November 2023 ASHRAE Journal

The following pages contain supplementary information for these articles in the November 2023 issue of ASHRAE Journal:

Hidden Figures in HVAC: David Nelson Crosthwait Jr
By Janice K. Means, P.E., Fellow/Life Member ASHRAE

Online Figure 1

Oct. 4, 1927. 1,644,114

C. A. DUNHAM

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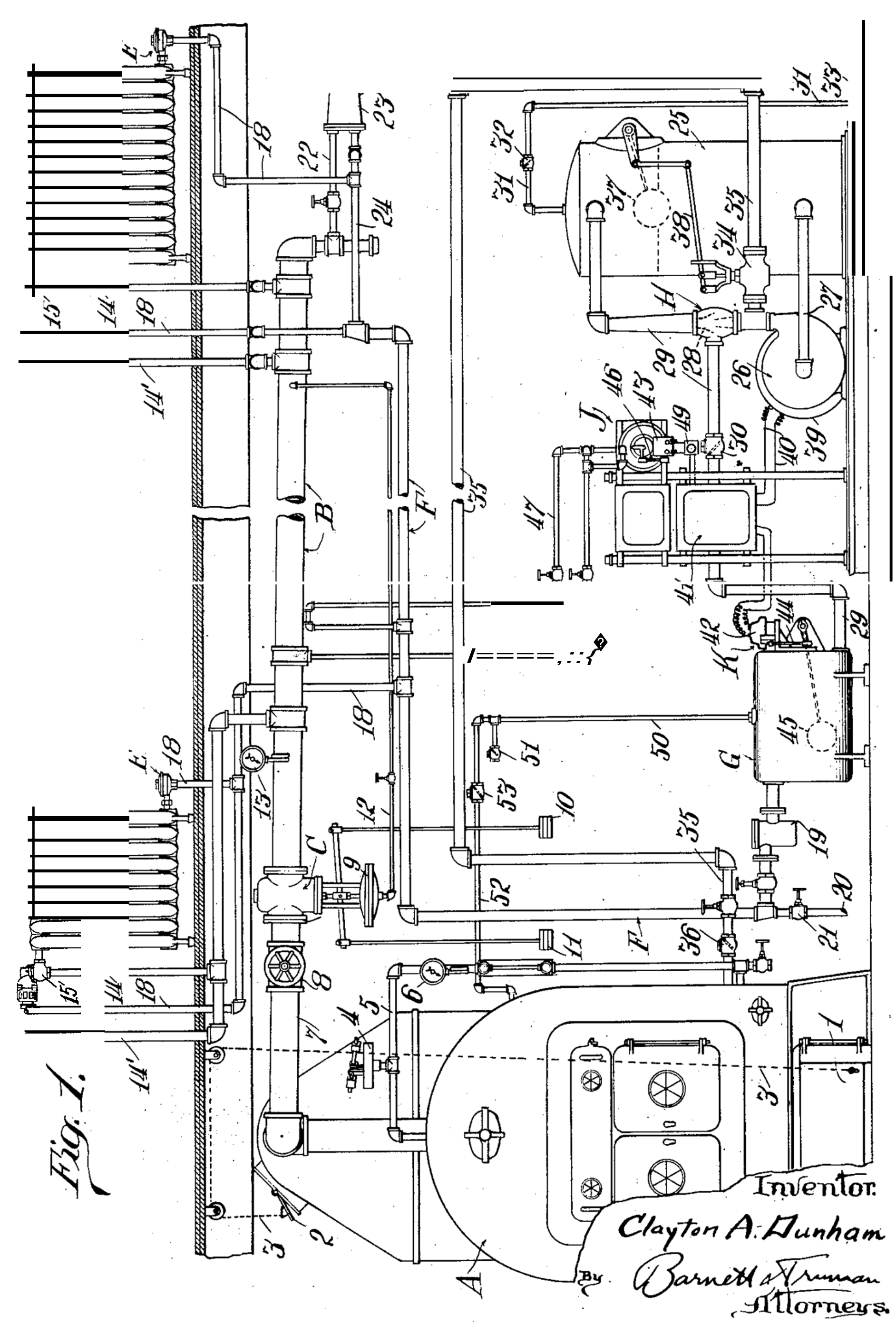
Filed Feb. 28, 1927 5 Sheets-Sheet 1



Dual-Temperature Chilled Water Enhances Energy Efficiency, Comfort

By Erik Elmtoft, P.E., Member ASHRAE; Saied Nazeri, P.E., Member ASHRAE; TG Davallou, Associate Member ASHRAE; Amber Welsh, P.E., Member ASHRAE

Cost Effectiveness

The project costs are confidential for protection of the client's financial data; specific total numbers cannot be given. However, the project scored the maximum incentive with PG&E's "Savings by Design" program, which evaluates new construction projects based on energy performance and total costs. This was verified through both independent energy modeling and energy site assessments, both performed by PG&E's third-party reviewers. In addition, energy modeling noted savings of $800,000/year compared to the Standard 90.1-2007 baseline. Actual operational data points to even greater savings. The justification of the system selection was an ROI of 15 years per the design studies; this was reduced to nine years when accounting for leasable area regain.

This was based on the PG&E commercial rate schedules E-19/G-NR2. Note that on-site fuel cells optimize the operational cost effectiveness by producing site electricity at times when electricity rates are high. The building also has a demand response sequence which automatically turns off nonessential loads during high demand events in the power grid.

Operations & Maintenance

Maintenance in actively conditioned areas were reduced through the radiant panels, which do not need to be altered or adjusted after being set in place compared to ceiling diffusers and dampers, which require periodic adjustments for airflow control, which was an option studied during the early design phases. The raised access floor enabled easy, ladder-free access to dampers in the air-sealed cavity.

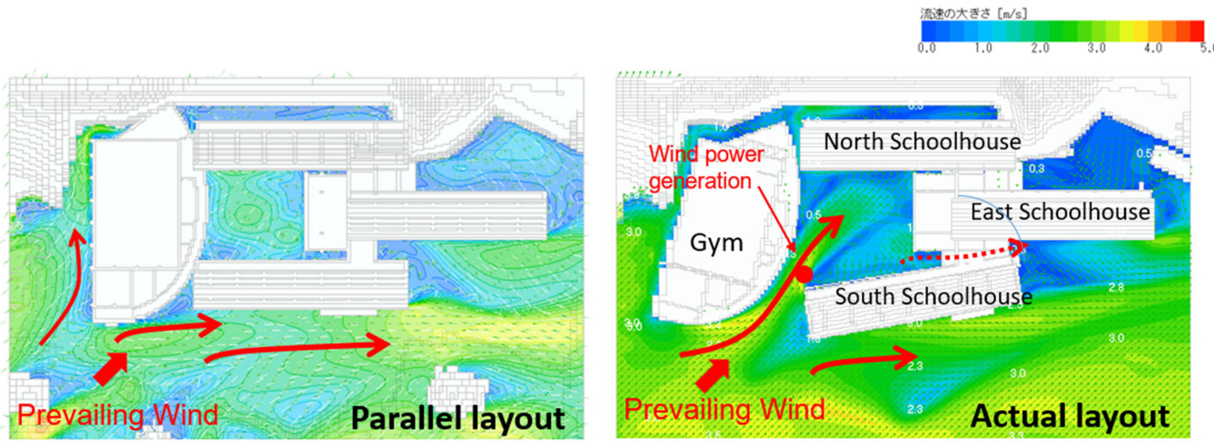
Both the radiant panels and underfloor air distribution provides flexible HVAC zoning, which is an important consideration when hybrid and collaborative work are new priorities for building owners. In passively conditioned areas, maintenance was greatly reduced by the automated operable windows and radiant floors, which require minimal interference and inspections compared to air systems, fan-coils and chilled beams.

Each naturally ventilated window zone was determined through wind tunnel modeling with measurements normalized to the roof, where the weather station is located. Each window zone was tested and verified on-site for wind speed response. All radiant zones and underfloor devices and dampers were verified for airflow and air velocity. The buildings were tested through a range of environmental conditions (summer/winter) and controlled to operate automatically at all load conditions. The commissioning team also reviewed and determined equipment start-up sequences after a power failure. Furthermore, an integrated building management system architecture ("smart building") converged lighting control, elevator control, graywater systems, fuel cells, HVAC, fire alarm and other building systems to the same network topology. This was a novelty at the time without a manual/standard for how to integrate these building systems.

Environmental Impact

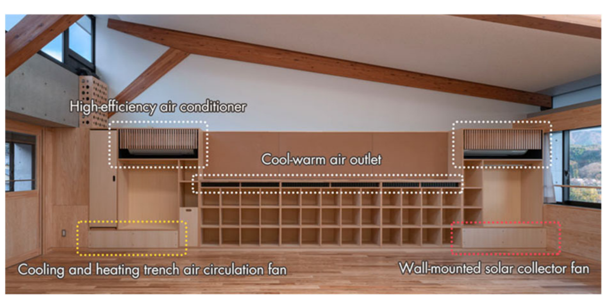
According to EPA eGRID2020 Subregion CAMX/WECC California data, the energy offset contributes with an annual reduction of 460,000 lb of CO_2. Variable refrigerant flow and water-source heat pumps were not pursued as part of the office design, which reduced the presence of on-site synthetic refrigerants with high global warming potential. Refrigerant use was limited to the central chillers (R-134a) as well as distributed condensing units required for emergency operations and/or kitchen operations (R-410A), all refrigerant charges in compliance with California Mechanical Code. The project was certified as WELL v2 Gold and LEED v3 Gold+ (Platinum ready with addition of rooftop PV in the next certification cycle).

Achieving Net Zero Energy By Maximizing Natural Energy: Page
By Hiroaki Tanaka, Ph.D., Member ASHRAE; Takahiro Sato, Member ASHRAE



Online Figure 1. The results of CFD simulation on air flow due to differences in building layout.

Online Figure 2: Climbing kiln.



Online Figure 3: Cool-warm lockers.

Indoor Air Quality and Thermal Comfort

When the outside temperature is higher than the room temperature, the hybrid air-conditioning combined with the air conditioner and the ventilation through the trench was performed to be satisfied by the room air temperature setpoint. The data aggregated by the central monitoring system was analyzed for air temperature, relative humidity and CO_2 concentration.

Air temperature (criterion: 17°C to 28°C [63°F to 82°F[); the air temperature met the standard value for about 90% of the period. Most of the time below the standard was between 8:00 and 9:00, and there was a tendency to fall below the standard in the morning. **Relative humidity** (criterion: 30% RH to 80% RH); relative humidity met the criteria for about 95% of the analysis period. From April to May, there was a time that was less than 30% RH, but after that, it was 40% RH or more, and after June 27, 60% RH or more continued. **CO_2 concentration** (criterion: under 1,500 ppm); the CO_2 concentration in the class rooms met the criteria for about 94% of the period.

A normal classroom space was modeled using computational fluid dynamics (CFD) and reproduced the airflow characteristics that confirmed the absence of drafts due to the cooling and heating trench and the airflow of the room air conditioner. In the center of the classroom, the airflow velocity is often -below the school environmental sanitation standard v = 0.5 m/s (1.1 mph) (maximum, and the airflow from the locker area served by the cooling and heating trench is behind the last row of seats. Also, at the speed of v = 0.2 m/s (0.4 mph), it was found that the environment was without drafts.

Operation and Maintenance

In schools where equipment is often used manually, energy conservation activities by students and teachers are essential to achieve a zero energy school. At this school, instead of optimizing energy consumption with an automated system, zero energy is achieved through the environmental experience of the students. It is important to provide a place for gaining experience. For this school, the biggest feature of this school is that the students themselves think, decide and operate it through trial and error.

For the cooling and heating trench in the underground pit, an observation window was installed to visually convey the airflow in the underfloor space so that the temperature and airflow could be grasped intuitively.

In the science room, to confirm that the effect of introducing daylight into the room by the lightshelf fluctuates depending on the season and time, a scale was provided on the ceiling surface to visually understand the effect.

An eco-monitor in each classroom can be manipulated to see the entire school's real-time environmental conditions, as well as classroom temperature, humidity and carbon dioxide concentration. By comparing the temperature in the classroom and the cool trench, students can decide whether or not to direct air into the classroom. Eco-monitors also play a role in inducing gamification. The system displays the "energy saving ranking" of any one classroom vs. other classrooms, which is a good conservation motivator. Designers collaborated to determine what and how environmental data should be displayed.

Cost Effectiveness

Compared to the ordinary junior high school, the cost effectiveness is worse because the running cost for power consumption is less so the energy consumption is less. By using such general products and system, it was as cost effective as possible. Compared to the draft Japanese standard, the increase in initial investment of mechanical and electricity energy-saving system were US$200,000. The reduction in running costs by reducing power consumption was US$20,800 per year, and the simple payback period is 10 years. If the load will be same energy consumption as the office, it will be achieved in three years. The increase of architectural energy-saving methods was US$900,000. The reduction in running costs was US$13,900 per year, and the simple payback period is 60 years. The increase of the total initial cost including solar and wind power generation system is 7%, and the reduction in running costs by reducing power consumption was US$50,000 per year. Therefore, the simple payback period is 34 years. Judging with 35-years life-cycle cost reduction is expected to be lower than the standard school.

Environmental Impact

Compared to the standard model, energy savings are reduced by 50% in the first year, and energy generation increases this reduction to 72%. Including the supply of solar power exported off-site, which flows back into the grid from the site, the total reduction is 101%, achieving net zero energy. In the second year, energy consumption increased due to different operational use than the initial assumptions, such as the use of air conditioners with windows open due to the influence of COVID-19, an energy reduction of 97% was still achieved. As a measure against COVID-19, the air conditioner was used with the windows open to ensure ventilation, and electric power consumption increased significantly due to the impact of the increase in the fresh air ventilation volume. Cumulative consumption from September to March increased by 13.7%, but in the future, plans are to implement continuous energy management such as operational improvement in response to the convergence of COVID-19.