JULY 2013 | www.hpac.com A Penton Publication

HEATING/PIPING/AIR CONDITIONING

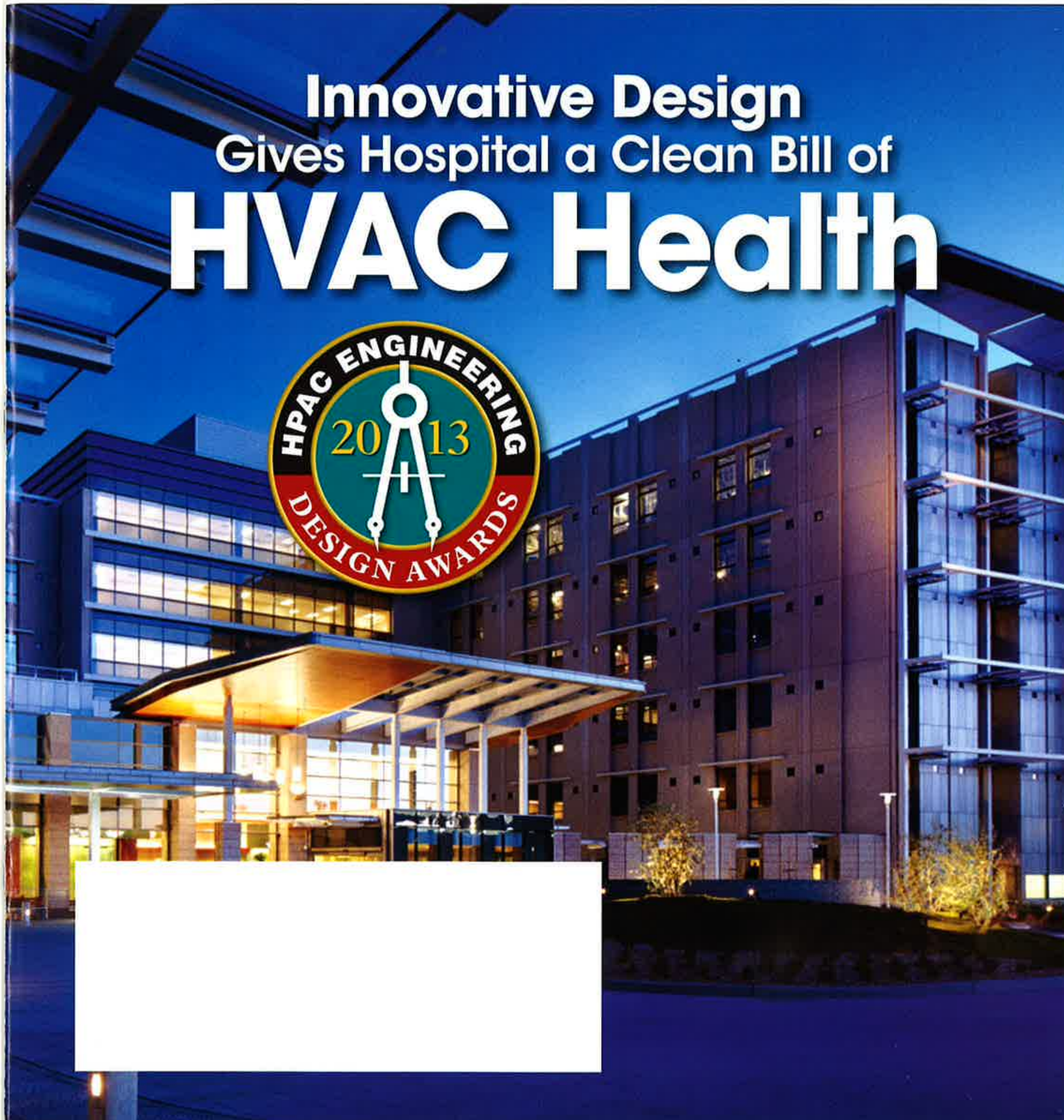
HPAC ENGINEERING

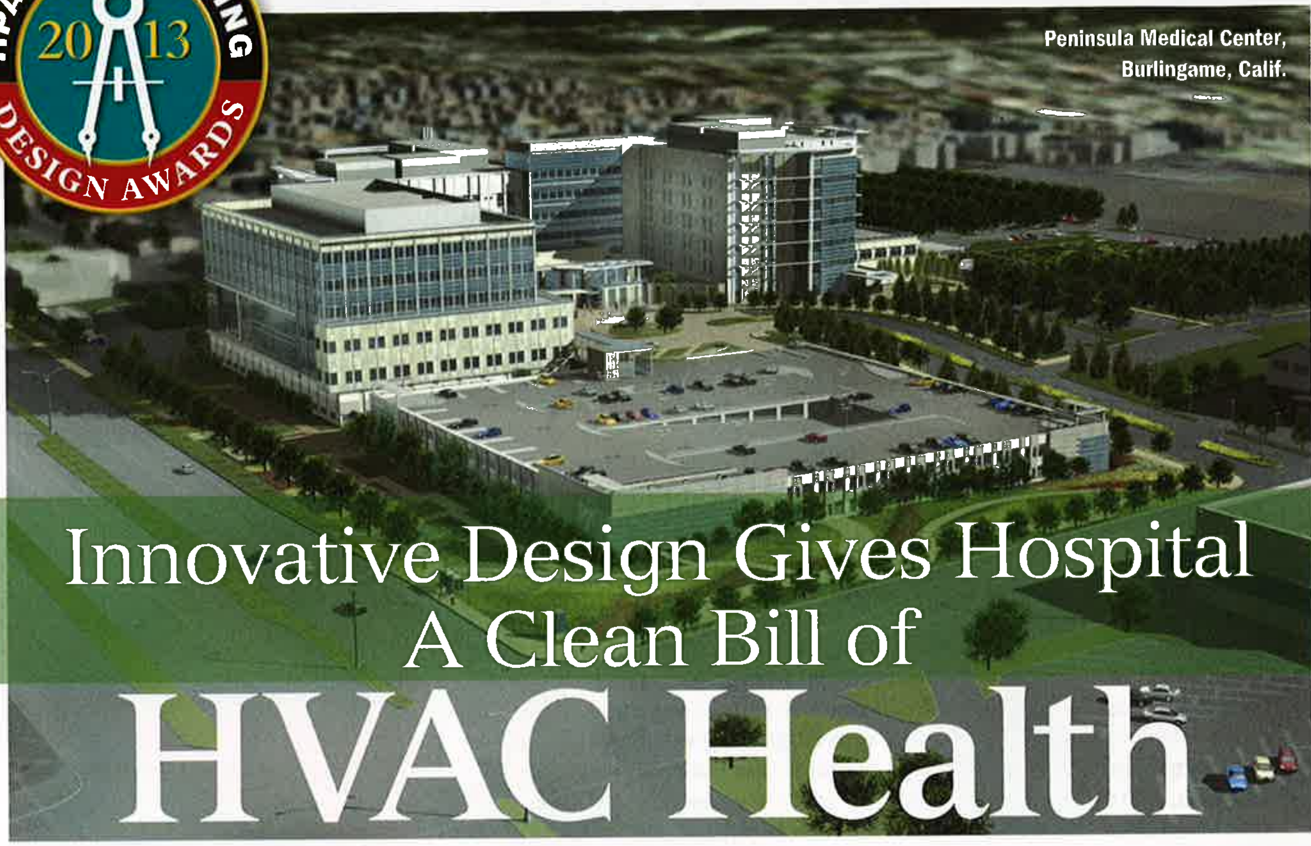
Managing Your Facilities: Maintaining Air-Conditioning-System Performance With Ultraviolet-C

News & Notes: ASHRAE Installs Officers and Directors

Taking Innovative HVAC Design to School

Innovative Design Gives Hospital a Clean Bill of HVAC Health





Peninsula Medical Center, Burlingame, Calif.

PHOTOGRAPHS COURTESY OF JOE FLETCHER PHOTOGRAPHY AND STANTEC

Innovative Design Gives Hospital A Clean Bill of HVAC Health

By RON RAJECKI, Senior Editor

Hospitals can be notoriously challenging for HVAC design engineers. The mission-critical nature of the work, the need to provide tight temperature and humidity control in specific areas and visitor comfort in others, strict ventilation requirements to prevent the spread of airborne infection, and the need for it all to run as efficiently as possible all conspire to make the design engineer's job a tough one. Add in the presence of an active fault less than two miles away and the need to design a building that will withstand a magnitude 8.0 earthquake, and you've got an idea of what Ted Jacob Engineering Group Inc. (TJEG) faced when long-time customer Sutter Health called for help.

Condenser-water pumps serve the mission-critical needs of Mills-Peninsula Medical Center.

In 1994, following a state-mandated seismic review of all California hospitals, Peninsula Medical Center in Burlingame, Calif. was classified as a potential earthquake collapse hazard requiring a seismic retrofit or demolition. Local not-for-profit health-care provider Sutter Health then began the long process of developing and realizing a vision for a new health campus on the site.

The new Mills-Peninsula Hospital opened in 2011 as part of Mills-Peninsula Medical Center. It represents one of the latest examples of California's program to upgrade the state's hospitals into seismically safe and technologically advanced facilities. The hospital is designed to meet 21st-century requirements for health-care delivery and energy conservation.

The new facility consists of a two six-story buildings: a 440,000-sq-ft hospital connected to a 150,000-sq-ft professional medical office building. The hospital has 311 private patient rooms separated into two L-shaped towers connected by a central circulation core atop a two-story podium. Power, steam, and hot and chilled water for the entire medical center are distributed from a central utility plant located on the hospital's lower level.

As a member of the design/assist team, TJEG provided mechanical, electrical, and plumbing consulting engineering services for the new facility, from conceptual design through construction, commissioning, and post-occupancy. The design/assist approach, along with 3-D building-information modeling during design and shop-drawing production, dramatically minimized the number of space conflicts and related change orders throughout the project, saving the client both time and money.

WINNER

Ted Jacob Engineering Group Inc., Oakland

PROJECT: Mills-Peninsula Hospital, Burlingame, Calif.

PROJECT SUBMITTED BY: Shulamit Rabinovich, PE, project manager

TOTAL PROJECT COST: $484 million

TOTAL MEP COST: $80 million

EQUIPMENT LIST:

- Hot water boilers: Bryan
- Steam boilers: Bryan
- Building-management system: Johnson Controls
- Chillers: Carrier
- Air-handling units: HUNTAIR
- Cooling towers: Marley
- Pumps: Bell & Gossett
- Variable-frequency drives: ABB

THE PROJECT TEAM:

From Sutter Health Facility Planning and Development:

- Oren Reinboldt, director
- Larry Kollerer, director
- Robert DeMann, program manager

From Ted Jacob Engineering Group Inc:

- Shulamit Rabinovich, PE, project manager
- Octavian Dragos, chief electrical engineer
- Hyung Ryu, PE, chief plumbing engineer
- Pol Marzan, senior mechanical engineer
- Jun Timbang, PE, senior electrical engineer
- Burgos Vibat, senior plumbing engineer
- Kevin Rutherford, construction administration
- Thomas Ho, senior mechanical engineer

Inside the System

The facility incorporates eight redundant high-pressure, high-efficiency steam boilers and three high-efficiency hot-water boilers. The hot-water boilers can utilize natural gas or fuel oil. Variable-frequency drives (VFDs) modulate the operation of secondary heating hot-water pumps.

The chilled-water plant consists of three high-efficiency electric centrifugal chillers and six counterflow cooling towers. VFDs modulate tower fans and secondary chilled-water pumps.

The HVAC-system design includes numerous energy-conservation features. Life-cycle-cost analysis was used to determine the economic viability of features such as 100-percent outside air, variable-air-volume (VAV) systems in patient rooms, run-around heat recovery, bypass dampers at all coils in air-handling units, fan-wall systems with VFDs, and dedicated cooling systems.

To prevent the spread of multiple-drug-resistant airborne infections, all air-conditioning systems in the hospital use 100-percent outside air. Therefore, excluding dedicated exhaust systems, there are only two ductwork systems: supply and exhaust. To implement the VAV system, the local code requires automatic modulating dampers in the room supply/return/exhaust ducts. The two-duct, 100-percent-outside-air system allowed for a reduction in the number of control dampers required and, thus, made possible the use of VAV systems in patient-occupied areas. This innovative approach represents a departure from the conventional constant-volume air-conditioning system typically found in a health-care environment and greatly increases patient comfort control of individual spaces.

A run-around heat-recovery system is used to transfer energy from the exhaust-air stream to preheat outside air. In the coastal region of California, this system not only has the lowest construction cost, but also the lowest operation-and-maintenance cost while providing outstanding indoor-air quality.

Through an extensive study (see sidebar, "Energy and Life-Cycle-Cost Study") TJEG determined that when compared with a conventional, three-duct supply, return, and exhaust system, the two-duct, 100-percent-outside-air system with run-around heat recovery and VAV not only offered energy savings, but had the lowest life-cycle cost.

Secondary heating hot-water pumps help provide outstanding system control.

Heating hot-water boilers located in the central utility plant can utilize either natural gas or fuel oil.

High-pressure steam boilers in the central utility plant.

"Using a 'less is more' approach helped us select this system, which offered the customer many benefits, including outstanding indoor-air quality, prevention of the spread of airborne infections, increased patient comfort control of individual spaces, energy savings, and low construction, operation-and-maintenance, and life-cycle costs," Shulamit Rabinovich, PE, project manager, said.

Other features of the system include bypass dampers at all AHU coils programmed to open when the coils are not in use. This measure allows reduction in system air-pressure drop and, thus, a reduction in the energy consumption.

Fan-wall systems create uniform airflow in the duct-

The chilled-water plant at Mills-Peninsula Medical Center.

Cooling towers in the service yard. Note their proximity to a nearby residential area.

work and minimize vibration and noise. Multiple fans increase system redundancy and reliability. Fan-wall installations reduce length of the AHU cabinet because of shorter downstream airflow requirements. Also, they eliminate the need for sound attenuators, thus further reducing overall AHU length and required fan horsepower.

When outside air is low enough in temperature to cool the building, the chiller plant is de-energized. Areas with high heat gains are cooled by small dedicated systems.

All AHUs have 30-percent-efficient pre-filters and

ENERGY AND LIFE CYCLE COST STUDY

Numerous energy-efficiency measures were considered and studied by TJEG during the conceptual phase of the project by the design team with participation of the owner, energy consultant Architectural Energy Corp, and contractors ACCO/Turner.

The objective of the study was to develop a benchmark and define the California Standard Title-24 and Optimized Proposed Baseline Building. The Optimized Proposed Baseline Building was created as a starting point to evaluate the cost-effectiveness of various energy-efficiency measures. It, and the buildings' energy models, were created using Pacific Gas & Electric's 2003 Savings-by-Design modeling procedure.

Visual DOE 4.0 was used to create the model, and hourly weather data for San Francisco Airport was used for load calculations. Life-Cycle Cost Analysis Program BLCC 5.2 developed by the Office of Applied Economics Building and Fire Research Laboratory of the National Institute of Standards and Technology was used to analyze 23 system alternatives.

Operating schedules H, B, and C from 2003 Savings-By-Design Healthcare were used to represent 24-hr, 18-hr, and 12-hr operations, respectively, and Pacific Gas and Electric's E-19 electricity rate and GNR-1 natural-gas billing rate were used for cost projections.

Based on the life-cycle cost analysis, the alternative selected for implementation was a 100-percent-outside-air system with heat recovery, VAV in patient rooms and other specific areas, and a minimum of four air changes per hour during the day and two air changes per hour at night. Given the anticipated reduction in energy demand, the team also was able to significantly reduce the capacity of mechanical equipment originally proposed for the design. The cost savings realized by the elimination of equipment offset the increased costs of the VAV and heat-recovery system. Essentially, the option with the lowest life-cycle cost also had one of the lowest initial costs.

Shulamit Rabinovich, PE, project manager, recently received information from the owner regarding the facility's gas and electricity consumption. The hospital's energy-use index (EUI) is just under 227 Btu per square foot per year, which meets the 2030 Challenge target (U.S. national average site EUI for a hospital) and is well below the Optimized Proposed Baseline of 295.73 Btu per square foot per year.

Despite these positive results, Rabinovich is not satisfied.

"The EUI is good, but it is higher than our anticipated calculated energy use," she said. "Now that we have an actual baseline, we plan to work with the owner to improve operation of the systems."

90-percent final filters. In addition, AHUs serving the surgery department and other sensitive areas contain 99.99-percent-efficient HEPA filters.

Lastly, a Johnson Controls Inc. building-management system was selected to control the operation of all HVAC systems, including the AHUs, air-supply and exhaust systems, and chilled-water, hot-water, and steam plants.

A fan-wall system creates uniform velocity in the ductwork and minimizes vibration and noise.

Commissioning agents joined the team during schematic design and continued their work well into the post-occupancy phase. All systems were thoroughly commissioned and de-bugged by the commissioning agent with the design team's support.

A STATE-OF-THE-ART SYSTEM FOR EARTHQUAKE PROTECTION

Located less than two miles from the active San Andreas Fault, Mills-Peninsula Hospital is designed to withstand and remain operational after a magnitude 8.0 earthquake. It is the first hospital in California to be base-isolated on friction pendulum bearings, a state-of-the-art seismic technology designed by Structural Engineer Rutherford + Chekene.

As the earth beneath the hospital shakes, the building itself rises like a pendulum on concave dish-shaped isolators, separating itself from the shaking ground and moving as much as 30 in. in any direction. An open "moat" circumscribes the entire perimeter of the building to accommodate this movement.

Custom-designed sliding moat covers protect pedestrians and allow access across the moat, as well as ventilation of the space below. All piping entering the moat, including water, sewage, medical gases, and condenser-water piping, is fitted with flexible joints to accommodate 30 in. of movement in any direction.

Teamwork, Analysis, Innovation

Larry Kollerer, director, Sutter Health Facility Planning and Development, has known and worked with TJEG for nearly 30 years. He said this project was not without its challenges, some of which are ongoing.

"Hospitals are complicated, and there was an operational learning curve," Kollerer said, "but the TJEG team is always willing and able to help and review operational issues. I believe their design is strong and will service Mills-Peninsula for many years to come."

Rabinovich likewise tips her cap to the team at Sutter Health.

"Projects do not happen in a vacuum, and without the owners' understanding and support, this project and this award wouldn't have happened," she said.

Overall, the combination of teamwork, thorough analysis, and innovative thinking led to an excellent design in a challenging environment. Congratulations to Ted Jacob Engineering Group Inc., winner of the 2013 *HPAC Engineering* Design Award.

Alternative	Description	Total electricity, (KBTU/yr)	Total gas (KBTU/yr)	Total energy (KBTU/yr)	KBTU/yr/sq.ft.	savings, (kbtu/yr/sq.ft.)	% Savings (kbtu/yr/sq. ft.)	% Savings ($)
T-24	Title-24 Baseline Based on Savings By Design Guidelines for Hospital. See Table 26 and Table 27	48,793,311	89,735,300	138,528,611	314.84			
Alt 0	Proposed Design Baseline. Based on current architectural and mechanical plans, excluding heat recovery and some exterior shades. See Table 26 and Table 27	60,397,391	142,358,600	202,755,991	460.81			
Alt 1	Optimized Proposed Design Baseline. Same as Alt 0, except that mechanical equipment sizing is optimized based on simulation model loads	46,312,257	83,807,600	130,119,857	295.73			
Alt 2	Alt 1, but with VAV control in patient room areas. Min. ACH is same as proposed @ 6 ACH	43,061,824	77,721,800	120,783,624	274.51	21.22	7.18%	6.90%
Alt 3	Alt 1, but with VAV control in patient room areas. Min. ACH @ 4 ACH	38,701,253	67,331,600	106,032,853	240.98	54.74	18.51%	17.10%
Alt 3b	Alt 1, but with VAV control in patient room areas. Min. ACH @ 4 ACH during the day and 2 ACH at night	37,835,000	64,229,500	102,064,500	231.96	63.76	21.56%	19.20%
Alt 4	Alt 1, but with VAV control in patient room areas. Min. ACH @ 2 ACH	35,858,946	59,764,800	95,623,746	217.33	78.40	26.51%	23.80%
Alt 5	Same as Alt 2 with VAV control in patient rooms and other specific zones. Min. ACH is same as proposed @ 6 ACH	41,791,255	75,292,800	117,084,055	266.10	29.63	10.02%	9.70%
Alt 6	Same as Alt 3 with VAV control in patient rooms and other specific zones. Min. ACH @ 4 ACH	36,310,188	62,200,300	98,510,488	223.89	71.84	24.29%	22.40%
Alt 6b	VAV control in patient rooms and other specific zones. Min. ACH @ 4 ACH during the day and 2 ACH at night	35,018,835	57,551,500	92,570,335	210.39	85.34	28.86%	25.70%
Alt 7	Same as Alt 4 with VAV control in patient rooms and other specific zones. Min. ACH @ 2 ACH	32,931,413	51,752,600	84,684,013	192.46	103.26	34.92%	30.90%
Alt 8	Interior Blinds. Same as Alt 1, with interior shades added to patient rooms	46,202,104	83,465,400	129,667,504	294.70	1.03	0.35%	0.30%
Alt 9	Exterior shade Option A added to Alt 1	46,192,307	83,630,400	129,822,707	295.05	0.68	0.23%	0.30%
Alt 10	Exterior shade Option B added to Alt 1	46,220,606	83,483,300	129,703,906	294.78	0.95	0.32%	0.20%
Alt 11	Alt 10 and VAV (with min. 6 ACH) added to patient rooms	42,929,598	77,458,000	120,387,598	273.61	22.12	7.48%	7.20%
Alt 12	Alt 10 and VAV (with min. 4 ACH) added to patient rooms	38,463,559	66,199,600	104,663,159	237.87	57.86	19.56%	17.60%
Alt 13	Alt 10 and VAV (with min. 2 ACH) added to patient rooms	35,765,154	59,061,000	94,826,154	215.51	80.21	27.12%	24.20%
Alt 16	Alt 1 with heat recovery	46,264,438	59,466,900	105,731,338	240.30	55.43	18.74%	7.70%
Alt 17	Alt 10 with Heat Recovery	46,071,207	59,115,100	105,186,307	239.06	56.67	19.16%	8.20%
Alt 18	Alt 2 with heat recovery	42,774,552	53,810,600	96,585,152	219.51	76.22	25.77%	15.00%
Alt 19	Alt 3 with heat recovery	38,450,805	47,359,700	85,810,505	195.02	100.70	34.05%	23.80%
Alt 19b	Alt 3b (VAV in patient rooms with 4 and 2 ACH) with heat recovery	37,387,629	42,948,100	80,335,729	182.58	113.15	38.26%	26.70%
Alt 20	Alt 4 (VAV in patient areas with 2 ACH) with heat recovery	35,550,324	43,947,600	79,497,924	180.68	115.05	38.90%	29.40%
Alt 21	Alt 6b (VAV in patient rooms and other specific zones with 4 and 2 ACH) with heat recovery	34,426,109	38,293,400	72,719,509	165.27	130.46	44.11%	32.70%
Alt 22	Alt 7 (VAV in patient rooms and other specific zones with 2 ACH) with heat recovery	32,233,049	36,106,600	68,339,649	155.32	140.41	47.48%	36.90%
Alt 23	Alt 21 plus evaporative pre-cooling	34,087,032	38,314,400	72,401,432	164.55	131.18	44.36%	33.50%

Ted Jacob Enginnering group analyzed 26 options before making their recommendations to Sutter Heatlth.