



Swedish Issaquah, Issaquah, Wash., is a 175 bed, 353,000 ft² (32 810 m²) community hospital, where a 16,000 ft² central plant heat recovery system helped the building achieve an EUI of only 114.

Low EUI Community Hospital

By **Jeremy McClanathan, P.E.**, Associate Member ASHRAE

Health-care buildings currently consume 9% of all building energy and 4% of the total energy consumed in the U.S. Designers of Swedish Issaquah decided to use a central plant heat recovery system to make the hospital one of the most energy efficient in the U.S. The facility includes a 353,000 ft² (32 515 m²) acute care hospital, a 200,000 ft² (18 581 m²) medical office building, and a stand-alone central utility plant (CUP). The acute care part consists of two four-story wings with 175 beds. Construction began in May 2009, and the hospital opened in July 2011.

About the Author Jeremy McClanathan, P.E., is senior energy analyst at CDI Engineers in Lynwood, Wash. He is an ASHRAE certified Building Energy Modeling Professional and a Healthcare Facility Design Professional. He is a member of the Puget Sound ASHRAE chapter.

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Setting the Stage

The Swedish leadership team decided to take a critical look at the past performance of Swedish's existing facilities in the Seattle area. They reviewed the mechanical systems, energy budgets, control strategies, maintenance logs, and forged these findings into a plan for reducing energy and increasing operational efficiency for the new facility.

Swedish's corporate facilities engineering group, with support from senior management, set a goal for the acute care hospital part of Swedish Issaquah to achieve an energy use intensity (EUI) of 150 kBtu/ft²-yr (1 703 550 kJ/m²-yr). Greatly increasing the challenge, the owner also dictated that the design and construction schedule would total just over two years, which is about one year less than a traditional design-bid-build project of similar magnitude. It was quickly determined that an integrated project delivery (IPD) approach would be necessary to meet schedule.

Occurring in parallel with the development of the Swedish Issaquah was the ongoing work and research being done by the Integrated Design Lab (IDL) of the University of Washington. Funded in large part through a grant from Northwest Energy Efficiency Alliance (NEEA), IDL was developing new strategies for reducing energy use in hospitals by drawing on the expertise of local architects and engineers. The Swedish project mechanical engineers were early contributors.

When the study began, IDL realized that most of the health-care buildings were designed at code minimum with a CBECS EUI of 250. Its roadmap "Targeting 100!" was developed to provide designers the tools, options and strategies to meet the 2030 challenge and still abide by the stringent code requirements unique to health-care buildings.

Project Approach

When the engineering team began to integrate the impact of the schedule and energy targets into its work plan, we realized that "mechanical design as usual" would not work. To drive the EUI down to the targeted level required a different

technical approach than had been used on other recent projects, and also required a well-orchestrated and committed stakeholder involvement throughout the process.

With the aggressive schedule looming, the engineers knew decisions on mechanical systems needed to be made prior to completing the schematic design phase. An energy model needed to be developed unusually early in schematic design so that key design decisions could be made early, and then follow-up testing could be done "on the fly." This model would have to be accurate to the degree that precise energy and cost decisions could be made with equipment ordered and shipped well in advance of what could be achieved through a traditional delivery process.

A new energy modeling protocol was developed to "design in the model," to help the team make informed decisions and provide accurate information about building systems, and components from pumps to chillers to VAV terminals and duct performance. Importantly, the new modeling protocol gave the team accurate return on investment (ROI) data that made system and equipment selection meaningful.

In an effort to develop a meaningful energy model, a lengthy series of meetings were held with all of the departments represented at Swedish and 45 typical space profiles were created. Heating and cooling loads, hours of use, equipment, lighting, control requirements, were captured and modeled. This owner participation was critical for accurately determining loads and to accurately calibrate owner/user impact on building performance.

Another significant departure from design as usual is that the engineering team assigned an in-house energy engineer to monitor and evaluate relevant project decisions *as they were being made* from an energy impact point of reference. A constant focus on the energy target had to be maintained.

Additionally, the local electric and gas utility played a large role in reviewing options developed by the team (energy

savings, ROI), provided estimates of energy grants they might be able to contribute and helped the team to target and refine (and ultimately fund) many of the major cost-saving measures that were implemented.

Selecting the Mechanical Systems

As active members of several health-care code committees, the engineering team was well versed in the evolving local and national codes and current best practices that drive the design of health-care building infrastructure. VAV systems had recently become more frequently used in hospitals to distribute and return measurable amounts of air and to control pressurization between spaces. The team was well aware of the hospital's unique demand for simultaneous heating and cooling throughout the year, and also how much energy consumption was dedicated to reheat. We asked: what if we could recoup 80% of waste heat and reduce the need for boiler energy used in reheating air?

Building at a Glance

Swedish Issaquah Hospital

Location: Issaquah, Wash.

Owner: Swedish

Principal Use: Acute care hospital

Includes: Emergency department, surgery, imaging, labor and delivery, pediatrics, ICU, cancer care, and medical surgical spaces

Gross Square Footage: 353,000

Conditioned Space: 335,000 ft²

Substantial Completion/Occupancy: June 2011

Occupancy: 100%

National Distinctions/Awards: 2013 ASHE Vista Award: Infrastructure

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Photo 1: Heat recovery chiller.

The heart of the engineer's solution was to use a heat recovery chiller (which can generate usable heating and cooling energy at the same time) and use a low-temperature heating system (*Figure 1*). To optimize its effectiveness, the heat recovery chiller was sized to maximize its use, rather than meet peak demand. This was accomplished by plotting individual annual hourly cooling, building heating, and domestic hot water demand on a scatter plot; then choosing the machine capacity that was just large enough to meet the majority of the demand.

On *Figure 2*, purple points indicate hourly true chilled water demand from process cooling loads and ventilation cooling. The dark blue points represent the energy available in the chilled water loop when exhaust and available relief air heat recovery are added to the true demand. The nominal size of the heat recovery chiller is 300 tons (1055 kW), and it has a maximum heating capacity of 4,520 MBH (1.3 million kW). It can be seen on the graph that for a majority of the year, the sum of the heating water and domestic hot water hourly demand is below 4,520 MBH (1.3 million kW).

The system was designed to serve 80% of the building heating and domestic hot water (DHW) demand with recovered energy. To meet the building

peak heating demand, six condensing boilers were provided. These boilers augment the heat produced by the heat recovery chiller and can provide back-up heating if the HRC were off-line.

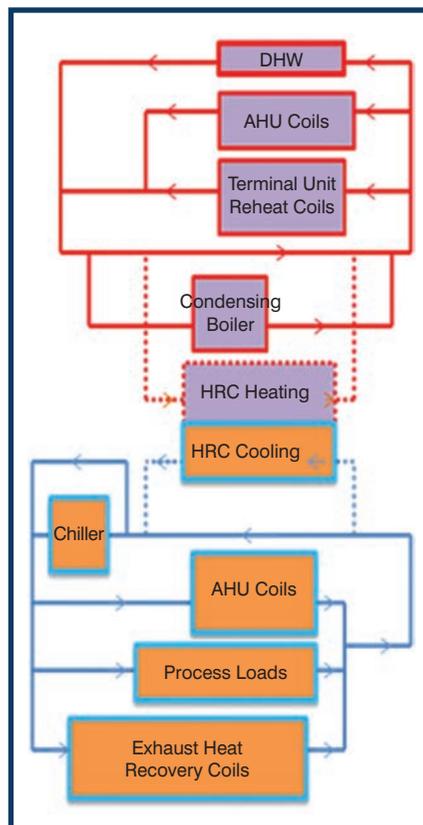


Figure 1: Hydronic systems.

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To load the heat recovery chiller in the heating season, chilled water coils were added in the exhaust air to recover heat from the hospital's exhaust airstreams.

In addition, advanced controls were included that allow the system to use selected AHU central cooling coils to recover heat from relief air during economizer mode.

Another way the heat recovery system was optimized was the use of multiple DHW tanks piped in series with plate and frame heat exchangers connected to the heating water system maximize the amount of recovered energy the DHW system can use, and helped optimize the overall efficiency of the system.

height throwing the air high above the hospital. Relief air, steam, and quenching vents are outboard on the various lower roofs much further away from intakes than required.

For example, the relief air for the basement units dump into the loading dock from two sides. The effect is to plunge air past the recycle and trash bins, reducing obnoxious odors and keeping the area warmer with a side effect of no extra heaters on the loading area as is a typical request of northwest hospital owners. The central utility plant, which includes diesel emergency generators, was located as far from the hospital site as practical with the cooling towers placed on the backside.

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Indoor Air Quality & Thermal Comfort

The code that governed indoor air quality for the project was the 2006 FGI Guidelines, which requires a minimum of two air changes per hour of OA for a majority of spaces. In addition to meeting 2006 FGI guidelines, the project meets ASHRAE Standard 170-2008, *Ventilation of Health Care Facilities*. All ventilation air in the building is filtered with MERV 14 filters.

Airborne infection isolation rooms have low wall exhaust grilles placed on both sides of the infectious patient bed. Each operating room has four return air grilles, two high and two low, to reduce static air regions and enhance the HEPA central non-aspirating airflow over the operating table. Special areas, such as the lobbies to the parking garage and emergency department, have vestibules with pressurized supply air and no return air. The design team carefully evaluated and chose air intake locations that take advantage of the cleanest air available on site.

About half of the building's airflow is served by units in a basement that get their air from a central open garden. The intakes are high in the garden all along one building side. The units on the roof all get their air from the garden side as well. Critical exhaust fans use plumbing fittings to increase their effective stack

Energy Efficiency Economics

The incremental additional cost to implement the energy strategies necessary to achieve the energy goal was roughly \$3 million. This represented less than 6% of the mechanical construction cost and only a little more than 1% of the total construction cost. With approximately \$500,000 of annual energy cost savings, the overall simple payback (not accounting for the energy rebate from the utility) was six years. Significant energy rebates brought the net payback to the owner to less than one year.

Actual Performance

Currently, the building is operating at an EUI of 114 kBtu/ft²-year, more than 50% below a code minimum new hospital. Early actual operating equipment trend data indicates that the heat recovery chiller is capable of serving 100% of the heating demand in the building when outside air (OA) temperatures are above 40°F (4°C), closely matching what the energy model predicted. Trend data also indicates a general pattern of the boilers running consistently at OA temperatures below 35°F (2°C), intermittently at temperatures between 35°F to 40°F (2°C to 4°C), and not running at all whenever the OA temperatures are above 40°F (4°C). Bin data indicates that the OA temperature in the region is greater than 40°F (4°C) for approximately

85% of the year. Therefore, for approximately 85% of the year, building heating and domestic hot water demand is expected to be met with the heat recovery chiller operating with a coefficient of performance (COP) of approximately 4.0, compared to a traditional steam boiler operating with a COP of approximately 0.8. Coupled with the relatively low cost of electric power in the Northwest (approximately \$0.09 per kWh), this approach makes for a highly economical method to heat the building.

Project Schedule

To keep on schedule for Swedish Issaquah's integrated project delivery, timely decisions would have to be made throughout the design process. Weekly meetings with the mechanical engineers, mechanical contractors and owner's facility staff were held. The architect and general contractor were also present when decisions had to be made affecting general construction. With the tight schedule, there had to be a general consensus on equipment selection and other crucial decisions.

After the mechanical systems had been determined, efforts then concentrated on determining equipment features, selection and purchase; and scheduling to allow the mechanical piping and duct systems to be shop fabricated and then installed. The construction sequencing drove the mechanical design to fall outside a normal order. For example, the air-handling units had to be purchased early in the construction document phase.

In fact, all major mechanical equipment was purchased prior to the design being completed. Individual equipment packages were developed for the contractor to issue a request for proposal to equipment suppliers. The whole team methodically reviewed equipment information including first cost, used the energy model to analyze operational efficiencies with actual performance

curves, considered service and supplier performance history and other intangibles.

Additionally it was mutually decided that the engineer would develop preliminary plan drawings and finalize the diagrams, details, control sequences and specifications. The mechanical contractor would complete the final plan view drawings as part of developing their shop drawings, (all under the supervision of the engineer). They were also responsible for all budgetary and schedule feedback to the team, and for procurement. Shop drawings (which usually commence after contract documents are complete) started at 50% design development issue. Some of the remarkable results were:

- A large portion of equipment, pipe and ductwork was fabricated, delivered and installed three months prior to construction documents being completed (including basement level air-handling units, service water heating and medical gas equipment). Construction started with 50% design development drawings.
- Underground work was completed prior to release of 75% construction document drawings.
- The same week that the final construction documents were issued the entire central utility plant (14 discrete prefabricated packages of equipment) was delivered to the job site.
- Once the formwork was removed from the 300 ft (91 m) utility tunnel (which was angled and double sloped), pre-fabricated custom racked piping (steam, heating water, chilled water, domestic water, vacuum and oxygen) was installed in 40 ft (12 m) sections. The entire tunnel pipe installation was completed within seven days.

The final piece of the puzzle in Swedish Issaquah's design and construction process was the initial involvement with, and gradual handoff to, the building operators who would inherit and run the systems. The owner's building system engineer was on hand throughout the design process, during commissioning and on site for the first several months of start-up. He reviewed trend data daily and shared the information with the en-

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gineers and modelers. When something did not appear to be “per the model,” he worked closely with the engineer to find and correct the situation.

Conclusion

Looking back, the design team believes that the integrated project approach we used on Swedish Issaquah is the only way a complex hospital project such as this one could be delivered within tight time constraints and with an aggressive energy goal. Integrating traditional design and construction

processes, and eliminating traditional boundaries provided predictability of schedule and budget, ensured the best value was brought to the owner and allowed for an aggressive EUI target will be met. Why do it any other way? A year

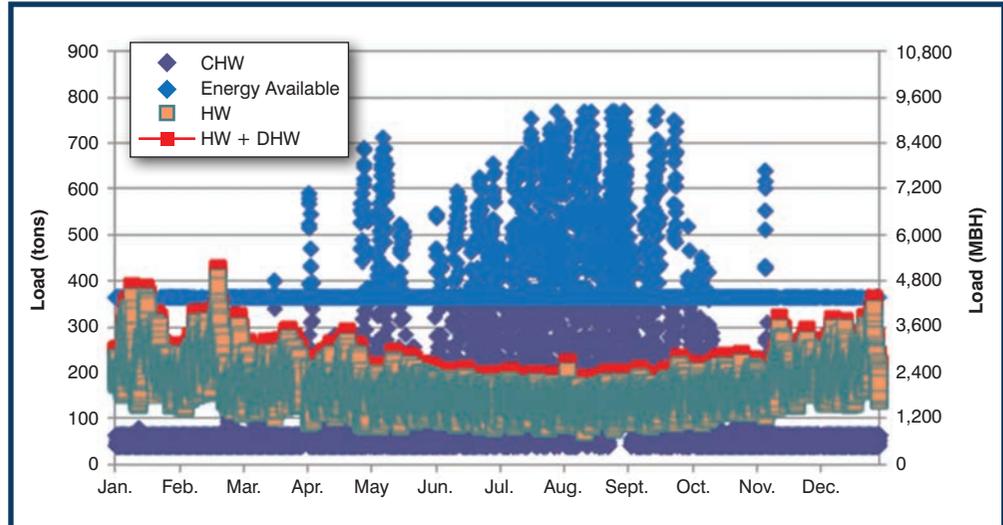


Figure 2: Hydronic loads scatter plot.

after opening, the hospital is operating at a record breaking EUI of 114, and with diligence and fine-tuning, may well hit 100 in the near future, and is presently one of the top-tier energy-efficient hospitals in the country. ■

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