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Power outage risks in all-electric homes: dispelling myths and identifying solutions

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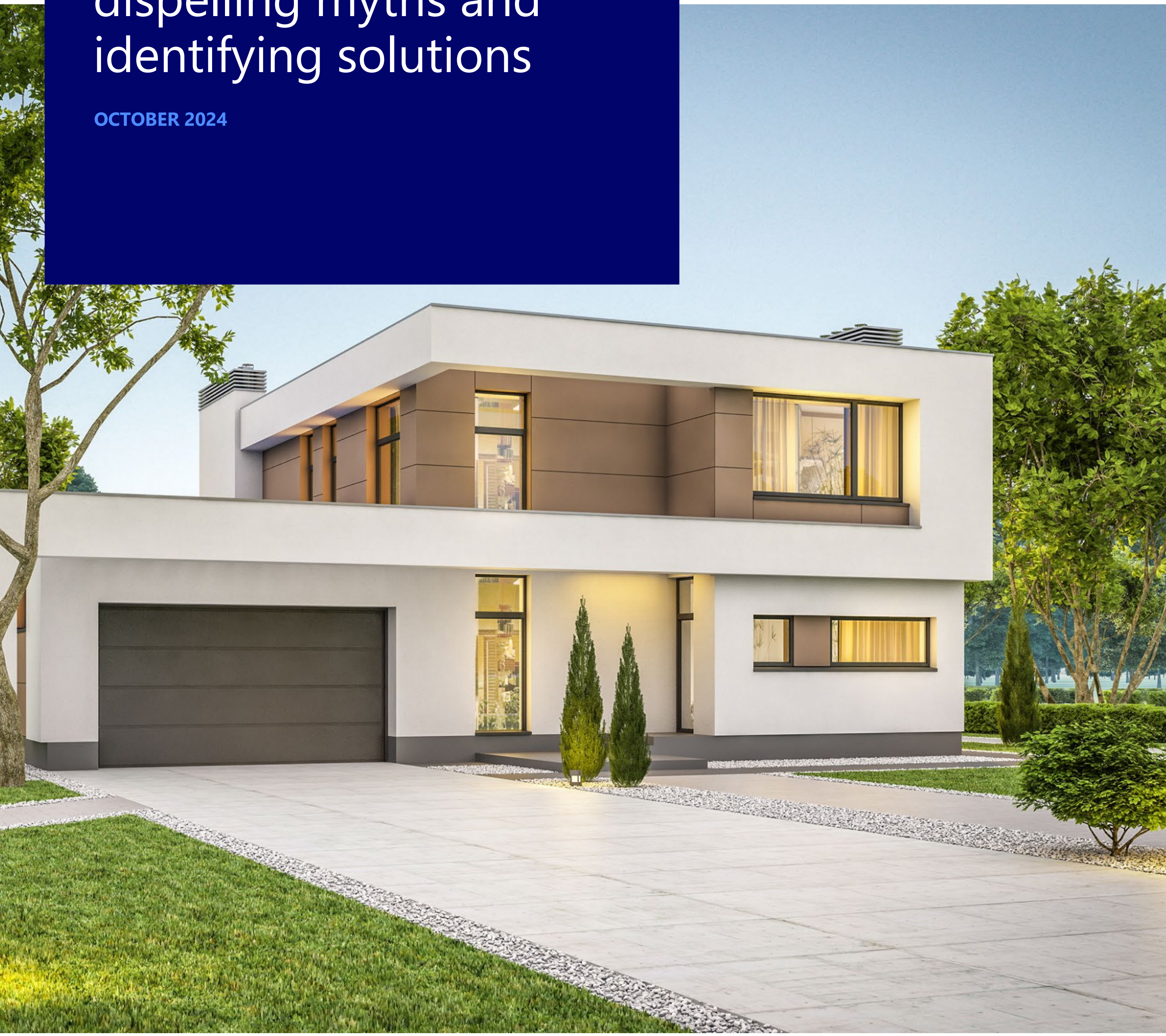

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1. Introduction

Building electrification, or the process of replacing technologies that use fossil fuels like natural gas furnaces or boilers with electrically powered equipment such as heat pumps, is one of the most important strategies to reduce emissions and contribute to climate objectives in British Columbia (BC). For homeowners, making the switch can result in a net reduction in overall energy use and costs, reduced household carbon pollution, and improved indoor air quality. According to a summary report of a survey of BC homeowners who converted their heating systems from natural gas furnaces or boilers to electric air-source heat pumps, two-thirds of study participants pay the same or less in overall energy costs to heat and cool than they did before the switch, and their utility bills have dropped 10% on average. Homeowners additionally reduced their household carbon pollution by an average of 73%.[1]

Despite these kinds of benefits, concerns have been raised that homeowners in all-electric homes may be at greater risk during power outages than those having both natural gas and electricity. Electricity is central in day-to-day life at home, providing energy to space heating and cooling and domestic hot water systems, powering appliances and lighting, and supporting various activities, including communication, teleworking, and entertainment. Electricity is also critical for operating life-support medical equipment for people who rely on them to live independently.

This reliance on electricity naturally translates into the potential for significant concerns when the power goes out. But what is the actual risk to all-electric homes? Is it actually greater than for gas-heated homes? The goal of this report is to explore this issue in further depth, in the hopes of alleviating fears among all-electric homeowners about the potential impacts of power outages and providing them with strategies to enhance their comfort, safety, and resilience in all-electric homes.

2. Understanding Power Outage Risks in BC

2.1. Province-Wide Trends in Power Outages

A starting point for this exploration begins with an understanding of the actual frequency and duration of power outages across the province. To conduct this analysis, data was obtained from BC Hydro that includes the following information:

- **SAIFI**: a metric that measures the number of sustained interruptions (longer than one minute) an average BC Hydro customer[2] in a community experienced in a year. Data was shared for years spanning 2019 to 2023.
- **CAIDI**: a measurement that reflects the average interruption, in hours, per interrupted BC Hydro customer in a community in a year. Data was shared for years spanning 2019 to 2023.
- **The number of outages in a community lasting beyond 4 hours and 24 hours** from 2022 to April 2024 when the data was extracted.
- **Customer counts** from 2019 to 2023.

Data for all four metrics was provided at the provincial, regional, and community levels. Regional data was divided into three main regions: the Interior, Lower Mainland, and Vancouver Island. At the community level, a total of 138 communities served by BC Hydro were included.

A robust analysis that assesses ranges and trends in customer experience in terms of both frequency and duration of power outages would require access to data on a per BC Hydro customer basis. As this dataset is not available due to privacy reasons, the analysis below is based on ratios of metrics provided for entire communities. It should be noted that this normalization very significantly limits the ability of the analysis to provide a complete picture of the how power outages impact individual BC Hydro customers, as it does not capture the diversity of experiences within a given community (for example some customers in a community may experience an outage while others do not). However, some trends can still be explored.

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[1] Make the Switch to a Heat Pump. (2023). Available: https://www.saanich.ca/EN/main/community/sustainable-saanich/climate-change/climate-friendly-homes/making-the-switch.html#study

[2] Please note that for the purposes on this report, customer refers to BC Hydro distribution customers, not transmission customers. These customers make up the bulk of accounts in BC.

Duration of Outages in BC Communities

The analysis explores the duration of outage events over 1 minute in duration when they do occur. Outage events are categorized into four groups: short (1 minute-3.99 hours), moderate (4-7.99 hours), long (8-23.99 hours), and prolonged (over 24 hours) based on yearly community-level CAIDI.

Table 1 provides the total number of residents living in areas where the average power interruption falls in the short, moderate, long, and prolonged power outage category. It needs to be emphasized that the intention of this chart is to simply show general trends over time. Any individual customer in a given community may be quite different than these averages. For example, some customers in communities with a short average duration may have experienced no or longer outrages and customers in communities with a prolonged average duration may have experienced no or shorter power outages. Table 2 presents the same information in terms of percentage of the population.

For both Tables 1& 2, it is important to note that zeros do not indicate that no one in BC experienced a prolonged power outage, but rather that their occurrence is so low that they will very rarely impact the total annual average for any community.

Table 1: Number of BC residents living in areas affected by short, moderate, long, and prolonged power outages, 2019 to 2023

Duration Classification	2019	2020	2021	2022	2023
Short (1 minute-3.99 hours)	2,604,481	4,016,749	3,796,332	3,767,339	3,558,299
Moderate (4-7.99 hours)	1,400,097	65,872	264,098	304,279	526,719
Long (8-23.99 hours)	78,121	3,403	25,201	13,887	1,006
Prolonged (over 24 hours)	3,325	0	393	519	0

Table 2: Percentage of BC residents living in areas where the CAIDI is classified as short, moderate, long, and prolonged power outages, 2019 to 2023

Duration Classification	2019	2020	2021	2022	2023	Average
Short (1 minute-3.99 hours)	63.7%	98.3%	92.9%	92.2%	87.1%	86.8%
Moderate (4-7.99 hours)	34.3%	1.6%	6.5%	7.4%	12.9%	12.5%
Long (8-23.99 hours)	1.9%	0.1%	0.6%	0.3%	0.0%	0.6%
Prolonged (over 24 hours)	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%

The data shows that 99.3% of residents in BC live in places with average short power outages (lasting under 4 hours per interrupted customer) and moderate power outages (lasting from 4 to 8 hours). This pattern has remained consistent over the past five years in BC (see Figure 1). However, the number of customers living in communities with a moderate average power outage has decreased from the high experienced in 2019.

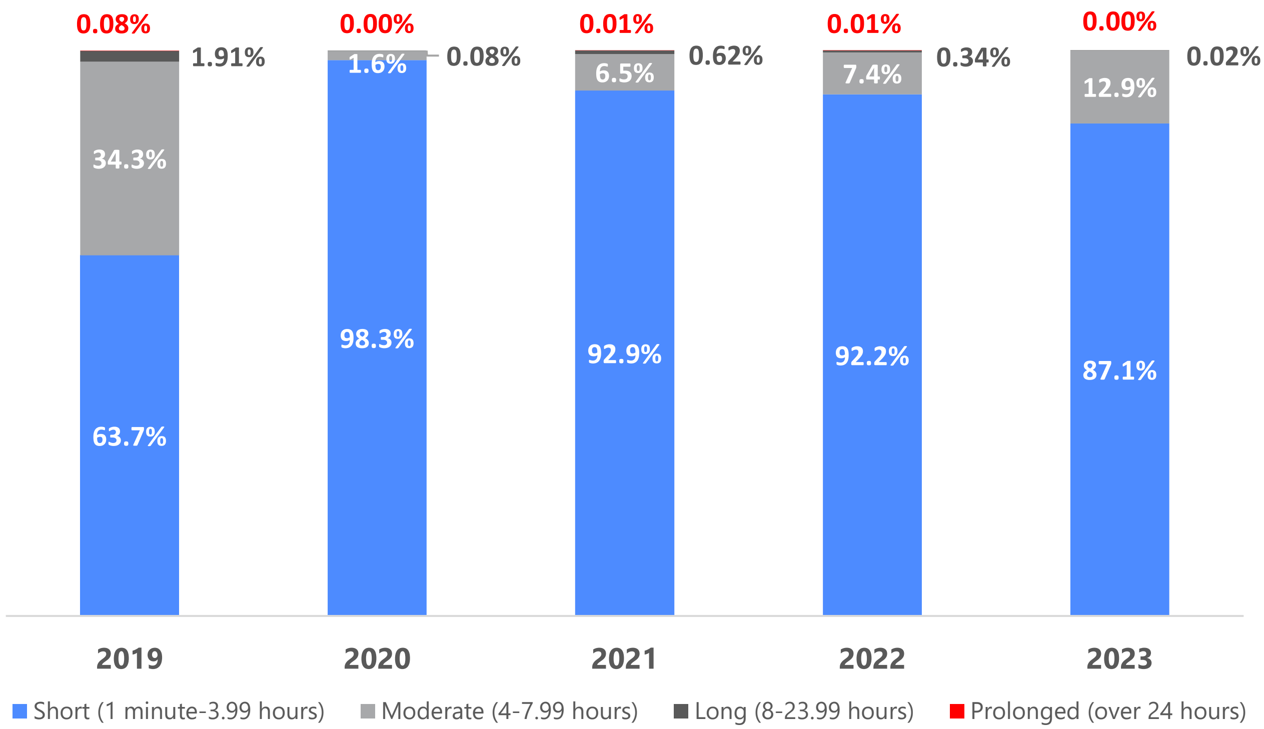

Figure 1. Outage duration trends based on CAIDI, 2019 to 2023

To investigate the impacts of power outages on different communities, specifically to understand whether there is a difference in power outage duration between population centers and rural areas[3], the analysis examined residents affected by short, moderate, long, and prolonged outages in these two areas. The results show that in both population centers and rural areas, outages lasting under 4 hours per interrupted distribution customer account for the majority of average outages, followed by moderate average outages (lasting 4 to 8 hours). While residents in population centers experience a slightly lower proportion of long and prolonged average outages compared to residents in rural areas, the difference is minor, at 2% (See Figure 2).

Figure 2. Proportion of distributed customers impacted by short, moderate, long, and prolonged power outages in population centers and rural area

[3] The data was categorized by classifying communities as either population centers or rural areas, taking into account population size and density based on Statistics Canada's Classification Framework. According to the Population Centre and Rural Area Classification 2016, a population center is defined as an area with a population of at least 1,000 and a density of 400 or more people per square kilometer. All areas outside population centres are defined as rural areas.

It should be noted that these results reflect the *average* duration of the power outages (CAIDI), which is significantly lower than the duration of the *longest* outage in a given year that affected customers in a community may have experienced. For instance, the average power outage duration (CAIDI) in the City of Coquitlam in 2023 was 2.19 hours, placing the community into the “short” category. However, the longest outage experienced by the city in that year lasted 20 hours, which is classified as a "long" power outage, and it impacted a total of 61 customers. As the average duration may underestimate the actual longest power outage one or more customers in a community may experience, Figure 3 compares the average power outage duration (CAIDI) in different communities and the duration of the longest power outage in 2023 in those same communities. Each dot in the scatter plot represents a community, with the values in the horizontal and the vertical axes showing the average and the longest outage duration, respectively. The number of affected customers is indicated by colour coding: green for communities where fewer than 10 customers were impacted by the longest outage, yellow for 10 to 99 customers, and red for communities with 100 or more customers affected. This analysis shows that even in communities with “short” CAIDI values (<3.99 hours), the duration of the longest outage in that same community is often an order of magnitude higher, in the range of tens (and sometimes hundreds) of hours.

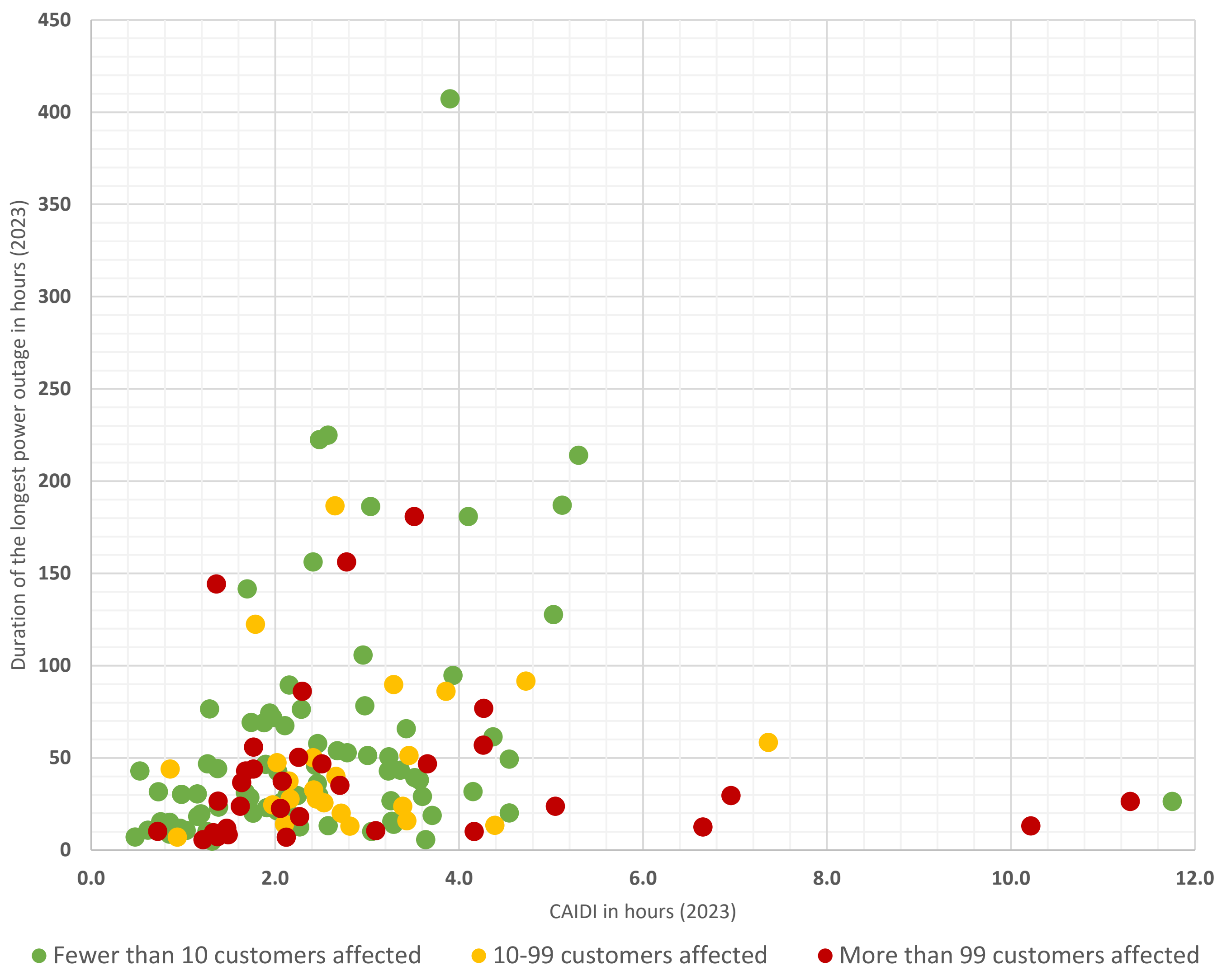

Figure 3. Average power outage duration (CAIDI) in 2023 vs. Duration of the longest power average in 2023

For a better understanding of how power outages affect your community, please see **Appendix A** for a CAIDI and SAIFI information by local government.

2.2. The Impact of Climate Change on Power Outage Risk

While the analysis in the section above reveals trends in power outages over the last five years, it's also important to consider potential outages in the future. One source of potential changes to the risk of power outages that is often noted is BC's changing climate. While the impacts may slightly differ across regions, the province is expecting to see a general trend of warming air temperatures, changing precipitation patterns, increasing frequency, intensity, and/or duration of extreme events, and rising sea levels. These changes pose the risk of disruption to energy supply, damage to electricity generation, transmission, and distribution infrastructure, as well as failures in end-use systems[4] leading to the consequence of power outages. Table 3 outlines a range of hazards that are expected to occur as a result of province-wide climate trends and their potential impacts across the entire power supply chain. The relationship is not strictly one-to-one, as a climate hazard may affect multiple power system assets or operations. Moreover, rather than happening independently, these climate hazards are interconnected and often occur simultaneously or back-to-back, resulting in significantly higher consequences. Overall, the risk of power outages is anticipated to rise in BC.

[4] Failures in end-use systems refer to circumstances in which electrically powered equipment and appliances cannot fulfill their intended functions due to factors under the end user's responsibility, such as component degradation, improper maintenance, and inadequate protection for electrical and mechanical equipment from climate hazards. In this context, homeowners emerge not only as individuals directly affected by changes in climate, but also as key decision makers along with utility providers tasked with the responsibility to prepare for power outages.

Table 3: Overview of potential climate hazards and impacts under a changing climate

Climate Change Trend	Climate Hazards	Potential Impacts	Disruption to Energy Supply	Damage to Energy Infrastructure	BC Hydro actions currently underway to address hazards	Failure of End-Use Systems
			Under BC Hydro's Responsibilities			Under Homeowner's responsibilities
Warmer temperatures	Increased average temperatures	• Rising temperatures can cause shifts in energy demand with demand from heating decreasing and demand from cooling increasing.[5] At the same time, hotter temperatures could diminish the capacity of transmission and distribution, resulting in compounded impacts in the summer. • Warmer temperatures can increase the proliferation of invasive species from plants. The dead or damaged trees are more vulnerable to winds and storms, leading to an increased risk of damaging transmission and distribution infrastructure. Additionally, increased water temperatures may also pose a threat to hydropower generation facilities if invasive species attach to water intake assets.	✓	✓	Forecasting increases in building cooling use into future load forecasts. Vegetation management program - Regularly inspecting and maintaining vegetation located near wires and other infrastructure. Adjust material selection of transmission and distribution infrastructure to adapt to climate change-related risks.	
	Heatwaves	• A warmer climate will escalate weather extremes, making heat waves hotter, longer, and more common, which will increase cooling demand and potentially lead to grid overload. • Potential for temperatures to exceed design thresholds for power systems, causing brownouts.[6] • Higher ambient temperatures can reduce the efficiency of the HVAC system and cause cooling capacity to be exceeded, leading to equipment failure.	✓			✓
Changing precipitation patterns	Intense rainfall and flooding	• Inundation of power substations and other transmission infrastructure. • Riverine and stormwater flooding can cause landslides, debris, and erosion, impacting slope stability, damaging power transmission and distribution infrastructure damage, and preventing access for restoration. • Inundation damaging buried electrical vaults causing on-site outage.	✓	✓	Considering risks such as, sea-level rise and riverine flooding when siting stations and route transmission and distribution infrastructure. Provincial and municipal flood mapping is used to assess flood risk. Any new stations are	✓

[5] Despite a gradual increase in temperatures, the peak energy demand in B.C. is more likely during the winter than in the summer, and the transition towards a summer peak period is not anticipated to happen in the near term.

[6] Notably, there is no record of brownouts in the province's electricity service, and BC Hydro has no plans to implement brownouts and rotating outages in the foreseeable future. To adapt to climate trends and future electricity demand, BC Hydro adopts a multi-faceted approach involving conservation, generation, transmission, and upgrades to existing infrastructure.

					designed to withstand a 1 in 200 year flood.	
	Drought and water supply constraints	• Lower river and reservoir levels due to less summer rain and winter snow storage can have significant impacts on hydroelectric power generation[7]	✓		See Casting drought: How BC Hydro is managing and adapting on pg 7.	
Increasing frequency, intensity, and/or duration of extreme events	Increased wildfire	• Warmer temperatures, combined with drought conditions and more lightning storms, can increase the risk of wildfires, which can damage power lines, poles, and other critical infrastructure. • Reduced availability of transmission and generation capacity due to proactive outages.		✓	Undertaking wildfire risk modelling to identify system locations most at risk and prioritize asset management activities at these locations. Vegetation management (see above) Pole protection practices - Using steel or fiber-reinforced polymer or treat wooden poles with fire retardant. Fire Smart principles used in facility site management plans	
	Snowstorms and changing snow and ice	• The likelihood of winter storms is projected to decrease in the mid-term (2050s) and long-term (2080s) future. However, amidst a less stable climate, there's a potential for short-term increases in the intensity of winter storms. • Winter storms, characterized by strong winds, heavy snowfall, and freezing rain, can lead to power disruptions as snow and ice accumulate on power lines. • Heavy snow loads and ice storms also pose a risk of physical damage to electrical and mechanical equipment that is exposed and located outdoor. • In the mid-to-long term, reduced snowfall and snow cover, coupled with glacier mass loss, may contribute to decreased water availability, potentially resulting in summer water shortages.	✓	✓	Working with the Canadian Standards Association to incorporate strategies for climate change in both existing and new standards and codes. Specific areas being addressed are adaptations to ice, hail, and snow loads.	✓

[7] See "Casting drought: How BC Hydro is managing and adapting" under Section 2.2.1 for BC Hydro's responses to drought conditions and find additional information from: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/news-and-features/bchydro-report-casting-drought.pdf

	Windstorms and debris	• More severe windstorms leading to debris damage to power generation and transmission infrastructure, with potential service outages & blocked access for restoration • High wind events or severe storms and associated debris can damage mechanical equipment on rooftops. Differential pressure and wind entering intakes, particularly those facing prevailing winds, can compromise HVAC system operation	✓	✓	Using improved meteorological models to forecast storms and deploy crews. Vegetation management (see above) Using smart meters to confirm all restoration is complete before crews leave an area. Improving customer notification processes	✓
Rising sea levels	Storm surge	• Inundation and debris damage to substations and other power transmission infrastructure • Submersion of electrical components in storm surges can cause short circuits and system failures	✓	✓	Considering risks such as, sea-level rise and riverine flooding when siting stations and route transmission and distribution infrastructure.	✓

BC Hydro has also developed a set of high-level principles to guide the enhancement of the reliability and resilience of the power grid in response to climate change and its impacts.[8] Table 4 lists these principles and some overarching actions to supplement the actions above.

Table 4: Actions for Managing and Adapting to Power Outage Risks

Adaptation Strategy	Detailed Adaptation Actions
Prevent the event (applicable to wildfires only)	• Inspect, identify, trim or remove vegetation at risk of contact with our lines • Conduct routine risk assessments documented in project development and crew tailboards • Perform an annual system-wide fire risks evaluation to update prevention and protection strategies as needed and allocate resources to areas where the potential impact of an approaching fire is greatest
Detect threats to the system	• Incorporate new tools and techniques to continuously improve weather and inflow forecasting and optimize generation operations plans • Invest in hydroclimate monitoring technology to provide accurate and timely information about the current state and to discover any new trends in temperature, precipitation, snow, and surface water availability • Maintain a wildfire risk mapping system to reflect the probability of wildfire based on vegetation type, climate and local site conditions together with the criticality of assets that would be impacted
Abate the impacts of an event	• Consider climate hazards in the decision-making process of siting stations and routing transmission and distribution infrastructure • Update design standards and codes in collaboration with the Canadian Standards Association, integrating adaptation strategies for specific areas such as ice, hail, and snow loads, floods, droughts, wildfires, wind, and permafrost thaws • Increase the operational reliability of flood discharge systems, such as spillways, gates and valves • Reinforce towers against erosion from high water levels by placing riprap around the tower foundation and along banks • Adjust material selection of transmission and distribution infrastructure on a case-by-case basis to adapt to climate change-related risks • Perform regular maintenance of the grid infrastructure
Respond to the impacts of the event and restore service	• Plan for inventory seasonality and increase volumes of inventory of overhead transformers and poles ahead of storm season • Employ enhanced prediction logic using an algorithm and the smart meter network to quickly confirm an outage • Activate corporate and regional emergency operations centers to communicate and coordinate with both internal and external groups during the outage response

[8] Climate change: How BC Hydro is adapting. (2020). Available: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/environmental-reports/bch-report-adapting-climate-change-20201200.pdf

Casting drought: How BC Hydro is managing and adapting[9]

Drought is caused by a combination of hotter and drier weather, insufficient snow accumulation, or delayed rainfall. It is a recurrent climate feature characterized by a prolonged deficiency in precipitation, resulting in water shortages and posting challenges for rivers and watersheds. BC Hydro's hydroelectric system is directly impacted by these conditions. However, despite the pressure on many of BC Hydro's smaller systems, continued power delivery is ensured as most of the electricity generated and used in B.C. comes from larger facilities in the north and southeast of the province, where water levels (although below normal) are sufficient to meet the province's power needs. BC Hydro has also taken proactive steps to manage these challenging conditions by using reservoirs for storage and strategically planning water releases to protect downstream river flows. While unpredictable weather patterns related to climate change are anticipated to persist, BC Hydro is adapting to these evolving conditions by:

We currently have the following tools to manage drought:

- ***Multi-year storage in reservoirs and regional diversity in generating*** - when it's dry in one region, we can ramp up operations in another region.
- ***Contracts for power*** - we have more than 120 contracts with independent power producers that provide additional geographic diversity.
- ***Our ability to import and export power through the Western Interconnection*** - we're part of a network of high-voltage transmission lines that connects B.C. with other utilities in western North America.

We are improving:

- ***Improving the weather and inflow forecasting -*** All coastal watersheds can now be forecasted down to the hour, which improves the forecast accuracy for extreme events.
- ***Expanding the hydroclimate monitoring technology*** - which includes custom-made solutions that have been designed inhouse, as well as upgrading snow survey stations to automated, real-time snow and climate stations.
- ***Investing in capital projects*** - like spillway gate replacements, to increase the system's resiliency to climate change.

[9] How climate change is contributing to uncertain weather and how BC Hydro's generation system is adapting. (2022). Available: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/news-and-features/bchydro-report-casting-drought.pdf

2.3. Impacts of Power Outages on All-Electric Homes

The sections above describe the past and potential future trends that may influence how power outage incidences change over time, some of their likely impacts, and what is being done at the utility scale to help minimize their occurrence. However, irrespective of the trends, power outages will always be a reality of life, as utilities cannot control all causes of outages for instance, vehicle accidents and bird strikes.

When power outages do occur, it’s important to understand how they are likely to impact a given household. Table 5 characterizes the potential impacts of a power outage, categorized by prevalent homeowner anxieties, and evaluates each one in reference to 1) an all-electric home and 2) a home that uses natural gas for heating, hot water and cooking, and electricity for lighting and all other appliances. Key anxieties explored include:

- Dependency on electricity for life-saving equipment
- Concerns around thermal comfort and safety
- Loss of perishable food
- Inability to safely store medication
- Loss of power for lighting and other uses
- Loss of hot water (or loss of all water if you are in a rural area with a well because the pump doesn't work)
- Inability to cook meals

Table 5 also specifies the actual impacts on building systems and occupants, noting that people with mobility challenges, serious illnesses, and those living alone without caregivers are among the most vulnerable individuals.

What can be immediately noted from Table 5 is that power outages impact homes that use natural gas as well as electricity in many of the same ways as all-electric homes. This is because while some natural gas-fired systems for heating and hot water may continue to work under a power outage, many will not. This is owing to the fact that many gas-based systems rely on electricity for some of the core components that allows them to be lit or safely operated. Of course, both homes with electric and gas systems heating and hot water will lose the ability to use lights or appliances, as these run solely on electricity.

Table 5: Overview of Typical Homeowner Anxieties and Actual Impacts of Power Outages

Anxieties	Description	Types of Homes Impacted		Impacts on Building Systems	Impacts on Occupants
		All-Electric Homes	Combustion-Based Homes (e.g. natural gas)		
"It's going to be freezing"	During winter power outages, a lack of heating systems makes indoor temperatures drop to uncomfortably low levels.	● **Applicable**	◑ **Partially applicable**	• **In all-electric homes** - *Electric space heating systems* such as baseboards and heat pumps will stop working when the power goes out. • **In combustion-based homes**[10] - *Natural gas furnaces* also do not function during power outages as they rely on electricity to operate key components of the system, including the ignition, the blower motor, and the thermostat. The igniter receives the signal from the thermostat, switches the furnace on, and gets the gas flowing. The blower motor distributes the hot air through ducts and into living spaces. Modern-day furnaces also have the gas valve, a built-in safety feature guiding and controlling gas that prevents gas flow into the system when there is no power. - *Natural gas boilers* used in hydronic heating systems, which heat water and distribute it via pipes under the floor, would cease to function in the event of a power outage as well because many components are electrically powered. It requires a thermostat to activate an igniter for combustion and relies on an electric pump to circulate water through the system. - *Gas and wood fireplaces, inserts, and stoves* with direct vent technology will continue to produce heat and warm up the home when the power is out. While some modern models may feature an intermittent pilot ignition system, which requires electricity to spark the pilot flame, most systems are equipped with battery backups capable of lighting the pilot in the event of a power loss. However, fireplaces that rely on powered vents or forced air systems will not work during a power outage as this type of fireplace works by forcing air through the system with a fan, and without electricity, the fan cannot operate. The system automatically checks for fan operation before ignition, therefore it will not function during a power outage.	• **Prolonged exposure to cold temperatures** can have direct effects on health, with hypothermia being the most serious. Hypothermia occurs when the body is incapable of keeping the proper temperature to function well and could potentially result in severe symptoms and even death as it progresses. The cold can also have an indirect effect on health by aggravating certain pre-existing illnesses, such as asthma, chronic bronchitis, and emphysema. • **Carbon monoxide (CO) poisoning** also presents a health risk during winter power outages. Fuel-burning appliances like gas fireplaces and wood stoves, if not properly maintained and vented, can release CO. The lack of functioning CO monitors due to power outages would further exacerbate the danger as CO is an odorless and invisible gas. CO poisoning can have severe and potentially fatal consequences.

[10] Gas Myth: All Gas Appliances Work in Power Outages. (2022). Available: https://oregoncub.org/news/blog/gas-myth-all-gas-appliances-work-in-power-outages/2489/

"We can't even have a warm meal"	During power outages, the ability to heat or cook food is restricted, leaving people with no choice but to rely on cold, ready-to-eat, and non-perishable options.	**Applicable**	**Partially applicable**	• **In all-electric homes** - Electric ranges and appliances become inoperative due to the loss of electricity during power outages. • **In combustion-based homes** - Gas stoves with manual ignition can remain operational. However, models with automatic ignition systems require electricity to generate the spark that initiates the burner's flames. While manually starting the flame might be feasible, certain safety features in newer models may prevent starting the pilot light by hand. Gas ovens, like gas stoves, rely on a pilot light to ignite the cooking flame that heats the oven. In most modern gas ovens, there is no manual option to ignite the flame, making them inoperable during a power outage.[11]	The inability to cook or heat meals during extended power outages can lead to reduced food variety, potentially resulting in nutritional deficiencies and decreased energy levels, which could further impact daily functioning and productivity.
"Starting the day with a freezing cold shower is just terrible"	Power outages can disrupt hot water supply, impacting essential personal hygiene practices like bathing and showering, as well as household chores that require warm water.	**Partially applicable**	**Partially applicable**	• **In all-electric homes** - Electric tankless water heaters depend on electricity for operation and have no water reserve. So, they will stop supplying hot water when power goes out. - Electric water heaters, unlike tankless systems, have a reservoir of hot water. With proper insulation and pre-filling before outages, the water in the tank can remain hot for a period. However, during prolonged power outages, the hot water supply in the tank will be depleted, and the heater will not function until power is restored. • **In combustion-based homes** - Gas water heaters, whether with a tank or tankless, can operate during a power outage if they use a continuous gas pilot light for ignition. However, models with electric ignition rely on electricity to initiate the heating process. Gas-powered tankless heaters cannot continue providing hot water, and for heaters with tanks, once the tank is empty, the heater is unable to reheat the water.[12]	Without access to hot water, individuals may struggle to maintain personal hygiene practices, which can increase the risk of skin infections, especially for those with pre-existing skin conditions or weakened immune systems.
"Sleeping in this heat is impossible"	Without electricity to power cooling systems, there is an increased risk of indoor overheating on hot days. The excessive build-up of heat inside a home leads to	**Applicable**	**Applicable**	• **In all-electric homes** Cooling options such as heat pumps, air conditioners, and fans rely on electricity for operation and will cease to function during a power outage. • **In combustion-based homes** Natural gas air conditioners can be used in homes but are	Exposure to overheating environments can have adverse effects on health, including dehydration, heat cramps, heat rash, dizziness, and fainting. Some individuals, like seniors and people who have chronic conditions, may experience more severe consequences, such as heat exhaustion from excessive sweating and heat stroke, which can be life-threatening.

[11] Ibid, 12.
[12] Gas Myth: All Gas Appliances Work in Power Outages. (2022). Available: https://oregoncub.org/news/blog/gas-myth-all-gas-appliances-work-in-power-outages/2489/

	discomfort, sleep loss, and other health risks.			more commonly found in large commercial and industrial settings due to their significantly higher upfront costs compared to standard electric AC units and the need for specialized maintenance. Their operation will be disrupted by power outages since they require electricity to power components like fans and pumps.	
"We have to toss out everything from the fridge"	When fridges and freezers lose power, the internal temperature begins to rise and they can no longer effectively prevent the growth of bacteria in perishable food, making it unsafe for consumption.	**Applicable**	**Applicable**	To safely store food, it's essential to maintain the refrigerator temperature at or below 40°F and the freezer temperature at or below 0°F.[13] At the core of refrigerators and freezers is a compressor, which powered by electricity to pressurize the refrigerant and circulate it throughout the system to maintain low temperatures. Power outages disrupt its operation, preventing the cooling cycle from occurring.	Food left at unsafe temperatures for an extended period could become dangerous to eat. Pathogenic bacteria grow rapidly in temperatures ranging between 40°F and 140°F and would cause food poisoning.
"I can't safely store my medications"	Some medications are sensitive to temperature and require specific storage conditions, as indicated on their labels. However, maintaining these conditions can become challenging during power outages.	**Applicable**	**Applicable**	The loss of electricity results in the failure of space heating and cooling systems as well as refrigerators. Fluctuating indoor temperatures, coupled with rising temperatures in refrigerators, making it difficult to store medications that require specific temperature ranges safely.	When medications are not stored properly, their effectiveness is reduced, potentially resulting in inadequate treatment of medical conditions and worsening symptoms. For individuals reliant on medications to manage chronic health conditions, the compromised effectiveness could lead to increased health risks and exacerbation of underlying medical issues.
"I won't be able to breathe if the power goes out"[14]	People dependent on life support equipment lose breathing assistance when power disruptions occur.	**Applicable**	**Applicable**	Plugged-in life support equipment and other home medical devices depend on electric power, and the disruption of continuous electricity supply makes them inoperative.	Individuals facing such circumstances may experience immediate life-threatening risks like respiratory distress or failure, especially when there are no alternative power sources available.
"Living in the dark is frustrating and navigating the homes will be a bit risky"	The absence of essential lighting during a power outage can complicate simple tasks, such as moving from one room to another or going up or down stairs, due to the lack of visibility.	**Applicable**	**Applicable**	Power outages disrupt the supply of electricity to lighting systems, resulting in electric lighting fixtures, including overhead lights, lamps, and emergency lighting systems, going out without a source of backup power.	Individuals with mobility issues or disabilities are more vulnerable during this situation. Reduced visibility in darkened homes can lead to an elevated risk of trips, slips, and falls, potentially resulting in injuries such as sprains, fractures, or head trauma. In addition, inadequate lighting during power outages could hinder one's ability to access emergency supplies or respond to potential hazards, compromising overall safety.

[13] Are You Storing Food Safely? (2023). Available: https://www.fda.gov/consumers/consumer-updates/are-you-storing-food-safely#:~:text=Keep%20the%20refrigerator%20temperature%20at%20or%20below%2040%C2%B0,freezer%20temperature%20should%20be%200%C2%B0%20F%20%28-18%C2%B0%20C%29

[14] Growing Power Outages Pose Grave Threat to People Who Need Medical Equipment to Live (2021). Available: https://www.npr.org/sections/health-shots/2021/05/15/996872685/growing-power-outages-pose-grave-threat-to-people-who-need-medical-equipment-to-

3. Improving Resilience to Power Outages

Section 2.3 above highlights the need to think carefully about home performance under power outages, regardless of whether a home is fully electric or partially electric. While the length and frequency of outages may be relatively low, those households who are more vulnerable to the impacts of power outages (e.g. inability to store medication, maintain thermal safety, etc.) or even those who simply want the assurance of continued comfort when the power goes out will want to explore strategies to increase the resilience of their home. The sections below outline some of the key characteristics that make a home more resilient.

3.1. Key Variables in Home Performance During Power Outages

Modern homes and buildings use a combination of passive and active systems. *Passive systems* help reduce overall demand for heating and cooling in a home or a building using orientation, shape or form, and enclosure design strategies to improve the safety, health, and comfort of occupants without using energy. *Active systems*, on the other hand, supplement the passive systems to achieve a desired internal environment and provide essential functions and services like hot water, lighting, and cooking with an input of energy.

Homes and buildings that enable occupants to live safely and comfortably under conditions of power outage make use of both passive and active strategies. Based on a research scan of studies on home and building performance during power outages (see **Appendix B**), the following *passive strategies* have been noted as particularly important to reducing temperature fluctuations during power outages, improving thermal comfort and safety:

- **Highly insulated building envelope** minimizes heat transfer between the interior and exterior of homes. During a winter blackout, the warmth generated inside is retained and cold air is prevented from seeping in, and during a summer blackout, it ensures that homes are not continually absorbing heat, helping to maintain a comfortable indoor temperature.
- **Optimized window design** with high-efficient glazing, electrochromic glazing, and reasonable Window-to-Wall-Ratios, helps strike a balance between maximizing natural light and minimizing heat loss or gain during power outages in winter and summer, respectively, as windows are less insulated than walls.
- **Thermal mass**, comprised of materials like concrete, brick, or stone, can help reduce indoor temperature fluctuations by absorbing heat during the day when temperatures peak and releasing it gradually at night, which can then be removed via natural ventilation. A more stable indoor thermal environment is beneficial for both winter and summer power outages.
- **Exterior shading** serves to intercept direct solar gains before they enter a home or building, helping to prevent overheating during summer power outages. Strategically planting trees around a home can also provide some shade from incoming solar gains.
- **Natural ventilation** harnesses wind and stack pressures to promote air crossflow through operable vents and windows. When integrated with shading solutions, it is an effective passive strategy for managing overheating by removing heat buildup during periods of extremely high outdoor temperatures.
- **Cool roof designs** that use reflective shingles in a full range of colors help reduce indoor and outdoor temperatures. By using high-albedo colors like white, they minimize the absorption of solar heat into homes and buildings. Green roofs can further reduce the urban heat island effect in surrounding neighborhoods.

Many of these passive strategies are necessary not only to increase thermal comfort, but also improve the energy efficiency of homes and buildings. This means that *in general*, the more energy efficient a home, the more resilient it will be to power outages as strategies such as better building envelopes, optimized window designs, and the use of natural ventilation can all help to maintain safe and comfortable indoor temperatures without the use of active systems. Homes built to higher levels of the **BC Energy Step Code** are designed to achieve higher levels of energy efficiency, and can be coupled with strategies such as cool roofs and shading to reduce the risk of overheating in the summer.[15] The most effective solution to ensuring a home stays warm in a power outage is to improve the building envelope.

However, while robust passive measures serve as a foundational starting point to maintain desirable indoor temperatures, they may be insufficient in ensuring thermal comfort or safety during a prolonged outage. Thermal comfort requirements and preferences vary significantly among occupants of different age groups and health vulnerabilities. This variability poses a challenge in providing a single set of strategies that applies to all locations, situations, and people, especially as climatic conditions change. Of course, such strategies also cannot provide a source of power that may be needed or desired to ensure continued access to lifesaving equipment or certain appliances. As such, it is also important to consider the use of more active strategies for enhancing resilience. These include:

- **Assisted heating and cooling systems** function with relatively small amounts of energy. These include ceiling fans, portable fans, evaporative coolers, portable air conditioners or heaters, and personal comfort systems like heating pads and desktop fans. They help create comfortable micro-environments, ensuring thermal safety for occupants while also reducing the demand for backup power capacity**.**
- **Back-up power,** including backup generators, solar photovoltaic (PV) systems paired with batteries, offers an alternative energy source to sustain continuous operations of critical equipment in homes and buildings during power outages, mitigating the exclusive reliance on the grid.

3.2. Going Deeper: Active Solutions for Power Outages

The remainder of this report digs deeper into the question of backup power, including the options available to the BC market and their efficacy. Three systems are explored in further depth, with the broad aim of providing all-electric homeowners with the information they need to identify the option that best suits their needs:

- **Back-up power:** strategies capable of meeting the minimum load capacity necessary to power essential home cooking, cooling, and/or heating systems and appliances.
- **Back-up heat**: strategies that represent commonly available strategies that do not depend on electricity supplied by a back-up power system, as electric space heating systems or plug-in space heaters are assumed to be unviable given their typically low efficiency.
- **Back-up cooking**: effective and common strategies that use alternative fuel sources to meet cooking needs, saving electricity consumption for other critical usage.

The tables below outline key options available under these three broad categories, with high level information on the strategy itself, any constraints or conditions of note, and a three-level rating scale across four evaluation criteria: cost, ease of implementation, capacity, and impact on a household's emissions. The evaluation criteria are further explained in Table 6.

[15] For a more fulsome exploration of the strategies necessary to achieve both energy efficiency and thermal comfort and safety, see BC Housing's BC Energy Step Code Design Guide Supplement S3 on Overheating and Air Quality

Table 6: Evaluation Criteria Applied to Back-Up Power Options

Evaluation Criteria	Rating Description		
	Low	**Medium**	**High**
Budget Friendliness	Demand a significant financial investment and incentives and financing are needed to remove financial barriers.	Moderate expenses are required but are still generally attainable without causing significant budget constraints.	No or minimal expenses expected, making them budget-friendly for a broad range of homeowners or builders.
Ease of Implementation	The lack of market readiness for the specific equipment and/or the installation and operation would demand specialized expertise, adding to additional complexity and potential challenges.	The market presents a moderate range of suppliers but with notable limitations in availability and variety, and/or the installation process requires support from skilled labor and adequate training is essential to ensure smooth operations.	The strategies are broadly applicable with readily available resources, and both the installation and the use of the equipment demand minimal expertise. Homeowners can easily undertake these tasks themselves.
Capacity	The strategy cannot reliably fulfill its role as an alternative backup power, heating, or cooking system, either due to insufficient power output or limited functionality.	The strategy demonstrates capability in serving as a backup system for power, heating, or cooking needs, yet it faces certain limitations that impede its ability to provide full reliability.	The strategy has the capability to reliably fulfill the intended purpose, offering ample power output, sufficient heat generation, or versatile cooking options.
Climate Friendliness	Implementing the strategy would lead to a rise in a home's operational emissions.	The strategy has neutral impacts on a home's emission performance. While it may not significantly decrease emissions, it also avoids notable increases.	Adopting the strategy would contribute to the overall home emissions reduction, leading to lower annual operational emissions.

Table 7: Back-Up Power Strategies

#	Strategies	Overview			Evaluation			
		How the Strategy Works	Constraints and Conditions	Evaluation Rationale	Budget Friendliness	Ease of Implementation	Capacity	Climate Friendliness
1	**Home standby generators**	Home standby generators are permanently installed on-site and directly connected to a home's wiring system. When a power outage occurs, an automatic transfer switch activates the generator, which then supplies electricity to the entire home or critical load circuits. These generators are typically fueled by natural gas or propane.	• **Space requirements:** Limited space available on the property may be a concern as the placement of generators requires a dedicated outdoor space. • **Fuel availability:** These generators rely on a consistent fuel supply and constraints arise if there are shortages or disruptions in the fuel supply chain, such as the shutdown of natural gas pipelines. • **Noise level:** The decibel level (dB) of a generator varies depending on its size, fuel type, and the distance of the listener. Home standby generators produce 60 to 70 dB during operation, equivalent to the noise level of a washing machine or dishwasher.	**Cost:** Depending on the size of the unit, home standby generators cost between $3000 and $10,000, with installation costs ranging from $800 to $2,500.[16] **Ease of implementation:** Operating home standby generators is relatively straightforward, especially with automatic transfer switches that automate the transition to generator power during outages. Some models are also equipped with self-diagnosis capabilities, notifying users when maintenance is required. However, professional technicians are needed for proper installation. **Capacity:** Standby generators are designed to meet the essential power demands of an entire home for prolonged use, with power output ranging from 8 kW to over 20 kW. **Impact on operational emissions:** Home standby generators are powered by fossil fuels and will emit GHG emissions during the combustion process for electricity generation.	Low	High	High	Low
2	**Portable generators**	Portable generators, like their stationary counterparts, convert fossil fuels such as gasoline, diesel, or propane into electrical power. However, portable generators	• **Carbon monoxide poisoning:** The operation of portable generators can lead to the buildup of CO gas, so they must be only operated outdoors and at	**Cost:** Portable generators offer lower upfront costs, ranging from $500 to $2,500, with no installation expenses. However, opting for a transfer switch or generator interlock	High	High	Medium	Low

[16] Backup Generator Canada Buying Guide: Things to Consider, Top Brands, Installation & FAQs (2023). Available: https://www.furnaceprices.ca/home-appliances/backup-generator-canada-buying-guide/#

		are more mobile, facilitated by features like wheel kits and fold-down handles. This mobility comes with the obligation of needing to start the generator manually. Users also need to decide on power distribution and manually connect electrical devices to the generator's outlets to meet specific demands during power outages.	a location where the exhaust cannot enter into homes and buildings. • **Storage and maintenance requirements:** Storing properly, ensuring fuel stability, and performing essential maintenance tasks, such as oil changes, air filter and spark plug replacement, are crucial to prevent portable generators from wearing out and ensure they are ready to use when needed. • **Noise level:** Portable generators tend to be louder than stationary generators, with noise levels ranging from 60 to 90 dB, equivalent to a power mower. • **Powering a home's electrical circuit:** The function can be realized by installing a transfer switch, which automatically or manually switches between grid and generator power for smooth transitions, or an interlock, which acts as a manual barrier, ensuring that only one power source can be active at any given time.	will incur an additional $500 to $1,500. **Ease of implementation:** Manual starting, refueling, and regular maintenance are necessary for portable generators, which may pose challenges for inexperienced users. **Capacity:** Portable generators offer a power range from 1kW to 9.5kW, which is ideal for running devices plugged into the generator rather than a home's electrical circuit. They are typically used to meet temporary power requirements. **Impact on operational emissions:** Portable generators will emit GHG emissions as a result of burning fossil fuels.				
3	**Inverter generators**	An inverter generator operates on the same mechanical principles as portable generators with an internal combustion engine fueled by gasoline, diesel or propane to produce alternating current (AC) as backup power for homes during power outages. Notably, inverter generators can provide more stable and reliable power, safeguarding sensitive electronics and medical devices. This is	• **Outdoor operation**: Like other portable generators, inverter models should only be used outdoors to prevent the accumulation of carbon monoxide. • **The trade off between lower power production and higher upfront cost**: Despite their quieter operation and fuel efficiency, inverter generators often have lower power output, which	**Cost:** The upfront costs of inverter generators are often higher than those of traditional generators, with average prices ranging between $400 and $5,000. **Ease of implementation:** Although inverter generators are designed to be more compact and portable, enhancing user convenience, they still require manual starting and regular refueling, same as the portable generators.	**Medium**	**Medium**	**Medium**	**Low**

		achieved through a process of converting the AC output into direct current (DC) and subsequently inverting it back to AC, thereby ensuring a consistent voltage and frequency.	may restrict their ability to power multiple high-demand appliances simultaneously. Achieving higher power output through parallel operation requires homeowners to invest in additional units and a parallel kit, adding to the initial capital costs.	**Capacity:** Inverter generators provide power outputs ranging from 1kW to 7kW, which is generally lower compared to traditional portable generators. However, some inverter generators have parallel capacity, enabling users to connect two or more units together to increase the overall power output. **Impact on operational emissions:** Inverter generators can adjust internal combustion engine speed to match the power demands, leading to less fuel consumption and emissions. Nonetheless, they still rely on fossil fuels, resulting in increased GHG emissions.				
4	**Grid-tied solar systems with inverters designed to disconnect from the grid during power outages**	Solar panels convert sunlight into direct current electricity, which is then converted into usable alternating current electricity. The electricity generated powers homes directly, with excess electricity flowing back to the grid. Grid-tied solar systems typically shut down automatically during power outages to prevent back feeding electricity into the grid and ensure the safety of workers repairing the grid. However, solar systems equipped with certain types of inverters enable homeowners to switch to off-grid mode during outages, disconnecting the system from the grid and allowing electricity to flow continually to meet energy demands at homes.	• **Installing BC Hydro-approved inverters:** Specially designed inverters are essential in enabling solar systems to remain operational during power outages. It is important to choose inverter models equipped with this capability from BC Hydro's approved list to effectively implement this strategy. • **Equipment compatibility:** Compatibility issues may arise when integrating inverters with existing solar systems. Professional assistance is necessary to ensure compatibility and proper installation.	**Cost:** The cost of solar systems varies depending on the size and number of panels. A grid-tied solar system in BC can range from $10,000 to $30,000. As a benchmark, a 5kW solar system cost around $13,000 - $16,500.[17] **Ease of implementation:** Inverters that have the function of islanding the solar system from the grid are readily available and commonly employed within the industry. Once installed, the systems are relatively easy to use, as they automatically switch between grid-connected and standalone modes during power outages. **Capacity:** Expanding the size and quantity of solar panels can increase electricity generation. However, solar systems produce electricity that fluctuates throughout	**Low**	**High**	**Medium**	**High**

[17] How Much to Install Solar Panels: The Comprehensive Guide (2023). Available: https://solarbc.ca/how-much-to-install-solar-panels/#:~:text=BC%20Solar%20Power%20Incentives%201%20Federal%20Solar%20Tax,Utility%20Company%20Incentives%20...%205%20Tax%20Breaks%20

				the day and across seasons, resulting in uncontrollable power output. Despite designing the system size based on required energy use, mismatches between supply and demand are very likely to occur without the incorporation of energy storage technologies, such as batteries. **Impact on operational emissions:** Solar power generation does not release any GHG emissions. In addition, by reducing reliance on grid electricity, homes with solar systems contribute to emissions reduction.				
5	**Stand-alone solar systems**	A stand-alone solar system operates independently of the electrical grid. During power outages, it continues to supply electricity when consistent sunlight is available.	• **Installation complexity**: Compared to grid-tied systems, stand-alone systems entail more intricate component integration and require the expertise of solar professionals for installation. • **Exclusion from utility net metering programs**: The net metering program allows utility customers to connect a small electricity-generating unit to the distribution system and receive credits to offset future consumption. Without a connection to the grid, stand-alone solar systems are unable to capitalize on net metering incentives for solar energy production. • **Off-grid limitations**: Stand-alone solar systems are often used in remote areas where grid connectivity is unavailable. In most practical scenarios, these systems are paired	**Cost:** Stand-alone solar systems share similar capital costs for solar panels as their grid-tied counterparts but would incur slightly higher installation expenses due to additional components needed. **Ease of implementation:** Due to their independence from the grid, stand-alone systems are unaffected by power outages. Also, little manual intervention is required after installation. **Capacity:** While smaller solar systems may offer limited capacity, larger ones have the potential to provide sufficient backup power when sunlight is abundant. However, maintaining consistent electricity production over extended periods can be challenging for systems without energy storage.	Low	High	Medium	High

			with battery banks to store excess energy for later use. However, in regions where grid access is present, regulatory restrictions may prohibit homes from disconnecting from power services. In such instances, a stand-alone solar system without batteries may be employed to power a portion of the home, with the rest of home relying on grid power. While this concept is conceivable, it is rare in real-world applications and largely remains theoretical.	**Impact on operational emissions:** By harnessing solar power, these systems replace energy sourced from the grid or fossil fuels, contributing to overall emissions reduction.				
6	**Portable solar-charged batteries**	Portable solar-charged batteries consist of four main components: solar panels, a charge controller, an integrated battery, and an inverter. The solar panels take in sunlight and turn it into direct current to charge the battery. When devices are plugged into the generator during power outages, the inverter converts the stored DC into usable AC to power these devices for continued operations.	• **Storage capacity and restrictions:** Unlike generators fueled by fossil fuels, this portable system provide power from stored energy, making the capacity of internal battery a critical factor in determining how much power a generator can deliver before needing to recharge. Due to its nature as a solar-charged battery system, it could be subject to Technical Safety BC regulations and the BC Electrical Code. • **Sunlight availability and recharge time:** The recharge time of the portable batteries is impacted by available sunlight. During cloudy days, the generators may not receive sufficient solar input, leading to longer recharge times and affecting the overall output performance.	**Cost:** Costs range between $150 and $5,000, depending on the output capacity of the models. Rebates are available. **Ease of implementation:** The setup process is straightforward and requires minimal assembly. Users can deploy the solar panels and set up the units quickly without specialized tools or knowledge. **Capacity:** Small units typically have an output range of 100-500 W, while larger models can provide 3 kW to 4 kW of power output with up to 10.8 kWh of capacity. Assuming critical loads require 1,000 watts of power, a system with a storage capacity of 10 kWh can sustain operation for 10 hours. Multiple portable solar-charged batteries can be paired up to offer increased battery storage capacity over more extended periods. **Impact on operational emissions:** A solar generator has a minimal environmental impact during its operation, with no GHG emissions generated.	**Medium**	**High**	**Medium**	**Medium**

7	**Home battery backup systems**	Backup batteries store excess energy from the grid or alternative energy sources like solar panels and generators. When the power goes out, the system automatically switches to battery power. An inverter then converts the DC stored in the battery to usable AC to power homes. Battery systems are often paired with solar panels, resulting in hybrid solar systems that enhance the resilience of both the battery and solar components. When utilized as a standalone backup system, the battery is limited by its energy storage capacity and is unable to recharge until the grid is restored. However, when integrated with a solar system, the battery can recharge whenever sunlight is available, allowing it to sustain home power for extended durations. When a power outage occurs, the battery storage automatically activates, enabling the continuous operation of the solar system to generate energy and store excess power for later use.	• **Compliance with energy storage system regulations:** The size of storage batteries in BC is subject to Technical Safety BC regulations and the BC Electrical Code. These regulations are expected to be updated with the new Canadian Electrical Code (CEC). In the updated CEC, batteries intended for use in residential dwellings must either be certified to UL9540A standards or be installed in a room that complies with the BC Building Code. Upon meeting the requirement, a single energy storage system is limited to a storage capacity not exceeding 20 kWh, and the aggregate capacity of multiple energy storage systems must not exceed 40 kWh.	**Cost:** The upfront cost of a home battery backup system can be substantial, with the median cost estimated at $1,300 USD per kilowatt-hour. In this case, a typical 10 kWh battery that can power home electric load of 1,000 watts for 10 hours could cost around $13,000 USD.[18] Rebates are available. **Ease of implementation:** With automated power outage detection, switching, operation, and recharging, minimal user intervention is required for home battery backup systems. Also, most systems feature user-friendly interfaces for monitoring and control, enhancing ease of use. **Capacity:** Large battery systems have the capacity to fulfill the requirements of whole-home backup power for extended durations. However, the capacity of home battery backup systems varies depending on the size and model, and it may also be subject to local regulations. **Impact on operational emissions:** The operation of battery backup systems does not generate any emissions. By enabling homeowners to store excess solar energy and utilize it during power outages or peak demand periods, they can help reduce emissions.	**Low**	**High**	**High**	**High**
8	**Vehicle-to-Home (V2H) charging**	In the event of a power outage, bidirectional charging technology leverages EVs as mobile battery storage for homes. An EV equipped with bidirectional charging capabilities discharges energy back into a designated	• **Compatibility issues:** Bidirectional EV charging is limited to specific EV models equipped with this technology, and the bidirectional charging feature may only work with	**Cost:** The estimated cost for the bidirectional charging unit is around $4,000 USD. While this may appear high compared to typical home EV chargers, it is more affordable than installing a dedicated home battery backup system.	**Medium**	**Medium**	**High**	**High**

[18] What are the best batteries for whole home backup? (2022) Available: https://www.energysage.com/energy-storage/best-batteries-for-whole-home-backup/

		charging unit, which then converts the DC stored in the EV battery into AC, providing backup power.	homes with specific systems. For instance, the Ford Charge Station Pro can only be used in conjunction with Ford's Home Integration System.[19] These compatibility requirements could hinder widespread adoption.	**Ease of implementation:** The bidirectional charging equipment provides user-friendly interfaces for monitoring and control. However, a V2H system could be complex for users to manage and operate as it involves the interaction of multiple systems, including EV battery, home electrical panels, the grid, and potentially the solar systems.				
				Capacity: The average useable battery capacity of electric vehicles is around 71.8 kWh, which can power a home with electric loads of 1,000 watts for three days.[20]				
				Impact on operational emissions: V2H charging systems do not generate direct emissions during operation, as they rely on the stored energy in the EV's battery. Additionally, their ability to power homes during peak hours and compatibility with solar systems can help reduce emissions.				

[19] The Best Bidirectional EV Chargers (2023). Available: https://switchingtoelectric.com/blog/Best-Bidirectional-EV-Chargers#ford-charge-station-pro

[20] Useable battery capacity of full electric vehicles. (2024). Available: https://ev-database.org/cheatsheet/useable-battery-capacity-electric-car

Table 8: Back-Up Heating Strategies

#	Strategies	Overview			Evaluation			
		How the Strategy Works	Constraints and Conditions	Evaluation Rationale	Budget Friendliness	Ease of Implementation	Capacity	Climate Friendliness
1	**Wood-burning appliances**	Wood-burning appliances, including fireplace inserts, woodstoves, pellet stoves, open hearth fireplaces, masonry heaters, and wood burning furnaces, generate heat by burning wood within an enclosed compartment known as the firebox. The heat is then radiated out into the surrounding space, offering reliable space heating.	• **Impacts on air quality and health:** Wood-burning appliances emit harmful fine particles during operation. These fine particles in wood smoke are linked to respiratory and cardiac issues, especially for vulnerable populations such as infants, the elderly, and individuals with existing heart and lung conditions. • **Bylaw requirements**: Under Metro Vancouver's residential indoor wood burning bylaw, burning is prohibited from May 15 to September 15 unless the appliance serves as the sole source of heat in a residence, is in an off-grid residence outside the Urban Containment Boundary, or during emergencies, such as power outages lasting for three hours or more. The bylaw also requires the registration of appliances. Eligible appliances must meet emissions criteria, provide the sole source of heat in a home, or use only manufactured fire logs.[21] • **Safety concerns:** Improper use of wood-burning appliances can pose fire hazards, so users should	**Cost:** Typically ranges from \$2,000 to \$4,000, covering both the appliance and installation expenses. **Ease of implementation:** The supply market for wood-burning appliances is well-developed. However, using the appliances may require a learning curve involving proper fueling, fire management, and regular maintenance, including cleaning of ashes and chimneys. **Capacity:** Wood-burning appliances are powerful enough to heat average-sized, modern homes.	Medium	High	High	Low

[21] About the Residential Indoor Wood Burning Bylaw. (2024). Available: https://metrovancouver.org/services/environmental-regulation-enforcement/air-quality-regulatory-program/about-the-residential-indoor-wood-burning-bylaw

			adhere to safety guidelines, such as keeping flammable materials away from the stove and using a fire screen. In addition, it is important to ensure proper ventilation, conduct regular maintenance, and install carbon monoxide detectors capable of operation during power outages when using wood-burning appliances. • **Fuel availability:** Homeowners relying on wood stoves as a backup heat source need to ensure access to an adequate supply of seasoned firewood.	**Impact on operational emissions:** During combustion, wood-burning appliances will emit GHG emissions. Catalytic wood stoves and EPA-certified units are more efficient and produce less emissions.				
2	**Gas fireplaces**	Gas fireplaces that have a standing or vertical pilot light can continue to operate during a power outage because they do not require electricity to start the pilot flame. Although some models require electricity to trigger the pilot flame, most of them come with a battery backup system that allows them to function as an alternative heat source during power outages.	• **Carbon monoxide poisoning:** Proper ventilation and regular maintenance are important to ensure safe operations of gas fireplaces during power outages to prevent the buildup of carbon monoxide. • **Loss of gas supply:** Gas furnaces depend on gas supply to function, and natural gas infrastructure is equally challenged by extreme weather events. When gas outages happen, gas furnaces will no longer be able to provide heating.	**Cost:** A new residential gas furnace including installation, will cost between $4,000 – $6,500 on average. **Ease of implementation:** Gas furnaces are widely available in the market, with various brands and models to choose from, and they are easy to operate once installed by professionals. However, performing routine maintenance tasks is essential to ensure safe operation of the furnace. **Capacity:** Although gas fireplaces vary in size and efficiency, most of them can provide significant heating capacity to the entire home. However, it is worth noting that the fireplace blower uses electricity to circulate heat around the room. During power outages, the blower will not operate. Although the fireplace will continue to warm up the room with radiant heat, the radius will be smaller.	**Medium**	**High**	**Medium**	**Low**

				Impact on operational emissions: Operating gas fireplaces results in releasing GHG emissions, contributing to an increase in a home's overall operational emissions.				
3	**Solar air heaters**	Solar air heaters function by utilizing sunlight to generate warmth for indoor spaces. The heater consists of an absorber plate that converts sunlight into heat energy. Behind the plate, a network of channels or tubes, often coated with materials to enhance heat absorption, is positioned. As the plate heats up, the air within these channels also becomes warmed. A fan or blower then circulates cold air from the room through these heated channels, warming it in the process.	• **Sunlight availability:** Like other solar backup systems, solar air heaters rely on sunlight to generate heat, making them less effective during periods of low sunlight, such as cloudy days or nighttime.	**Cost:** The average cost of whole-home solar air heaters exceeds $15,000 USD, with additional installation expenses ranging from $900 USD to $5,000 USD. **Ease of implementation:** Solar air heaters are easy to use once installed, requiring minimal user intervention. However, solar air heaters are uncommon and are rarely used in Canada. The limited market feasibility of this option makes it less appealing for BC homeowners. **Capacity:** The heating capacity of solar air heaters depends on multiple factors, such as the size and efficiency of the absorber plate and consistent sunlight availability, and due to the reliance on local climate conditions, they may offer less reliable heating supply compared to wood stoves. **Impact on operational emissions:** Solar air heaters operate using renewable solar energy and produce no emissions during the process.	**Low**	**Low**	**Medium**	**High**
4	**Catalytic heaters**	Catalytic heaters employ a catalyst, often a platinum-coated plate, to accelerate a chemical reaction with natural gas, propane, or butane. This reaction is a flameless heat source that breaks down molecules and produces heat, warming the surrounding space.	• **Maintenance needs:** Dust particles can diminish the efficiency of the catalytic process. So, it is important to cover the heater when not in use and perform regular cleaning to maintain optimal performance. • **Ventilation is still necessary:** While catalytic	**Cost:** The cost of catalytic heaters ranges between $400 and $2,000, representing a moderate upfront investment compared to other alternative heating methods. **Ease of implementation:** Catalytic heaters are straightforward to use. The process of starting the heater includes ensuring the fuel supply, opening the valve to	**Medium**	**Low**	**Medium**	**Medium**

		Catalytic heaters have been utilized in industrial applications since they were first introduced several decades ago. For example, they are commonly used in the natural gas industry in situations where traditional forms of heating are not suitable due to safety concerns about explosive gases in the environment. Catalytic space heaters, which can be wall-mounted or placed on the floor for targeted heat distribution, are employed to maintain a comfortable environment for people or to prevent equipment from reaching critical temperatures.	heaters are safe in terms of emitting no carbon monoxide, they can deplete ambient oxygen levels, potentially leading to hypoxia. Therefore, adequate ventilation is essential when operating catalytic heaters.	allow the fuel to flow to the heater, and using the ignition system for ignition. Once started, the heater provides heat output with minimal user intervention required. **Capacity:** Catalytic heaters come in different sizes to accommodate heating needs, but they are primarily designed for small to medium-scale space heating. **Impact on operational emissions:** Catalytic heaters produce heat through a chemical reaction with fuel, releasing minimal emissions compared to traditional combustion methods.				

Table 9: Back-Up Cooking Strategies

#	Strategies	Overview			Evaluation			
		How the Strategy Works	Constraints and Conditions	Evaluation Rationale	Budget Friendliness	Ease of Implementation	Capacity	Climate Friendliness
1	**Wood cook stove**	A wood cook stove uses wood as its heat source and features a firebox designed to trap and transfer the heat to a cooking surface and oven. In addition to serving as an alternative cooking method, it can also fulfill space heating needs.	• **Space preparation and installation requirements:** Homeowners opting to install a wood cook stove in their homes need to either remove or cover all combustible materials in the designated area for the stove. Additionally, all wood cook stoves should be installed per the manufacturer's guidelines to ensure maximum safety. Local fire and building codes should also be followed when installing a wood cook stove. • **Indoor air quality concerns:** The combustion process of wood cook stoves can increase indoor particulate matter and hazardous air pollutants, resulting in reduced indoor air quality and potential health hazards for occupants.	**Cost:** The initial capital cost for a wood-burning cook stove ranges between $2,000 to $5,000. **Ease of implementation:** Wood cook stoves are readily accessible on the market, offering homeowners plenty of brands and models to select from. A wood cook stove needs to be manually fired up and do temperature control, which would demand a certain level of skill and experience. **Capacity:** Wood cook stoves offer a high cooking capacity, enabling versatile cooking and the simultaneous preparation of multiple dishes with the cooking surface, which provides an efficient method of meal preparation for households. **Impact on operational emissions:** Wood cook stoves emit particulate matter and emissions during the combustion of wood fuel.	Medium	High	High	Low
2	**Camp stove**	A camp stove operates using canisters of butane, propane, or isobutene and offers a portable solution for cooking,	• **Risk of CO poisoning:** Indoor use of camp stoves could lead to CO poisoning, particularly	**Cost:** Camp stoves are relatively affordable options, with prices ranging from $20 to $200.	High	High	Medium	Medium

		boiling water, and heating food during power outages.	during power outages when electric CO monitors may be non-functional and unable to alert of reaching any dangerous levels. Therefore, camp stoves should only be used outdoors. • **Fuel availability:** It is important to maintain an adequate compatible fuel supply to ensure continued operation of camp stoves, especially during prolonged power outages.	**Ease of implementation:** Camp stoves are easy to operate, equipped with simple ignition mechanisms and intuitive controls. **Capacity:** Camp stoves are also versatile and capable of preparing a wide range of meals, but they are primarily designed for small-scale cooking. **Emissions impact:** Camp stoves rely on propane, butane, or other liquid fuels, resulting in emissions production, but the impact is relatively minimal due to small-scale operation.				
3	**BBQ grills**	A BBQ grill allows users to prepare hot meals outdoors using charcoal, propane, or natural gas as fuel, offering an alternative cooking solution when electric ranges and appliances are inoperative.	• **Outdoor use only:** BBQ grills are designed for outdoor use only and should never be operated indoors due to the risk of carbon monoxide poisoning and fire hazards. • **Fire risks:** When using BBQ grills, users should follow safety guidelines, take precautions to prevent flare-ups, grease fires, and accidental burns, and keep a fire extinguisher nearby.	**Cost:** Small models are available for under $500, though the majority are priced between $500 and $1,500. **Ease of implementation:** BBQ grills often feature easy-to-use ignition systems, although some experience may be needed to achieve desired cooking results. **Capacity:** BBQ grills often have spacious cooking surfaces and multiple burners, accommodating different food needs and facilitating the efficient preparation of large quantities of food. **Impact on operational emissions:** By burning charcoal, propane, or natural gas for operation, BBQ grills will contribute to GHG emissions.	**Medium**	**High**	**High**	**Low**
4	**Induction stove with built-in battery**	This type of induction stove combines induction cooking with battery storage. It can plug into a standard 120V wall outlet, storing the energy to drive the induction cooking when needed. The	• **Battery lifetime:** The built-in battery has an estimated lifespan of around ten years. • **Compatibility:** The induction technology	**Cost:** Stoves can be priced at several thousand dollars before rebates are applied, representing a significant upfront investment compared to other cooking equipment.	**High**	**Low**	**High**	**Low**

		stove uses an electromagnetic field that transfers currents directly to the cookware placed on the glass surface.	requires cookware made from magnetic stainless steel, cast iron, enameled iron, or nickel-based materials. If the current cookware isn't compatible, additional costs are incurred to purchase new pieces.	**Ease of implementation:** Installing an induction stove is as straightforward as setting up a new fridge or washing machine. However, they are not yet widely available in the Canadian market. Two leading U.S.-based companies, Impulse Labs and Channing Street Copper, currently offer shipping only within the United States. **Capacity:** Battery-powered induction stoves come equipped with a 3 kWh to 5 kWh battery, depending on whether they feature a cooktop alone or include an oven as well. This storage can provide enough power to prepare between three to five meals. **Impact on operational emissions:** Induction stoves are up to three times more energy-efficient than gas stoves and about 10% more efficient than conventional smooth top electric ranges.[22] Coupled with the use of electricity, it has low operational emissions.				

[22] Making the Switch to Induction Stoves or Cooktops. (2023). Available: https://www.energy.gov/articles/making-switch-induction-stoves-or-cooktops

4. Conclusion and Key Takeaways

This report has sought to provide homeowners of all-electric homes in BC with the information and resources necessary to prepare for power outages. While the risk of power outages depends on location and the ability of a given household to withstand and adapt to their impacts, the analysis and findings in this report indicate that there is a wide array of strategies available to help increase households' resilience when the power goes out. Other key findings and takeaways include the following:

- Prolonged power outages lasting over 24 hours are rare in BC, and this trend has remained stable over the past five years. While long outages can and do happen, most communities in BC experience power outages that are on average much shorter in duration.
- BC Hydro is actively managing and adapting to the potential impacts of a changing climate on the power grid to help ensure operational reliability and enhance system resilience.
- Most natural gas-powered systems for heating, hot water and cooking are equally vulnerable and cease to operate during power outages, as core parts of the system rely on electricity to function.
- A well-insulated home with passive measures that improve energy efficiency – such as those designed to achieve the highest levels of the BC Energy Step Code – can better withstand temperature fluctuations during power outages, especially those coinciding with cold spells or heat waves.
- The thermal comfort needs and preferences differ greatly among individuals of different age groups and health conditions. Although additional active strategies, such as backup power, space heating, and cooking equipment, may not be required by everyone, they are available for all-electric homeowners to maintain the power supply and essential services and ensure comfort and safety during power outages.
- Equipped with the knowledge of backup systems and equipment, and proper preparedness, all-electric homes can be resilient during power outages.

Readers of this report are encouraged to share the results with both those who are already owners of all-electric homes, as well as those who may be contemplating or those who are simply curious of the benefits of going all-electric.

5. Appendices

5.1 Appendix A. Community Reliability Metrics - 5 Year CAIDI and SAIFI by Community

This section includes the following two indices:

- **SAIFI**: a metric that measures the number of sustained interruptions (longer than one minute) an average BC Hydro distribution customer in a community experienced in a year. Data was shared for years spanning 2019 to 2023.
- **CAIDI**: a measurement that reflects the average interruption, in hours, per interrupted BC Hydro distribution customer in a community in a year. Data was shared for years spanning 2019 to 2023.

Community	F2019		F2020		F2021		F2022		F2023		F2024 (YTD)	
	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI
100 Mile House	1.11	3.79	3.43	1.53	8.42	2.60	1.98	4.95	2.92	1.70	2.96	3.10
Abbotsford	2.98	4.33	1.65	1.74	2.84	2.49	2.49	2.07	2.17	2.68	1.67	2.65
Alert Bay	4.86	2.46	1.36	2.59	9.37	5.64	15.30	6.78	3.39	3.64	2.73	6.86
Anmore	4.52	2.62	3.29	0.82	5.76	2.38	2.62	2.58	6.54	3.29	1.79	8.69
Armstrong	1.69	2.59	4.54	2.15	1.70	2.41	0.65	2.85	2.58	0.98	3.05	1.28
Ashcroft	3.93	1.47	2.62	1.43	7.44	2.17	3.06	7.47	1.21	1.37	2.77	1.34
Atlin	2.71	4.26	1.32	0.75	12.20	3.80	5.75	3.56	4.36	1.15	1.11	1.33
Barriere	1.75	1.65	6.91	2.83	4.01	1.83	4.41	1.10	2.39	1.33	8.06	3.28
Belcarra	5.45	3.49	5.83	2.83	6.51	2.42	0.49	2.10	2.41	3.43	4.31	2.15
Bowen Island	3.44	8.35	5.44	1.70	1.40	4.58	9.48	2.69	4.31	2.08	7.17	2.88
Burnaby	0.86	2.33	0.84	1.79	0.91	1.88	0.62	2.71	0.67	5.03	0.89	2.98
Burns Lake	4.16	11.35	8.39	3.45	4.36	3.67	4.68	2.69	3.48	3.51	5.79	1.35
Cache Creek	5.00	0.89	2.56	1.52	5.58	2.15	3.67	12.05	1.62	2.16	4.44	1.87
Campbell River	2.45	2.69	1.69	3.20	4.58	3.43	3.74	4.94	1.78	3.57	3.03	4.77
Canal Flats	2.99	0.89	8.08	1.45	5.30	2.07	1.04	0.18	0.00	1.22	9.14	2.35
Central Coast	7.13	3.67	13.98	2.68	31.88	4.07	11.85	2.78	12.86	2.25	8.42	1.18
Central Saanich	1.01	5.07	0.95	2.51	1.22	4.53	1.97	1.11	2.56	3.23	0.73	2.79
Chase	1.80	1.74	6.50	7.05	5.37	1.99	3.38	4.70	4.16	2.28	2.44	1.06
Chetwynd	3.04	2.17	3.49	2.15	8.40	3.16	5.99	2.20	1.87	1.91	3.37	4.06
Chilliwack	1.55	3.20	2.18	2.39	3.66	3.02	2.47	2.77	1.88	3.29	2.29	1.89
Clearwater	1.88	1.38	4.57	2.01	8.56	3.52	4.46	6.23	1.48	1.38	3.85	4.06
Clinton	1.60	3.47	4.34	1.63	4.13	3.11	2.84	3.91	2.01	0.94	5.75	1.67
Coldstream	0.86	2.17	2.24	1.22	1.21	2.08	2.56	1.66	1.09	1.49	1.61	2.36
Colwood	5.24	2.87	2.93	2.39	4.09	2.27	1.92	2.99	3.02	2.48	1.10	1.29
Comox	1.30	1.52	1.44	2.75	1.38	1.91	0.67	1.68	0.49	0.91	0.92	0.69
Coquitlam	1.41	2.05	1.45	1.52	1.33	2.47	0.79	2.17	1.26	2.72	0.95	2.80
Courtenay	1.93	3.53	1.40	2.26	3.51	2.67	3.50	4.03	1.51	2.78	2.52	2.66
Cranbrook	1.33	2.23	1.72	2.36	2.34	4.10	1.42	2.21	1.84	1.64	1.89	2.93
Cumberland	1.10	11.27	1.54	3.79	4.59	1.49	7.68	1.24	2.52	2.12	2.12	2.74
Dawson Creek	2.91	1.55	3.47	2.19	5.69	1.78	3.35	1.50	1.90	0.85	1.13	1.72
Dease Lake	2.69	15.16	6.64	2.45	9.05	1.87	2.52	1.46	1.60	1.70	6.10	2.96
Delta	1.51	5.66	1.70	1.91	1.11	2.38	1.91	2.23	1.55	2.66	1.15	4.79
Duncan	4.39	9.69	3.77	1.63	6.72	5.20	2.38	2.21	6.96	2.29	3.54	3.08
Elkford	2.02	1.43	5.21	2.05	4.55	4.10	2.60	3.96	2.95	4.16	1.54	3.35
Enderby	3.95	1.87	3.41	4.20	3.12	1.07	0.12	1.50	2.34	0.72	2.16	1.84
Esquimalt	0.09	3.23	0.13	2.66	0.61	0.74	0.24	1.90	0.91	1.97	0.88	1.35
Fernie	4.41	1.21	2.41	2.80	6.91	1.96	3.16	1.45	1.44	0.75	2.95	1.01

Community	F2019		F2020		F2021		F2022		F2023		F2024 (YTD)	
	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI
Fort Nelson	7.21	1.58	4.67	9.27	2.95	1.19	4.20	2.73	2.22	1.79	5.70	7.59
Fort St. James	0.58	2.53	12.88	2.95	6.48	2.46	2.28	1.60	4.57	4.26	3.46	6.87
Fort St. John	3.13	1.85	3.54	2.43	2.96	3.26	1.75	5.39	2.29	2.65	2.36	2.68
Fraser Lake	1.03	1.36	3.48	2.66	1.74	1.30	2.24	2.53	1.44	1.90	1.71	1.94
Gibsons	1.67	1.81	1.73	2.81	3.48	1.98	2.32	1.65	3.00	1.94	1.79	1.33
Gold River	3.98	6.21	5.47	3.34	11.31	5.05	13.78	5.18	4.65	3.26	3.64	3.16
Golden	1.52	3.08	5.00	2.11	4.47	3.28	8.95	4.20	3.13	1.74	2.94	1.52
Granisle	0.11	13.55	5.25	2.04	1.27	4.16	1.21	2.81	3.21	2.51	3.11	2.24
Harrison Hot Springs	3.04	1.78	1.02	2.07	4.31	2.24	3.11	2.59	3.08	2.42	2.20	7.20
Hazelton	3.25	2.76	3.49	1.95	4.91	4.63	1.65	2.69	2.17	4.54	2.14	5.39
Highlands	4.61	9.33	5.28	2.89	14.61	3.54	4.34	1.82	5.59	6.96	2.83	1.86
Hope	3.05	3.46	7.59	2.22	10.30	3.35	7.56	6.12	5.58	5.30	4.88	3.80
Houston	1.43	2.41	3.61	1.83	3.78	2.25	1.01	4.31	2.42	3.66	1.85	5.00
Hudson's Hope	3.03	2.50	2.66	1.73	9.01	2.78	2.50	2.30	1.75	3.27	3.73	2.06
Invermere	2.67	0.64	2.06	1.38	5.33	1.36	3.96	0.64	1.40	0.85	3.55	1.23
Islands Trust	4.31	4.71	4.15	5.80	4.40	6.15	8.25	6.76	3.49	8.93	5.14	9.14
Islands Trust	8.45	13.38	5.92	2.92	17.89	3.17	6.72	2.53	10.30	4.81	5.55	2.64
Kamloops	1.81	1.72	3.16	2.19	2.89	1.76	1.76	2.69	1.06	2.15	1.62	1.83
Kent	4.55	7.32	3.28	4.79	8.60	4.94	7.22	3.54	4.31	3.36	2.19	3.46
Kimberley	2.05	1.60	2.78	1.17	1.93	2.90	0.87	1.55	0.22	3.05	1.45	2.91
Kitimat	1.38	1.03	2.23	2.87	3.92	7.57	1.45	3.33	1.33	1.72	2.33	2.39
Ladysmith	3.01	18.59	0.59	2.50	3.20	3.45	1.31	2.32	3.24	4.27	2.24	3.98
Lake Country	1.87	1.82	0.65	2.11	2.57	3.82	1.61	2.73	1.59	3.71	1.31	2.32
Lake Cowichan	2.69	31.07	3.45	4.00	6.66	3.03	3.03	1.71	2.75	3.04	6.23	2.13
Langford	2.39	5.55	1.53	2.53	2.40	2.42	1.87	2.46	2.54	2.48	0.55	1.51
Langley City	1.34	2.81	2.47	1.80	1.89	3.33	1.51	2.02	1.64	4.15	1.28	2.43
Langley Township	2.92	7.65	3.04	2.24	4.38	4.31	2.51	2.52	2.60	4.37	1.98	2.58
Lantzville	3.64	6.66	2.49	3.71	2.97	1.38	0.65	3.05	5.34	3.45	1.54	2.24
Lillooet	2.25	1.49	4.33	2.15	4.40	1.85	1.94	2.87	1.36	0.90	1.47	4.08
Lions Bay	2.26	4.78	2.19	1.32	4.77	0.98	9.22	2.54	5.20	2.81	23.57	2.76
Logan Lake	2.01	4.08	1.29	1.59	0.09	1.62	3.59	8.59	2.43	3.09	1.91	0.09
Lumby	1.88	1.50	6.67	2.83	4.03	6.51	3.18	3.75	0.35	0.86	3.20	3.90
Lytton	6.94	1.94	8.35	2.46	12.23	2.64	12.88	2.65	3.18	3.93	3.76	2.62
Mackenzie	1.44	5.79	5.23	1.25	0.61	3.33	0.32	3.18	3.38	2.46	1.43	3.83
Maple Ridge	3.12	5.44	2.17	2.01	2.51	2.68	1.58	2.57	2.72	1.88	2.71	2.33
Masset	5.21	2.12	4.37	1.05	5.04	1.96	6.67	1.43	3.27	0.97	6.53	1.61
McBride	7.37	0.82	5.17	0.57	11.33	4.85	12.29	2.17	5.29	0.84	7.39	1.55
Merritt	2.29	2.82	2.41	1.82	2.03	2.82	2.31	15.43	1.62	2.45	0.74	2.47
Metchosin	7.03	4.29	8.12	2.33	6.16	2.88	5.17	3.61	7.71	3.60	6.56	2.14
Mission	3.36	5.24	4.81	1.69	3.11	3.79	3.71	2.38	2.38	2.41	1.82	2.29
Nakusp	2.20	6.31	9.77	5.46	10.68	5.53	2.85	6.74	2.20	2.57	2.10	3.10
Nanaimo	1.81	7.79	0.91	2.11	1.00	2.11	0.59	1.21	1.54	3.01	0.62	1.79
New Denver	0.59	6.04	8.82	6.18	3.94	7.42	0.59	1.35	1.76	10.22	1.00	5.13
New Westminster	2.71	3.07	1.64	0.14	2.63	2.22	0.63	3.00	1.80	2.53	1.40	2.78

Community	F2019		F2020		F2021		F2022		F2023		F2024 (YTD)	
	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI
New Westminster	1.32	5.78	5.16	1.34	6.52	1.83	6.47	1.82	4.13	5.84	2.01	1.26
North Cowichan	3.76	13.02	2.99	1.02	4.09	3.17	2.34	1.99	3.39	3.86	2.11	2.12
North Saanich	4.24	4.30	2.11	2.91	3.85	3.22	2.11	2.22	4.20	1.68	1.39	3.80
North Vancouver	0.85	1.63	0.48	3.11	0.19	2.07	1.17	3.49	0.65	2.70	0.72	1.12
North Vancouver District	1.37	1.62	1.09	3.72	0.71	1.95	1.00	5.17	1.82	3.52	1.45	2.56
Oak Bay	0.78	4.19	1.21	2.44	0.73	2.29	1.45	1.31	0.88	2.11	0.23	2.57
Parksville	0.69	9.09	1.18	1.56	1.65	1.64	0.77	1.55	3.82	2.27	1.08	0.71
Peachland	0.84	5.12	1.17	1.90	2.67	2.57	1.27	6.12	0.87	2.07	4.43	1.72
Pemberton	3.22	4.19	2.23	3.58	3.95	3.08	1.92	4.31	3.25	2.14	5.13	1.87
Pitt Meadows	1.72	5.38	0.22	2.11	1.11	3.17	0.79	3.01	1.34	1.76	1.25	2.02
Port Alberni	2.36	4.16	1.54	2.50	2.99	2.27	3.97	1.08	2.13	1.62	2.86	1.29
Port Alice	9.01	3.18	3.93	2.51	8.00	11.40	7.15	12.06	2.04	4.55	3.04	4.70
Port Clements	13.98	5.17	12.05	2.28	38.11	3.63	15.07	2.58	3.02	2.27	13.71	2.84
Port Coquitlam	2.15	2.49	1.46	1.20	1.95	2.43	2.53	1.98	1.89	1.76	1.34	3.34
Port Edward	1.52	2.15	4.34	2.23	6.73	1.56	5.97	0.96	1.02	7.36	4.35	0.89
Port Hardy	6.29	2.28	4.62	1.17	15.25	6.97	12.61	7.02	5.68	3.24	4.79	3.88
Port McNeill	8.26	1.84	6.25	1.16	9.45	7.06	5.64	11.32	3.28	2.96	1.27	9.73
Port Moody	0.87	1.79	1.39	1.00	1.62	1.24	0.57	3.06	1.29	2.15	1.13	1.29
Port Renfrew	13.67	7.13	14.19	4.29	27.85	5.45	8.94	5.62	13.92	4.73	9.84	4.58
Pouce Coupe	3.09	0.85	2.39	1.67	1.23	1.51	3.44	0.81	2.03	0.48	0.20	1.92
Powell River	2.50	3.61	2.33	1.00	5.54	2.33	4.25	2.02	1.59	2.02	4.14	3.84
Prince George	1.55	2.30	2.38	1.95	2.27	3.93	1.42	2.08	1.17	4.10	1.55	3.49
Prince Rupert	1.84	4.15	2.41	2.80	3.82	3.11	5.65	1.54	1.40	5.12	3.03	1.45
Qualicum Beach	5.34	6.87	5.50	1.67	8.46	2.00	4.38	1.39	6.77	2.44	4.47	1.85
Queen Charlotte	9.63	3.39	11.10	2.24	22.08	2.20	9.32	2.01	12.46	1.47	7.81	2.49
Quesnel	2.24	1.15	2.69	2.43	4.45	2.52	1.76	1.78	0.75	1.38	2.27	1.78
Radium Hot Springs	2.80	0.87	1.92	1.05	3.29	0.74	4.28	0.62	2.01	1.37	2.83	1.99
Revelstoke	2.85	2.59	1.94	2.70	0.96	3.14	5.71	2.31	2.34	1.97	0.99	3.53
Richmond	0.57	3.28	1.26	1.44	0.57	2.44	1.24	2.05	0.85	2.46	0.61	3.76
Saanich	1.28	3.33	0.98	2.50	2.73	2.59	2.13	1.80	1.97	1.68	0.84	3.05
Salmon Arm	3.49	2.49	8.03	5.29	7.68	2.03	3.79	2.48	4.70	1.29	5.32	2.00
Sayward	9.00	11.28	11.78	5.42	8.89	3.41	21.37	6.44	8.89	6.65	8.60	4.20
Sechelt	2.09	2.26	3.40	2.54	8.12	2.51	8.05	2.68	4.93	2.97	4.04	3.67
Sicamous	3.67	1.73	7.79	4.34	2.70	2.12	1.57	0.92	3.41	0.73	3.13	2.65
Sidney	0.40	3.08	1.52	2.23	2.03	1.77	0.71	4.56	2.51	0.53	0.80	1.02
Silverton	11.11	4.36	16.94	9.52	18.15	7.02	14.61	5.07	3.97	4.39	4.47	6.16
Smithers	2.80	2.38	6.77	1.56	7.14	3.55	1.77	3.29	3.27	1.26	3.85	3.85
Sooke	4.12	3.94	4.13	2.33	3.79	3.62	3.41	5.21	4.84	2.03	3.33	2.40
Sparwood	2.56	1.56	0.34	2.02	3.43	0.85	0.62	6.19	0.32	1.26	0.51	1.93
Squamish	2.26	3.65	1.46	4.58	2.07	10.60	3.45	2.92	1.63	1.03	5.30	1.16
Stewart	2.74	6.32	6.11	9.16	7.86	10.38	4.07	17.33	2.18	2.06	4.00	7.53
Surrey	1.49	4.17	1.24	1.99	1.05	2.51	1.23	1.97	1.57	2.78	1.36	3.34
Tahsis Village	2.10	1.05	0.05	3.51	3.10	25.34	3.14	57.20	2.02	11.75	0.26	6.20

Community	F2019		F2020		F2021		F2022		F2023		F2024 (YTD)	
	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI	SAIFI	CAIDI
Taylor	2.09	6.08	1.21	2.10	1.17	1.88	0.49	5.71	1.12	0.62	0.10	2.94
Telkwa	9.40	1.82	5.44	1.23	5.06	2.94	2.13	3.85	6.47	1.19	2.04	4.86
Terrace	2.13	2.82	4.56	2.70	4.84	3.73	1.91	5.00	1.91	3.43	1.43	4.06
Tofino	10.76	8.01	7.25	2.37	11.33	4.69	7.44	2.77	9.20	5.05	11.09	1.86
Tumbler Ridge	2.02	0.41	2.50	1.81	3.72	1.42	2.95	2.53	1.73	2.10	2.23	12.80
Ucluelet	7.81	8.70	5.10	4.67	6.95	7.28	6.67	4.11	5.96	3.39	10.32	3.66
Valemount	1.27	0.81	4.28	0.70	5.74	6.42	9.84	2.12	4.07	1.16	2.39	1.57
Vancouver	0.51	2.11	0.53	1.84	0.79	1.50	0.68	2.21	0.62	2.53	0.57	2.79
Vanderhoof	2.62	1.96	10.66	1.77	4.86	2.64	2.59	2.53	1.50	3.90	2.19	3.08
Vernon	1.50	3.37	3.51	2.75	3.57	2.88	2.84	5.83	2.73	1.76	2.38	2.43
Victoria	0.44	2.82	0.44	0.89	0.62	2.09	1.05	1.22	0.69	2.41	0.43	1.66
View Royal	2.95	2.99	0.80	2.04	1.65	1.76	1.96	1.71	1.61	2.24	0.61	1.24
Wells	9.46	3.11	9.15	6.01	16.26	3.76	9.22	2.10	5.38	1.31	8.03	5.15
West Vancouver	0.81	2.34	1.19	2.02	1.72	6.67	1.87	2.53	1.30	2.13	2.32	3.01
Whistler	0.67	5.11	0.48	2.27	0.88	1.81	0.92	1.82	0.66	2.02	0.69	3.41
White Rock	2.32	3.47	0.14	1.81	2.10	2.75	1.75	0.68	0.93	2.58	0.97	1.57
Williams Lake	2.74	2.44	4.08	2.96	7.39	2.18	1.94	2.83	3.86	1.36	2.29	3.02
Zeballos	3.30	10.74	6.62	11.15	8.81	22.76	5.75	38.68	6.22	11.30	2.16	3.11

*Please note this data represents all “forced outages” or those power interruptions caused by factors outside of the utilities control (e.g. a falling tree breaking the conductor). The data also includes outages from major storms and weather events. Scheduled maintenance or system upgrades, often referred to as planned outages, are not included in this data.

5.2 Appendix B. Compilation of Studies on Home Performance During Power Outages

Study/ Modelling	Description	Performance Focus/Metrics	Study/Modelling Results	Characteristics that Enhance Performance
"Baby, It's Cold Inside" Report[23]	The report models six representative residential building categories in New York (climate zone 4) to assess the indoor temperature conditions in existing and high-performing buildings in non-extreme summer and winter conditions following a blackout.	**Indoor temperatures during a winter blackout**	• In a typical detached single-family home, the indoor temperatures would be 35°F (1.7°C) after three days and fall below freezing on the fourth day. A high-performing single-family home, however, would stay above 60°F (15.6°C) after three days without power and is expected to maintain temperatures above 54°F (12.2°C) by the end of the week. • For the remaining residential building categories, indoor temperatures in standard existing buildings would range between 32°F (0.0°C) and 43°F (6.1°C) after a week.	• Year-round applicable: - More insulation - Fewer air leaks - Reasonable amount of window area - High-performance windows • Summer-specific: - Sunshades
		Indoor temperatures during a summer blackout	• An existing single-family home would heat to nearly 90°F (32.2°C) on the first day and peak over 95°F (35.0°C). In contrast, a high-performing single-family home stays below 85°F (29.4°C) for the initial four days, though it would still rise above 90°F (32.2°C) at the end of the week. • As for other residential building categories, temperatures in a standard all-glass apartment would jump to over 100°F (37.8°C), while the others maintain a cooler environment throughout the week, still ending above 85°F (29.4°C). The high-performing glass building would peak at 88°F (31.1°C), with the remaining categories staying below 80°F (26.7°C). for the first half of the week and never exceeding 85°F (29.4°C).	
"Hours of Safety in Cold Weather" Report[24]	The study models the duration of time homes can maintain safe temperatures during a power outage for five representative homes in Duluth, Minnesota, including a typical 1950s home, a typical 1980s home, a home meeting the 2009 IECC Code, a net-zero energy ready home, and a home built to Passive House standards. All homes feature 2x4 construction, slab foundations, two floors, and two zones.	**Number of hours fall below 40 °F (4.4°C)**	• During the first day of a power outage, indoor temperatures in typical 1950s homes drop below 40°F within eight hours, and in 1980s homes within 23 hours. For homes compliant with the 2009 IECC Code, indoor temperatures fall below 40°F after 45 hours. Net-zero energy ready homes maintain temperatures above 40°F for 61 hours. The Passive House building buffers the cold the longest, keeping temperatures above 40°F for 152 hours.	• Year-round applicable: - Increased insulation - Fewer leakage - High-performance windows
	This publication aims to guide the design of	**Thermal**	• The modeling results for thermal autonomy indicate that space heating is	• Year-round applicable: - High-performance

[23] Baby, It's Cold Inside. (2014). Envelope properties of existing building stock and high-performing residential buildings are available in the Technical Appendix of the report. Available: https://www.urbangreencouncil.org/baby-its-cold-inside/
[24] Hours of Safety in Cold Weather: A Framework for Considering Resilience in Building Envelope Design and Construction. (2020). Available: https://rmi.org/insight/hours-of-safety-in-cold-weather/

Multi-Unit Residential Buildings (MURBs) Design Guide[25]	MURBs in a Canadian climate. In the discussion of resilience measures, energy simulations that modeled typical MURB suites, consisting of 40% or 80% window-to-wall ratio scenarios, in four orientations, are performed to analyze ten combinations of passive measures using Vancouver (climate zone 4) weather data.	**autonomy[26]**	required even when applying passive design strategies to the base case with minimum envelope requirements. However, the demand for cooling can be eliminated in buildings with high performance envelope metrics and passive measures adopted.	enclosures, and in particular high-performance glazing • <u>Summer-specific:</u> - Operable shading devices - Natural ventilation
		Passive survivability[27]	• The energy modeling for passive survivability indicates that conventional enclosures would result in overheating within the first day. Conversely, a high-performance enclosure with passive measures can maintain a comfortable indoor environment during hot summer. In winter, the high-performance enclosure ensures habitability for well over a week.	
"Designing Climate Resilient Multifamily Buildings" Report[28]	The study assesses the implications of increasing outdoor air temperatures due to climate change on the thermal comfort of multifamily residential buildings in the Lower Mainland. It aims to identify cost-effective design measures that will maintain thermal comfort under future climate conditions. One analysis in the report was conducted to compare a new high-rise building archetype designed to Step 4 with a Step 4 building with additional passive design measures during normal operation and during a power outage event for a summer week in the 2050s to help understand how a mechanically cooled archetype may perform in the event of a power outage.	**Modelled operative temperature**	• The results show that during a power outage, the Step 4 building with passive measures maintains internal temperatures near an acceptable comfort level, whereas the baseline Step 4 building exceeds the thermal comfort threshold. The findings suggest that passive measures can make a substantial difference to thermal comfort during a power outage, highlighting the additional resilience benefits of incorporating cooling-focused passive measures into a building with full mechanical cooling.	• <u>Summer-specific:</u> - Operable shading - Reduced solar heat gain coefficient
"Enhancing Resilience in Buildings Through Energy	The study examines the resilience metrics of single-family homes and MURBs constructed to	**Standard effective temperature (SET)[30] and days of safety[31]**	• Homes and buildings constructed to higher performance standards extend the number of safety days across all locations during extreme cold and heat events,	• <u>Year-round applicable:</u> - High-performance envelope - Thermal bridge-free

[25] Enhancing the Liveability and Resilience of Multi-Unit Residential Buildings (MURBs) MURB Design Guide. (2019). Available: https://www.egbc.ca/getmedia/ba39d6bb-0e49-4b85-bf23-d50cf7a43c46/MURB-Design-Guide-v2-Feb2019.pdf.aspx
[26] Thermal autonomy is a measure of the fraction of time a building can passively maintain comfort conditions without active system energy inputs.
[27] Passive habitability is a measure of how long a building remains habitable during extended power outages that coincide with extreme weather events.
[28] UBC-Designing Climate Resilient Multifamily Buildings. (2020). Available: https://planning.ubc.ca/sites/default/files/2020-05/REPORT_UBC_Climate%20Resilient%20Multifamily%20Buildings.pdf
[30] SET is a comfort indicator that considers indoor dry-bulb temperature, relative humidity, mean surface radiant temperature, and air velocity, as well as the activity rate and clothing levels of occupants. SET values fall between 54°F and 86°F.
[31] Days of safety is a metric used in the study to measure habitability. A cumulative value of SET degrees falling outside the SET thresholds, expressed as SET degree hours, that exceed 216 over a 7-day period indicate uninhabitable conditions. The days of safety indicates the time elapsed before the SET degree hours reach this established threshold.

Efficiency" Report[29]	historical code, current model code, and beyond code requirements during a seven-day power outage that coincides with extreme cold and heat events. The buildings included in the analysis are located in six U.S. cities spanning climate zones 2 through 6.		except Los Angeles. In Los Angeles, typical existing homes and buildings have already maintained temperatures within habitability thresholds for the entire seven days. • The impact of increased performance is most notable in Portland (climate zone 4) during extreme cold events with power outages in single-family homes. Existing homes can safely shelter occupants for only 1.1 days, while homes built beyond code requirements ensure safety for the whole week. • During power outages coinciding with heat waves, single-family homes in Atlanta (climate zone 3) would experience the most significant improvement in the duration of maintaining safe conditions. A home built to both current code and beyond code requirements can remain a habitable condition for the full seven days, four days longer than existing homes.	- Air-tight
"Thermal Resilient Buildings: How to be Quantified?" Report[32]	The study quantifies the thermal resilient performance of a two-story Norwegian single-family house in Oslo facing a four-day power failure during cold winter days. It evaluates the impact of building design options, with the standard design based on the 2017 Norwegian building code and the passive design based on the Norwegian passive house standard NS3700, and resilience enhancement strategies on thermal performance during and after the disruptive event.	**Indoor operative temperature**	• The standard design would experience the uninhabitable level during a four-day power failure. In contrast, the passive house design would maintain temperatures above the habitable level throughout the power outage. • The electricity generated by the PV systems is assumed to be directly used for heating during a power outage. In both standard and passive designs, the integration of PV systems increases the minimum temperature by 1.5°C but does not alter the experienced levels for either design option.	• <u>Year-round applicable:</u> - Passive house standard building envelope - Implementation of PV systems - Batteries as a storage system
		Exposure time to the disruptive event[33]	• The implementation of battery storage would delay the onset of power failure by 15 hours in the standard design and 13 hours in the passive design. However, employing batteries as a storage system does not change the experienced levels for both design options.	
		Weighted unmet thermal performance[34]	• The addition of battery storage and PV systems would decrease the WUMTP for both standard and passive designs. For standard design, the inclusion of a battery decreases WUMTP from 113 to 91 degree-hours, representing a 19% reduction, and when PV is added, WUMTP decreases to 63 degree-hours, reflecting a 44% reduction. For the passive design, the	

[29] Enhancing Resilience in Buildings Through Energy Efficiency. (2023). Available: https://www.energycodes.gov/sites/default/files/2023-07/Efficiency_for_Building_Resilience_PNNL-32727_Rev1.pdf

[32] Thermal resilient buildings: How to be quantified? A novel benchmarking framework and labelling metric. (2021). Available: https://www.sciencedirect.com/science/article/pii/S0360132321004200

[33] The exposure time encompasses both the initiation time of the disruptive event and the recovery time for a building to return to its pre-disturbance state.

[34] WUMTP is determined by calculating the thermal performance deviation from the temperature targets during the occupied hours. A lower WUMTP indicates the building is more thermal resilient.

			application of a battery reduces WUMTP by 9 degree hours, a 27% decrease, and the addition of PV results in a drop from 33 to 13 degree hours, marking a 60% reduction.	
BC Energy Step Code Design Guide Supplement on Overheating and Air Quality[35]	The Design Guide Supplement provides a set of design principles, strategies, and practices for Part 3 buildings to reduce the risks of overheating caused by rising average temperatures and an increase in extreme temperature events, such as heat waves and address indoor air quality issues due to an increase in wildfire events as wells as other localized sources of air pollutants, supporting the industry's transition towards safe, resilient, and adaptive buildings for the future. A modeling analysis was conducted on a mixed-use residential building in Vancouver to understand the design strategies needed to reduce overheating risks, using data from 2016 and projections for 2050.	**Average suite summer overheating hours**	• Under a 2016 climate, the model showed that operable windows reduce overheating hours from 2271 to 29, making them a good passive cooling strategy. However, with the warmer temperatures projected for the 2050s, operable windows become less effective. Although the reduction is still significant, from 3075 to 239 overheating hours, the number exceeds the BC Energy Step Code's limit of 200 hours for the general population and 20 hours for vulnerable populations. The results show that additional strategies are necessary to cool the building.	• Year-round applicable: - Building shape and massing - Building orientation - Thermal mass - Window design - One or more refugee areas • Summer-specific: - Cool roofs - Exterior shades - Natural ventilation - Fan-assisted cooling - Mechanical cooling systems

[35] BC Energy Step Code Design Guide Supplement S3 on Overheating and Air Quality. (2019). Available: https://www2.bchousing.org/research-centre/library/residential-design-construction-guides/bc-energy-step-code-design-guide