



DEPARTMENT OF ELECTRICAL  
AND COMPUTER ENGINEERING

**ENEL 674: Industrial and Commercial Power Systems**

**Group – 10**

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## Inclusion of UPS Equipment

This report is crafted with the primary objective of ensuring the consistent availability of power on the building floor, thereby safeguarding both equipment functionality and the integrity of data stored within the premises. To achieve this, the installation of an Uninterruptible Power Supply (UPS) system is deemed indispensable for commercial building floors. The rationale behind this imperative installation encompasses several critical factors that underscore the necessity of such a system:

**Equipment Protection:** In a commercial setting, various sensitive electronic equipment, such as computers, servers, and networking devices, are in operation. These devices are susceptible to damage or malfunction in the event of sudden power interruptions or fluctuations. By providing a stable and uninterrupted power supply, a UPS system serves as a protective barrier, shielding these vital assets from potential harm and ensuring their continued functionality.

**Data Integrity:** Modern businesses rely heavily on digital data for their operations, ranging from customer records and financial transactions to proprietary information and intellectual property. Any disruption in power supply poses a significant risk of data loss or corruption, potentially leading to severe operational setbacks or even legal ramifications. A UPS system acts as a fail-safe mechanism, offering sufficient backup power to safely shut down systems in the event of a power outage, thereby mitigating the risk of data loss and preserving data integrity.

**Operational Continuity:** Interruptions in power supply can bring business operations to a halt, leading to productivity losses, missed deadlines, and dissatisfied customers. For businesses operating in competitive markets, maintaining operational continuity is paramount to sustaining a competitive edge. By ensuring uninterrupted power supply, a UPS system enables businesses to remain operational during power outages, minimizing disruptions and ensuring continuity of services.

**Cost Savings:** The financial implications of power-related downtime can be significant, encompassing not only repair or replacement costs for damaged equipment but also potential revenue losses resulting from interrupted operations. Investing in a UPS system represents a proactive measure to mitigate these costs by minimizing the likelihood and impact of power-related disruptions. Additionally, by extending the lifespan of electronic equipment and preventing data loss, a UPS system offers long-term cost savings and a favorable return on investment.

Within this building, the UPS will serve a diverse array of loads, ensuring uninterrupted power supply during instances of power failure. These loads encompass various critical components vital to the functioning of the organization:

**IT Equipment:** This category encompasses servers, storage systems, switches, routers, and other networking equipment essential for the organization's operations. Maintaining power to these systems is imperative to sustain connectivity, data accessibility, and overall business continuity.

**Communication Systems:** Essential communication infrastructure such as telephone systems, intercoms, and other communication apparatuses rely on uninterrupted power to facilitate seamless internal communication within the organization. Ensuring their continuous operation

during power outages is crucial for maintaining productivity and coordination among staff members.

**Lighting:** Certain areas within the commercial building, notably emergency exits, necessitate consistent illumination even during power failures to uphold safety standards and facilitate orderly evacuation procedures. The UPS will provide backup power to ensure that these critical areas remain adequately lit, thereby safeguarding occupants in the event of an emergency.

**Security Systems:** Access control systems, alarms, and closed-circuit television (CCTV) cameras play a pivotal role in maintaining the security and integrity of the premises. Continuous power supply to these systems is essential to uphold surveillance capabilities, monitor access points, and promptly respond to security threats or breaches, thereby bolstering the overall safety and security of the building.

By accommodating these varied loads, the UPS system serves as a reliable backbone, mitigating the impact of power disruptions on essential organizational functions. Its ability to sustain critical equipment, communication channels, safety measures, and security protocols during power outages underscores its indispensable role in maintaining operational resilience and safeguarding the well-being of occupants within the commercial building.

We compiled a comparison chart featuring several models under consideration.

Model	Power Rating	Battery Type	Estimated Cost	Advantages	Disadvantages
<b>APC 1500VA UPS</b>	1500VA/900W	Sealed Lead Acid	\$350 - 600	Cost-effective and low-maintenance	Limited operational duration, reduced effectiveness in elevated temperatures
<b>CyberPower PR2200LCDSL</b>	2070VA/1980W	Lead Acid	\$1000-1200	Consistent and reliable power delivery, extended operational duration	Greater upfront investment, larger and heavier compared to alternative models
<b>Tripp Lite SMART1500RM2U</b>	1500VA/1350W	Lead Acid	\$1000-1200	Straightforward installation and maintenance procedures	Limited operational time, decreased efficiency in elevated temperature conditions
<b>APC 2200VA UPS</b>	2200VA/1980W	Lead Acid	\$1500 - 1800	Efficient operation, extended battery lifespan, and compact form factor	Greater initial investment, extended recharging period
<b>Eaton 5S1500LCD UPS</b>	1500VA / 900W	Lead-Acid, AGM	\$400-600	Cost-effective and low-maintenance	Limited operational duration, reduced effectiveness in elevated temperatures
<b>Vertiv Liebert GXT5</b>	1500VA-3000VA	Lithium-ion or AGM	\$1000-\$3000	Optimal efficiency, durable battery life, and customizable runtime capabilities	It's pricier, bulkier, and heavier than other models.

Now, regarding the installation configuration of the UPS, there are generally two ways to do it: N and N+1. In a UPS N setup, simplicity and cost-effectiveness are prioritized, albeit at the expense of redundancy. Conversely, the UPS N+1 configuration offers enhanced reliability and fault tolerance through redundant UPS modules.

In a UPS N configuration, cost-effectiveness and simplicity are key advantages. This setup, while more affordable and easier to implement, carries the risk of a single point of failure. With a single UPS module supporting the load, any malfunction or downtime in the UPS system can lead to interruptions in power supply, potentially impacting critical operations. Additionally, the lack of redundancy in this configuration limits fault tolerance, leaving the system vulnerable to unexpected failures.

On the other hand, UPS N+1 configurations offer heightened reliability and fault tolerance. By incorporating redundant UPS modules, this setup ensures continuous power supply even in the event of a UPS module failure. Despite its advantages, the UPS N+1 configuration comes with a higher initial cost and increased complexity in installation and management. It also requires more physical space due to the presence of additional UPS units. While slightly reducing energy efficiency compared to UPS N configurations, the UPS N+1 setup provides scalability and maintenance flexibility, making it a preferred choice for organizations prioritizing uninterrupted power supply and operational resilience.

For a commercial space where uninterrupted power is crucial, the UPS N+1 configuration would be more suitable. This setup provides an extra layer of reliability and fault tolerance, ensuring continuous power supply even in the event of a UPS module failure. While it comes with a higher initial cost and increased complexity compared to UPS N, the added redundancy and scalability make it well-suited for maintaining critical operations and minimizing downtime in commercial settings.

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## Generator Type, Location and Sizing

Based on the analysis of the owner's requirements and design restrictions as well as the calculations we provided in Milestone 1, a 100KW natural gas generator will be sufficient for providing a total power output from our calculation 89KW and also will be able to provide an additional 11KW power.

A natural gas generator is used to provide back up for the whole facility and considering the owner's future plans. A backup generator is essential for the building to meet the owner's requirements for functionality, safety, and security:

1. **Continuous Power Supply for Multi-Use Facility:** The building serves as a multi-use community gathering space, educational hub, and local art gallery, hosting various events and activities. A backup generator ensures uninterrupted power supply during power outages, allowing events such as weddings, business socials, and cultural exhibitions to proceed without disruption.
2. **Critical Power for Commercial Kitchens:** The building includes both a small kitchen for snacks and a larger kitchen for catering, both equipped with commercial-grade equipment. A backup generator ensures continuous power to these kitchens, preserving food safety and preventing interruptions in food preparation and service during emergencies.
3. **Energy Monitoring and Metering:** The owner desires to closely monitor energy consumption and meter power usage for different areas of the building. A backup generator ensures that power monitoring systems remain operational even during power outages, allowing the owner to track energy usage and make informed decisions about energy efficiency measures.
4. **Security Systems and Access Control:** The owner requires access control using keypads or ID cards for staff, as well as secure rooms for data, electrical, and mechanical systems. A backup generator powers security systems, access control devices, and surveillance cameras, ensuring continuous monitoring and protection of the building and its occupants during power outages.
5. **Emergency Lighting and Safety:** The building features expansive use of daylighting and requires lighting control using a digital master system with low voltage controls. A backup generator ensures that emergency lighting systems remain operational, providing illumination for safe evacuation during power outages or emergencies.

Considering all the above conditions, we are proposing the 100KW Generac SG100 Natural Gas Generator. The specifications are given below:

### **100 kW Generac SG100 Natural Gas Generator #6**

SKU: GEN040523TJH1

CATEGORIES: New And Used Generators, Generac

<b>CONDITION:</b>	Used
<b>MANUFACTURER:</b>	Generac
<b>YEAR:</b>	2012
<b>HERTZ:</b>	60
<b>MODEL:</b>	SG0100GG036.8N23HPSYE
<b>PHASE:</b>	3
<b>VOLTAGE:</b>	120/208v
<b>STOCK #:</b>	GEN040523TJH1
<b>RATING:</b>	Standby
<b>OPTIONS:</b>	100 amp & 225 amp breakers
<b>ENGINE:</b>	6.8L Generac V10
<b>FUEL TYPE:</b>	Natural Gas
<b>KW OUTPUT:</b>	100
<b>KVA OUTPUT:</b>	125
<b>HOURS:</b>	166
<b>MOBILITY:</b>	Stationary
<b>ENCLOSURE:</b>	SA

The suggested generator is a dependable and efficient standby power solution tailored for commercial and industrial settings. With a power output of 100 kW, this generator is well-suited to meet the peak demand of the building, including critical loads such as lighting, HVAC systems, data servers, and security equipment. Powered by natural gas, it offers clean and cost-effective operation while ensuring continuous power supply during outages.

#### **Considerations:**

The following should be considered while using the generator:

- 1. Installation Requirements:** Proper installation and ventilation are essential to ensure safe and efficient operation of the natural gas generator.
- 2. Environmental Impact:** While natural gas generators produce fewer emissions than diesel generators, it is essential to implement proper exhaust systems and environmental controls to minimize their environmental impact.



**Location:** The northwest corner of the building's site would be an ideal location for the generator.

The outdoor placement of the backup generator in the northwest corner of the building's site is strategically chosen to address concerns regarding noise disturbance and safety, while also ensuring efficient fuel delivery and easy accessibility for maintenance operations. Situating the generator away from occupied areas such as interpretive trails and outdoor gathering spaces minimizes potential noise disruptions and enhances safety for building occupants and visitors. Additionally, the proximity to the natural gas supply line reduces piping costs and facilitates seamless fuel delivery, while the accessible location allows for routine inspections, servicing, and repairs by maintenance personnel. Overall, this location provides an optimal balance of considerations, making it ideal for reliable backup power generation.

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## Distribution Options for the Site

Residences and commercial establishments across North America consume roughly 70% of the electricity supply and 40% of the total energy usage. Consequently, the role of electrical energy within the building sector is crucial for reducing overall energy consumption, managing peak demand, and mitigating greenhouse gas emissions. Despite the importance of enhancing the electrical efficiency of advanced buildings, the focus tends to be on improving individual consumer devices rather than optimizing electrical distribution systems. These systems within buildings consist of a vast array of components. (Waters et al., 2014). The equipment used is influenced by the building's size, type, equipment deployed, and other unique circumstances. There are minimum standards for the design and construction of electrical systems set in the National Electrical Code (Association et al., 1915), National Building Code (Association & Underwriters, 1915) and Canadian Electrical Code (Association, 2012) which cover design, methods and protection for wiring and various equipment and materials that should be used.

In most commercial buildings, a low-voltage (LV) distribution system comprising both 480Y/277 V and 208Y/120 V three-phase AC setups is typically installed (Frank & Sen, 2011). The 480Y/277 V system is responsible for managing significant loads such as HVAC equipment and commercial lighting fixtures, predominantly operating at 277V. Conversely, the 208Y/120 V system is tasked with distributing power to receptacle loads. Smaller commercial structures may rely solely on a 208Y/120 V service, while tiny commercial buildings might opt for a single-phase 240/120 V service instead of utilizing three phases. (Poole, 1987).

In a building or facility, the primary goal of an electric power distribution system is to acquire power from one or multiple sources and allocate it to various electrical loads, including elevators, lighting, chillers, and motors. An ideal distribution system should be capable of delivering adequate electricity reliably and cost-effectively to meet both present requirements and anticipated future needs. Selecting the right system layout can have a substantial impact on the reliability and ease of maintenance of the electrical system. (*Electrical Distribution Systems Explained*, 2022).

The subsequent section outlines various commonly utilized electrical distribution systems. Typically, combining two or more of these configurations is essential to enhance the reliability of the system.

**Radial System:** The radial system is an inexpensive electrical distribution setup that is straightforward but lacks reliability because it relies on a single utility source. If a component fails, the entire system experiences a service outage, and maintenance activities necessitate shutting down the loads. This system is often chosen when simplicity and affordability outweigh the importance of reliability. It typically includes a primary switch, transformer, and low-voltage switchboard housed in a single-unit substation. (Barker & De Mello, 2000).

**Expanded radial system:** Broadening the basic radial system can improve its reliability by incorporating more transformers, as the failure of one transformer will not result in a total service outage. Installing extra transformers in proximity to load clusters can also mitigate voltage drops. However, a different configuration is needed for a more dependable system where the loss of a transformer or feeder cannot lead to service interruptions. (Latreche et al., 2020).

**Radial System with primary selectivity:** This setup offers similar economic advantages to the simple radial system but boasts enhanced reliability due to its dual utility sources. Maintenance procedures involve shutting down all loads, and any malfunction or failure of transformers or distribution equipment can lead to service disruptions. To mitigate such risks, an automatic transfer scheme can be employed to switch between sources in the event of a failure. (Burke, 2017).

**Primary and Secondary simple radial system:** The enhanced version of the basic radial system delivers power at a primary voltage, which is then lowered to the utilization level via secondary unit substation transformers. Any faults occurring in the primary feeder circuits or transformers will only impact specific loads. However, if there is a fault in the primary main bus or a utility service outage, all loads will experience a service disruption. Utilizing primary voltage helps minimize losses, enhance voltage regulation, and decrease the interrupting duty on load circuit breakers. (Burke, 2017).

**Primary Loop Systems:** This distribution setup employs multiple loops and transformers, making it most suitable for systems with two available services. It enables maintenance on one feeder without causing service interruptions and safeguards against service loss due to a single transformer or feeder cable failure. However, there may be a temporary outage until the loop is reconfigured to compensate for the loss. Sectionalizing switches can disconnect loop conductors, and key interlocking prevents all sectionalizing devices from closing simultaneously. (Jirapong et al., 2015).

**Primary Selective System:** The secondary selective system necessitates backup sources to avert total power loss if voltage drops occur. Likewise, the primary selective system mandates interlocked circuit breakers and backup sources to prevent parallel operation. In instances of voltage loss, manual or automatic transfer methods can reinstate the system. Metal-Clad switchgear is favored due to the constraints of metal-enclosed load interrupter switches. A blended system can be formulated by integrating the primary selective setup with secondary radial or selective systems. (Brown, 2017).

**Secondary Selective System:** The secondary selective system ensures the continued operation of the distribution system following the failure of a component. Each transformer secondary is linked within a double-ended unit substation equipped with interlocked circuit breakers. In the event of voltage loss on one side, a transfer mechanism is employed to reestablish power supply to all secondary loads. (Burke, 2017).

**Secondary Spot Network System:** The secondary network system operates in parallel with utility services at low voltage to guarantee continuous service, making it a popular choice in densely populated areas where reliability is paramount. Network protectors isolate faults in transformers, and the shared secondary bus is referred to as the "collector bus." This system finds widespread application in hospitals, tall office buildings, and institutional structures. (Behnke et al., 2005).

**Sparing Transformer System:** The transformer sparing scheme employs a standby transformer and single-ended substations sharing a common secondary bus to deliver power in the event of a substation transformer failure. Precise parallelism and directional relaying are essential, and

interlock schemes guarantee correct functioning. Automatic transfer mechanisms can switch between failed and operational transformers. (Burke, 2017).

To ensure the provision of safe and cost-effective services, the design of the distribution system must consider the varying needs of users by anticipating their electricity requirements and considering factors such as building type, adaptability, installation techniques, and suitable equipment, as suggested by Poole (1987). Additionally, it is vital to consider both current usage patterns and future demands, including load predictions, and to assess the trade-offs between maintaining excess capacity and investing in equipment upgrades or alternative methods to meet increased demand as needed. Combining different power distribution system topologies and configurations can enhance reliability, but this often comes with increased complexity and costs. Economic considerations are therefore crucial in determining the optimal balance between system complexity and reliability.

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## Renewable Energy or Alternative Sources

Aligned with the owner's vision for sustainability and efficiency, our exploration of renewable energy solutions for the commercial space within the proposed building in Alberta emerges as a strategic response to their articulated requirements. With a keen focus on meeting the owner's objectives while advancing environmental stewardship, the following suggestions are tailored to seamlessly integrate with the envisioned multi-use community gathering space, educational hub, and local art gallery.

In responding to the owner's aspiration for a forward-thinking establishment, our proposed energy solutions not only prioritize functionality but also emphasize the utilization of renewable resources. As such, these recommendations aim to enhance the operational efficiency and environmental performance of the commercial space, aligning closely with the owner's commitment to sustainable development.

**Solar power:** Amidst the sprawling landscape of the owner's 10-acre land, solar power is a prime candidate for fulfilling the dual objectives of sustainability and operational efficiency. By leveraging photovoltaic (PV) technology, solar panels can be strategically installed atop the commercial space's roof, capitalizing on unobstructed access to sunlight and maximizing energy generation potential. Moreover, integrating solar panels into the building's design seamlessly aligns with the owner's aspiration to dedicate part of the land to renewable energy sources.

The benefits of solar power extend far beyond mere energy generation. In line with the owner's desire for expansive daylighting, solar panels can serve a dual purpose by providing shade while harnessing sunlight to generate electricity. This integrated approach not only enhances the aesthetic appeal of the commercial space but also underscores its commitment to sustainable design principles.

Furthermore, solar power offers unparalleled versatility, catering to the diverse energy needs of the commercial space. From powering lighting fixtures and HVAC systems to supporting the operation of commercial equipment, solar energy serves as a dependable and cost-effective alternative to traditional grid-based electricity. The owner's interest in closely monitoring energy consumption finds its perfect complement in solar power, as smart metering technology can be seamlessly integrated into the solar panel installation, enabling real-time tracking and optimisation of energy usage.

Beyond its immediate operational benefits, the adoption of solar power aligns closely with the owner's long-term sustainability vision. By reducing reliance on fossil fuels and mitigating greenhouse gas emissions, solar panels pave the way for a cleaner, more resilient energy future. Moreover, integrating solar power into the commercial space's infrastructure serves as a tangible manifestation of the owner's commitment to environmental stewardship, setting a precedent for future developments on the property.



For the optimal size of the solar panel system for our facility, we must first find its total energy demands. With each building necessitating an approximate total load of 15 kW and our premises comprising 4 such buildings, our cumulative energy requirement amounts to:

Total load demand per building = 15 kW

Total number of buildings = 4

Total load demand = 15 kW x 4 = 60 kW

Average monthly power outage duration = 3 hours

The energy required to cover power outage = Total load demand x Average monthly power outage duration

Energy required to cover power outage = 60 kW x 3 hours = 180 kWh

Total load demand per day = Total load demand x 24 hours

Total load demand per day = 60 kW x 24 hours = 1440 kWh

Energy required to cover power outage per day = Energy required to cover power outage

Total energy demand per day = Total load demand per day + Energy required to cover power outage per day

Total energy demand per day = 1440 kWh + 180 kWh = 1620 kWh

Average daily energy generation of solar panels (assumed): 4 kWh/kW/day

Required solar panel capacity (in kW) = Total energy demand per day / Average daily energy generation per kW

Required solar panel capacity (in kW) = 1620 kWh / 4 kWh/kW/day  $\approx$  405 kW

Therefore, you would need a solar panel system with a capacity of approximately 405 kW to cover both the total load demand and the energy required to cover power outages for your facility.

The solar panel taken for this calculation is the EF ECOFLOW Solar Generator DELTA 2 Max, which costs \$2,898.00. This solar generator has a capacity of 2048 Watt-hours.

To calculate the number of units of this solar panel needed:

Convert the required solar panel capacity to Watt-hours.

Required solar panel capacity (in Watt-hours) = Required solar panel capacity (in kW) \* 1000

Required solar panel capacity = 405 kW x 1000 = 405,000 Watt-hours

Determine the number of units needed.

Number of units needed = Required solar panel capacity / Capacity of one unit

Number of units needed = 405,000 Watt-hours / 2048 Watt-hours  $\approx$  197.27

Since we cannot purchase a fraction of a unit, we must round up to the nearest whole number. So, we need 198 units of the EF ECOFLOW Solar Generator DELTA 2 Max.

Now, let's calculate the total cost:

Total cost = Number of units needed × Cost of one unit

Total cost = 198 units × \$2,898.00 = \$573,804.00

Therefore, the total cost for installing the solar panel system with a capacity of approximately 405 kW using the EF ECOFLOW Solar Generator DELTA 2 Max would be roughly \$573,804.00.

However, the installation of the solar panel system would provide significant cost savings over the long term, as the facility would no longer be reliant on the grid for its energy needs. The facility could also potentially sell excess energy back to the grid, reducing energy costs. Furthermore, it will reduce the facility's carbon footprint and contribute to a sustainable future. It's important to consider that while the initial investment in installing the solar panel system may seem substantial, the long-term benefits far outweigh the upfront costs. Additionally, investing in renewable energy sources aligns with environmental goals and sustainability initiatives, which can enhance the facility's reputation and attract environmentally-conscious customers or investors. Overall, the adoption of solar energy not only brings economic advantages but also fosters environmental responsibility and resilience for the future.

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## Renewable Zero Carbon Initiatives

### Embodied Carbon:

To reach a state of zero carbon emissions, it's vital to lower both operational carbon emissions (arising from energy usage during building operation) and embodied carbon emissions. This entails employing materials and products with low carbon footprints, obtaining materials from nearby sources to cut down on transportation emissions, and designing buildings to minimize waste and enhance recycling efforts. (US EPA, 2024)

### Operational Carbon:

Operational carbon refers to emissions linked to the energy used in a building's operation, covering heating, hot water, cooling, ventilation, lighting systems, equipment, and lifts. This aspect often receives primary attention when considering sustainable building practices. It can be addressed through actions like enhancing insulation, adopting energy-efficient lighting and appliances, and producing renewable energy onsite. The aim is to decrease the building's energy demand and transition to renewable energy sources to eliminate carbon emissions from energy consumption. (UKGBC, 2023)

As per the Zero Carbon Building Standard, "avoided emissions on site" are the carbon emissions prevented or displaced due to the utilization of renewable energy sources for generating electricity or heating within a building. By producing renewable energy onsite, buildings can substantially diminish their carbon footprint and play a part in lowering overall greenhouse gas emissions. (Tambjerg, 2022)

### Electrical

### Considerations:

1. Integration of renewable energy sources: By incorporating solar and wind into the building's electrical system, dependence on non-renewable sources can be minimized or eliminated altogether.
2. Utilization of energy-efficient lighting: Adoption of energy-efficient lighting like LED lights can decrease electricity usage and lessen the building's carbon footprint.
3. Management of electrical load: Controlling the building's electrical load aids in reducing energy consumption during peak periods and easing demand on the electrical grid.
4. Implementation of energy storage systems: Integration of energy storage systems, such as batteries or flywheels, facilitates the storage of surplus energy generated by renewable sources and offers backup power during outages.
5. Deployment of building automation systems: Building automation systems optimize energy usage by monitoring and adjusting lighting, heating, and cooling systems based on occupancy and other variables.
6. Provision of electric vehicle charging stations: Installing electric vehicle charging stations in the parking area encourages the use of electric vehicles, further diminishing carbon emissions.
7. Energy-efficient transformers: Upgrading to energy-efficient transformers can minimize energy losses during power distribution, improving overall system efficiency.

8. Passive design strategies: Incorporating passive design strategies like natural daylighting and passive solar heating reduces the need for artificial lighting and heating, further enhancing energy efficiency.
9. Life cycle assessment: Conducting life cycle assessments of electrical systems and components helps evaluate their environmental impact over their entire lifespan, guiding decisions towards more sustainable choices.

Incorporating renewable energy sources like solar and wind power, along with energy-efficient lighting and careful electrical load management, significantly reduces a building's carbon footprint and reliance on non-renewable resources. Implementing energy storage systems and advanced automation optimizes energy usage and enhances reliability. Providing electric vehicle charging stations promotes sustainable transportation, while upgrades like efficient transformers and passive design strategies further boost energy efficiency. Conducting life cycle assessments ensures informed decisions for long-term sustainability. Together, these initiatives represent a holistic commitment to environmental stewardship and a greener future.

The electrical grid in Alberta plays a pivotal role in achieving zero carbon emissions in buildings. To reach net-zero emissions, it's crucial to ensure that the electricity powering buildings originates from renewable sources like wind and solar power, while also maintaining grid stability and reliability.

In recent years, Alberta's electrical grid has seen significant transformations, with a growing emphasis on utilizing renewable energy sources. The province has set an ambitious goal of achieving 30% renewable electricity generation by 2030. As of 2019, around 16% of Alberta's electricity was sourced from renewables. To facilitate the integration of renewable energy, the Alberta Electric System Operator (AESO) has introduced various initiatives, including the Renewable Electricity Program (REP). (AESO, 2022)

Canada has joined over 120 countries in committing to be net-zero emissions by 2050, including all other G7 nations (United Kingdom, United States, Germany, Italy, France, and Japan). A number of provinces and cities have already made net-zero-by-2050 commitments, including Guelph, Vancouver, Hamilton, Toronto, Halifax, Newfoundland and Labrador, and most recently Quebec. Prince Edward Island has also pledged to reach net-zero greenhouse gas emissions by 2040. Nova Scotia and British Columbia have put into place, or plan to put into place, provincial net-zero-by-2050 legislation. (Government of Canada)

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## Consideration of Future Technologies

The building sector has the potential to perform better when newer and more advanced technologies are applied to the field. Adopting proven technologies that are predictable and reliable can boost productivity in the construction business by thirty to forty-five percent, according to study. Not only that, but there have also been significant improvements in other areas that need careful observation, such cost, timing, and safety. Emerging technologies have had a lot of good effects on the building sector. While attempting to incorporate new technology into design frameworks, it is imperative to recognize how energy usage and sustainability are changing. The increasing demand for energy efficiency around the globe necessitates that future technology be designed to maximize energy use while conforming to sustainable principles. A number of factors are taken into account, such as the use of smart lighting systems, energy-efficient appliances, and occupancy monitoring. These developments improve built environments' sustainability while simultaneously improving energy efficiency.

Automation and control systems play an ever-more-important role as buildings become smarter entities. These systems, which include lighting, HVAC, and other building elements, are essential for efficiently controlling and tracking energy use. By managing the temperature, humidity, airflow, and general quality of the air within a building, HVAC systems help to sustain its climate. An air conditioning or heating system takes in outside air, combines it with air coming into or going out of the system, filters the air, runs it through a coil to get the desired temperature, and then distributes the air to the different parts of the structure. While simultaneously optimizing its operations and associated energy consumption, the HVAC system must respond to a variety of conditions both inside and outside the building (such as weather, time of day, different types of spaces within a building, and building occupancy) to maintain the building's air quality. In the event of a fire, the HVAC system is also essential for managing smoke. Building Automation Systems (BAS) allow buildings to optimize energy consumption while maintaining occupant comfort and productivity by dynamically adjusting their systems based on real-time data.

The flexibility and upgradability of future technologies is one of the major obstacles to their acceptance. With the speed at which technology is developing, it is critical to create systems that can easily incorporate new advancements. Future-proofing infrastructure and buildings against obsolescence begins with flexible electrical systems that can adapt quickly to changes in technology.

Furthermore, it is crucial to remember that buildings play a major role in lowering carbon emissions as societies struggle with the pressing need to slow down climate change. The creation of heat in buildings and industry is a major contributor to the emissions of carbon dioxide worldwide. It is critical to switch to low-carbon heat generation options, such as biomass, solar heating, air or ground-source heat exchangers, and solar heating, in order to reduce emissions and move toward a more sustainable future.

The commercial sector has significant energy demands, therefore it makes sense to employ cutting-edge technology like fuel cell Combined Heat and Power (CHP) systems. These systems have a high degree of efficiency and can drastically cut down on the need for centrally produced power, which lowers carbon emissions and electricity costs. The advantages of adopting cutting-edge technology exceed the drawbacks, even with regard to issues like cost and technological maturity, especially when it comes to addressing climate change and promoting sustainable development.

One of the most important developments in lighting is still the LED. Compared to buildings that use traditional fluorescent bulbs, LED-lit buildings use a great deal less energy and even have better lighting. Moreover, LEDs last longer and are safer to use. Electrical experts predict that in the future, LEDs will be the main component of voice, heat, and remote control smart systems. Nowadays, LED lights in cars and homes can be linked to Alexa for more useful control. An industry-changing technological advancement doesn't happen very often, but it appears that LED technology is growing more and more well-known and efficient every year. The lifespan of LEDs is significantly longer than that of conventional counterparts.

Significant savings were found in both cases by the research, with integration with HVAC yielding the greatest benefits—as HVAC uses over half of the energy used in a typical commercial facility. The greatest possible benefit can be found in large complexes, retail establishments, healthcare facilities, and other large buildings with high energy-use intensity. The savings from occupancy-controlled HVAC effectively liberate previously inhibited LED lighting savings. A typical large building's HVAC energy use can be reduced by approximately 30% with the use of NLC occupancy sensors. The total energy consumption of a large building can easily be reduced by 20% when a Building Management System uses NLCs to manage lighting and occupancy signals from NLC sensors as input for HVAC control.

In conclusion, adopting a comprehensive approach to sustainability is more important than merely increasing efficiency when incorporating future technology into infrastructure construction and building design. Buildings and communities can be made to be both environmentally conscious and highly robust, by utilizing advancements in energy management, automation, and renewable energy sources.



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