cooling, reducing electricity use by existing electric chillers.

1.2 Background Information

There are three hot water (HW) boilers and one cogeneration unit (CGU) at the Fackler plant. The boilers and cogeneration unit produce hot water that is used in several buildings for space heating, domestic hot water, process heat, and even cooling by an absorption chiller (Sinsheimer Labs). Figure 1.1 shows the different load profiles related to the Fackler plant, with the existing hot water usage.

The load profiles in this study were created using trend data from the energy management system. We used data from January 2010 to November 2012.

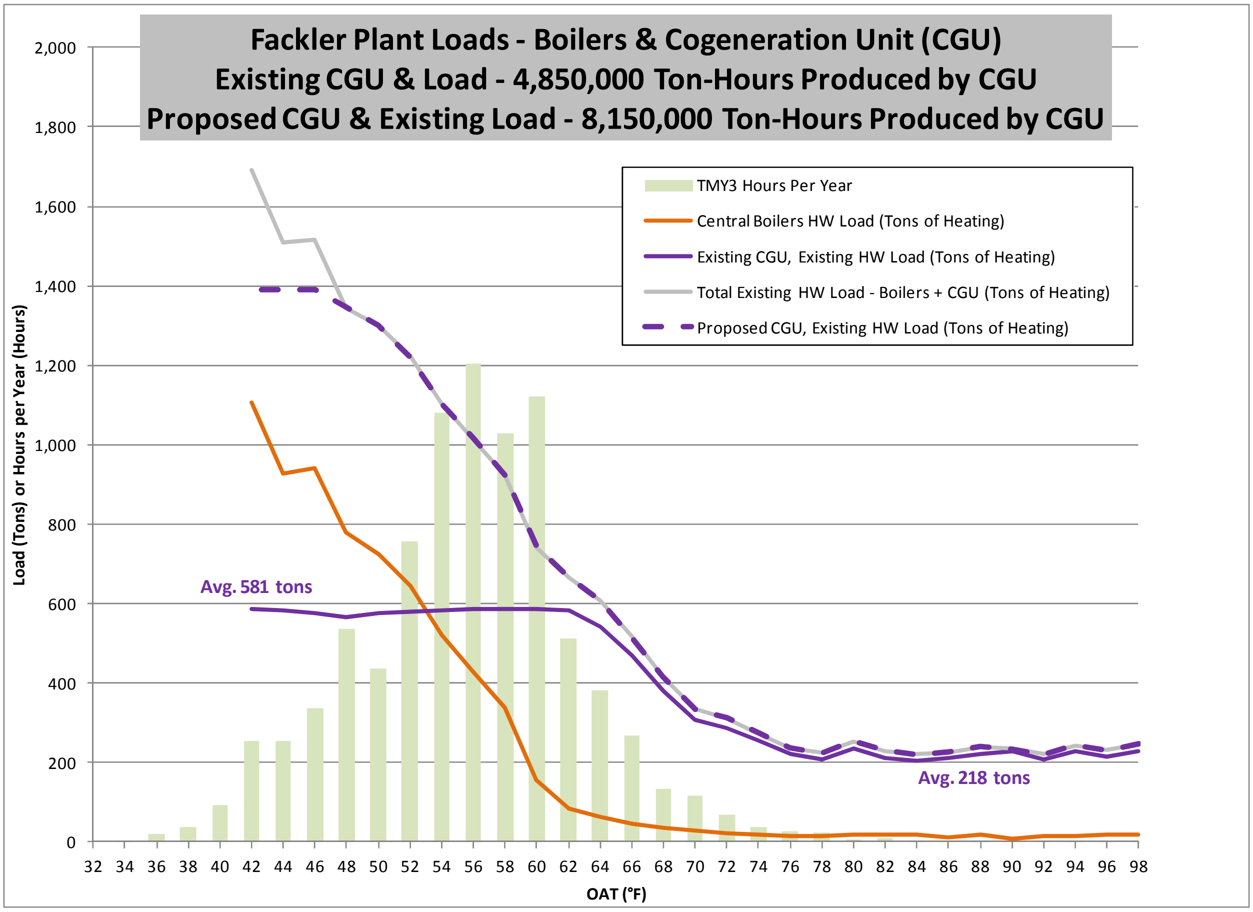

Figure 1.1 Fackler Plant Hot Water Load Profiles

Study of the Fackler plant load profiles (Figure 1.1) compared to outside air temperature (OAT) shows that the current cogeneration unit provides an average of 581 tons of heating (6,970 kBtu/h) at low OATs when most of this energy is used for space heating. At higher OATs, the current cogeneration unit produces an average of 218 tons of heating (2,620 kBtu/h) only, which are used for reheat, domestic hot water, process heat, pipe losses and cooling by the existing absorption chiller at Sin Labs. The existing CGU provides approximately 4,850,000 ton-hours of heating per year and has an average utilization of 95% of its heat output.

The new 4.4 MW cogeneration unit will generate more than double the heating output of the existing unit, with a capacity of 1,391 tons (16,693 kBtu/h) of heating. If the new cogeneration unit was installed without any changes to the HW loop, it would provide approximately 8,150,000 ton-hours of heating per year. It would be able to meet HW demand 91% of the time, without use of boilers (see the dotted purple curve in Figure 1.1). The average heating utilization of the new CGU would be approximately 67%, leaving significant waste heat exhausted up the stack.

There is good potential to use the unused new CGU heating output to provide space and process cooling using additional absorption chillers, particularly during the many hours of moderate conditions (OAT between 50°F and 65°F).

1.3 Chilled Water Usage Load Profile at Potential Buildings

The following buildings were originally identified as potential buildings for the installation of an absorption chiller, due to their chilled water needs:

- BioMed
- Engineering II (E2)
- Earth & Marine Science (EMS)
- Jack Baskin Engineering (JBE)
- Sinsheimer Labs (SinLabs)

The figures below (Figure 1.2 to Figure 1.6) show for each building how an absorption chiller designed to operate with low grade hot water and relatively low hot water flows would use the available hot water capacity of the proposed cogeneration unit. A COP of 0.70 was used based on specs received from Trane.

Note that the load profiles presented in the figures below are average instantaneous loads at a given outside air temperature. The number of hours per year at each given outside air temperature, also presented on the figures, needs to be taken into account.

Based on load profile considerations only, Figure 1.3 and Figure 1.5 show that Engineering II and Jack Baskin Engineering are the best potential candidates to install an additional absorption chiller. This is because both buildings have a constant cooling load even at low outside air temperatures. Note that we used updated data collected in March 2013 to calculate the chilled water load profile at JBE. Based on load profile only, Sinsheimer Labs would also be a good candidate, but there already is one absorption chiller in this building.

Other buildings only have comfort cooling loads, which start at higher outside air temperatures, and increase rapidly with OAT, and therefore would require a much larger, more costly absorption chiller that would operate for relatively few hours per year, providing little annual savings. In these cases the payback would be very long.

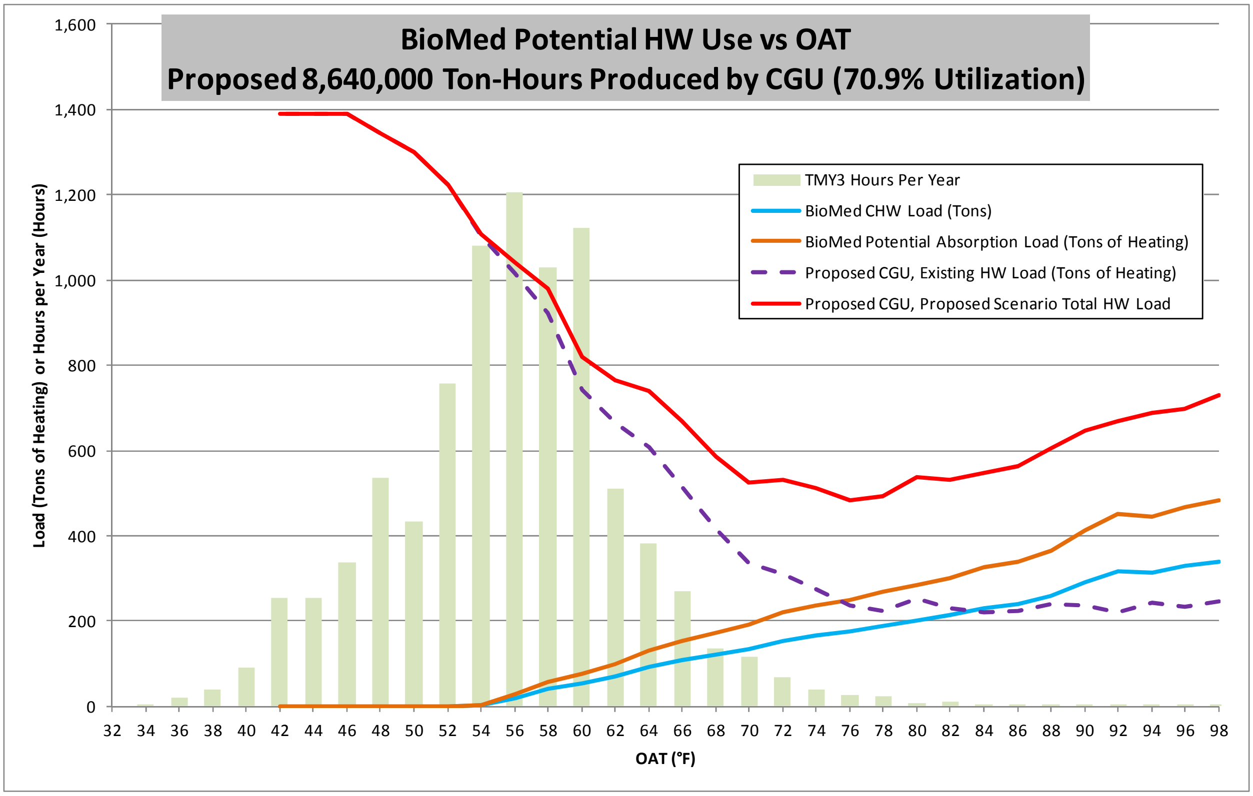

Figure 1.2 BioMed Building, Existing & Potential Plant Load Profiles

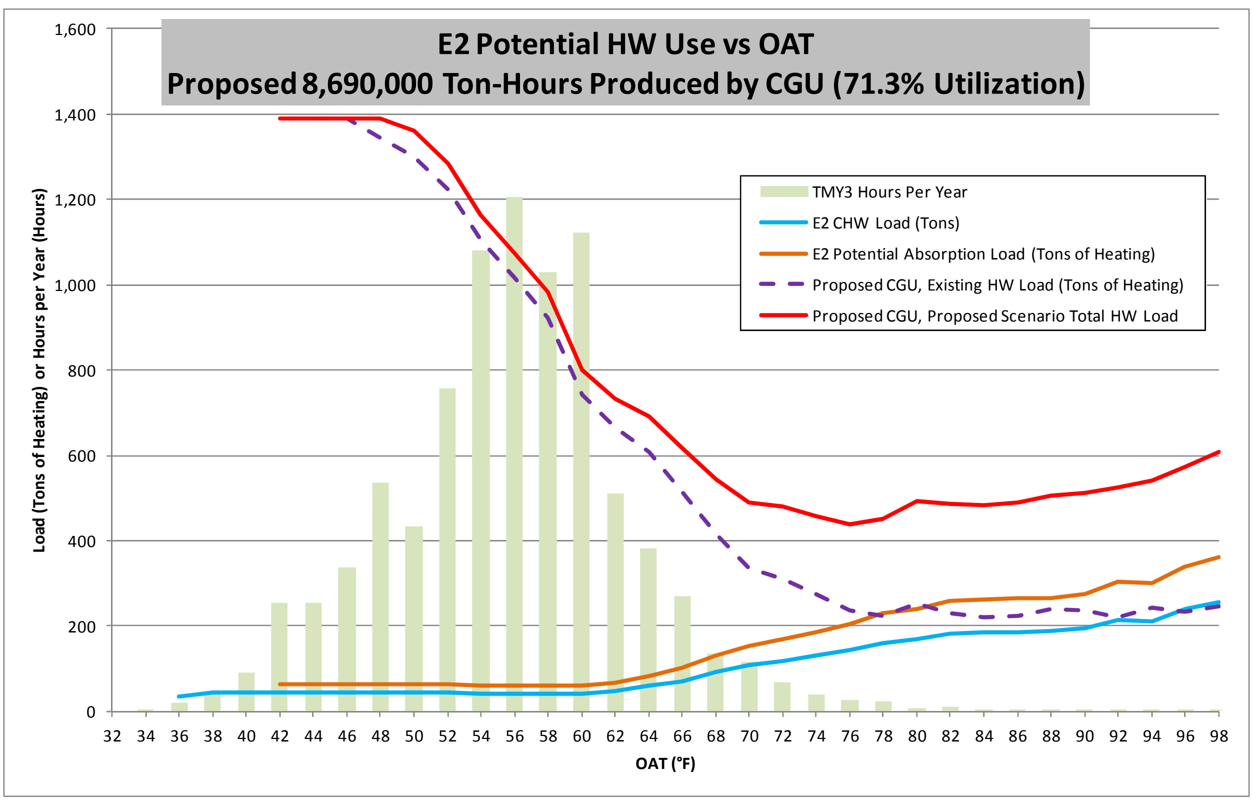

Figure 1.3 Engineering II Building, Existing & Potential Plant Load Profiles

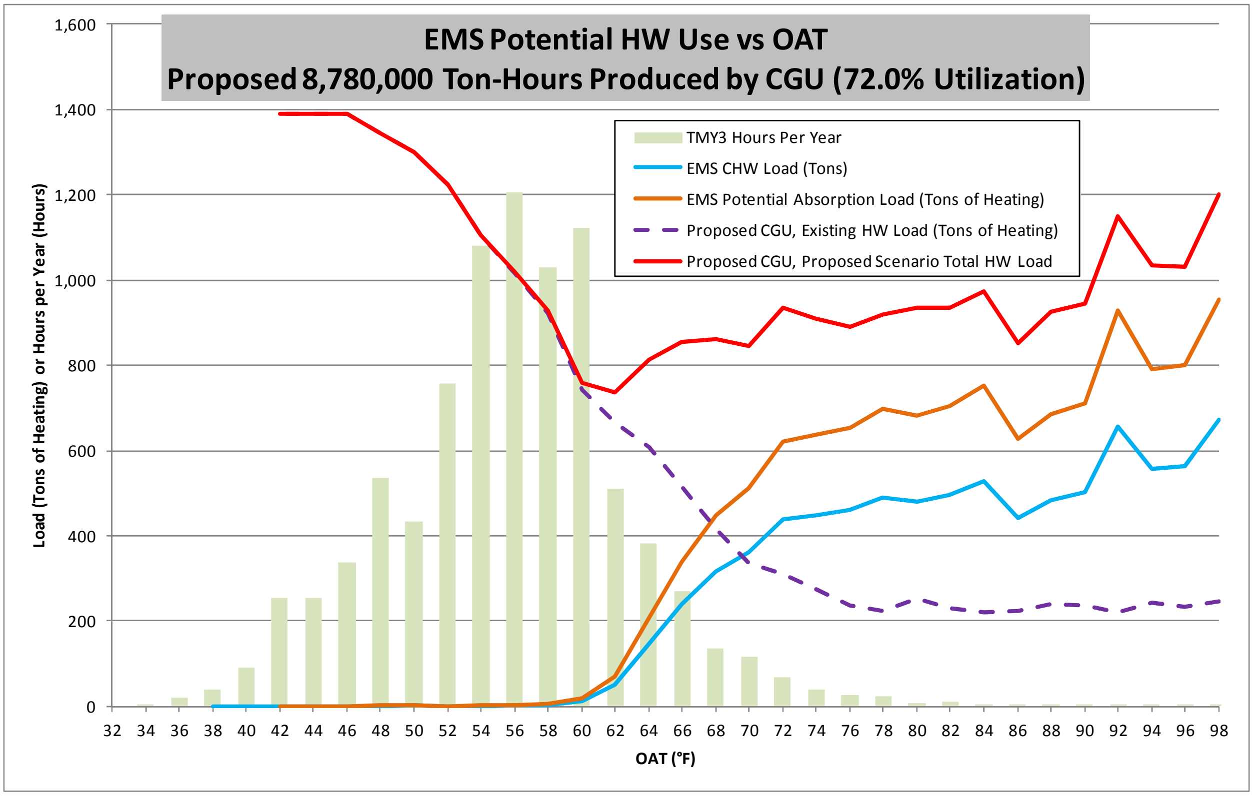

Figure 1.4 Earth & Marine Science Building, Existing & Potential Plant Load Profiles

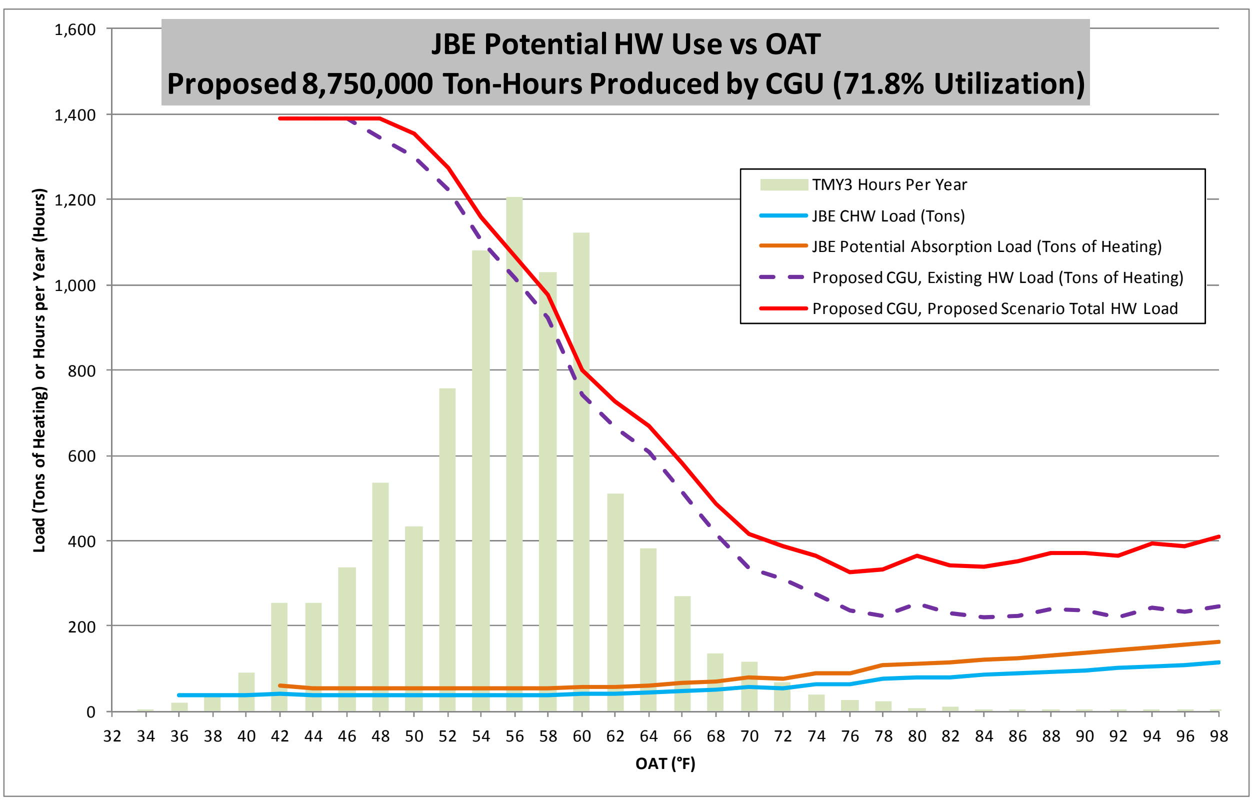

Figure 1.5 Jack Baskin Engineering Building, Existing & Potential Plant Load Profiles

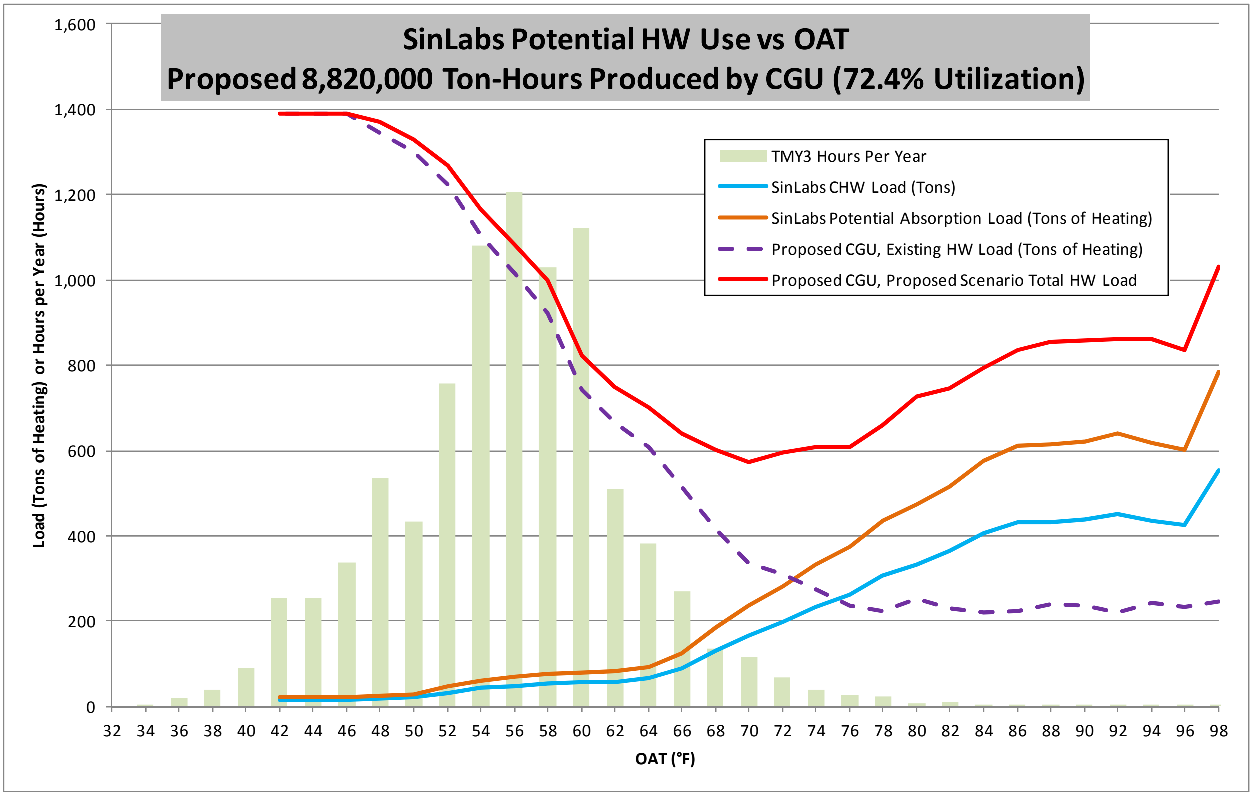

Figure 1.6 Sinsheimer Labs Building, Existing & Potential Plant Load Profiles

1.4 Preliminary Strategy and Cost Analysis

Based on the above load profiles, we selected Jack Baskin Engineering and Engineering II for further study. Because there is an old R22 chiller at Earth & Marine Science, we also included this building in our preliminary cost analysis.

The size of the proposed absorption chillers was selected so as to meet the constant cooling load (if any) and part of the comfort cooling load in each building. We obtained custom specifications and budget pricing for each absorber from Trane/Thermax and York.

As part of this preliminary analysis, we did not account for the additional heating water flow and cooling tower fan usage that will be necessary to operate the new absorption chillers.

Due to restrictions on the condenser water flow available in each building, we considered that the absorption chillers could not be operated at the same time as other electrical chillers.

Jack Baskin Engineering

There is no ready space available in the basement at Jack Basking Engineering to install an additional absorption chiller. We propose the following strategy: remove the inoperable reciprocating chiller, replace one of the two 60-ton scroll chillers with one 100-ton absorption chiller.

Based on the trending data we analyzed, the new 100-ton chiller could meet the chilled water load demand up to outside air temperatures of 85-90°F, and would therefore provide approximately 310,000 ton-hours of cooling annually. Chiller cost is approximately $115k-$130k (chiller only). We used a rough 60% adder to account for the necessary demolition, installation, piping and contingency.

The resulting simple payback for this project would be approximately **7.5 years**.

Engineering II

We propose the following strategy: install one 150-ton absorption chiller in addition to the existing chillers, and use the absorption chiller to meet chilled water load demand at low-load conditions.

Based on the trending data we analyzed, the new 150-ton chiller could meet the chilled water load demand up to outside air temperatures of 70-75°F, and would therefore provide approximately 370,000 ton-hours of cooling annually. Chiller cost is approximately $125k-$140k (chiller only). We used a rough 50% adder to account for installation, piping and contingency.

The resulting simple payback for this project would be approximately **8.1 years**.

Earth & Marine Science

We propose the following strategy: install one 300-ton absorption chiller in addition to the existing chillers, and use the absorption chiller to meet chilled water load demand at low-load conditions.

Based on the trending data we analyzed, the new 300-ton chiller could meet the chilled water load demand up to outside air temperatures of 65°F, and would therefore provide approximately 170,000 ton-hours of cooling annually. Chiller cost is approximately $200k-$230k (chiller only). We used a rough 50% adder to account for installation, piping and contingency.

The resulting simple payback for this project would be approximately **33.6 years**. In addition to this long payback, this project would not be feasible due to inadequate condenser water flow to this site to serve the higher need of an absorption chiller.

1.5 Sources for Manufacturer Specifications

Trane / Thermax

Adrian Giovenco
TRANE San Francisco / Specialty A/C Products
Office: 408-481-3659 or 3677
Mobile: 415-418-0197
Fax: 888-418-3991
Email: agiovenco@trane.com

York

Arlene Mendoza
Johnson Controls
843 Auburn Ct.
Fremont, CA 94538
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1.6 Next Steps

Based on our preliminary feasibility study and cost analysis, we recommend the installation of one 100-ton absorption chiller in the Jack Baskin Engineering building, and one 150-ton absorption chiller in the Engineering II building. Detailed investigation of these two projects is needed to confirm their feasibility and to firm up installation costs and energy savings.

We confirmed that new absorption chillers could operate with the current condenser loop, at low flows and high temperature differentials (i.e. higher condenser water return temperature, CWRT). As part of this initial study, we also confirmed that the existing cooling tower capacity was insufficient to maintain the supply condenser water temperature setpoint at higher outside air temperatures. Therefore, we recommend upgrading the condenser water loop.

Next steps for the detailed investigation of the two proposed projects at JBE and E2 include:

- Confirm there is enough space in both buildings, after potential demolitions, to install the new absorption chillers and all the associated HW and CW piping.
- Develop detailed project installation costs.
- Prepare design intent and performance specifications.
- Investigate condenser water loop capacity and efficiency, including piping, pumps, cooling towers and sequences of operation.
- Determine optimal sequences of operation for the modified chiller plants.

1.7 Appendices

Appendix A – Conference Call Minutes

Appendix B – Analysis