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CADDET IEA OECD
energy efficiency

Energy efficient HVAC and thermal storage

HVAC system for bank headquarters uses heat reclaim and thermal storage

Summary

The HVAC system for the new Standard Federal Bank headquarters in Troy, Michigan, the United States, was designed for energy efficiency, low operating costs and a high quality indoor environment. Ice thermal storage and heat reclaim from the building's data centre, in combination with a well-insulated building envelope, have resulted in calculated savings of USD 62,000 per year with a payback period of 3.3 years. The design of this building's HVAC system, completed in 1989, exceeds all codes and standards for energy efficiency in the United States.

This project won a 1992 ASHRAE Technology Award and also the ASHRAE Award of Engineering Excellence given only to projects of especially high quality.

Highlights

- **Annual energy savings of USD 62,000**
- **High quality indoor environment**
- **ASHRAE award winner**

Exterior of Standard Federal Bank headquarters.

Aim of the Project

The aim of this project was to provide the lowest possible operating costs and energy usage for the new Standard Federal Bank building while providing a high quality indoor environment that would increase the staff's productivity. This was to be accomplished by using the latest technologies in the areas of energy efficiency and indoor air quality.

The Principle

A combination of ingenious technologies was used for heating and cooling generation in this building. Heat is reclaimed from the building's 24-hour data (computer) centre for reuse in heating and ventilating the building.

Electricity demand has been reduced through the use of a thermal storage system as the second stage which means that the conventional electric chillers will operate to full load. If the building cooling load increases further then the thermal storage capacity will be added to the fully loaded electric chillers to cool the building properly. The cold water/glycol mixture from the ice storage system is also used for dehumidification, allowing the building's sensible cooling system to operate at higher chilled water temperatures for lower energy use. Since the water/glycol mixture in the thermal storage cooling circuit is 6 °C (42 °F) and will not freeze during winter months this fluid was selected to perform dehumidification.

Variable speed pumping is used for both heating and cooling. For energy efficiency, all systems were optimised for minimum energy consumption by using the most efficient components. Digital controls contribute to precise use of energy.

A number of technologies are combined to provide a high quality indoor environment. Constant air volume motion and high ventilation rates are used to dilute and remove indoor contaminants. The dehumidification system is separated from the air-handling system for minimisation of microbiological contamination. A digital building automation system provides very accurate control and has remote monitoring capabilities to spot and correct potential system problems before they affect the staff.

The building's envelope is well insulated for minimum energy input. The U-value for the high-mass granite exterior walls is 0.34 W/m²K and for the roof it is 0.28 W/m²K. Windows and skylights are low "E" (emissivity) with a U-value of 2.16 W/m²K.

The Situation

The new Standard Federal Bank building has an area of 42,750 m² (460,000 ft²). It includes office space for bank staff, a central data centre which operates 24 hours a day, seven days a week, and a food service pavilion which provides food for about 1,500 people each week day for lunch and several hundred people for breakfast and dinner.

A primary consideration in the design of this building was to achieve a high quality indoor air environment in order to increase the staff's productivity. The key elements for excellent indoor air quality were good ventilation, proper air motion, and minimisation of microbiological contamination of indoor air. The air system design selected was a constant air volume coil module system. Constant air motion fan units heat or cool the air to meet required space conditions. Quiet axial-flow fans with 65 % filters (ASHRAE standard 52-76) deliver air to the coil modules for heating or cooling of individual space. The outdoor primary air units introduce ventilation air to the fan units, at a constant volume, upstream of the filter units to remove microbiological contaminants. The air is heated or cooled as necessary. In the summer the cooled air (7 °C, 45 °F) is very low in humidity and provides a constant dehumidification effect to the building. In the winter, electric canister-type humidifiers keep humidity levels at or above minimum.

This building was designed to exceed all codes and standards for energy efficiency. The equipment selected was based on minimum primary energy input. Chillers, boilers, pumps, fans, and all energy using equipment were selected for long term minimum energy consumption.

The largest reduction in the use of energy in the project came in the generation of heating and cooling energy. Since the building has a data centre which operates on a 24-hour basis, the cooling of this area is used as a heating source during

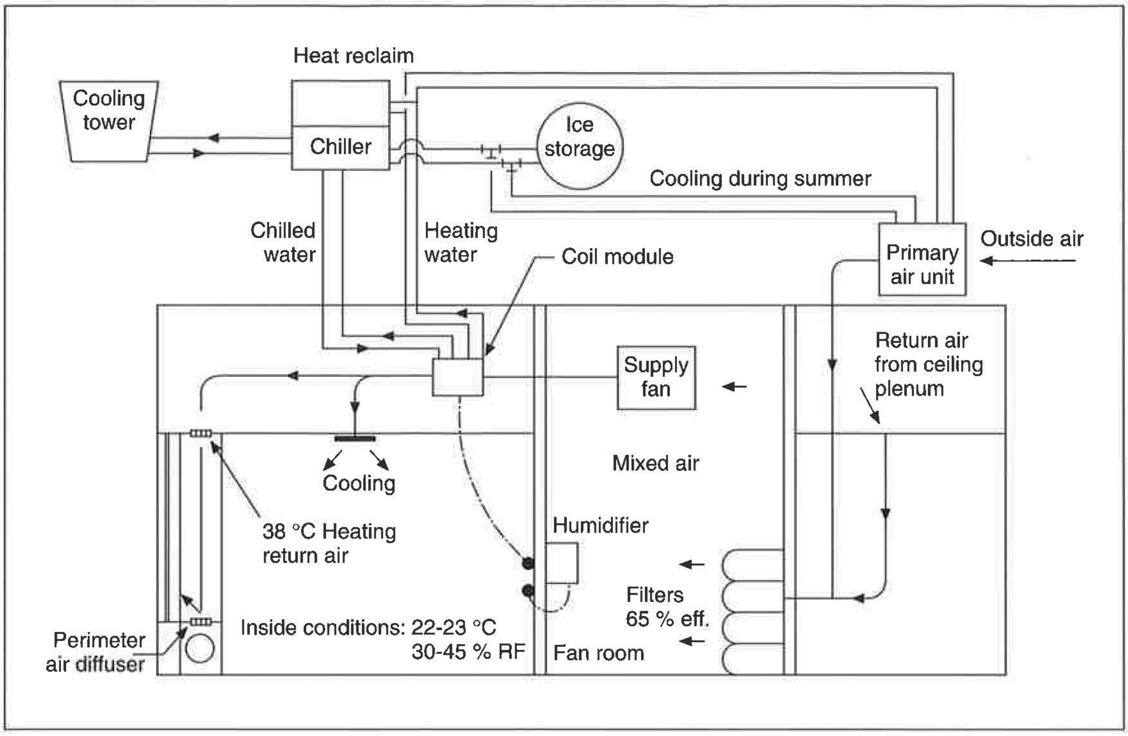

Figure 1: Coil module HVAC system.

winter months. The system design uses a 986 kW (280 RT) heat reclaim chiller with back-up by two 580 MW gas-fired boilers. The heat that the heat reclaim chiller removes from the chilled water is transferred into the building's hot water heating system during winter months and is transferred to the building's cooling tower condenser water system in non-heating months. The reclaim chiller provides 90 % of the building's heating needs. The boilers are only needed when outdoor temperatures are below -9 °C (15 °F). By shifting part of the cooling energy use to night-time hours when electricity is much less expensive, major operating cost savings were made. The system designed is a partial thermal storage chiller system using ice as the storage medium due to its superior economics. A 1,197 kW (340 RT) cooling-only chiller and two 1,056 kW (300 RT) ice chillers are used for ice-making at night and cooling during the day. Twenty vat-type tanks provide 3,100-RT-hours of storage. The very cold water/glycol mixture discharged from the ice tanks is used both to dehumidify and cool the building. Outdoor air is cooled to 25 °C (45 °F) during summer months, allowing the building's chilled water system to operate at a higher temperature and efficiency. A 3,520 kW (1,000 RT) cooler removes excess heat when the temperature is below 13 °C (55 °F) outside.

The pumping system is a variable speed system with piping friction sized between 0.3 to 1 m/30 m (1 to 3 ft./100 ft.) equivalent pipe. The system can throttle down to 25 % maximum flow.

The Organisation

The Standard Federal Bank is headquarted in Troy, Michigan. This federal savings bank has over 1,600 employees and USD 10.9 billion in assets and deposits of USD 7.7 billion. Over the past 20 years the bank has grown geographically, primarily as a result of 16 mergers and acquisitions. Standard Federal currently operates more than 150 full-service branch offices as well as over 200 automated teller machines and eight loan production offices throughout northern Indiana, lower Michigan and north-western Ohio.

The Economics

The new Standard Federal Bank headquarters was designed to reduce operation and maintenance costs to a minimum, since these make up a large part of the building's cost to the owner. The digital building automation system finds problems before a major failure occurs. The use of valves for temperature control, as opposed to dampers, reduces maintenance. The servicing of major equipment from the floor provides for easy and prompt maintenance and preventive care. Careful design speci-fication meant that components with a 20-year life, but no undue increase in cost, could be used.

The additional first cost for a combined thermal storage and heat reclaim system for this building was USD 205,000. With an estimated energy savings of USD 62,000 annually, the payback period is 3.3 years.

The additional HVAC cost to provide the high level of indoor air quality was USD 1.4 million. The estimated savings from an increased staff productivity of 2.5 % is USD 1.25 million per year. The payback period is estimated at 1.2 years.

Host Organisation

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* IEA: International Energy Agency
OECD: Organisation for Economic Co-operation and Development

IEA

The IEA was established in 1974 within the framework of the OECD to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among the 23 IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D).

This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the framework of 35 Implementing Agreements, containing a total of more than 60 separate collaboration projects.

The Scheme

CADDET functions as the IEA Centre for Analysis and Dissemination Demonstrated Energy Technologies for all IEA CADDET member countries.

This project can now be repeated in CADDET member countries. Parties interested in adopting this process can contact their National Team or CADDET.

Demonstrations are a vital link between R&D or pilot studies and the end-use market. Projects are published as a CADDET 'Demo' or 'Result' respectively, for on-going and finalised projects.