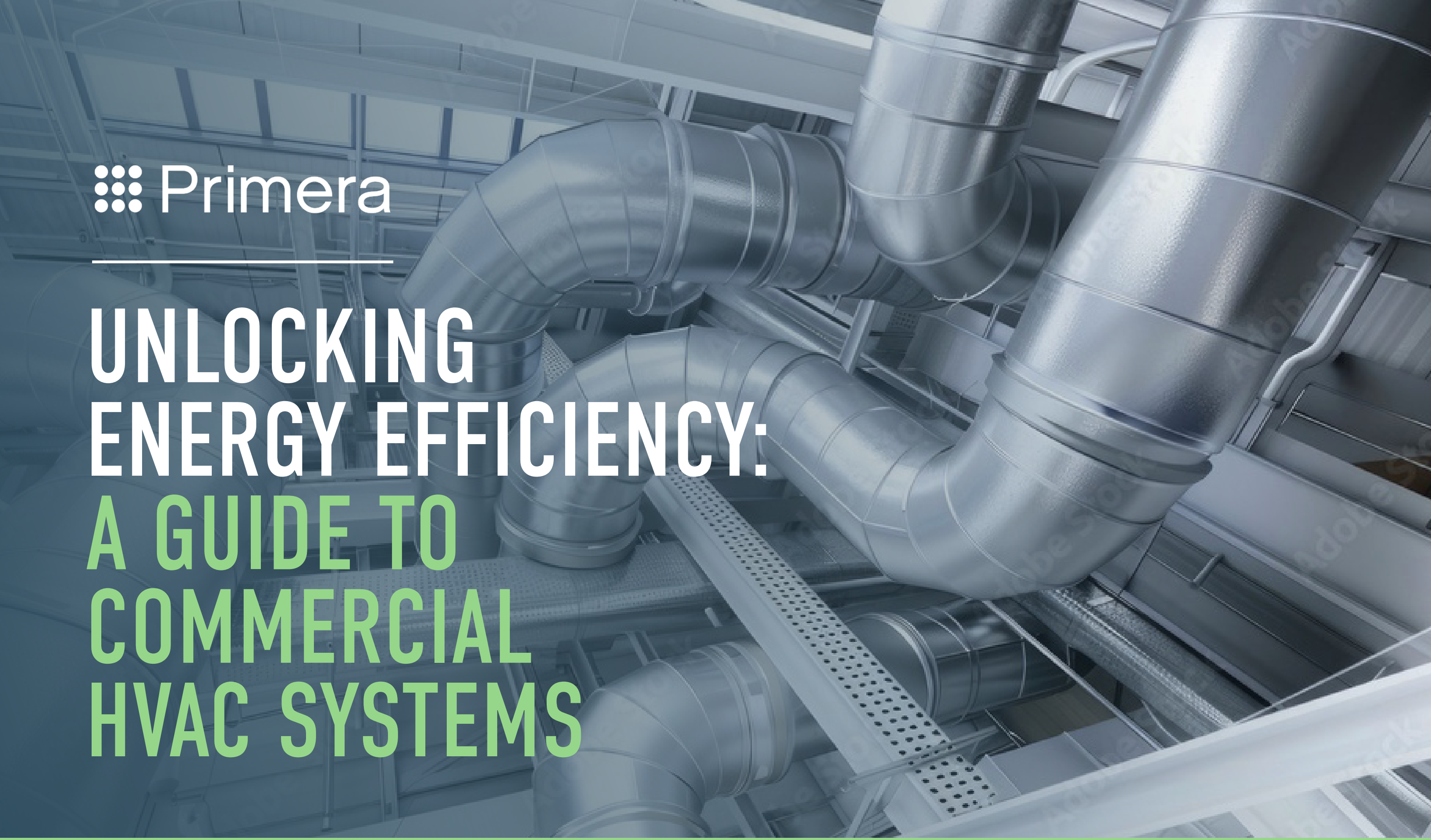

Primera

UNLOCKING ENERGY EFFICIENCY: A GUIDE TO COMMERCIAL HVAC SYSTEMS

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While strolling the streets of a large city, walking through campus, or wandering through the neighborhood, one of the first things we're drawn to is the architecture that surrounds us. From sleek glass contemporary skyscrapers, and quaint traditional historic mansions, to vibrant mixed-use complexes with housing, shops, and offices; the diversity of buildings and beautiful facades often impresses and captivates us. However, beyond aesthetics of such spaces, there is also a focus on sustainable design which is vital to the environment. Architects and designers alike strive to create environmentally friendly structures that minimize resource consumption, reduce waste, and promote energy efficiency.

As a mechanical engineer, I play a pivotal role by considering environmental, social, and economic factors in my work, particularly when designing solutions for commercial spaces. Whether creating new construction or renovating the existing, engineers and designers aspire to achieve Leadership in Energy and Environmental Design (LEED) certification, which is the most widely used green building rating system in the world.

LEED certification is recognized globally as a symbol of sustainability achievement and leadership, as defined by the U.S. Green Building Council (USBGC).

The objective is to encourage health-conscious, safe, and efficient structures, resulting in sustainable buildings that also yield cost savings. New and existing interior spaces, buildings, homes, cities, and communities are the type of projects that can apply for LEED certification.

When it comes to commercial buildings, most energy consumption stems from the heating, ventilation, and air conditioning (HVAC) system. When considering the most suitable energy-efficient HVAC system, it is essential to first conduct a thorough energy analysis. Factors such as local climate, building size, occupancy, user behavior, indoor floor plan, and budget are critical evaluation points. The system choice also needs to account for building constraints and sustainability goals.

Additionally, consulting with HVAC professionals and engineers is essential to ensure systems are appropriately designed, installed, and maintained for optimum performance and energy efficiency. For example, an oversized or undersized system can lead to inefficiency and higher energy costs. Proper equipment maintenance schedules and procedures should be established based on manufacturer recommendations and the owner's requirements. Regular maintenance can prevent costly breakdowns, reduce energy consumption, and extend the lifespan of the equipment. Life cycle cost of an HVAC system varies significantly based on factors such as location, energy prices, building usage, and maintenance practices.

There are several commercial building HVAC systems known specifically for their energy efficiency. Let's delve into some of the most used options:

1. VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS:

Description: VRF systems are known for their energy efficiency and zoning capabilities. They can heat and cool different zones of a building independently, which helps reduce energy waste. These systems depend on one outdoor unit housing a condenser and compressor connected to multiple indoor evaporator and fan units. They have advanced controls to moderate flow of refrigerant to meet heating and cooling demands of various zones within a building.

Application: Ideal for multi-zone commercial buildings, such as office spaces, hotels, and retail stores, where different zones require varying heating and cooling loads. VRF systems are a smart choice for large commercial facilities.

Maintenance: Periodic leak detection and repairs are necessary to prevent refrigerant loss and system inefficiency. Filter and coil cleaning and inspection of electronic components, such as sensors and control boards, is also needed to ensure proper system operation.

Life Cycle Cost: VRF systems are energy-efficient and can have a moderate upfront cost. Their zoning capabilities and lower energy consumption contribute to favorable life cycle cost.

2. VARIABLE AIR VOLUME (VAV) SYSTEMS:

Description: VAV systems modify the amount of air supplied to an area to meet changing heating and cooling needs, resulting in energy-efficient HVAC operation.

Application: Commercial buildings.

Maintenance: Air filters in the air handling unit should be regularly inspected and replaced to maintain indoor air quality. Heat recovery wheels and coils should be checked and cleaned to optimize energy recovery.

Life Cycle Cost: VAV systems are deemed energy-efficient and can have an associated moderate upfront cost. Their zoning capabilities and lower energy consumption are conducive to favorable life cycle cost.

3. GEOTHERMAL HEAT PUMP SYSTEMS:

Description: Geothermal systems use the stable temperature of the ground to heat and cool a building, making them highly energy efficient.

Application: Suited for various commercial buildings, especially those with consistent heating and cooling needs, such as schools, hospitals, and government buildings.

Maintenance: The ground heat exchanger (loop) may require occasional cleaning or repair to maintain efficient heat exchanger. Monitoring and maintaining the quality of the water circulating in the ground loop is crucial to prevent corrosion and scaling.

Life Cycle Cost: Geothermal systems typically have higher upfront costs but offer excellent energy efficiency and long lifespans, resulting in lower operating and maintenance costs over time.

4. CHILLED BEAM SYSTEMS:

Description: Chilled beam systems use water to transfer heat, which can be more energy-efficient than traditional air-based systems. They are commonly used in commercial spaces.

Application: Often used in offices, healthcare facilities, and educational institutions, where precise climate control and quiet operation are imperative.

Maintenance: Chilled beams can develop condensation; therefore, regular cleaning and maintenance are needed to prevent water damage and maintain efficiency.

Life Cycle Cost: Chilled beam systems are efficient and run low in volume; however, they may have a higher initial cost and require regular cleaning and maintenance to maintain performance.

5. DEDICATED OUTDOOR AIR SYSTEMS (DOAS):

Description: DOAS systems provide ventilation independently of the HVAC system, allowing for better control and energy efficiency. They use energy recovery mechanisms to reduce energy consumption.

Application: Medical facilities, laboratories, and cleanrooms, where maintaining high indoor air quality is a priority, makes this offering a suitable fit. These systems are often paired with chilled beams or VRF systems to provide ventilation.

Maintenance: Air filters in the DOAS unit should be regularly inspected and replaced to maintain indoor air quality. Heat recovery wheels should be checked and cleaned to optimize energy recovery.

Life Cycle Cost: DOAS can enhance indoor air quality and energy efficiency at a moderate initial cost. Proper maintenance is crucial for maintaining efficiency.

6. HIGH-EFFICIENCY ROOFTOP UNITS (RTUS):

Description: Rooftop units are common in commercial buildings. High-efficiency RTUs use advanced technology and insulation to reduce energy consumption.

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Application: Frequently used in retail stores, restaurants, and small to medium-sized commercial buildings to provide both heating and cooling from a centralized location.

Maintenance: Filters should be replaced regularly to maintain good indoor air quality and system efficiency. Checking refrigerant lines for leaks and ensuring the coils are clean is a basic need.

Life Cycle Cost: High-efficiency RTUs can offer good energy savings and have moderate initial costs. Regular maintenance is essential to maximize their life cycle cost benefits.

7. SOLAR-POWERED HVAC SYSTEMS:

Description: Incorporating solar panels to power HVAC systems can significantly enhance energy efficiency, especially in sunny regions.

Application: Applicable in any commercial building looking to reduce energy costs and environmental impact, solar panels can be integrated with existing HVAC systems.

Maintenance: Keeping solar panels clear of dust and debris maximizes energy production. Periodic inspection of electrical components, such as inverters and wiring, is recommended.

Life Cycle Cost: Solar-powered systems provide significant energy savings and lower operating costs. However, the overall life cycle cost depends on factors like solar panel installation costs and local sunlight conditions.

In addition to the individual system details we have reviewed, there are other components to consider when implementing your HVAC system choice. Those include:

- **Energy-Efficiency Ratings:** Understanding what energy efficiency numbers on different HVAC models denote is vital. Efficiency is measured by a rating system whereas the higher the rating, the more efficient your HVAC system will be. Two critical ratings that measure the energy efficiency of HVAC systems for cooling are Seasonal Energy Efficiency Ratio (SEER) and Energy Efficiency Ratio (EER). The Annual Fuel Utilization Efficiency (AFUE) rating measures the heating efficiency.
- **Energy Recovery Ventilation (ERV) System Specifications:** ERV systems capture and transfer energy between incoming and outgoing air, reducing the load on the HVAC system, and improving energy efficiency. Appropriate for most commercial buildings, ERV systems help improve indoor air quality while saving energy.
- **Smart Thermostat:** Smart thermostats regulate energy use and maintain optimal temperatures in different zones of the building.
- **Demand-Controlled Ventilation (DCV):** Incorporating DCV systems adjust ventilation rates based on occupancy levels, optimizing energy use by providing ventilation only when needed. Accurate calibration of occupancy sensors and controls is crucial to ensure proper ventilation rates. Routine checks of control system and components are necessary to prevent malfunctions.
- **Building Automation Systems (BAS):** BAS allows for centralized control and optimization of various building systems, including HVAC. Remarkable energy savings are likely through better management and automation. Future design should consider smart building technology for collaboration of building automation systems, integration systems, and telecommunication systems to enhance the energy-efficiency and cost-effective performance of buildings. *For additional insight into smart technology solutions for building systems, check out our article, **"Can Smart Buildings Become Smart Savings."***

Many of the systems described above were incorporated into the HVAC design of a recent project of mine - the David Rubenstein Forum at the University of Chicago. The Forum is a 97,000-square-foot facility consisting of a two-story podium and a 10-story tower with a zinc-and-glass exterior. The ground floor lobby includes a dining room and bar, the third and fourth floors house a 285-seat lecture hall, and the tower is home to multi-purpose rooms, board rooms, and collaboration/pre-function spaces and lounges. This project highlights how understanding the architectural layout and structure of the building, its occupancy, sustainability goals, and meeting University standards all play into the decision on which system(s) to select.

David Rubenstein Forum exterior. Photography by Angie McMonigal.

David Rubenstein Forum interior. Photography by Jason Smith.

Chilled water service to the building is supplied from the campus utility chilled water mains while a central hot water plant utilized high efficiency gas-fired condensing boilers. The podium and lecture halls are serviced by custom VAV air handling units, with hot water reheat, demand control ventilation, and energy recovery. During the design phase, mechanical challenges posed were the staggered and stacked "neighborhoods" of the tower, post tensioned concrete structure with a centered core for (elevator banks, shafts), and limited space above the ceiling. Because of this, several HVAC systems were considered. Ventilation for the tower floors was provided by DOAS, with enthalpy wheel and a passive dehumidification wheel. Cooling and heating of the spaces was provided by active chilled beams, both exposed (horizontal) and concealed (vertical) types. Integrated chilled beams in the design allowed the architect to maximize the space's floor-to-ceiling height by reducing the space required for ductwork. This also made it easier to achieve a desirable noise level in the space and allows for flexibility in for future use/layout changes.

Furthermore, centralized control for the management and monitoring of the HVAC systems is one of the most important components controlled by the BAS. The BAS system and the HVAC systems within the David Rubenstein Forum were designed and implemented to optimize performance and energy efficiency of the HVAC systems within the facility. The building was awarded LEED Gold status for sustainable design.

In conclusion, in a world decorated with innovative and attractive architecture, it is equally important to continue to build our surroundings in alignment with the guiding principles of the USGBC. HVAC systems are instrumental in us realizing our highest energy efficiency potentials and sustainability globally, particularly in commercial buildings. By implementing the most effective energy-efficient HVAC option(s) available to us today, we create an aesthetically pleasing and sustainable environment that brings us pride now and will continue to do so in the future.

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Rina Vidri, PE, LEED AP BD+C is the senior mechanical group manager at Primera Engineers and oversees the development and execution of all mechanical engineering projects. As an accomplished engineer and highly experienced industry expert with nearly 30 years of experience, her work encompasses the design, project management, coordination, and quality assurances for all phases of project development for higher education, healthcare, and institutional environments. Rina was recently named as an Engineered Systems 2024 20 to Watch: Women in HVAC.

In the last eight years, Rina has helped Primera garner more than 10 industry awards for various projects. Most recently, Rina served as a lead mechanical engineer for the David M. Rubenstein Forum, a 90,000-square-foot high rise building at the University of Chicago. Rina designed the HVAC utilizing energy efficient systems. This project won the 2022 ACEC-IL Engineering Excellence Award, recognized for its engineering systems, and the 2021 ASHRAE Technology Award for its occupant comfort, indoor air quality, and energy conservation.