



## ***Power Outages***

### **Key Points**

- The 2003 Northeast Blackout highlighted the fragility and interdependence of the country's electrical system.
- About half of Seattle City Light's unplanned power outages are caused by falling trees or branches.
- Over 86% of Seattle's power comes from hydroelectric power; 51% of the power Seattle consumes is purchased.
- A regional cascading blackout is a distinct possibility in this region. It seems likely that a problem would originate outside the Seattle City Light system because the Bonneville Power Administration (BPA) transmission system is in need of a major upgrade.
- The largest impacts of an extended power outage would be economic because most businesses in the affected area would likely shut down.
- Seattle's power depends on the health of generating facilities that lay far outside the municipal boundaries, on snow and rain that are the "fuel" for hydroelectric power and finally on the health of the transmission and distribution lines that move the power.
- Expected climate and hydrologic changes will likely alter the annual patterns of hydroelectric supply and demand, lowering demand during the winter and increasing demand during the summer.
- By 2021, demand may not be met in late summer, early fall and winter.

### **Nature of the Hazard**

On August 14, 2003, a large part of the upper Midwest, East Coast, and Ontario, Canada lost power. The outage affected 50 million people. Some parts of the United States waited four days for the power to be restored. Estimated losses ranged from \$4 billion to \$10 billion. The outage highlighted widespread infrastructure problems.

Power is an essential component of modern society and is immediately noticeable when absent. The 2003 outage caused other areas of the country to look at their own networks to analyze the chances of a similar incident and its potential effects on their own networks.

A power outage may be referred to as a "blackout" if power is lost completely, as a "brownout" if the voltage level is below the normal minimum level specified for the system or a "dropout" when the loss of power is only momentary, from milliseconds to seconds. Some brownouts, called voltage reductions, are made intentionally to prevent a full power outage. "Load shedding" or "rolling blackout" is a common term for a controlled way of rotating available generation capacity between various districts or customers, avoiding total, wide area blackouts.



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In power supply networks, the power generation and the electrical load (demand) must be very close to equal every second to avoid overloading network components. In order to prevent this, parts of the system will automatically disconnect themselves from the rest of the system or shut themselves down to avoid damage. Under certain conditions, a network component shutting down can cause current fluctuations in neighboring segments of the network, though this is unlikely, leading to a cascading failure of a larger section of the network. This may range from a building, to a block, to an entire city or to the entire electrical grid.

The City of Seattle owns its own generating capacity, transmission lines and distribution system. It is operated by Seattle City Light and connected to the BPA network, which is part of the western electric transmission system made up of 11 western states, two Canadian provinces and northern Baja California, Mexico.

The high voltage transmission system is near capacity in many parts of the West, including the Pacific Northwest. A seasonal power exchange in this system takes advantage of the seasonal diversity between the Northwest's winter peaking and the Southwest's summer peaking loads. Utilities can transfer firm power from north to south during the Southwest's summer load season and from south to north during the Northwest's winter load season, allowing both regions to maintain less generating capacity than would otherwise be necessary. Seattle City Light's existing portfolio includes a seasonal exchange with utilities in Northern California. The interconnection brings danger of cascading failure and relief of load shedding under differing circumstances.

The City of Seattle gets most of its power from Seattle City Light, a City department. As a publicly owned power utility, it operates as a public service. It serves more than 330,000 customers and is the seventh largest public power system in the country. Seattle City Light owns seven dams, mostly on the Skagit and Pend Oreille Rivers. Over 86% of Seattle's power comes from hydroelectric power, both from its own dams and those of the BPA. Seattle City Light purchases 51% of the power that Seattle consumes. Seattle's power depends on the health of generating facilities that lay far outside the municipal boundaries, on snow and rain that are the "fuel" for hydroelectric power, and finally on the health of the transmission and distribution lines that move the power. More information on Seattle's power supply can be found in the Community Profile section.

## History

All power systems experience unplanned outages. Most are small, resolved within a few hours and do no lasting damage. Larger outages occasionally occur. These outages are usually secondary events caused by other hazards, e.g., winter storms. Some larger outages, such as the 2003 outage, demonstrated that power outages can be a primary incident. Two local examples are two fires in underground vaults serving the downtown areas that caused lengthy outages. This section lists major outages in Seattle and several regional events that did not directly affect Seattle but highlight issues with the Western power grid.

**1958. Seattle. Wind related outages.** Loss of power in many areas of the city, especially in West Seattle and Magnolia.

**1962. Seattle. Columbus Day Storm.** Biggest storm to hit the Pacific Northwest. It affected utilities throughout the region.



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**1988. Downtown Seattle Vault fire.** Six electrical cables were damaged resulting in a four-day loss of power to a 50 block area in downtown. The area included the Westin Hotel and the Pike Place Market. The cause was a contractor driving a steel piling through a buried cable. Businesses that lost power sued the city and the contractor. Newspaper reports that the city paid more than \$1.5 million to settle claims.

**1993. Downtown Seattle Vault fire on October 5<sup>th</sup>.** 1,800 customers in about 270 buildings were out of power for up to three days in 37 block area. Eight large generators were brought in to help the population. Fire destroyed huge underground cables that had to be replaced.

**1996. Western Interconnection.** Two major outages struck the Western power grid in 1996. On July 2, a localized outage caused by a tree in Idaho led to a cascading regional outage that resulted in 10% of the consumers in the western U.S. losing their power for at least a few minutes. The next month, on August 10, more than 7 million people across the West lost power. Areas were affected intermittently for up to several hours.

**1997. Western Interconnection.** Two separate disturbances in the Western grid that interconnects with Seattle City Light's system. Both outages had minor customer impact but could have been worse.

**2000 – 2001. California.** Rolling blackouts plagued much of California. The Northwest was involved as a power supplier. This event placed strain on transmission lines in the Northwest and caused two major outages during peak demand periods.

**2006. Seattle.** Seattle City Light suffered its most extensive outages in the utility's history as a result of a severe regional windstorm. More than 49% of customers lost power. Some customers were without power for more than a week. Neighboring utilities were also suffered major damage.

**July 2009. Western Washington.** While Seattle avoided power outages during record heat, Tacoma and Monroe did not. Typically, summer is a low demand time for Pacific Northwest power but this event demonstrated that Seattle is also vulnerable to demand spikes during the summer.

## Likelihood of Future Occurrences

No system is 100% reliable. The costs of such a system would be prohibitive even if possible. Seattle will have major unplanned outages in the future. The more important questions are how frequent will these outages be, how many customers will they affect and how long will they last?

Wind will continue to be a hazard to power transmission. Although it has fewer trees than the rest of the county, Seattle is attempting to re-grow its tree canopy. Seattle City Light has increased its tree trimming program, but it is still possible that the number of tree-related outage could increase.

Improvements have been made to underground electrical vaults, including automatic fire suppression. These improvements should reduce the likelihood and duration of downtown outages.

A regional cascading blackout is a distinct possibility in this region. It seems likely that a problem would originate outside the Seattle City Light system because the BPA transmission system is in need of a major upgrade. Seattle has the ability to isolate itself but, because the city can only generate a portion of its power, an "islanding" could cause short-term, supply-related brownout problems.



## **Vulnerability**

Power lines are underground in the downtown core and other dense areas. They are vulnerable to vault fires but extremely resistant to wind damage. In the rest of the city the situation is reversed. Wind damage is linked to the number of trees close to wires. Locally, more power has been going underground. The underground system is less likely to fail but can be more time consuming and expensive to repair when it does fail.

Communities with older high-rise and commercial buildings are generally more vulnerable to a blackout because they often lack backup generators. During the 2006 storms and power outages, it was discovered that many nursing homes lacked back-up power. With many residents dependent on electrical equipment, these facilities proved highly vulnerable to outages.

Hospitals are even more sensitive than nursing homes. For this reason, hospitals have emergency power generators that are typically powered by diesel fuel and configured to start automatically as soon as a power failure occurs. During Hurricane Katrina, hospital patients began experiencing life-threatening conditions within hours of power loss. Seattle is the major concentration of hospitals in the region.

Other life-critical systems such as telecommunications are also required to have emergency power. The City of Seattle is currently upgrading all its fire stations to have emergency generators.

General economic health and social climate has a significant effect on what happens during a blackout. The 1978 New York blackout occurred during a time of political instability and discontent. As a result, there was widespread looting. In 2003, there was none. The social climate is an important external variable in any widespread outage.

Many businesses depend on reliable power, especially with growing technology dependence. Other businesses with perishable inventory, like grocery stores and restaurants, stand to take permanent losses during extended outages. When the power is out only in one community, the retail stores in that community lose customers to neighboring communities. If the outage is short but widespread, then retail stores do not suffer because post-incident sales trend accelerate and make up for the downtime.

## **Consequences**

The December 2006 windstorm demonstrated the importance of power. Some parts of the city were without power for nearly a week during very cold weather. The outages led to several fatalities outside the City of Seattle. The response was the second costliest in the City's history after the Nisqually Earthquake.

Despite the seriousness of the 2006 outage, Seattle has never suffered a catastrophic blackout like the Northeast nor has it had rolling blackouts like California experienced during 2000 and 2001, however several events on the Western grid have come close to affecting the city.

Seattle has experienced three large unplanned and multi-day outages in the past 30 years. It is therefore plausible that another as large or even larger could occur. The most likely sources are another underground vault fire or a regional windstorm. The effects would be similar or worse than past incidents, with major parts of Seattle losing power.



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The largest impacts of an extended power outage would be to the economy as most businesses are likely to shut down in an extended outage. During the 2006 power outages, more than \$6.9 million was spent repairing and replacing wires, transformers and poles. Local transportation networks collapse when traffic signals are out. In 2006, 150 traffic signals went dark.

The maximum credible scenario would probably be some sort of “perfect storm” of disparate elements coming together to create a huge problem. This would probably include a regional outage involving the Western Interconnection during a period of peak power demand in Seattle. Even if Seattle could successfully island its infrastructure, it might not be able to meet all the demand. Since extreme demand tends to be driven by extreme weather, it is likely that Seattle would be facing either very hot or very cold temperatures at the same time. Currently, Seattle’s social climate seems very stable, but if it is not, that could be one more potential element in the mix.

**Most Likely Scenario**

An accident and fire in an underground vault cuts power to a large part of downtown for three days. The City is able to acquire generators to partially meet demand, but many businesses must shut their doors. Many residents of downtown high-rises are unable to walk the stairs to their apartments.

Category	Impacts 1 = low 5 = high	Narrative
Frequency	5	Large power outages occur on a fairly regular basis. Most are associated with storms or accidents. In most cases the outages last less than a day, but occasionally the power takes days to come back. The scenario here is based on two outages in the late 80's and early 90's.
Geographic Scope	3	A major section of downtown and Belltown goes dark during hot weather in August.
Duration	2	Full power is restored in 3 days.
Health Effects, Deaths and Injuries	2	No one is killed in the incident but one City Light line worker is critically injured. 18 people contract a food borne illness when they consume non-refrigerated food.
Displaced Households and Suffering	2	A Seattle Housing Authority property in Pike Place Market loses power. Many residents are disabled or elderly. Most have no other place to go. Altogether 65 people need shelter.
Economy	2	The Pike Place Market loses power in the middle of high tourist season. Many small businesses that operate on the edge of profitability are losing money each day. Several biomedical research projects are destroyed when refrigerators lose power.
Environment	1	The environment is not directly affected by this incident.
Structures	1	No buildings are impacted by the power outage.
Transportation	2	Surface transportation in the affected area is disrupted. Traffic lights are dark and operate as four way stops. The downtown transit tunnel loses power.



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Critical Services and Utilities	2	Aside from the power outage itself, critical services and utility services are able to be maintained at street level. High-rises lose elevator and water service.
Confidence in Government	1	The public sees local government response as timely and effective.
Cascading Effects	2	The power outage increases the incidence of food borne illness.

**Maximum Credible Scenario**

The western power grid fails during December when City Light needs power from it. Cold temperatures are creating a high demand for power for heating. City Light must attempt to meet demand using only its own resources (which can supply 30% of demand). Several large events are planned for the time period: Seahawks and UW Husky games, and an event at Westlake mall. Holiday shopping is in full swing and businesses are eager to maintain sales. City Light would have to implement rolling black outs to spread the pain among customers, including high-priority customers like hospitals.

Category	Impacts 1 = low 5 = high	Narrative
Frequency	3	Failure of the western grid, called the Western Interconnection, has not had major impact on Seattle, but there have been several close calls. City Light has its own generating and transmission capability which mitigates vulnerability to problems with the Western Interconnection, but City Light relies on its power during peak demand. As a result, this scenario is estimated to have a 1 in 100 chance of occurring each year.
Geographic Scope	5	Failure of the Western Interconnection would cause a region wide power outage.
Duration	4	Power is out for 10 days. The transmission is severely damaged in a storm. Local systems also suffer damage in the storm and due to load imbalances when the Western Interconnection is lost.
Health Effects, Deaths and Injuries	2	Despite the best efforts of public health a family of five dies when they attempt to heat their home with a charcoal grill. Public outreach has saved lives, however.
Displaced Households and Suffering	4	700 people including 45 residents of a nursing home require shelter from the cold. The prolonged outage reduces the capacity of food distribution centers resulting in shortages of perishable food and medicines. Medical service providers, mainly outpatient services, operate at reduced capacity.
Economy	3	All businesses in Seattle without generators are affected. There is a surge in sales after the outage. Because the outage is so large, consumers are not able to redirect their spending elsewhere. Unfortunately, the post outage surge does not cover losses. The biotech industry loses research when they cannot refuel generators.
Environment	1	The environment is not impacted by the outage.
Structures	2	The power outage cuts water service to high rise buildings without generators. Water pumps fail in some parts of the city.



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Transportation	3	Surface transportation is disrupted throughout the region. Airports are able to remain open, but have to curtail non-essential functions. Marine terminals continue to operate on generator power. Gas stations lose ability to pump gas.
Critical Services and Utilities	3	Critical services operate on generators. As fuel becomes harder to obtain, some facilities run out of power. 800 MHz sites go dark.
Confidence in Government	5	The Western Interconnection is operated by government authorities. As the outage continues past the third day, the public becomes increasingly frustrated with government.
Cascading Effects	3	The outage causes a number of secondary effects: a number of fires start due to people burning wood to stay warm. The outage leads to infrastructure failures in the water and communications systems.

**Long term impacts**

In October 2005, local experts in climate change evaluation, the University of Washington Climate Impacts Group, issued a report stating that “projected climate and hydrologic changes will likely alter the annual patterns of electricity demand and stream flow. Projected warming due to climate change will likely lower electricity demand during the winter and increase demand during the summer in Washington.” This will alter power transfers with other parts of the region. More impacts are discussed in the climate change chapter.

**Conclusions**

In order to plan for the acquisition of new resources, which can take many years, Seattle City Light forecasts future power consumption or load in its service area 20 years into the future. Over the 20-year planning period, load is expected to continue to grow. Additionally, some of the power purchase contracts will expire.

By 2021, loads may be unserved in late summer, early fall and winter. In order to reduce the risk of unserved energy, additional energy must be available. Forecasts estimate that the Pacific Northwest will have more than adequate reserves to meet a 12% recommended reserve margin for the next decade under normal conditions, accounting for climate impacts.

Currently, Seattle City Light sells much more electricity into the market on an annual basis than it purchases, primarily because it requires more resources to meet the three-month winter peaking load requirement than are needed during the remaining nine months of the year. If BPA were to go out, Seattle City Light could isolate the city and protect the city’s network. This strategy is more feasible in the summer when Seattle supplies power to other areas than in the winter when Seattle needs to draw it from BPA to meet increased demand.

About half of Seattle City Light’s unplanned power outages are caused by falling trees or branches. Starting in January 2007, Seattle City Light revitalized the schedule for power-line clearance, focusing on feeders and the main lateral lines.