ACHIEVING NET ZERO ENERGY FOR HOSPITAL BUILDINGS

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As the world's natural resources such as fossil fuel and water are becoming scarcer, government legislators along with professional societies are setting energy strategies to meet certain goals of building energy performance.

As an example, the U.S. Green Building Council supported by the U.S. Department of Energy and other professional organisations are focusing on designing Net Zero Energy Building with the ultimate goal of Carbon-Neutral buildings by 2030. Dubai has set clean energy strategy of 7 per cent by 2020, 25 per cent by 2030 and 75 per cent by 2050.

The key to achieving these goals is by incorporating energy efficient strategies into the design, construction, and operation of the new building and undertaking retrofits to improve the efficiency of existing building. Once the building energy usage has been optimised, renewable energy such as solar can be applied to achieve Net Zero Energy Building.

Net Zero Energy Building

Using the concept of a Net Zero Energy Building, one which produces as much energy as it uses over the course of a year, can further reduce dependence on fossil fuels by increasing use of on-site and off-site renewable energy sources. Net Zero Energy design depends on two key elements, the reduction of energy demands and the on-site production of energy. Building design in achieving Net Zero Energy includes the following:

Passive design is the key to sustainable building. It responds to local climate and site conditions to maximise building users' comfort and health while minimising energy use. Some of the features include:

- Building orientation
- High-performance envelopes
- Daylighting
- Sun control and shading devices
- Prudent selection of windows and glazing

Active building design includes all the mechanical and electrical system designs to achieve the most energy efficient systems with better indoor air quality, such as:

- High-performance HVAC systems
- Energy efficient plug loads
- Energy efficient lighting

Energy efficient strategies, such as energy conversion systems including:

- Combined heat and power systems
- Fuel cells
- Micro turbines
- Co-generation

Renewable energy strategies to accomplish Net Zero Energy Building capturing energy from natural resources such as solar, wind, geothermal, etc., is not derived from fossil fuel or nuclear fuel. It can be tapped into from:

- Photovoltaic
- Solar hot water
- Wind turbines
- Ground water

Design Challenges for Healthcare Facilities

Healthcare building design presents both challenges and opportunities in the development of sustainable facility. Some of the challenges are:

- The 24/7 operation of the hospital.
- Infection control.
- Indoor air quality.
- High outside air ventilation rate.
- Stringent temperature and humidity requirement for critical areas.
- Room pressurisation.
- Room supply air-changes per hour as required by code.
- High degree of systems reliability and redundancy.

Successfully Implemented Innovations

The incessant drive to reduce energy consumption while maintaining all functions and achieving goals of the mechanical systems spurned evolution of the energy reduction innovations in the hospital design that has been successfully implemented by Ted Jacob Engineering Group (TJEG).

Ventilated Double-skin Façade System (Figure 1)

Double-skin façade has been used in buildings as a passive building technology to enhance the energy efficiency and improve indoor thermal comfort at the same time. This includes the use of passive double-skin where air is taken from the bottom of the double façade and plumed up between the double façade layers. This concept has been used successfully in cold climates.

The passive double-skin facade would not work in hot and humid climate of the Gulf Region. We did implement ventilated double-skin façade concept where we discharged the building exhaust air at the bottom of the double-skin façade at a much lower temperature than the design ambient air temperature keeping the temperature in the intermediate space at constant supply air temperature year-round. The use of the above concept also eliminated condensation on the outer façade.

100 per cent Outside Air System with Run-Around Heat Recovery (Figure 2)

This concept requires only two main duct systems – supply air and general exhaust air, thus reducing first cost of the system as well as the maintenance cost. It is the most adaptable to the space utilisation changes.

In addition, Code permitted reduction of the amount of supply air led to the energy consumption reduction.

TJEG determined that when compared with the conventional, three-duct, supply, return and exhaust systems, the two-duct, 100 per cent outside air system, not only offered first cost and energy savings but also had lower life cycle cost.

The most important advantage of this concept is that it provides 100 per cent outside air and, as a result, the best Indoor Air Quality (IAQ) all year around.

Variable Air Volume (VAV) System

All outside air system allowed introduction of the VAV concept while achieving Code compliance.

To implement VAV system local Code requires automatic modulating dampers in the room supply/return/exhaust ducts. The two-duct, 100 per cent outside air system allowed for a reduction in the number of the control dampers required and, thus, made possible the use of the VAV system in the patient occupied areas.

This innovative approach represents a departure from the conventional constant volume air conditioning system typically found in the healthcare environment and greatly increases patient comfort control while reducing energy consumption.

Displacement Ventilation (Figure 3):

Displacement ventilation is a well-known approach to the air supply used in all kinds of the buildings, except healthcare. In order to respond to concerns related to the infection control and space comfort, air velocity, temperature and stratification rigorous CFD analysis was undertaken.

A mock-up patient room was built in the laboratory to test performance of the displacement ventilation and confirm validity of the CFD analysis.

Through an extensive study of several HVAC system options TJEG determined that when compared with other systems, the Displacement Ventilation, VAV, two-duct, 100 per cent outside air system with run-around heat recovery, offered energy savings and had the lowest life cycle cost.

Fan Array with Variable Frequency Drives

Fan arrays or fan wall systems create uniform air flow across the coils and in the ductwork and minimise noise and vibration. Multiple fans increase systems redundancy and reliability. Fan array installations reduce overall length of the air handler's cabinet due to shorter space requirements downstream of the fans. Also, they eliminate the need for the sound eliminators, thus further reducing the length of the cabinet as well as the fan horsepower. Multiple variable frequency drives control fan operation to modulate air supply to fit building needs.

Bypass Dampers

Air handling units contain heat recovery and cooling coils that introduce resistance to the air flow resulting in the pressure drop. By-pass dampers at all coils in the air handling units are programmed to open when the coil is not in use. This measure presents a reduction in the air pressure drop, and thus, a reduction in the energy consumption.

Heat Harvesting and Rejection

Heat is harvested from miscellaneous heat producing equipment, such as computer room air conditioning units, refrigeration equipment condensers, medical and lab equipment, etc. and is used for reheating coils and preheat domestic water. Heat recovery run-around system may be used to reject the excess harvested heat into the system. ▶

Integrated Project Delivery (IPD) and Net Zero Energy Building (NZEB)

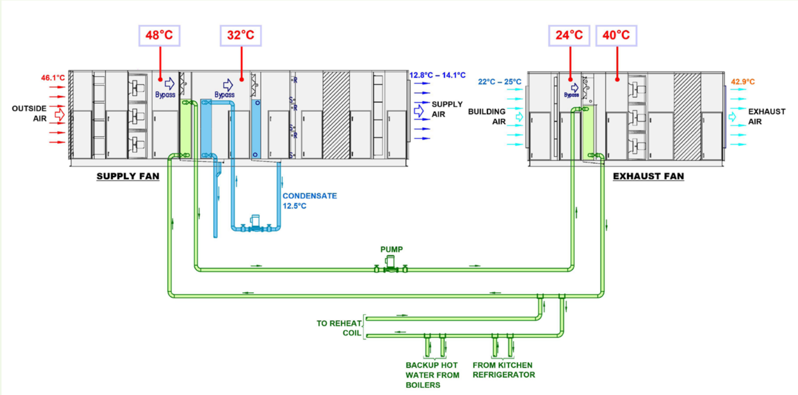
Adopting new technologies and creative systems is often met with challenges from the client and building operators since they don't want to be the first to implement these technologies.

IPD established a collaborative three-way relationship between owner, consultant and contractor that allowed thinking and visualisation outside the box. It anticipated future needs and identified potential energy efficiency strategies through the engagement of many different participants during the project delivery.

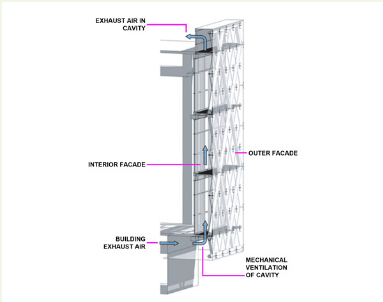
Vital to the success of the project was the participation of the owner's representatives supporting innovation and team work during the design process, and being open, receptive and encouraging the team to introduce new energy efficiency features to the ever-evolving HVAC systems.

In addition to the project coordination benefits of IPD, it provides a project delivery model that can better conceive and implement the concept of the NZEB by encouraging building design to minimise energy requirements and implementing renewable energy systems that meet these reduced energy needs.

▼FIGURE 2: 100 per cent Outside Air System with Run-Around Heat Recovery



▼FIGURE 1: Ventilated Double-skin Façade System



▼FIGURE 3: Displacement Ventilation

Ted Jacob will discuss 'Achieving Net Zero Energy', as part of the Design & Build conference, on October 3, at Building Healthcare.

Conclusion

In the past decade, the building design industry has undergone a major transformation due to the implementation of sustainable building design measures on projects. The guidelines for sustainable building design for hospitals is being set by the U.S. Green Building Council "LEED", and Green Guide for Healthcare and regionally by the Emirates Green Building Council. These are excellent guidelines for implementation of the Green Buildings approach that are encouraging innovation for the new designs towards Net Zero Energy Buildings.

New construction in healthcare facilities offer the greatest energy saving potential on a building-by-building basis. Renovation of existing healthcare facilities provides the maximum overall energy savings because of their remaining service lives and the large number of facilities in operation.

We encourage every design professional to integrate principles of the sustainable design into their practice when working on new and/or renovation projects. These designs should look at reducing the overall energy and water consumption and related emissions of greenhouse gases. The facility will be rewarded with better indoor air quality, lower building first and operating costs, and above all an environment that meets its mission of saving lives. AH