ENGINEERS & GEOSCIENTISTS
BRITISH COLUMBIA

PRACTICE ADVISORY

ELECTRICAL CONSIDERATIONS FOR DECARBONIZING EXISTING PART 3 BUILDINGS

Version 1.0, Published June 16, 2022

This practice advisory has been issued for registrants of Engineers and Geoscientists BC (engineering professionals) who provide services, such as design and field reviews, for retrofitting electrical systems to support decarbonization of existing buildings classified under Part 3 of the *British Columbia Building Code*.

Specifically, this practice advisory addresses:

- decarbonization of building systems (e.g., space heating, hot water);
- regulatory drivers for decarbonizing buildings;
- applicability of the *Canadian Electrical Code*;
- installation of electric vehicle (EV) charging infrastructure;
- technological considerations; and
- considerations for holistic, long-term planning for current and future electrical needs and implications for load planning, utility and peak demand-side management, and resiliency (e.g., power outages, climate adaptation).

Note that while this practice advisory addresses existing buildings, the information about load planning and technological considerations are also relevant to new buildings.

BACKGROUND

This practice advisory was developed in response to the publication of two Engineers and Geoscientists BC documents: the What We Heard Report (Engineers and Geoscientists BC 2020) and the Climate Change Action Plan (Engineers and Geoscientists BC 2021). The What We Heard Report summarizes the feedback obtained from registrants during the development of the Climate Change Action Plan. The Climate Change Action Plan itself provides a framework for how Engineers and Geoscientists BC can support registrants in their professional practice, allowing the organization to respond to climate change issues proactively rather than reactively.

In addition, engineering professionals have a legal and professional responsibility to uphold the safety, health, and welfare of the public, including the protection of the environment. As such, engineering professionals with the appropriate education, training, and experience to practice electrical engineering, and other registrants engaged in practice areas such as energy efficiency and renewable energy, must be of aware of emerging practices and policies related to building and transportation decarbonization and must use a risk-based decision-making approach when providing related professional services. Two risk factors that must be considered are:

- the implications of climate change on the building design; and
- the impact of the building design on climate change.

DEFINING BUILDING DECARBONIZATION AND RESILIENCE

In this advisory, the word "decarbonization” refers to taking actions to reduce greenhouse gas (GHG) emissions produced over the lifecycle of a building and by related transportation systems; for example, by installing EV-charging infrastructure.

This advisory focuses on electrical considerations for building decarbonization strategies. While numerous strategies are available—like choosing materials with lower embodied emissions or using drop-in fuel replacements such as renewable natural gas—this advisory focuses primarily on those that impact a building’s electrical infrastructure, consumption, and demand, and those that reduce a building’s operational carbon emissions.

Increased electrification is a core component of a decarbonization strategy and involves switching from combusting fossil fuels for energy end uses (e.g., for building mechanical systems or vehicles) to using low-carbon electricity to efficiently provide energy end uses.

In addition, there is increasing demand for climate-resilient buildings that provide cooling, improve air filtration (e.g., in wildfire smoke events), and increase local resiliency in response to power outages. Building systems in British Columbia (BC) need to be constructed to be more resilient to climate change-related effects, as the province is already experiencing frequent, devastating, extreme climate events, including wildfires and heat waves.

KEY POLICY DRIVERS OF BUILDING DECARBONIZATION

Existing and anticipated regulations, policies, and incentives at the municipal, provincial, and federal levels of government are driving building decarbonization.

The Province of BC has legislated targets to reduce GHG emissions to 40% below 2007 levels by 2030, 60% by 2040, and 80% by 2050. The provincially-adopted sectoral targets for the categories of “Buildings and Communities” and “Transportation” commit to GHG reductions of 59% to 64% and 27% to 32% below 2007 levels, respectively, by 2030, (Province of BC 2021a). Planned increases to the provincial carbon tax will further drive the need for decarbonization.

The Province’s CleanBC strategy includes a goal to retrofit millions of square metres of commercial space with electric space heating (e.g., heat pumps) by 2030. In the CleanBC Roadmap to 2030, the Province further commits to requiring that all space- and water-heating equipment sold and installed in BC after 2030 is to exceed 100% efficiency (i.e., conventional combustion equipment may no longer be installed) (Province of BC 2021b). The Province has similarly committed to zero-emissions transportation (e.g., plug-in electric transportation). The Roadmap to 2030 document, which is informed by the current *Zero-Emission Vehicles Act*, commits to requiring 90% of new vehicles sold to be zero-emission vehicles by 2030, and 100% by 2035.

In addition, the federal Clean Fuel Standard (Government of Canada 2021) and the provincial *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* and *Renewable and Low Carbon Fuel Requirements Regulation*—known collectively as the “BC low carbon fuel standard”—are further driving transportation electrification.

HOLISTIC BUILDING DECARBONIZATION

Engineering professionals who are providing retrofit services that are specifically focused on, or could include, building decarbonization must address life-safety considerations and encourage integrated design and holistic thinking to maximize opportunities for decarbonization.

Energy-efficient and cost-efficient building decarbonization is achieved through collaboration with project professionals and partners, including the following:

- Building owners and building occupants
- Authorities having jurisdiction
- Energy auditors
- Mechanical engineers, electrical engineers, structural engineers, acoustical consultants
- Utility providers (e.g., BC Hydro, FortisBC, municipalities[1])
- Architects
- Building enclosure engineers
- Tradespersons (electrical, gas, plumbing)

Engineering professionals should consider decarbonizing existing Part 3 buildings in the following situations:

- A building owner is required or incentivized by federal, provincial, local, or utility-provider policies or programs to achieve GHG reductions or implement energy-efficiency improvements.
- Building mechanical system(s) are being replaced, upgraded, or added (e.g., air conditioning).
- Changes to building systems are being considered that will change building electrical demand or peak load, including adding building or EV energy management systems (EVEMS).
- Building-scale renewable energy installations (e.g., solar photovoltaic [solar PV] technology) are being installed or considered.
- Energy efficiency, building envelope, or structural improvements are being implemented or considered, including in an adjacent parkade (as these can present opportunities for EV-charging retrofits).
- New, additional, or future EV-charging infrastructure is being installed or considered.
- Building condition assessments, strata depreciation reports, and other facilities assessments are planned or being carried out.
- Building owners or occupants are seeking resiliency and risk mitigation from climate impacts, including wildfire smoke and other air pollutants, heat waves, and extreme temperatures.

Each of these situations presents an opportunity for building decarbonization, although the scope of work, as well as the order and degree of engaging other professionals and stakeholders, may differ.

[1] Five municipalities in BC manage their own utilities: City of Grand Forks, City of Nelson, City of New Westminster, City of Penticton, and District of Summerland.

PROFESSIONAL PRACTICE

As noted above, this advisory focuses on electrical considerations for decarbonization strategies for existing buildings classified under Part 3 of the *British Columbia Building Code* (*BCBC*). Decisions related to electrification are central to a decarbonization strategy, and there is increasing demand for climate-resilient buildings that provide cooling, improve air filtration (e.g., in wildfire smoke events), and increase local resiliency in response to power outages.

PROJECT DESIGN

Holistic project design is critical to the success of decarbonization retrofits of existing buildings.

Engineering professionals should consider each of the following at the earliest opportunity when involved in such projects:

- Full range of decarbonization opportunities
  - Analyze opportunities to decarbonize building systems in all situations noted in Holistic Building Decarbonization above, and be aware of and in compliance with all applicable government and utility-provider policies and regulations that impact the building.
  - Consider opportunities for energy efficiency, fuel switching, energy management systems, and onsite renewable energy, in order to provide electrical capacity, minimize the need for electrical service upgrades, and reduce electrical utility costs.
- Electrical demand
  - Assess the capacity of the electrical system, and consider potential sources of future demand under decarbonization scenarios. For example:
    - mechanical-system retrofits should consider the effects of future EV-charging needs on total capacity and demand, and EV-charging retrofits should factor in current or future electrification of HVAC and domestic hot water; and
    - fuel-switching space heating and/or hot-water heating will increase demand, while retrofitting electric-resistance heating (i.e., baseboards) with high-efficiency retrofits (e.g., heat pumps) will result in increased capacity.
  - Analyze electrical capacity and opportunities to improve energy efficiency, such as installing better insulation—which would reduce electrical demand—before mechanical equipment is sized, to help limit oversizing of the equipment and any associated negative impacts. For example:
    - oversized heat pumps experience “short-cycling,” turning on and off more frequently, which reduces their efficiency and lifespan, and impacts building comfort.
- Electrical load management and utility demand response
  - View each building as part of a connected regional grid and not as an isolated point downstream from the utility connection and meter. Since each building in a given area represents just one load of many being supplied by a transformer, if the transformer is overloaded, it may not be possible for the building to electrify until that transformer is upgraded.
  - Engage utility providers early in a project’s life cycle regarding peak load and the impact on local grid capacity. Energy management systems should also be strategically leveraged to optimize performance during peak load conditions.

- Program and rebate opportunities
  - Conduct a detailed energy assessment or audit, to provide an overview of energy-reduction opportunities across the building and an estimate of potential GHG reductions, both of which inform program and rebate eligibility.
  - Consider all available programs and rebates, which are typically specific to geography, technology, building type, or end user, and emerge and evolve frequently.
- Climate risk and resilience
  - Consider opportunities to add or improve building cooling and air filtration (e.g., via heat pumps). Decarbonizing buildings presents opportunities to increase building climate resilience and improve building occupant safety, health, and comfort.
  - Consider the building's suitability for on-site renewable energy installations (e.g., solar PV, solar thermal, or geothermal), as they have the potential to reduce costs when tied to the electricity grid. When combined with battery energy storage systems, these installations can act as a resilience measure against power outages.
  - Consider and take steps to minimize operational risks and address safety risks in project and system design. For example, electrical equipment located in underground mechanical or electrical service rooms or parkades could be susceptible to flooding.

PERMITTING

Project and system design, and the associated choices of technology, can impact permitting complexity and requirements. Two documents—the CleanBC Roadmap to 2030 (Province of BC 2021b) and the Building Electrification Roadmap (Integral Group 2021)—identified streamlining permitting processes to support low-carbon and electrification projects as a key priority, with work underway by local governments, utility providers, and regulatory agencies.

Engineering professionals should be proactive in liaising with the authority having jurisdiction (AHJ)—which is typically a municipality or Technical Safety BC (TSBC)—to identify permitting requirements related to the project.

In addition, engineering professionals should consider other possible permitting requirements of a decarbonization project, such as the following:

- A development permit or variance may be needed for designs that impact building height or sightlines (e.g., rooftop installations of variable refrigerant flow heat pumps or solar PV), parking (e.g., locating heat-pump condensing units in parkades), or setback requirements.
- Local noise bylaws, which may provide specific guidance on heat pumps, should be reviewed by acoustical consultants when selecting technologies.
- Rooftop installations that increase structural load can trigger the need for a building permit, as can designs that require penetrations to a roof, floor, wall (especially a demising wall), or vapour barrier. Collaboration with structural and mechanical engineers, architects, and acoustical and building enclosure consultants may be required, in order to select appropriate designs and secure professional assurances for permitting.

CODE REQUIREMENTS

The *BC Electrical Code* defines safety standards for protecting electrical workers and end users, and prescribes installation methods. Recent updates that apply to decarbonization projects include sections on solar PV installations and energy storage. As well, the *Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation*, which adopts the CSA B52-13, Mechanical Refrigeration Code (which is relevant to heat pumps), is anticipated to be updated to better address the topics of electrification and refrigerants with low global warming potential (GWP).

Engineering professionals must meet code requirements and be aware of guidance published by TSBC and the AHJ for their project. Engineering professionals should also be aware of the following code changes regarding EVEMS.

EVEMS were enabled under Section 8 of the 2018 *Canadian Electrical Code* (*CE Code*). Rule 8-500 of the *CE Code* establishes criteria under which EVEMS are permitted to monitor electrical loads in services, feeders, and branching circuits for controlling loads for EV supply equipment (EVSE, also referred to as EV chargers). Previously, loads for EVSE had been calculated with a demand factor of 100%, increasing calculated load for building services and feeders. The 2018 *CE Code* relaxed the rules for calculating EVSE demand under certain conditions by adding the following two subrules:

- Subrule 8-106(10), which allows the demand load for EVSE controlled by an EVEMS to equal the maximum load allowed by the EVEMS; and
- Subrule 8-106(11), which removes the requirement to include the demand load for the EVSE in the determination of the calculated load under certain scenarios.

Although these provisions exist, implementation of an EVEMS is at the discretion of the AHJ's electrical inspector. For additional guidance, refer to the following bulletins published by TSBC and the City of Vancouver regarding EVEMS:

- Information Bulletin: Electric Vehicle Energy Management Systems (TSBC 2018)
- Bulletin: Electric Vehicle Charging for Buildings (City of Vancouver 2021)

The current *BC Electrical Code* does not address using energy management systems to control building energy end uses (e.g., space heating, domestic hot water). The use of energy management systems is therefore dependent on the professional judgment of engineering professionals, project teams, and the AHJ.

Future code updates may enable dynamic energy management systems at the electrical panel level to allow load shedding and maximize existing electrical capacity. Until then, engineering professionals must take care not to exceed the capacity of the system in retrofit projects where buildings may be at or near capacity.

ENGAGEMENT WITH UTILITY PROVIDERS

Early engagement with utility providers reduces the risk of unforeseen delays and costs associated with changes and/or upgrades to electrical infrastructure. Engineering professionals should be aware of electric tariffs (i.e., terms and conditions) relevant to the building, such as clauses related to load changes or thresholds above which the utility provider must be notified.

Where new electrical services are required to meet loads associated with electrification, engineering professionals should provide documentation to utility providers regarding project electrical demand (BC Hydro 2021a). Wherever possible, engineering professionals should give utility providers up-to-date and accurate total and peak (summer and winter) consumption data, to allow detailed impact analysis. As well, planning for existing buildings often benefits from historical usage data[2]. Engineering professionals should consider collecting and providing such information in all projects, to allow utility providers to accurately analyze infrastructure impacts; this is particularly relevant in northern and central BC, due to lower relative distribution of resources.

Decarbonization can impact utility costs and rates. Partial or near-total electrification of buildings that previously relied on fossil fuels can result in changes to electric and fossil fuel utility rates. Consequently, fuel switching may shift utility costs to tenants, which can impact low-income tenants significantly. Energy modelling could help project the utility cost changes subsequent to electrification.

Engineering professionals or other project professionals should discuss these impacts with their clients. Project teams should consider the potential of present and future utility demand-response programs that provide incentives for building upgrades and EV-charging infrastructure, to time their electrical consumption in a way that is more optimal for the electric grid, and to determine how designs can enable such demand response.

ELECTRIC VEHICLE (EV) CHARGING INFRASTRUCTURE

EV-charging infrastructure consists of electrical systems used for EV charging and encompasses the EVEMS. The EVEMS includes technologies that monitor and control EV-charging loads, enable load sharing, and reduce needed electrical capacity and operational costs, potentially eliminating the need for costly new electrical services.

EVEMS are increasingly being used to deploy EV charging at scale, because the systems can accommodate higher numbers of EVs within the finite electrical capacity of existing buildings. The SAE J1772, Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler standard defines different levels of EVSE, summarized in Table 1.

[2] Utility-specific metering and data may differ (e.g., New Westminster utility meters are analog, so peak load data is not available).

Table 1: Summary of Electric Vehicle Supply Equipment (EVSE)

POWER TYPE	POWER SOURCE	VOLTAGE OUTPUT (V)	CURRENT OUTPUT (A)	POWER OUTPUT (kW)	SPEED OF CHARGE	RANGE PER HOUR (km)
AC Level 1	1 phase outlet (NEMA 5-15R or 5-20R)	120	12 to 16	1.44 to 1.92	Slow	3 to 8
AC Level 2	1 phase	208 to 240	≤80	≤19.2	Medium	~15 to 120
DC Fast Charge (DCFC)	Not specified (typically 3-phase / 480V AC)	50 to 1,000	<400	<400	Fast to Very Fast	~150 to 2,500

Engineering professionals should understand and analyze the driving habits and EV-charging needs of current and future building users, as these will impact decisions about the number and power type (i.e., Level 1, Level 2, DCFC) of stations. The Province of BC's EV Ready rebate program includes an EV Ready plan component, which can be used as guidance to analyze factors such as building demographics, driving distances, and other key variables (BC Hydro 2021b; FortisBC 2022).

Conceptual designs for EV plans should consist of single-line diagrams, parking layouts, and wiring plans, and should include calculations of electrical loads for different design options and confirmation of capacities. For example, buildings located in remote or rural regions will likely require designs that support charging for vehicles with larger batteries and more intensive charging needs, due to the longer average driving distances in those areas. Engineering professionals should consider the resilience of EV-charging systems and assess the need for redundancy in regions with fewer charging stations spread across longer distances and possibly more extreme temperatures and conditions.

For new building construction, many local governments in BC require EV-ready installations, which refers to parking spaces with an adjacent energized electrical outlet (typically capable of Level 2 charging) for the purpose of future EV charging. These requirements, which are typically implemented via zoning or parking bylaws, increase the long-term resilience of buildings, and accelerate access to and availability of EV charging.

For existing buildings, EV-ready retrofits are a policy option to support the transition to electric-powered mobility, especially for multi-unit residential buildings (MURBs). There are two approaches:

- comprehensive 100% EV-ready retrofits; or
- incremental installations of EV-charging systems.

Critically, a comprehensive EV-ready retrofit would facilitate the integration of an EVEMS and significantly reduce costs per parking space, while also promoting compliance with anticipated demands and providing convenient access for all users. Incremental installations, it should be noted, may potentially exhaust building electrical capacity. Therefore, engineering professionals involved in incremental installations should consider future needs and the effect of future installations, advise the owner and project team of the risks, document decisions, and design accordingly.

TECHNOLOGICAL CONSIDERATIONS

To support a building system's compliance with anticipated demands, and to promote maximum possible decarbonization, design teams should consider technologies that align with future policy direction, in addition to meeting mandatory requirements of existing regulations and standards.

Energy-efficient, low-carbon, and mature electric building technologies are available that can be implemented in both new and retrofit applications (NBI 2021). The following subsections include a brief overview of these technologies. For technological considerations related to building enclosure aspects in decarbonizing buildings, refer to the *Practice Advisory – Climate Change Considerations for Building Enclosure Engineers* (Engineers and Geoscientists BC 2022).

Engineering professionals working on decarbonization projects should be aware of emerging technologies and consider those that are suitable and appropriate for their particular project, while both meeting current requirements and anticipating future requirements.

HEAT PUMPS

Electrical Demand and System Sizing

The building's existing electrical installation and the existing electrical load should be assessed, to determine whether the existing electrical installation has sufficient spare capacity to support the requirements of the heat-pump system, including any supplementary heating.

Heating and cooling loads should be determined by using recognized sizing methods, such as those from the CSA F280-12, Determining the Required Capacity of Residential Space Heating and Cooling Appliances standard, and paying attention to performance factors such as the heating seasonal performance factor (HSPF) and, for cooling, the seasonal energy efficiency ratio (SEER).

Geographic and Application-specific Considerations

Cold-climate heat pumps may be required for buildings in BC's northern and interior regions[3] (NEEA 2020). Dual-fuel systems that rely on natural gas or electrical heating, such as induction heaters for backup during peak demand, are another option when designing for cold climates. Ground-source and natural-gas heat pumps have useful applications for large commercial or industrial applications. Central heat pump water heaters, especially the low-GWP options, can maximize the extent of Part 3 building decarbonization.

Refrigerants

Refrigerant leakage is one of the biggest contributors to climate change within the building industry and can have a larger impact than operational GHG emissions (Integral Group 2020). Engineering professionals should help building owners be aware of the impacts of refrigerant leakage from heat pumps, and encourage frequent maintenance and education of operations and maintenance staff.

Low-GWP refrigerant heat pump systems—such as those using ammonia, CO_2, H_2O, and propane—produce lower lifetime GHG emissions and are expected to become increasingly

[3] The Northwest Energy Efficiency Alliance (NEEA) maintains a searchable "Cold Climate Air Source Heat Pump List" of variable-capacity ductless heat pump systems sold in North America that meet the Northwest Cold Climate Specification of COP ≥1.75 @ 5°F as reported by the manufacturer.

available in the future (and certified for use in BC), due to the mandatory national phasedown of hydrofluorocarbons and restrictions on products containing them[4] (Integral Group 2020).

Engineering professionals should work with other professionals to specify electrical considerations and provide recommendations on the lowest impact option(s) (i.e., systems that reduce both overall refrigerant charge and refrigerant GWP).

ENERGY MANAGEMENT SYSTEMS

Building energy management systems (BEMS) are sophisticated control systems for individual buildings or groups of buildings that use computers and distributed microprocessors for monitoring, data storage, and communication (IEA 1997). They can include attributes from multiple building control and management functions, such as heating, ventilation, and air conditioning, as well as lighting, fire protection, security, maintenance, and energy management (Levermore 2000).

BEMS and EVEMS enable strategic use of existing capacity, reduce demand, and mitigate oversizing of equipment and electrical supply infrastructure. They reduce or eliminate reliance on carbon-intensive backup energy during times of peak demand, and improve security and emergency procedures.

BEMS can monitor and integrate heating, cooling, and other functions of multiple related buildings (e.g., campus, residential complex, manufacturing) and can achieve higher energy savings than each building could individually.

Several recent reports outline different EVEMS configurations and comment on their potential applications (CSA Group 2019; City of Richmond 2018).

Engineering professionals should consider integration of BEMS and EVEMS into retrofit projects.

ON-SITE RENEWABLE INSTALLATIONS AND BATTERY STORAGE

On-site renewable energy sources, such as solar PV, provide local energy resilience against power outages when paired with battery storage. They also balance electricity demand, facilitate net-zero energy targets, and can improve the business case for energy retrofits (e.g., in MURBs) (Pembina Institute 2020).

Engineering professionals should consider renewable energy sources, particularly for buildings in remote or rural areas that experience more frequent grid disruptions. Central heat pump water heaters for multifamily and institutional applications that feature integrated demand control capability can act as a battery by generating and storing hot water during favourable pricing conditions.

[4] The *Montreal Protocol on Substances that Deplete the Ozone Layer* and subsequent Kigali Amendment require the phasedown of hydrofluorocarbon (HFC) refrigerants by 70% by 2030 and 85% by 2036 to reduce GHG emissions. Canada's *Ozone-depleting Substances and Halocarbon Alternatives Regulation* was subsequently amended and places restrictions on ozone-depleting substances (ODS) and products that contain them, including conventional high-GWP HFCs used in heat pumps.

ELECTRIC APPLIANCES

Engineering professionals should consider specifying appliances that use less energy and produce fewer GHG emissions, such as electric cooking (e.g., induction) and laundry appliances (e.g., heat pump clothes dryers) in MURBs and the commercial hospitality sector (FRESCo Building Efficiency 2021). Conversion from gas to electric cooking also increases indoor air quality and occupant health.

Engineering professionals should note that an additional 240V electrical outlet may be required when converting certain appliances from gas to electric.

REFERENCES

LEGISLATION AND REGULATIONS

Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act [SBC 2008], Chapter 16.

Power Engineers, Boiler, Pressure Vessel and Refrigeration Safety Regulation [B.C. Reg 104/2004].

Renewable and Low Carbon Fuel Requirements Regulation [B.C. Reg. 394/2008].

Safety Standards Act [SBC 2003], Chapter 39.

Zero-Emission Vehicles Act [SBC 2019], Chapter 29.

REFERENCES

BC Hydro. 2021a. BC Hydro and Power Authority – 2021 Integrated Resource Plan. Vancouver, BC: BC Hydro. [accessed: 2022 Apr 26]. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/integrated-resource-plan-2021.pdf.

BC Hydro. 2021b. EV Charging Rebates for Apartment and Condo Buildings. [website]. Vancouver, BC: BC Hydro. [accessed: 2022 Apr 26]. https://electricvehicles.bchydro.com/incentives/charger-rebates/apartment.

City of Richmond. 2018. Electric Vehicle Charging Infrastructure in Shared Parking Areas: Resources to Support Implementation and Charging Infrastructure Requirements. Prepared by AES Engineering. [accessed: 2022 Apr 26]. https://www.richmond.ca/__shared/assets/EV_Charging_in_Shared_Parking_Areas_Report51731.pdf.

City of Vancouver. 2021. Electric Vehicle Charging for Buildings. Bulletin 2019-006-BU/EL. September 20, 2021. [accessed: 2022 Apr 26]. https://vancouver.ca/files/cov/2019-006-electric-vehicle-charging-for-buildings.pdf.

CSA Group. 2019. Electric Vehicle Energy Management Systems. [accessed: 2022 Apr 26]. https://www.csagroup.org/wp-content/uploads/CSA-RR_ElectricVehicle_WebRes.pdf.

Engineers and Geoscientists BC. 2022. Practice Advisory – Climate Change Considerations for Building Enclosure Engineers. Version 1.0. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2022 Apr 26]. https://www.egbc.ca/app/Practice-Resources/Individual-Practice/Guidelines-Advisories/Document/01525AMWZ4OQNSFQRDEBA2GUPT6CRPJG7U/Climate%20Change%20Considerations%20for%20Building%20Enclosure%20Engineers.

Engineers and Geoscientists BC. 2021. Climate Change Action Plan. Version 1.0. March 15, 2021. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2022 Apr 26]. https://www.egbc.ca/getmedia/50e4e26b-30ad-46c8-8ca1-f06428af65dc/Engineers-andGeoscientists-BC-Climate-Change-Action-Plan.pdf.aspx.

Engineers and Geoscientists BC. 2020. Climate Change Action Plan: What We Heard Report. November 4, 2020. Burnaby, BC: Engineers and Geoscientists BC. [accessed: 2022 Apr 26]. https://www.egbc.ca/getmedia/fdcb28dd-39f3-4972-b838-34c09ad3b1c3/Climate-ChangeAction-Plan-What-We-Heard-Report.pdf.aspx.

FortisBC 2022. Electric Vehicle Charging. [website]. Surrey, BC: FortisBC. [accessed: 2022 Apr 26]. https://www.fortisbc.com/services/sustainable-energy-options/electric-vehicle-charging.

FRESCo Building Efficiency. 2021. Electrification of Multi-Unit Residential Buildings. October 21, 2021. Prepared for LandlordBC. Vancouver, BC: FRESCo. [accessed: 2022 Apr 26]. https://landlordbc.ca/wp-content/uploads/2021/10/FRESCo_Electrification-of-Multi-Unit-Residential-Buildings_final-v3.pdf.

Government of Canada. 2021. Clean Fuel Standard. [website]. [modified: 2021 Jul 26; accessed: 2022 Apr 26]. Ottawa, ON: Government of Canada. https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html.

Integral Group. 2021. British Columbia's Building Electrification Roadmap. Vancouver, BC: Integral Group. [accessed: 2022 Apr 26]. https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.

Integral Group. 2020. Refrigerants and Environmental Impacts: A Best Practice Guide. Version 1: September 2020. Vancouver, BC: Integral Group. [accessed: 2022 Apr 26]. https://www.integralgroup.com/news/refrigerants-environmental-impacts/.

International Energy Agency (IEA). 1997. Technical Synthesis Report: A Summary of IEA Annexes 16 & 17 Building Energy Management Systems. Energy Conservation in Buildings and Community Systems. [accessed: 06 Jun 2022]. https://www.iea-ebc.org/Data/publications/EBC_Annex_16-17_tsr1.pdf.

Levermore GJ. 2000. Building Energy Management Systems; Application to Low-energy HVAC and Natural Ventilation Control. Second edition. London: Routledge. https://doi.org/10.4324/9780203477342.

Northwest Energy Efficiency Alliance (NEEA). 2020. Cold Climate DHP Specification. Cold Climate Air Source Heat Pump List. [website]. Portland, OR: NEEA. [accessed: 2022 Apr 26]. https://neea.org/our-work/cold-climate-dhp-specification.

New Buildings Institute (NBI). 2021. Building Electrification Technology Roadmap (BETR). Portland, OR: NBI. [accessed: 2022 Apr 29]. https://newbuildings.org/resource/building-electrification-technology-roadmap/.

Pembina Institute. 2020. Solar Panels Boost Business Case for Electrifying Multi-unit Low-rise Housing. Case Study. Calgary, AB: Pembina Institute. [accessed: 2022 Apr 26]. https://www.pembina.org/pub/solar-pv-retrofit-case-study.

Province of BC. 2021a. BC Sets Sectoral Targets, Supports for Industry and Clean Tech. [News release]. Victoria, BC: Province of BC. [accessed: 2022 Apr 26]. https://news.gov.bc.ca/24087.

Province of BC. 2021b. Clean BC – Roadmap to 2030. Victoria, BC: Ministry of Environment and Climate Change Strategy. [accessed: 2022 Apr 26]. https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf.

Technical Safety BC (TSBC). 2018. Information Bulletin: Electric Vehicle Energy Management Systems. Reference number IB-EL 2018-01. 31 October 2018. Vancouver, BC: TSBC. [accessed: 2022 Apr 26]. https://www.technicalsafetybc.ca/alerts/information-bulletin-electric-vehicle-energy-management-systems.

VERSION HISTORY

VERSION NUMBER	PUBLISHED DATE	DESCRIPTION OF CHANGES
1.0	June 16, 2022	Initial version.