MAKING CONNECTIONS

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IN 2015, LinkedIn, the company known for helping people make business connections, began searching for additional office space near their existing offices in Sunnyvale, Calif.

After reviewing several candidates, they selected an existing building across the street from their current offices.

The building was not an inspiring space, inside or out, especially in comparison to their newer building with a glass façade.

ABOVE Skylight and natural wood ceiling. ©Jasper Sanidad

The single-story building was a 40,000 square foot square floorplate, with thin dark windows on the perimeter that allowed for very little natural light, and low t-bar ceilings despite a generous floor-to-roof height. But the company had a vision that the lackluster building could be transformed into an attractive new space.

To bring extra significance to the building, LinkedIn decided this project would be an ideal pilot project for zero net energy (ZNE). They selected a design team with ZNE experience to bring that vision to life. The project was designed, renovated, and open for occupancy in less than 10 months. By reusing an existing building rather than building new, the project construction carbon footprint was significantly lower than any new building, even an ultra-sustainable one.

The building now includes open office space for 240 employees, conference rooms, a central gathering area and a break room. The maximum occupancy is 700. The key design goals were to reduce heat gains and losses, reduce plug load energy consumption, reduce lighting energy consumption, and provide ultraefficient and comfortable HVAC. The project is pursuing Zero Net Energy Certification by the International Living Future Institute (IFLI). The building was designed to LEED Platinum standards but was not certified. Instead, the capital that would have been used to certify the building was used to fund additional solar panels.

Energy Efficiency

To achieve ZNE operation, several systems types and dozens of energy-efficiency measures (EEMs) were proposed and quickly modeled. With a large floor plate and small windows, natural ventilation and perimeter daylighting were not practical. However, the roof area for solar was vast, and the recent low cost of solar beat most EEMs.

The office renovation included replacing the end-of-life boiler and rooftop units with a variable refrigerant flow (VRF) system, which enables heat to be transferred from spaces requiring cooling to spaces that require heating, allowing for better zoned thermal control of the building and higher efficiencies. Refrigerant runs from rooftop condensing units through branch selectors and then out to fan coil units serving the space. The VRF system, which includes heat recovery, contributed to a 37% reduction in HVAC energy consumption.

The building has a dedicated outdoor air system (DOAS), using 100% outdoor air, for demand-controlled ventilation based on CO_2 sensors. The four DOAS units are equipped with air-to-air plate heat exchangers, which transfer heat from exhaust air to supply air, thus requiring no additional conditioning of the ventilation air.

The single-story building provided an opportunity to bring light deep into the core by way of 20 skylights that were cut into the roof and evenly spaced over the open office spaces. Each skylight has a motorized louver to control the lighting levels, and diffusing glass to eliminate direct beams of sunlight and scatter daylight evenly. While the lights are sometimes used during the day, they are typically using only 10% to 20% of their possible energy consumption (which is already reduced because they are LEDs).

The building is currently on track and using 29.14 kBtu/ft^2·yr (June 2017 to June 2018) and is designed to produce 30 kBtu/ft^2·yr via renewable energy on the roof. The building uses almost entirely LED lights. In addition, due to smart controls and skylights, the lighting consumption for this building is 60% to 70% less than a standard building. The measured average operating energy for the lights is 0.17 W/ft^2.

Indoor Environmental Quality

A large skylight was added by the design team to brighten up the interior of the building and serve as a gathering point in the central, park-like courtyard. It has double pane low-e glass to reduce heat gain. This provides a sunny, light-filled warm and welcoming space for employees to relax, contemplate, and collaborate.

The project uses a collaborative open plan, combined with breakout spaces for team meetings and concentrated work. The existing low ceilings were removed to expose 13 to 15 ft ceilings. New cloud ceilings were installed to provide acoustical benefits and light reflection properties over the open office while allowing for the existing natural wood ceilings to remain visible

The building's all-electric VRF HVAC system is served by four 100% outdoor air-handling units with heat recovery. Occupants enjoy superior air quality and high fresh air quantities in addition to eliminating the use of combustion on site. The design included 17 temperature-controlled 7 ft diameter smart fans to reduce cooling demand. These fans increase air movement, allowing the building to run a little warmer than a standard office space, which saves AC energy. The fans also provide occupants with a visual connection to the workings of the building HVAC systems.

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Removing the existing ceilings and installing exposed ductwork over the communal areas created a bright, modern look to the space.

Innovation

Design Build. In the design/build/assist process, stakeholders were involved in weekly meetings, enabling the use of rapid, collaborative analysis to determine the most cost-effective way to meet the energy targets. LinkedIn was an integral part of the design team and created firm goals that reduced confusion and redesign. The general contractor worked closely with LinkedIn and the design team from inception to provide rapid pricing and constructability feedback. Subcontractors were brought on board early to execute the design build under the close watch of the design engineers.

Green Building Pilot for LinkedIn. LinkedIn envisioned the

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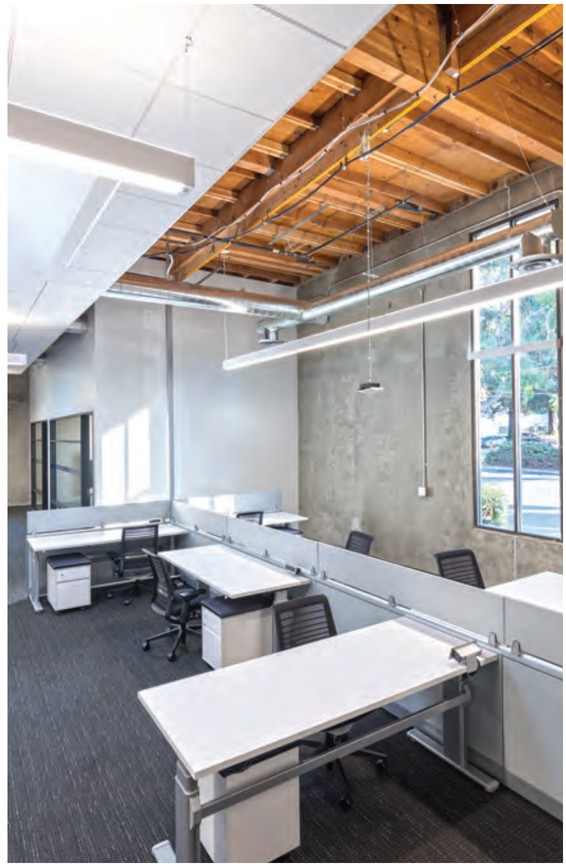

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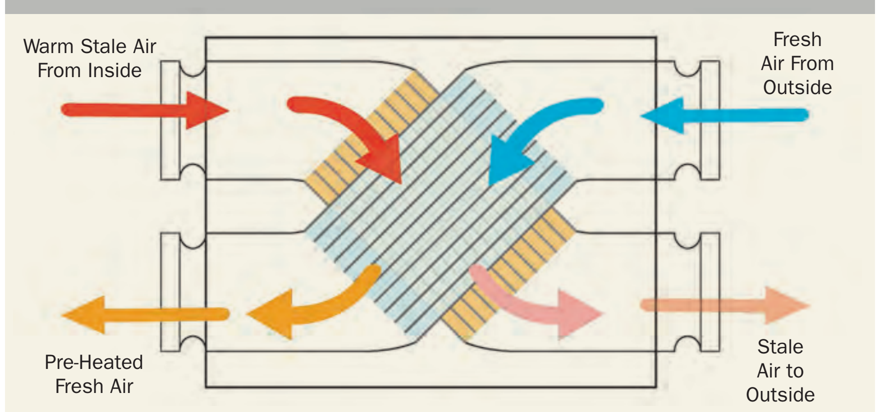
TOP A large low-e skylight was installed over the lunchroom to create an indoor/outdoor feel within the space. **ABOVE** Cloud ceilings and custom shaped skylights created a bright and acoustically comfortable open office space **RIGHT** The existing walls were left uninsulated because it was more cost-effective to add more solar than more insulation.

Figure 1 HEAT RECOVERY VENTILATOR



project as a ZNE pilot project and has since applied lessons learned across their portfolio of new and existing buildings. Portfolio energy metering software was piloted by LinkedIn on the project, then rolled out on other existing buildings in their portfolio to allow for energy tracking and savings. The project was LinkedIn's first to use on-site renewable energy. The lessons learned on maintenance and sizing of the solar system are shaping how LinkedIn will deploy more renewable energy on its portfolio of buildings.

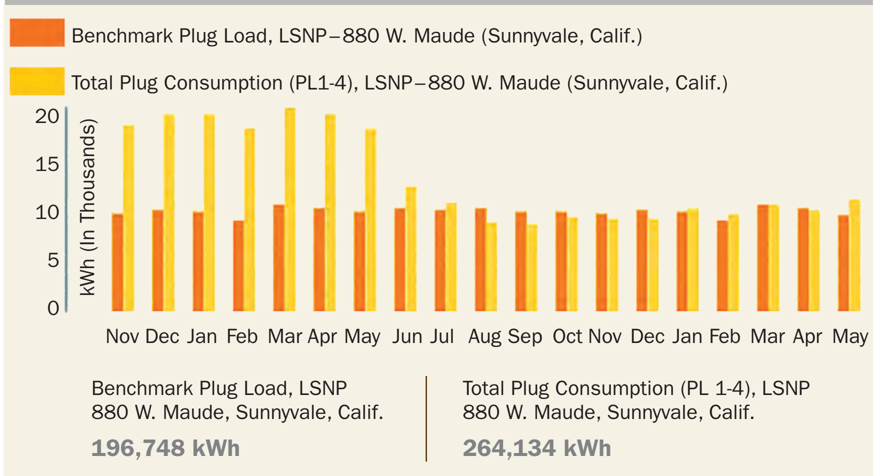
Building Reuse. The structure and insulation on the existing tilt-up construction building was subpar. To support almost 800 solar panels, new skylights, and new mechanical equipment, the roof had to be reinforced. Each wood beam was reinforced by bolting a second beam next to each existing beam. Also, steel beams were added to hold up the new large skylight over the atrium. Four inches of ridged insulation added R-24 to the roof and allowed the existing batt insulation to be removed, exposing the wood structure to the spaces below. The roof is white to reflect heat and reduce heat island effect.

Operation and Maintenance

Each of the major energy loads for the building is metered to track performance. The energy data is sent directly to the cloud where it is processed by the energy management software and displayed on a dashboard in the lobby for the occupants to see. The data is available remotely for LinkedIn and others to monitor and course correct. Water is metered on site.

The design of an energy-efficient building often inherently assists in the simplicity of the operation and maintenance. The building's VRF and DOAS system have internal controls that only require scheduling and setpoint controls by the building maintenance team.

Figure 2 DASHBOARD DISPLAY. PLUG LOAD DESIGN SPEC VS. ACTUAL



Shortly after full occupancy, investigations into the energy performance showed the building was trending about 20% off track for ZNE. The data showed that plug loads were double the expected use. LinkedIn moved an engineering group into the building rather than the originally planned support staff. This change in program increased the plug loads.

Despite the high plug loads, the operating staff at LinkedIn has remained committed to reducing the energy of the building. A task force consisting of LinkedIn operating staff and the LinkedIn sustainability team meets monthly to review the energy consumption and brainstorm energy-saving opportunities. As a result, both HVAC and light consumption have trended downward and are below design benchmarks.

In July 2016, a new engineering group moved into the building and the task force jumped into action. A welcome packet was provided to each employee describing the building and its goal to operate at ZNE. Tours were provided, and the senior executive for the building's team has been a vocal supporter of the ZNE energy goals.

Through the energy dashboard, a two-week plug load reduction competition was held. The building was split into halves, and one side reduced their plug loads by 23%, and the other, 25%. Incentive of a future award ceremony reinforced the progress, and the energy savings have continued. So far, monthly plug load consumption has dropped 50% compared with the original occupants. The occupants still get monthly energy updates, and the building is back on track toward ZNE. The lessons learned by exposing the building's operations combined with the occupant's strategies for reducing plug loads are being applied to other LinkedIn buildings, leading to energy savings across their entire portfolio.

For the first 12 months, the building was operating at an EUI of 40 $kBtu/ft^2 \cdot yr$. After the period of measurement and verification, the building has been operating at an EUI of 29.14 $kBtu/ft^2 \cdot yr$. Unfortunately, the solar system has had significant inverter issues that were not caught right away. The solar PV production for the last 12 months was only 20.8 $kBtu/ft^2 \cdot yr$ despite being designed to be approximately 30 $kBtu/ft^2 \cdot yr$.

Cost-Effectiveness

The rooftop PV cost $2.85/W installed. Less than 10 years ago, the cost for solar was around $9 to $10/W in the San Francisco Bay Area. Falling solar costs and ample roof space allowed the team to choose between energy-saving measures and additional solar panels based on cost-effectiveness. Costs were further offset by taking advantage of incentives and rebates. For example, the 30% federal rebate and rapid depreciation effectively cut the price of solar in half.

By removing VFDs and VAVs on the DOAS, the project saved over $100,000. Offices tend to have fairly constant occupancy and there would have been minimal energy savings from reducing the amount of fresh air. Instead, a few extra solar panels were installed to offset the small energy penalty, and the occupants will have more fresh air then code requires.

Just a few years ago, solar thermal was a cost-effective solution for hot water generation. But based on current solar PV prices, an all-electric domestic hot water system offset by solar PV proved to be significantly more cost-effective than solar hot water.

The building was originally constructed in the late 1980s in the "concrete tilt-up" construction style typical to the era. When the building was renovated, the only things that remained were the exterior walls, the roof and one of the two bathroom cores. The existing 6 to 12 inch concrete walls were not insulated, but did provide some thermal mass. After conducting a cost analysis, it was determined to be more cost-effective to add additional solar panels than to wrap the entire building in foam insulation for the same energy savings. Similarly, upgrading the tall slot perimeter windows to double pane would have yielded only minimal savings compared to additional solar panels.

California code and good practice design now already exceed many of LEED's requirements. The building was designed to meet LEED Platinum but the project is pursuing Zero Net Energy Certification by the International Living Future Institute instead. It would have cost over $100,000 to document and certify the building through LEED. It cost less than $10,000 to submit and certify as ZNE. The cost savings was earmarked for the solar system.

The upper management encouraged the ZNE focus for the project and approved the budget, which had higher first costs than a regular business-as-usual design and build project. LinkedIn's corporate mission is to deliver economic opportunity to the global workforce, and one of the core values is "act like an owner." The sustainability team's mission is to accelerate green economic opportunity. This project supported green jobs in the solar industry and green products and green businesses.

Environmental Impact

Making new "green" buildings does not reduce the environmental impacts of the millions of buildings that we already use. However, by continuing to reuse existing buildings and adapting them both to meet our current needs and to use fewer resources and produce less waste, we can move toward a sustainable future.

This project is another example of the current viability of designing ZNE buildings that are simple to operate but still provide excellent comfort. Its success allows it to be used as a case study to further the mission of designing all office buildings in California to be ZNE by 2020. ●

ABOUT THE AUTHORS

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