Office of Water (4608T) EPA 810-F-23-013 March 2023

POWER RESILIENCE

Guide for Water and Wastewater Utilities

EPA
epa.gov/waterresilience

Overview

Power loss can have devastating impacts on drinking water and wastewater utilities and the communities they serve. Inoperable pumps at a drinking water utility can halt the production of finished water, make firefighting difficult, and cause local health care facilities and restaurants to close. Pressure loss can allow contaminants to enter the drinking water distribution system from surrounding soil and groundwater. Power loss can also result in cascading infrastructure failures. For example, a chemical plant without power could discharge contaminants into source water supplies. For wastewater utilities, pump failure may lead to direct discharge of untreated sewage to rivers and streams or sewage backup into homes and businesses.

EPA developed four resources to help water utilities prepare for, respond to, and recover from power outages:

- This document, developed for water and electric utilities, which also serves as a resource for anyone interested in power resilience. In addition to providing information on increasing power resilience through several approaches, it also includes case studies and planning considerations for both short (e.g., 2-3 days) and long (e.g., several weeks) duration power outages.
- The Public Safety Power Shutoff Standard Operating Procedure Template is a comprehensive checklist that helps water utilities better manage power shutoffs implemented by electric utilities to reduce wildfire risks. However, most of the information is relevant to any power outage at any water utility. The SOP covers eight topics over six timesteps, spanning blue sky planning to full grid power restoration.
- The Incident Action Checklist – Power Outages provides concise "rip & run" checklists that remind water utilities of actions they can take to better plan for, react to and return to normal operations from power outages.
- The Water Sector Guide to Telecommunications During Power Outages provides information to help water utilities diversify their telecommunications plans and equipment and help ensure they can continue to communicate with employees, response partners, and customers during a prolonged power outage.

Eight areas in which water sector utilities can increase power resilience are:

1. **Communication** – Establish capability to communicate with electric providers, local agencies, and the public to help your utility respond more quickly and efficiently to a power loss.
2. **Power Assessments** – Conduct a power assessment to understand your essential equipment energy needs.
3. **Emergency/Standby Generators** – Learn how to select, maintain, and register requirements for a fixed or portable emergency generator for your utility.
4. **Fuel** – Develop plans to ensure you have enough fuel for your generator during a power outage emergency.
5. **Energy Efficiency** – Increase your energy efficiency to allow you to operate on back-up power longer during emergencies and to reduce your electricity bills during normal operations.
6. **Renewable Energy and Microgrids** – Consider options for generating your own power.
7. **Black Sky Planning** – Prepare for long-duration, widespread power outages.
8. **Funding** – Learn about possible funding sources for resilience measures.

1. Communication

TOP TIP: Get your utility on the priority list for power restoration.

Good relationships, information sharing and collaboration between water and electric utilities and local emergency management agencies (e.g., county, parish or city) are critical to having power restored quickly after an outage. Depending on the nature of the emergency and your local communication and response procedures, you may call your electric utility directly or you may need to coordinate through an emergency management agency (EMA). For more information on working with your EMA, see the EPA's Connecting Water Utilities and Emergency Management Agencies.

Becoming familiar with your county's emergency protocols and how response and recovery decisions are made, can help ensure that your utility is high on the power restoration prioritization list. Depending on your county's emergency protocols, the order in which power is restored to local critical infrastructure, such as your water utility, may be determined by your electric power provider, the local EMA or elected officials such as county commissioners. Communicate your emergency power needs and the consequences to the community should you have to cease operations due to a power failure. This should include details regarding "minimum" power requirements for essential functions only and any existing capabilities for back-up power and corresponding fuel requirements. Be sure you know who makes the power restoration prioritization list for your community and take steps to share relevant information with them. You should also become aware of and involved in the total community restoration plan. Your assistance may be needed to locate, prioritize and restore parts of the drinking water distribution system and wastewater collection system that serve critical infrastructure, such as mass care shelters.

Tip:

Another important part of communications is ensuring your utility has the means to communicate among employees, response partners, and customers. During power outages, some of our common means of communicating (e.g., Internet, cell phones) may begin to fail as batteries and fuel for generators are depleted. EPA's Water Sector Guide to Telecommunications During Power Outages provides information to help water utilities diversify their telecommunications plans and equipment and help ensure they can continue to communicate during a prolonged power outage.

Step 1 – Make Contacts and Establish Emergency Communications Protocol

- Get to know the key staff or points of contact at your electric utility responsible for power restoration prioritization. You may find that you have a dedicated account representative who fulfills this role for your utility. If this is not the case, find that person who prioritizes your restoration. When possible, have face-to-face meetings.
- Ask for 24/7 emergency contact information for the electric utility, the local EMA, and the local Emergency Operations Center (EOC) and save these numbers in your phone.
- Establish or verify, as applicable, the proper structure for the most efficient communications for power prioritization and restoration. Make sure that this structure is National Incident Management System (NIMS) compliant.
- Ensure that your community's emergency manager has your contact information in his or her cell phone so that when you call, your name will be recognized.

Did you know?

Many agencies and organizations share information and resources to support incident management activities at Emergency Operations Centers (EOCs). EOCs focus on the response to and the short-term recovery from an incident or natural disaster and provide access for cross-sector key personnel.

Step 2 - Request Key Information

- **Physical locations of critical assets.** Make sure your electric utility has the physical locations (Global Positioning System (GPS) latitude and longitude in degrees-minutes-seconds or in decimal degrees of the location) of all critical components of your water or wastewater system, as the physical address of your facilities can differ from your administrative address where bills are delivered. Give the physical address when reporting an outage. Also, request a review of the corresponding electric grid infrastructure that supports your critical assets. Depending on how your system is laid out, there may be different distribution feeders or substations for the treatment facility and individual pumping stations. Assess risks associated with the current electric power plan.
- **Critical Interdependencies.** You should also maintain situational awareness of activated, deactivated and non-activated mass care facilities, 911 centers, emergency services sector, and other critical infrastructure locations. For example, keep your fire department informed of water pressure problems and ask for their assistance in clearing debris (e.g., downed tree limbs) at your facilities as needed based on their availability. There may also be a need to coordinate the restoration of electric power and water and wastewater services to these assets.
- **Communication Resources.** Learn what communication resources, such as two-way radios or satellite phones, are available in your community. Be sure your radios are compatible with your response partners (e.g., P25 Standard). During a long-duration power outage, landlines and cellular phones may stop working. Conduct periodic tests with partners to ensure communications interoperability. Make sure you understand the procedures and processes for communicating with your electric utility during an outage and during the recovery process.
- **EOC street address.** Know where your local EOC is so that you can send a liaison there during an emergency if needed.
- **Mutual Aid Agreements.** Share information about your membership in mutual aid agreements such as your state's Water and Wastewater Agency Response Network (WARN).
- **Access.** Discuss what identification requirements or procedures are necessary to ensure that utility staff can access critical assets during an emergency when there are road closures and security checkpoints.

Did you know?

Most EOCs have representatives from the electric utility, gas utility, transportation sector, and other critical infrastructure sectors. During a disaster, call the EOC if you have trouble contacting your electric utility. Better yet, send a representative to the EOC and you will be able to directly coordinate with the electric utility, fuel, and transportation representatives.

Amateur Radio Emergency Service

The Prince William County Service Authority has a great relationship with two local amateur radio clubs. Both clubs have their primary repeater sites on Service Authority property, including antennas on top of water towers. The Service Authority, county and radio clubs are working to establish alternative communications paths between the Service Authority Department Operations Center (DOC), the Prince William County Emergency Operations Center (EOC), and the Service Authority's Advanced Water Reclamation Facility. In November 2018, the Service Authority and the Prince William County Amateur Radio Emergency Service (PWCARES) entered into a Memorandum of Understanding (MOU) for emergency cooperation. During a widespread power outage when land lines and cellular phones may no longer work, amateur radio operators can provide vital communication services to the Service Authority.

Step 3 – Get on the Priority Power Restoration List

- Learn how critical customers are managed and prioritized in your community.
- Engage the power restoration prioritization list manager.
- Determine your utility's prioritization status and take additional measures to get as high on the priority list as possible.
  - Meet with your local EMA to stress the value of water and wastewater services during an incident.
  - Meet with your electrical utility account representative to see what information the electric utility needs to place you on their power restoration priority list.
- Inform the prioritization list manager of your "storm-ready" capabilities and be sure that he or she understands the consequences to the community of drinking water and wastewater service disruptions and reduced service levels. Ensure the list manager understands how quickly water services can degrade without power and how long it takes to restore water services once power is lost.
- Inform the list manager of the critical assets at your utility that rely on grid power including their individual power requirements (e.g., critical functions vs. administration building).
- Gain an understanding of the other critical infrastructure facilities prioritized in the community so that you can align water and wastewater support accordingly.
- Ask for annual updates to the critical customer and prioritization lists.

Critical Customers

Dominion Energy has worked closely with Virginia Emergency Operation Centers (EOCs) to identify the 10-20 most critical services in each of the EOC's jurisdictions. Once identified, these critical facilities are further assigned Special Condition Categories, and water and sewage treatment facilities are considered "Critical Infrastructure." These "Special Conditions" accounts are flagged so Dominion knows instantly when a water or wastewater treatment facility loses power. An intranet application allows Dominion Energy to remain focused on these locations to ensure critical infrastructure accounts receive the highest restoration priority.

In addition, during large-scale power outages, Dominion Energy establishes Electric Regional Operations Centers to better manage its response. Water utilities have a direct line to these centers and to representatives of Dominion Energy.

Step 4 – Planning, Training, and Exercises

Planning, training, and exercises allow power and water utility staff to learn, practice, test, and improve emergency response plans (ERPs) and procedures. Often, these plans and procedures involve response partners. Consider the following options to enhance the quality of your training and exercises:

- Plan with your electric utility to know how various power outage scenarios will affect your utility and what steps you can take together to mitigate impacts.
- If your utility conducts planning activities or annual exercises, invite staff from your electric utility and local EMA.
  - The EPA offers a Tabletop Exercise Tool for Water Systems to help utilities develop exercises for different scenarios.
  - The EPA has also developed How to Develop a Multi-Year Training and Exercise (T&E) Plan to help water utilities create successful training plans.
- Ask your electric utility to allow you to attend any exercises or planning activities it hosts.
- Participate in national exercises focused on grid resilience such as GRIDEX and EARTH EX.
- Ask your local EMA to include both your utility and the electric utility in its exercises.
- Share your emergency response plans with your electric utility and EMA and ask for information and updates on their plans. Consider a dedicated planning component to emergency back- up power (generators).

Grid hardening - *Activities such as tree-trimming help prevent weather related power outages. When talking to your electric utility, you can ask what grid hardening steps are being taken and what you can do to help. For example, do you have the resources to assist in tree-trimming? If your water utility has a remote pump station in the woods serviced by electric power from street lines, consider installing that service line underground along the access road. Although this is more expensive than typical pole installation, the service line will be better protected from tree falls.*

Step 5 – Communicating with the Public

Develop a plan for how you will communicate boil water notices, water use restrictions and other information during a power outage. Many of the strategies below will only work during the first 24-48 hours of a power outage when cellular towers still have back up or battery power. Consider approaches for reaching the public that would work even if landlines, cellular phones, and the Internet are not working. EPA's Water Sector Guide to Telecommunications During Power Outages can help.

- Appoint a communications manager or Public Information Officer who can assist in getting the correct messages out to your customers before, during, and after emergencies.
- Contact local news and radio stations to broadcast your messages or post on their social media accounts.
- Ask the fire department, local EMA, and municipal office to help with your public messages. They may already have emergency communication systems such as reverse 911 in place. Check whether such systems would work for an extended period without power furnished by the electric grid.
- Develop an automated system to send emails and text messages to customers. Some areas may already have an emergency texting service that you can use.
- Post frequent, time-stamped updates on your utility's website.
- Utilize social media by posting updated information with a Facebook or Twitter account.
- Collaborate with homeowners' associations to post signs near different community gates and on community bulletin boards at the Town or City Hall.
- Train communications personnel in Crisis and Emergency Risk Communications (CERC) and Message Mapping for timely, accurate, and productive crisis communications. The EPA offers numerous tools for Water Utility Communication During Emergency Response.

Eye on the Weather - W*eather services can usually forecast storms 24 hours or more ahead of time. The EPA's mobile app Water Utility Response On-the-Go allows you to monitor and track all types of weather. For ice storms, you can also check the Sperry-Piltz Ice Accumulation Index (SPIA IndexTM), which gives a 0-5 ice accumulation and ice damage prediction index. The SPIA IndexTM covers the continental United States and provides predictions days before a storm, including power outage duration possibilities. In California, the Public Safety Power Shutdown (PSPS) is an operational practice of shutting off the power to a limited area during extreme and potentially dangerous weather conditions based on several factors such as red flag warnings, humidity levels, and high wind conditions. Check to see if you have something similar in your state and ensure your utility is closely coordinated with the agency issuing the PSPS.*

2. Power Assessments

TOP TIP: Have a licensed electrician assist you with your power assessment.

Power assessments determine your utility's emergency power requirements for critical equipment to maintain water and wastewater services. A power assessment team typically includes electrical, mechanical, and operational subject matter experts. These are the appropriate utility professionals who can fully assess utilities' power needs and operational implementation requirements. They will inspect all infrastructure assets at your utility. You will determine electrical assets critical to your operation. Critical infrastructure components will be unique at each utility, but usually include treatment processes and key pumping stations. This information is required to properly size an emergency generator(s), and a reference to its location should be included in your ERP. You can learn more about power assessments and generators in the free, two-hour online course, IS-815: ABCs of Temporary Emergency Power, offered by the Federal Emergency Management Agency (FEMA) Emergency Management Institute.

Step 1 – Conduct an Emergency Power Assessment at Your Utility

- Conduct a Self-Assessment – Perform your own emergency power assessment, with the assistance of a qualified power assessment team.
- When you upgrade your facilities or build new components, re-assess your power requirements to determine if you also need to add generator capacity, battery banks, or on-site renewable energy.
- Periodically review and update your emergency power requirements, especially when replacing assets and remodeling buildings.
- If possible, conduct a hydraulic model-based assessment of how performance measures would be impacted when your facility is powered by generators instead of the electric grid, and how failures of one or more generators would affect performance.
- Consider installing stationary generators with automatic transfer switches at all "critical" facilities to ensure they will stay in operation should the power go out.

Step 2 – Keep Records of Your Assessment

- Maintain a copy of all information from the power assessment with your ERP, so you can easily locate it during emergencies. You should have a summary of the power requirements, siting requirements, location, and capacity of any existing on-site generators at all critical infrastructure components.
- Generator-specific information requirements include the kilowatt, voltage, and phase of the generator required. The assessment should also include the electrical connection type, either delta or wye.
- Appendix A is an example of a Generator Information Sheet* that a utility could use for each of its generators.
- The assessment should include the GPS latitude and longitude in degrees-minutes-seconds or in decimal degrees of the location of any existing or needed generators. If possible, record any decimal degree GPS data values to the sixth place to the right of the decimal point.
- The assessment should also include a basic order of materials with information on the number and length of cables needed to connect a generator to the utility's electrical system, the number and size of lugs to connect the cable runs, and the number and designed location of grounding rods required.

** Clicking this link will open a MS Word document you can modify and/or complete.*

3. Generators

TOP TIP: Know what type of generators you need and where you would get them during a power outage.

Choosing a Generator

Once you know your generator requirements, you need to make several decisions to find the best one for your utility. A generator is classified by its power rating. Two distinct power ratings are prime power and emergency standby. The average load factor for both types is 80%. Table 1 below compares some general characteristics of the two types of generators. The Cybersecurity and Infrastructure Security Agency's (CISA's) Resilient Power Best Practices for Critical Facilities and Sites provides detailed comparisons and information on generator types including rating and fuel type.

Table 1. Generator Comparison

	Prime Power	Emergency Standby
Length of use	Rated for extended periods of operation at variable loads	Designed for short-term use; typically rated to operate no more than 200 hours per year
Impact of operating longer than prescribed hours	N/A	More frequent breakdowns and malfunctioning
Cost	More expensive because they are designed to meet operational loads for an extended period of time	Less expensive

Regulations

As you compare generator options, check local, state, and federal regulations on generators, fuel storage, and use and maximum permissible testing. In most cases, a local or state air permit is needed to install and operate a stationary generator. There are also federal regulations for stationary reciprocating internal combustion engines (RICE). Most states implement the federal air quality program and states can also impose additional requirements. The specific requirements depend on your jurisdiction, as well as the age, type, and size of the generator. The regulatory requirements also depend on the type of fuel. Compression Ignition (CI) RICE run on diesel fuel while Spark Ignition (SI) RICE use natural gas, propane, and gasoline.

Step 1 – What Size Generator Do I Need?

The first step in choosing a generator for your utility is to determine the right size. Your power assessment can help you size your generator(s). The key components of a generator are voltage, load, phase, and rotation.

1. **Voltage** - The generator must have the appropriate voltage to match the motor(s) it will be powering.
2. **Load** - You need to know the Full Load Amps (FLA) of all the motor(s) you intend to run off the generator. This is the amount of current (amps) the motors will draw from the generator when producing their rated output horsepower. If running more than one motor, you must know the startup (inrush power) in kWs needed to start multiple motors. There are formulas for calculating this value.
3. **Phase (Rotation)** – Phase is a requirement for a single or multiphase generator based on what the generator will be powering. The direction of the motor rotation (i.e., clockwise or counterclockwise) determines the order of voltage waveform sequences, or the phase rotation. If incorrect, it could damage the pump(s) at startup.

In addition to knowing your equipment's electricity requirements, consider the following when sizing your generator:

- If you are relying on a single, large generator (e.g., greater than 500-kW), consider installing two smaller generators in parallel instead to increase backup power reliability. It is unlikely that both smaller generators will fail at the same time. While you would not be able to power everything if one failed, you could still maintain part of the load.
- There are limited generators that produce two megawatts (MW) or more. Segmenting your load (e.g., pumps) so that smaller generators used in combination can meet the demand will increase your chances of locating and receiving generators during an emergency and thus increase resilience.
- Determine whether a portable or stationary generator will work best for your critical infrastructure assets. Portable generators are better for smaller electric demands that do not require uninterrupted power. These generators can also be transported to multiple sites.
- If your electric demands are significant, consider larger, stationary generators fueled by either natural gas or diesel. These generators can start-up within seven to ten seconds of a power outage and provide power to critical equipment quickly.
- Supplement your planning with hydraulic modeling across multiple “what if” scenarios to determine the service consequences of reduced power support and to explore the potential benefits of portable generators and “rolling blackouts” of specific components.

Step 2 – Should I Buy, Rent, or Borrow a Generator?

Your state's WARN can make it easier to borrow a generator and other resources during a regional emergency. If you are not a member, consider joining.

- Know what "type" of generator you may need and can receive from WARN partners. The American Water Works Association (AWWA) Resource Typing Manual provides information on resource typing.
- Investigate how your state water sector associations and local emergency management agencies can help. In Florida, both the Florida Rural Water Association and the Florida Division of Emergency Management maintain generator pools for distribution as needed. A good working relationship with your local emergency manager will be critical to receiving a state or federal generator.
- Many private vendors sell or rent generators (see Table 2 for pros and cons). If you plan to rent a generator, set up a contract with a vendor. Since many people may need to rent generators during a power outage, know where you stand in terms of priority with your generator vendor.
- Another option is to rent and store a portable generator during storm season.
- You may want to try electrical resiliency-as-a-service with a private provider. For example, a microgrid (see Section 6) may be able to be installed at your utility that uses natural gas and renewable natural gas generators. These microgrids are managed around the clock by the private provider and come with design, installation, operation, maintenance, warranty, and support services at an ongoing and predictable expense. The expense is offset by the provider aggregating the generators and selling power back to the grid when the generators are not being used in an emergency.
- Appendix B is an example of a Generator Request Form*.

** Clicking this link will open a MS Word document you can modify and/or complete.*

3
Generators
Step 1
Size
Step 2
Ownership
Step 3
Fuel Type
Step 4
Connection
Step 5
Placement
Step 6
Maintenance
Tips

Table 2. Generator Purchase or Rental - Pros and Cons

Generator	Pros	Cons
On-site (purchased)	• You know you have one • Reduced time to respond • Can be wholly managed by others	• Could be costly and unaffordable, depending on option selected • You perform the maintenance if you own the generator • The disaster that strikes your utility could also damage your generator
Off-site (rented or borrowed)	• Multiple sources to get one – EOC, WARN, vendor, FEMA • Someone else performs the maintenance • Costs less than buying	• Travel delays to get it to your site • Your utility might not be high on the priority list to get a generator

Step 3 – What Type of Fuel Should I Use to Run my Generator?

In addition to portability, fuel type is an important consideration for selecting a generator.

- Diesel generators are the most common and offer the largest selection, availability and power range.
- Smaller water utilities with lower power requirements and fewer resources might consider portable, gasoline powered generators.
- Smaller water utilities can rotate several portable, gasoline generators between lift and pump stations as necessary. This method (rolling blackout) allows a utility to have backup power without buying a dedicated generator for each site.
- You could also consider bi-fuel generators to increase your fuel options during an emergency. These generators can switch between two different fuel types, such as natural gas and diesel. Usually, this choice is automated and dictated by what fuel type is more efficient for the given conditions and needs, but the choice can also be made manually based on what fuel type is available. For example, if natural gas lines are broken or shut off during a disaster, diesel can be used.
- Natural gas generators do not require truck refueling and usually run quieter and with less air emissions than diesel generators. However, natural gas generators tend to produce less power than diesel generators and therefore your utility may require a larger natural gas generator to power the same load as a smaller diesel generator. You should also consider that the incident may affect natural gas delivery and prepare a contingency plan for such situation. For example, an earthquake could cause breaks in natural gas pipes, which would shut off supply to affected areas. See Table 3 for a comparison of fuel types.

Starting Currents and Generator Sizing - *Cross-line starts (as opposed to soft starts) of equipment require higher starting currents and therefore a larger generator. High and premium-efficiency motors also require higher starting currents and therefore a larger generator to handle the startup current draw.*

Useful Tip:

If using multiple generators, try to select generators from the same manufacturer to make servicing the units easier.

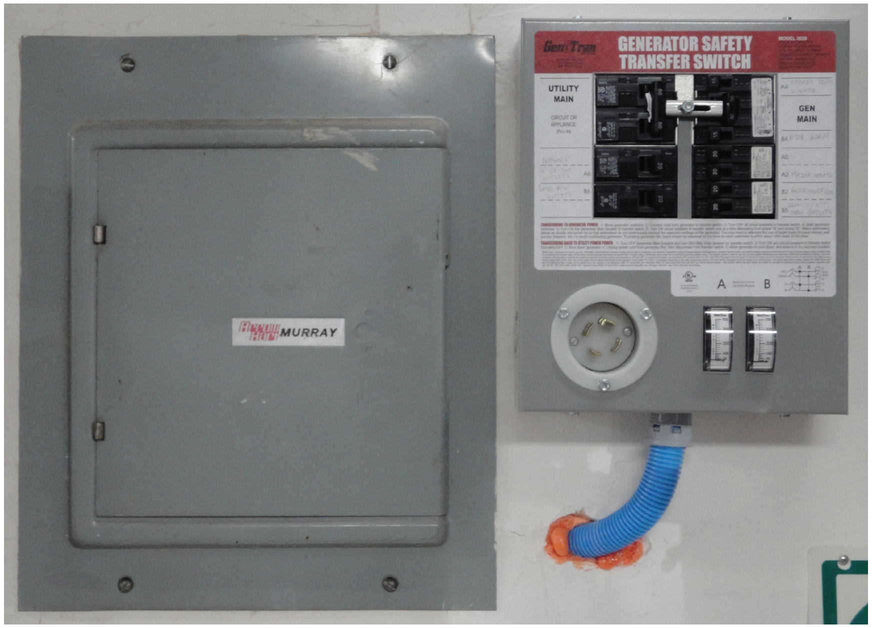
Step 3 – What Type of Fuel Should I Use to Run my Generator?

Table 3. Generator Fuel Type - Pros and Cons

Fuel Type	Pros	Cons
Diesel	• Powers large generators • Lasts longer than gasoline • Readily available • Safer to handle and store	• Requires deliveries • Requires on-site storage • Risk of spills • Environmental restrictions • Limited storage life
Natural Gas	• Does not require truck delivery • Does not require on-site storage • Does not expire • Supply is relatively inexhaustible	• Generator cost may be more expensive • If natural gas service is interrupted, there are limited back-up options • Risk of explosion
Propane	• Does not expire • Easily available in rural areas	• Requires deliveries • Requires on-site storage • Limitation of generator size • Leased storage tanks limit fuel provider choice • Risk of explosion
Gasoline	• Powers smaller, portable generators • Readily available	• Typical shelf life is 2-3 months or less if stored in the equipment • Requires deliveries • Requires on-site storage • Risk of spills • Worst storage life of all options • Size limitations • Risk of explosions

Step 4 – How Will I Connect a Generator to my Loads?

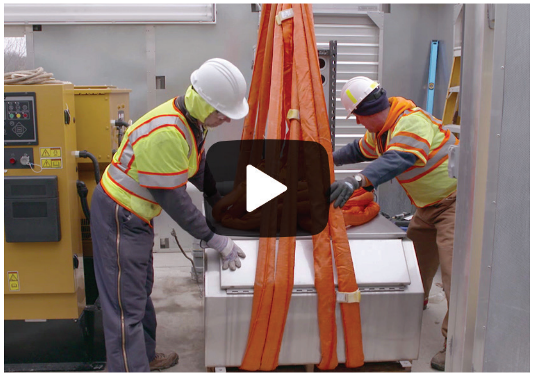
Generators require a special connection, or transfer switch, to rapidly connect to your facility's equipment and prevent potentially harmful back-feeding into electric lines. Transfer switches allow you to easily switch back and forth between grid power and on-site generator power sources. See the additional tips below on installing transfer switches.



- Clearly depict the location of the transfer switch on site maps.
- Install transfer switches at eye level to make generators easier to connect in an emergency under poor weather and lighting conditions.
- Consider installing automatic transfer switches that automatically move from grid power to generator power when an outage is detected at unmanned facilities or at critical equipment.
- Consider connecting these sites into the utility supervisory control and data acquisition (SCADA) system to know when the automatic transfer switch has been activated.
- Consider installing a manual transfer switch for facilities or other pieces of equipment that do not need to be automatically transferred to an alternate power source during a power outage. The likely dispatch time for an operator to access the site should be considered in the determination of a manual versus automatic transfer switch.
- Ensure that personnel responsible for manual transfers receive appropriate training on switch operations.
- The connection type for portable generators must be considered when sharing resources or ordering from an outside vendor. Examples of some known plug types are Appleton, single cable cam-locks, hardwired, and outside building tap-box.

Step 5 – Where Will I Keep a Generator?

Make sure you keep your generator at a secure location. Some tips include:



Video: Generator Placement

- Locate generators and their fuel tanks above flood levels. A common height requirement for critical infrastructure is three feet above the 100-year floodplain, although some utilities are using the 500-year floodplain for an added margin of safety. Check your local and state requirements.
- Consider installing a concrete pad to provide a stable surface for a portable generator during an outage.
- Use weatherproof enclosures to protect generators and electric equipment.
- Get an enclosure large enough to provide easy access to the generator's radiator, fuel tanks, air and oil filters, and charging system.
- Cover a generator with a roof to increase its life expectancy. Position the generator pad so that a roof can be added later.
- Maintain three or four feet of clear space on all sides of the generator for adequate ventilation.
- Buy or rent a generator built with acoustical steel and sound insulation if it will be in a residential area.
- Address security at all planned mobile generator locations to prevent generator or fuel theft.
- For portable generators, consider where you will store them (e.g., single location, distributed locations) and how you will transport them (e.g., pickup bed, trailer) to their potential areas of use.

3
Generators

Step 1
Size

Step 2
Ownership

Step 3
Fuel Type

Step 4
Connection

Step 5
Placement

Step 6
Maintenance

Tips

Case Study: Monmouth County, New Jersey

In southern Monmouth County, a wastewater pumping station was redesigned to utilize a mobile trailer to house the pumping station's expensive primary electric equipment and controls. This way, the trailer can be moved out of danger during floods. Cables and plugs provide the connection between the pump station and the electric and control equipment in the trailer. When a storm threatens, the utility removes the trailer and mounts a cheaper secondary electric and control system at the site. The secondary system then powers and operates the pump station on either grid or generator power until after the storm, when the trailer can be safely returned to the pumping station. A mobile enclosure may seem costly, but it saved the South Monmouth Regional Sewerage Authority an estimated $1.5 million in repair and recovery after Hurricanes Irene and Sandy.

Step 6 – How Should I Maintain a Generator?

If generators are not maintained, they will not function properly during emergencies. This could leave your utility without backup power when you need it the most. Maintenance requirements for generators vary, so be sure to have a contractor or trained utility staff perform scheduled maintenance as recommended by the manufacturer. Store printed maintenance manuals where they are protected and accessible.

Generator Operation and Maintenance Tips

- Regularly run generators under full load for extended periods to test for any problems.
- Test the generator under load every time after it is serviced. One utility has specific requirements for load tests for a specific run time at each interval of 50%, 75%, and 100% to fully test under expected loads for a proper time duration.
- Perform additional maintenance requirements for a generator that is planned to be used for ten days or longer.
- Record all maintenance activities to assess performance and operating costs to inform predictive maintenance requirements and future buying decisions.
- When you change the oil in your generator, consider sending a sample to be tested for the presence of metals. Metals could indicate engine wear, which may indicate that other repairs are needed.
- Test fuel to make sure it is still viable. Consider fuel conditioning or fuel replacement on a regular basis to maintain the quality of the fuel in the tank.
- Consider service requirements when selecting the generator location for ease of service access and replacement.
- Consider National Fire Prevention Association (NFPA) 110 requirements.

Generator Servicing Requirements

The manufacturer provides recommendations for operational generator service requirements. The standard service interval is 240 operational hours or ten days of continuous operations. During emergencies, scheduled maintenance should be used instead of 'condition-based' or 'predictive' maintenance. Typical items serviced at this interval include:

- Change diesel engine oil.
- Change diesel engine oil filter(s).
- Change diesel engine fuel filter(s).
- Change diesel engine air filter(s).
- Check diesel engine coolant levels and replenish as required.
- Check items such as the fan belts for any abnormal wear or damage while the engine is turned off.

Did you know?

During Hurricane Sandy, many generators failed after 24 to 48 hours because they had not been properly exercised and maintained.

Generator Use Tips

Your utility can take basic actions to prepare for disasters that may include power loss. Below are tips for utilities using generators in emergency situations. Keep in mind that when operating under emergency power protocols, you now have the added requirement of operating like your own electric power utility and staff will be needed to fuel, operate, and maintain your generators.

- ☐ Conduct a facility-specific power assessment to determine generator needs. This can significantly reduce response time during an emergency. If possible, couple this with a hydraulic modeling-based assessment of system service performance.
- ☐ Give completed assessment forms to your local EOC or emergency management agency.
- ☐ For large scale incidents with advance warning, such as Category 3 and above hurricanes or major ice storms, consider going off the grid and using your generators in anticipation of a power outage. This proactive measure can prevent operational disruptions and protect electric equipment but will need to be balanced with how long your on-site fuel supplies can last.
- ☐ Monitor power quality and go off the grid and switch to generators if there is poor power quality. Power fluctuations can damage equipment.
- ☐ Consider using SCADA programming to inhibit some wells and boosters if a generator is installed. Some stations have too many motors for a portable generator to run. Running all the motors could cause the generator to kick-off due to the high load.
- ☐ Identify three-phase requirements and require monitoring capabilities and procedures. When power is restored, all three phases may not be available, which can damage three-phase equipment.
- ☐ Determine the need for protection against equipment failure caused by undervoltage, overvoltage or frequency variance.
- ☐ Keep smaller generators on trailers for emergencies. The generators can be safeguarded during the incident, but easily transported to sites when needed. Address operations, security, and logistics (maintenance, fuel, parts) for mobile generators at each site.

Generator Use Tips (continued)

- ☐ If possible, outfit portable generators with GPS to keep track of their locations when moved both inside the system, or outside (in the case of sharing a WARN resource).
- ☐ Maintain printed maintenance manuals and keep readily accessible.
- ☐ Keep basic maintenance supplies on hand (e.g., coolant, belts, oil, fuel filters) to quickly repair or service a generator if it breaks down.
- ☐ Develop an Asset Management Plan for your generators to make sure they and their resources are maintained properly.
- ☐ Plan for a “backup” to your backup power. One option is to reserve a portable generator from a rental pool during storm season and determine how you will connect it to your backup system.
- ☐ Outfit equipment connected to stationary generators with another generator cable connection to bring in an additional unit should the stationary generator fail

Video: Paralleling Generators

4. Fuel

TOP TIP: Have multiple ways to get and move fuel during an emergency.

You must maintain fuel on-site and have multiple ways to obtain additional fuel from vendors and other sources during emergencies. It may be difficult or impossible to get fuel from outside sources to keep your generators operating for an extended period. Your fuel suppliers may stop their operations due to the power loss, transportation difficulties, or other damage. If you lease propane fuel tanks, the supplier from whom you leased them is typically the only one who can fill them. Buying your own propane storage tanks may give you more supplier options.

Video: Fuel

To keep your generators running during an emergency, you should develop a fuel plan that addresses:

- How much fuel you need to operate each of your generators for one day
- Total on-site fuel capacity
- How you will re-fuel your generators, including those in remote locations
- Contracts with multiple fuel vendors
- Plans for using alternate fuel, such as for bi-fuel generators
- Multiple options to move fuel during an emergency
- Staffing the significant 'extra' operation of fuel supply
- Risks associated with conducting a resupply operation in a seriously disrupted operational environment

The rule of thumb that the U.S. Army Corps of Engineers uses to calculate diesel fuel requirements is:

0.07 gallons/hour x kW size of the generator x 24 hours/day = gallons of fuel required per day

Fuel Tank Sizing - *You do not want to run out of fuel during a power outage. One utility manager recommends storing enough fuel to run a generator at 70% load for five days. Typically, having this amount of fuel on hand enables this utility to run a generator for seven to nine days without running out of fuel, while it transitions to a continual resupply situation.*

Tips

- ☐ Consider green power options that could supply some of your equipment during an outage and offset the need for a generator and fuel supply.
- ☐ Determine fuel storage constraints (regulatory and security). Fuel regulations vary by state and local jurisdiction.
- ☐ Know and continually update your fuel demands – how much fuel do you need to run your generators for 24 hours? One week? One month? Do some generators burn through fuel faster than others?
- ☐ Write refueling requirements into generator rental contracts. For example, the generator must be delivered with a 24-hour fuel supply.
- ☐ Add fuel management into your generator maintenance schedule to ensure availability of clean, reliable fuel.
- ☐ Clean all fuel tanks at least every five years to avoid sludge build up.
- ☐ Use gel and fuel additives (e.g., algaecides) to reduce biological activity that produces fuel sludge.
- ☐ Use a portable fuel polishing unit to avoid contamination and to ensure fuel is always ready to use.
- ☐ Refill fuel tanks before they are empty to avoid drawing up any fuel sludge accumulation.
- ☐ Ask if your fuel service provider can remotely monitor your fuel tank levels and automatically dispatch a truck to fill them when they fall below an agreed upon level. This ensures your tanks are as full as possible in the event of a no-notice incident such as an earthquake.
- ☐ Have multiple vendors from different supplier regions under contract so that you can maintain your fuel supplies if one vendor cannot deliver.
- ☐ Create a map of all your fuel providers and note details such as the types of fuel they sell and their backup power options (e.g., do they have their own generator, or would they need you to hookup one of your portable generators to pump fuel?).
- ☐ Ask your vendor to store additional fuel for your utility during storm months.

Tips (continued)

- ☐ Ask your WARN and local EOC to help provide fuel for your utility's generators during an emergency.
- ☐ Coordinate your fuel needs with other critical infrastructure in your area (e.g., hospitals, police stations, schools), as it may be possible to have multiple deliveries from one fuel truck and realize economies of scale when establishing contracts.
- ☐ Be aware of limits on who can refuel leased fuel storage tanks. You can purchase your own tanks if necessary.
- ☐ Have fuel filters (at least one complete filter set per generator) on hand because they will not be readily available during an emergency.
- ☐ Be prepared to move your own fuel without contractors. Trucks mounted with 100-gallon fuel tanks do not need HazMat placards. Generally, any tank over 119 gallons requires hazardous materials placarding and licensing.
- ☐ Reduce your energy consumption while using generators using pre-planned protocols to make the most of the available fuel.
- ☐ Consider establishing a local and regional emergency fuel plan to increase fuel availability through emergency channels during a disaster.

Reducing Fuel Consumption

In 2012, the New Brunswick Water Utility in New Jersey was able to stay operational for an additional six days during Superstorm Sandy by reducing generator fuel consumption. Thinking creatively, the operators put the entire plant on gravity filters, shutting down the energy consumptive membrane filters. This operational change successfully reduced fuel consumption by approximately two-thirds (from 120,000 gal/day to 40,000 gal/day).

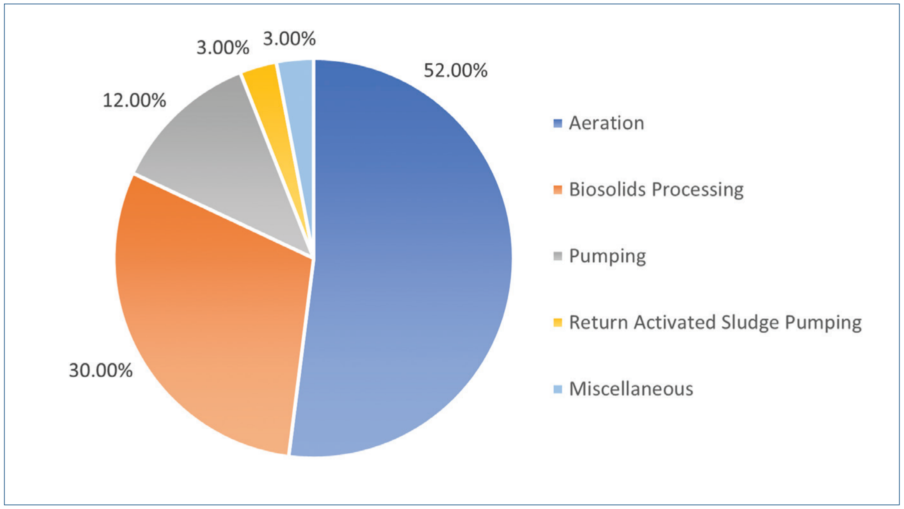
5. Energy Efficiency

TOP TIP: Install energy efficient equipment to reduce energy needs and increase power resilience.

An important first step to increasing power resilience is to conduct an energy assessment and identify ways to decrease overall energy use. There are often no- and low-cost measures water utilities can implement to decrease their energy usage (e.g., improving operations and maintenance procedures). These measures not only provide cost savings but can also increase resilience as they reduce the back-up power needs (e.g., generator capacity or fuel requirements) during a grid outage.

Public drinking water and wastewater utilities, which are primarily owned and operated by local governments, can represent 30%-40% of a municipality's energy bill (CRS, 2017). U.S. public drinking water systems comprise approximately 1% of the total electricity use in the country and municipal wastewater treatment systems use about 0.8% of the total electricity use in the U.S. (EPRI and WRF, 2013).

Even small improvements in energy efficiency can lead to significant energy and costs savings. Pumping is the largest energy use at drinking water utilities and includes raw water pumping, in-plant pumping, and finished water pumping. Estimates vary depending on distribution system hydraulics, but pumping can range from 55% to 90% of overall electricity use at a drinking water utility (EPRI and WRF, 2013). At wastewater utilities, the largest energy uses are typically aeration, biosolids processing, and pumping (EPRI and WRF, 2013).



Typical Energy End-Uses in Municipal Wastewater Treatment (WRF and EPRI, 2013)

Energy Assessments

The first step in increasing energy efficiency is often to conduct an energy assessment. An energy assessment, or energy audit, can help you understand how much energy your utility uses, which processes consume the most energy, and opportunities to increase energy efficiency. An energy assessment would likely include:

- An analysis of utility energy bills
- Site data collection
- Determination of original plant design capacity and current plant capacity
- Comparison of current performance with potential performance
- List of potential energy efficiency improvements with cost estimates, energy savings, and anticipated payback periods

Some electric utilities provide energy assessments and there are professional energy assessment services. Additionally, water associations and the Department of Energy (DOE) and offer a variety of technical assistance and tools.

Technical Assistance Program and Tools

- The National Rural Water Association (NRWA) has an Energy Efficiency Technical Assistance Program in 33 states to promote energy efficient practices in small water and wastewater systems. The program performs energy assessments, recommends energy efficient practices and technologies, and provides support in following recommendations.
- Drinking water and wastewater utilities with annual energy bills between $100,000 to $3.5 million may be able to receive no-cost energy assessments from DOE Industrial Assessment Centers (IACs). Teams located at 37 universities around the country conduct the energy assessments to identify opportunities to improve productivity and competitiveness, reduce waste, and save energy.

- DOE developed a free, open-source tool, Manufacturing Energy Assessment Software for Utility Reduction (MEASUR) Software Suite, to help water utilities and other manufacturers improve the efficiency of specific systems and pieces of equipment within a plant. MEASUR includes numerous assessment tools and over 65 standalone calculators including a wastewater optimization module, pump system assessment tool, and a treasure hunt module to help users quantify savings for low/no cost energy opportunities.
- DOE's Better Plants Program is a voluntary partnership that aims to drive significant energy efficiency improvements across energy-intensive industrial companies and organizations. The program components include energy-saving resources, technical assistance, and in-plant training. Better Plants works with leading U.S. manufacturers and wastewater treatment agencies to set ambitious energy, water, waste, and carbon reduction goals and commit to reducing energy intensity by 25% over a 10-year period across all U.S. operations.

Case Study: Wastewater Treatment Plant Energy Assessment, Blairsville, Georgia

The Georgia Rural Water Association (GRWA) implemented its Energy Efficiency Program in July 2019 to assist water and wastewater utility systems in evaluating their energy consumption and costs. Improved energy efficiency can reduce operating costs and free capital for other priorities and additional investments. The GRWA standard energy efficiency assessment evaluates current and past energy use, identifies the primary energy consuming components, and seeks to identify low-cost opportunities for energy efficiency.

Blairsville is a small city of about 724 people in Union County, Georgia. The city's wastewater treatment plant (WWTP) is a Sequencing Batch Reactor (SBR) Activated Sludge Plant designed to treat one million gallons per day of wastewater. The plant began receiving leachate in September 2019. The plant staff used this increase in organic and nitrogen loading as an opportunity to observe the process and take steps with GRWA to optimize the operation of the facility.

GRWA conducted an initial energy assessment for the WWTP in the latter part of 2019 and identified several conservation measures. The city implemented a variation of two of those recommendations. First, the city modified the target dissolved oxygen concentration in the aeration basin. Next, the city reduced the digester aeration time. As a result of implementing these two strategies and experimenting with some additional strategies, in 2021 the city realized a 16% reduction in energy consumption and a 15% reduction in energy cost amounting to an annual savings of $17,715 compared to 2019.

In 2022, GRWA conducted a follow-up assessment to identify additional ways to increase the energy efficiency of the plant. The alternatives, outlined in the table below, include installing two variable frequency drives (VFDs) and reducing the aeration run time. As the table illustrates, the payback period can be very short for energy conservation measures with minimal capital costs.

Item #	Project Item	Energy Conservation Measure Discription	Annual Energy Savings (kWh)	Annual Cost Savings ($)	Estimated Cost of Improvement ($)	Payback (Years)
1	Influent Pump	Add a VFD to the Influent Pump Station and Set to Operate at a minimum 80% speed during normal operating conditions.	13,310	$2,296	$4,700	2.0
2	SBR Blower	Add a VFD to the Blower motor and Set to Operate at a minimum 85% speed during normal operating conditions.	107,862	$13,432	$8,300	0.6
3	Digesters	Reduce Aeration Run time from 12 hrs/day to 6 hrs/day.	87,008	$5,372	$0	0.0
		Total	**208,180**	**$21,101**	**$13,000**	**2.6**

Energy Efficiency Measures

EPA's Energy Efficiency in Water and Wastewater Facilities describes three categories for improving energy efficiency in water and wastewater facilities: equipment upgrades, operational modifications, and modifications to facility buildings.

Equipment Upgrades

Equipment upgrades usually involve installing energy efficient products and technologies and are often included as part of larger capital improvement projects. Some examples of equipment upgrades include:

- Replace pumps or blower with more efficient models
- Install right sized pumps and blowers
- Install automatic controls such as variable frequency drives (VFDs) where appropriate

Case Study: *Wastewater Treatment (WWTP) Plant Upgrade Project, Weiser, Idaho*

The City of Weiser received $6 million in Clean Water State Revolving Fund (CWSRF) financing to upgrade its WWTP with:

- *Biological phosphorus removal using anaerobic and anoxic conditions*
- *Installation of a new Dissolved Oxygen control system, new aeration blowers, VFDs, new larger diameter air piping, new tapered aeration diffusers, and chemical treatment for polishing phosphorus removal*

The project resulted in energy savings of approximately $45,000 per year. The cost savings from reduced energy bills will offset initial cost. The project also improved effluent quality and increased the treatment capacity needed for the growing community.

Variable Frequency Drives: *A variable frequency drive (VFD) is a type of motor drive controller that drives an electric motor by varying the frequency and voltage of its power supply. At pumping stations, VFDs can reduce the speed of the pump motor shaft and the resulting pumping rate. While VFDs can significantly reduce energy costs, utilities should examine pumping curves and operational data to determine where they can be cost effective. Additionally, VFDs can introduce cybersecurity vulnerabilities that need to be addressed. Many new generation VFDs allow for vendor access to support configuration and optimization monitoring, which introduces a significant third-party risk vector.*

Operational Modifications

Operational modifications involve changing procedures to reduce the amount of energy required to perform specific functions or to reduce energy costs by changing how and when equipment is operated. They may not require capital investments and can result in greater savings than equipment upgrades.

- Optimize pumping: Water utilities can use pump curves, operational data, and pump tests to determine the most energy efficient use of pumps for current conditions.
- Match the oxygen supplied to the system demand
  - Test, calibrate, and maintain dissolved oxygen level/sensors in aeration tanks
  - Turn down or turn off aerators
  - Adjust the number of bacteria in the system
  - Avoid excessively high dissolved oxygen concentrations
- Turn off equipment when not in use
- Maintain and check equipment
  - Check aeration diffuser operating pressure
  - Change aeration blower intake filters regularly to minimize air intake resistance
  - Check for buildup of pressure in air distribution piping (condensate, control valves)
  - Identify and fix compressed air leaks
  - Clean dissolved oxygen sensors and diffusers
  - Clean ultraviolet lamps (mechanically and chemically)
  - Calibrate meters and sensors
- Reschedule plant operations or reduce load to avoid on-peak hours. Learn more about your rate structure from your electric provider and look for opportunities to reduce energy costs.

Case Study: *Wastewater Treatment Plant, Carthage, Tennessee*

The Carthage WWTP participated in an Energy Management Initiative of the Tennessee Water and Wastewater Energy Efficiency Partnership, a joint technical assistance program through the U.S. EPA Southeast Regional Office, U.S. Department of Energy, and the Tennessee Department of Environment and Conservation. The plant reduced its energy usage by 19.4%.

Carthage is city of approximately 2,300 residents about 50 miles east of Nashville. The wastewater treatment plant has a design capacity of 625,000 gallons per day (gpd) and currently treats 330,000 gpd. The plant has an annular aeration basis with a clarifier in the middle. Two aerobic digesters, operated in series, further treat the biosolids.

The energy assessment revealed that the solids retention time in the aeration basin and first digester was sufficient to treat the solids. Since the aeration in the second digester was redundant, the team recommended decreasing the operating time of the aerator in the second digester from continuous to six hours per day. The utility staff started manually turning the aerator on and off as a part of their routine duties and this single change reduced electric costs by 14% per month. Overall, the utility reduced its electric bill by $8,000 per year and used some of the savings to purchase a timer to automate turning the aerator on and off.

Modifications to Facility Buildings

Modifying buildings to utilize more efficient heating, air conditioning, and lighting enable can decrease energy demands and costs. Some common improvements include:

- Install timers and occupancy sensors on light switches
- Install programmable thermostats
- Reduce space conditioning during non-occupancy times
- Check for exposed air and water piping in need of insulation

Case Study: *Wastewater Treatment Plant Heating, Ventilation, and Air Conditioning (HVAC) Tuning, City of Albany, Oregon*

The City of Albany, Oregon, used existing equipment to save 91,480 kWh per year, which reduced its energy costs by $5,269 annually. Staff used a remote terminal unit (RTU) in the operations building to adjust settings to match occupancy. They also increased the cooling set point and cycle fan in influent pump station and motor control center room.

6. Renewable Energy and Microgrids

TOP TIP: Start small such as adding some solar panels, then use the energy savings to increase your renewable energy portfolio and add energy storage so that your utility has the potential to create a microgrid and supply its own power during a grid outage.

There are increasing opportunities for water utilities to use renewable energy sources, also known as distributed energy resources (DERs). These opportunities have become available as DERs continue to develop and improve, the relative costs of implementing the technologies decrease, and funding becomes available through resources such as the Inflation Reduction Act (see Section 8). DERs can provide a variety of benefits for water utilities. DERs can help utilities be more resilient during grid power outages, meet goals and mandates, deliver cost and energy savings, potentially provide revenue through the sale of excess power produced back to the grid/electric utility, and provide environmental benefits (e.g., less air pollutants).

An emerging application for DERs is resilience—providing power during the loss of grid electricity. To enable renewable energy sources to provide backup power, a method to store renewable energy for later use is needed, as well as the ability to operate these power sources independently of the grid. This is when a microgrid is helpful. A microgrid is a group of interconnected loads (e.g., pumps, treatment systems) and DERs (e.g., solar, wind, batteries) that acts as a single controllable entity with respect to the grid. It can connect and disconnect from the grid to operate in either grid-connected or "island" mode (NREL, 2022). In island mode, a water utility's microgrid can provide backup power during a grid outage.

DERs and microgrids are further discussed below.

Solar

Solar power is more affordable, accessible, and prevalent in the United States than ever before. From just 0.34 gigawatts (GW) in 2008, U.S. solar power capacity has grown to an estimated 97.2 GW in 2022 (DOE, 2022). In the simplest terms, solar panels absorb sunlight as a source of energy to generate electricity. They can be installed in a variety of ways at water utilities including ground mount on vacant land surrounding treatment plants; sites such as Brownfields, Superfund, Underground Storage Tank, and Resource Conservation and Recovery Act areas deemed safe for use; canopy in a parking lot; building integrated; and rooftop systems. Technologies include photovoltaic (PV), concentrating solar-thermal power (CSP), thin film, and building-integrated photovoltaics (BIPV). During Hurricane Ian in 2022, the solar-powered community of Babcock Ranch, Florida never lost power or water despite the heavy damages and power outages to surrounding communities (NPR, 2022).

An emerging area in solar power is floatovoltaics (FPV), which are floating PV solar panels or floating photovoltaics. FPVs work well in areas with limited land availability and are well suited for use with an asset such as a surface water reservoir or wastewater treatment lagoon. The Town of Windsor in California installed a 1.8 MW floating array on one of its recycled water ponds.

Case Study: Blue Lake Rancheria, California

In 2019, California experienced widespread power shutoffs, known as public safety power shutoff (PSPS) events. These shutoffs occurred in several counties in Northern California and several areas in Southern California to reduce the chances that a sparking power line would start a large wildfire. Despite the shutoffs, the Blue Lake Rancheria Tribe's main campus remained operational, relying on a solar microgrid. The Rancheria's gas station also stayed operational, running on a backup diesel generator (which has since been replaced by a second solar microgrid). The gas station delivered fuel and other services for emergency response vehicles and government agencies. Ultimately, the microgrid allowed community members to charge cell phones and electric vehicles, access the Internet, protect the medically vulnerable, and it gave an electrical boost to municipal water and sewage systems.

As shown by the USDA Forest Service's Greening Fire Team, solar can also be used on a very small scale to aid incident response during power outages. For example, phones and radio banks can be charged using portable solar panels during daylight hours. Solar light towers make use of solar panels combined with batteries to help illuminate work areas post-sundown.

Wind

The United States' wind power capacity was about 136 GW at the end of 2021, making it the largest renewable energy source in the United States (DOE, 2022). Wind energy offers many advantages: it is domestically sourced, cost effective, clean, and sustainable. Many of the best wind sites are found in rural areas, and many utilities have assets in remote areas that could work well to site a wind turbine.

Wind turbines convert kinetic energy from wind into electrical energy. Turbines can be large or small and matched to the electrical needs of an individual facility. "Micro" turbines can be used for tasks such as recharging batteries. Much more information regarding small scale wind applications can be found in DOE's Small Wind Guidebook for homeowners and small businesses.

Case Study: Inland Empire Utilities Agency, (IEUA) Chino, California

IEUA is a regional wastewater treatment agency and wholesale distributor of imported water in Southern California. IEUA serves approximately 875,000 people in western San Bernardino County. To offset both operation and maintenance costs and electricity costs, IEUA manages five MW of solar facilities, a one MW wind turbine, and four MW of battery energy storage as part of a microgrid. The battery storage systems integrate IEUA's DER installations and give IEUA the ability to optimize the delivery of self-generated electricity. Although IEUA currently relies on generators for backup power, the Agency is exploring the possibility of installing a microgrid that would have the ability to island during a grid outage.

The wind turbine stands 180 feet high and has three blades that span 100 feet in length and provides a portion of the electricity needed at the plant. The wind turbine went online in 2011 and the construction time was around one year. The wind power project was fully funded by Foundation Windpower. IEUA and Foundation Windpower have a power purchase agreement which lays out the terms and conditions for IEUA to purchase the wind power. The rate for wind power is pre-established for 20 years and is lower than the imported power rate. For more information click here.

Hydropower

Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy, using the natural flow of moving water to generate electricity (DOE, 2022). Hydropower currently accounts for 31.5% of total U.S. renewable electricity generation. Hydropower facilities come in all sizes. Some may be very large (e.g., Hoover Dam), but they can also be very small, taking advantage of pressure differentials in municipal water pipes or other water facilities. Increasingly water utilities are considering in-conduit hydropower generators in lieu of pressure relief valves when excess pressure exists.

According to an Oak Ridge National Laboratory (2022) study, in the municipal sector, conduit potential scales generally with population – which is roughly proportional to flows in municipal water and wastewater systems – and terrain. The study found California to have more than twice the conduit development potential, 109 MW, than the second-ranked state, New York, which was followed by Colorado, Utah, Washington, Oregon, and Pennsylvania. Municipal water supply systems accounted for 90% of the total potential, compared with 10% for wastewater systems, due mainly to the greater water pressure in closed pipelines in water supply systems.

Case Study: *San Gabriel Valley Water Company (SGVWC), El Monte, California*

SGVWC is a public water utility headquartered in El Monte that provides drinking water to communities throughout the Los Angeles region. Sandhill is one of SGVWC's drinking water treatment plants (WTP). Its water supply is gravity-fed from higher elevations, creating 115 to 150 pounds per square inch (psi) of pressure upstream of the treatment plant. Rather than losing that energy at a pressure relief valve, SGVWC installed a dual-turbine array of pumps-as-turbine powerhouse, effectively turning the WTP into a 310-kW renewable energy generator. The turbines create sufficient energy such that the plant is net energy neutral. Since commissioning in November 2013, the site has generated nearly two million kilowatt hours of clean, renewable electricity, the equivalent of 1,300 tons of CO_2 saved. The project cost was $1,675,000 with a payback period of eight years. To learn more about in-conduit hydropower, see California's In-Conduit Hydropower Implementation Guidebook.

Biogas and Combined Heat and Power (CHP)

Biogas is an energy-rich gas produced by anaerobic decomposition or thermochemical conversion of biomass (EIA, 2022). Many municipal sewage treatment plants use anaerobic digesters as part of their waste treatment processes. Some sewage treatment facilities collect and use the biogas produced in anaerobic digesters to heat the digesters, which enhances the anaerobic digestion process and destroys pathogens. Some facilities use it to generate electricity to use or to sell. Biogas can also be used as fuel for a CHP system.

The existing 82 GW of CHP capacity at over 4,700 industrial, commercial, and institutional facilities represents approximately 8% of current U.S. electric generating capacity (EPA, 2022). According to the EPA's CHP Partnership, CHP, sometimes referred to as cogeneration, is an efficient and clean approach to generating onsite electric power and useful thermal energy (e.g., steam, hot water) from a single fuel source. With on-site power production, losses are minimized and heat that would otherwise be wasted is applied to facility loads in the form of process heating, steam, hot water, or even chilled water. CHP can be located at an individual facility or building, or it can be a district energy, microgrid, and/or wastewater utility resource that provides power and thermal energy to multiple end-users. CHP equipment can provide resilient power 24/7 in the event of grid outages, and it can be paired with other distributed energy technologies like solar and energy storage.

A CHP system consist of individual parts—prime mover, generator, heat recovery, and electrical interconnection—configured into an integrated whole. The type of prime mover in use (i.e., the engine, turbine or fuel cell that drives the system) typically identifies the CHP system. There are several types of CHP systems that use different prime movers, each with its own attributes, benefits, and performance characteristics. CHP systems can incorporate renewable fuels in the form of biomass and biogas.

Waste heat to power (WHP) is the process of capturing heat discarded by an existing thermal process and using that heat to generate power (EPA, 2015). The recovery of waste heat for power is a largely untapped type of CHP. Although WHP is not widespread in the water sector, the Albany County Sewage District's (ACSD) North Plant does leverage this technology. ACSD uses multiple-hearth incineration as the ultimate disposal method for sewage-sludge produced in the District's 35 million gallons per day (MGD) wastewater treatment plant. The flue-gas exhausted from the incinerators is ducted to a WHP system where it is used to make electricity that is used onsite for some of the plant's electrical and space heating needs. It is currently not a source of backup power.

Solar
Wind
Hydropower
Biogas and Combined Heat and Power (CHP)
Geothermal
Batteries
Fuel Cells
Microgrids

Case Study: Bergen County Utilities Authority (BCUA), New Jersey

The authority's wastewater treatment plant uses a 2.8 MW reciprocating engine CHP system. The facility runs off biogas and processes sewage for 47 communities. The system was completed in June 2008 for a little under $12 million. Originally operated by the project developer, the BCUA took over operation of the CHP facility in 2010. The energy produced by the CHP system is consumed entirely by the BCUA wastewater treatment plant. The CHP plant uses two biogas fueled reciprocating engine generator sets with emission control and heat recovery equipment. Natural gas is used as a backup source of fuel. The CHP system operates in parallel with the Public Service Electric and Gas Co. (PSE&G) electrical distribution system. The engines supply approximately 85% of the electric needs of BCUA's plant. Treated water from the BCUA facility is also supplied as cooling water to an adjacent power plant.

The CHP system was able to remain up and running during Superstorm Sandy in 2012. There was a momentary controlled blackout when PSE&G service went down, but the CHP system operated seamlessly for 24 hours without PSE&G and was recognized by the adjacent power plant for being able to provide treated cooling water throughout the storm event. The current CHP system is not equipped with black start capability since the plant already has an independent backup power system in place, but BCUA is planning on retiring the standby power system and will then install black start capabilities. For more information click here.

Geothermal

Geothermal energy is a renewable energy source because heat is continuously produced inside the earth (EIA, 2022). Direct use and district heating systems use hot water from springs or reservoirs located near the surface of the earth to directly heat individual buildings or to heat multiple buildings. Geothermal power plants require high-temperature (300°F to 700°F) hydrothermal resources that come from either dry steam wells or from hot water wells. These resources are accessed by drilling wells into the earth and then piping steam or hot water to the surface. The hot water or steam powers a turbine that generates electricity.

Geothermal heat pumps use the earth's constant temperature to heat and cool buildings. Geothermal heat pumps transfer heat from the ground (or water) into buildings during the winter and reverse the process in the summer. According to EPA, geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective systems for heating and cooling buildings. All types of buildings, including homes, administrative and office buildings, schools, and hospitals, can use geothermal heat pumps.

Case Study: Drinking Water Plant, Stockbridge, Massachusetts

The Town of Stockbridge's drinking water plant treats and delivers 55–60 million gallons of drinking water to 1,548 customers every year. In 2015, the facility installed an open-loop, water-source heat pump that replaced its electric resistance heating system put in when the plant was constructed in 1996. The new system consists of two six-ton heat pumps capable of air conditioning and heating, and the open loop has a recycle feature that sends the used water to their plant filters to be retreated. The total project cost was $44,000, and the town received a $39,000 grant from the Massachusetts 2014 Gap Energy Funding program. Annual cost savings are $19,600 which represents a 33% reduction in the utility's electric bill and an annual energy savings of 83,300 kWh. Although the heat pump cannot operate on its own without grid power, the town is investigating the feasibility of adding a hydropower resource to its DER portfolio. As its DERs increase, the town may be well positioned to consider adding energy storage (such as batteries) and a microgrid in the future.

6
Renewable Energy and Microgrids

Solar

Wind

Hydropower

Biogas and Combined Heat and Power (CHP)

Geothermal

Batteries

Fuel Cells

Microgrids

Batteries

Energy storage plays a pivotal role in enabling power grids to function with more flexibility and resilience. At the end of 2019, 163 large-scale battery storage systems were operating in the U.S., a 28% increase from 2018. The maximum energy that could be stored at these sites was 1.7 GW. In 2019, 402 MW of small-scale total battery storage power capacity existed in the U.S., most of it in California (EIA, 2022). The DOE's Long Duration Storage Shot establishes a target to reduce the cost of grid-scale energy storage by 90% for systems that deliver 10+ hours of duration by 2031.

Batteries or battery banks store energy from the grid or from on-site renewable sources (e.g., solar, wind). This is important, as the ability to store energy helps to overcome one of the biggest obstacles to renewable energy: the cycling between oversupply when the sun shines or the wind blows, and shortage when the sun sets or the wind drops. Battery systems can use lithium ion, lead acid, or other technologies. Battery storage systems can be paired with solar and wind generation systems at water utilities to create more resilient microgrids that can help offset the loss of grid power (WRF, 2020).

Case Study: *The University Area Joint Authority (UAJA), State College, Pennsylvania*

UAJA provides wastewater collection, treatment and reuse to the greater State College area surrounding Penn State University, with a total population served of approximately 92,000. In 2021, UAJA and its partners held a ribbon-cutting ceremony for the Phase II solar array and microgrid (Phase I was completed in 2018). The result of a public-private partnership, the now five MW solar array provides about 80% of the wastewater treatment plant's annual energy demand. The array is projected to save UAJA more than $10 million over the next 25 years and produce 7,845,429 kWh in the first year. The Phase II solar project also included a 500 kVA battery and a microgrid to power the wastewater treatment plant during extended electrical grid outages.

Fuel Cells

A fuel cell uses the chemical energy of hydrogen or other fuels to cleanly and efficiently produce electricity. Fuel cells are unique in terms of the variety of their potential applications; they can use a wide range of fuels and feedstocks and can provide power for systems as large as a utility power station or as small as a laptop computer. They can provide power for applications across multiple sectors, including transportation, industrial/commercial/residential buildings, and long-term energy storage for the grid in reversible systems. Fuel cells work like batteries, but they do not run down or need recharging. They produce electricity and heat so long as fuel is supplied.

Fuel cells are classified primarily by the kind of electrolyte they use. This classification determines the type of electro-chemical reactions that take place in the cell, the kind of catalysts required, the temperature range in which the cell operates, the fuel required, and other factors. These characteristics, in turn, affect the applications for which these cells are most suitable. Both Polymer Electrolyte Membrane (PEM) and Alkaline (AFC) fuels cells are suitable for applications such as backup power (DOE, 2016).

Case Study: Fayetteville Public Works Commission (PWC), Fayetteville, North Carolina

The Fayetteville PWC will install 1.5 MW of solid oxide fuel cells adjacent to its P.O. Hoffer Water Treatment Facility and near the former Texfi industrial site, which is considered one of the most polluted sites in North Carolina. The installation will generate renewable energy from multiple biogas streams by combining ambient air with biogas from the Cross Creek Water Reclamation facility and methane gas from local and neighboring swine farms. It will be among the first of its kind to combine multiple waste gas sources to generate carbon-neutral electricity.

As waste generation increases – possibly by 70% by 2050 – this project will reduce biogas flaring at wastewater and landfill facilities, reduce emissions, improve air quality, and help meet North Carolina's clean energy standards. Moreover, the project will complement the industrial pollution cleanup in the region and provide an always-on and reliable source of electricity.

"This project is an anchor for the broader plan to remediate and establish a Cleanfields Renewable Energy Demonstration Park in the community," said Elaina Ball, CEO and general manager, Fayetteville PWC.

Microgrids

A central concept to DERs is the microgrid. During a grid power outage, a water utility could switch to an electric microgrid powered by both on-property and off-property sources such as solar photovoltaics, wind turbines, biogas, and battery banks. In a community, microgrids are often used to link critical public services and critical private businesses together in their own, larger microgrid. These key facilities could become "islands" of power during an outage.

Microgrids can provide revenue streams while grid-connected, meaning the electric utility pays or credits for the power produced, and these energy and cost savings may lower the overall cost of a microgrid and allow for the incorporation of additional microgrid components. When integrated into a microgrid, distributed energy technologies can also increase survival time during a grid outage when fuel supplies are limited. DER and microgrids are emerging technologies, so be sure you check your state regulatory commission rules on grid interconnection. If the microgrid is only dedicated to critical loads, you may not need to address these regulatory issues. The National Conference of State Legislatures maintains a website that shows the status of state policies to support microgrid development and microgrid laws.

Case Study: Northeast Water Purification Plant (NEWPP) Expansion, Houston, Texas

To serve fast growing Harris and Fort Bend counties, Houston is expanding its NEWPP to add 320 MGD in capacity by 2024. To ensure power resilience for the expanded facility, the city decided to construct a microgrid. This 30 MW microgrid is believed to be the largest in the United States supporting a water treatment plant. Powered by natural gas generators, the system should be able to run indefinitely and provide 100% of the backup power needed for the NEWPP. The city elected to use a service agreement with the microgrid supplier, which means the supplier will own and operate the system. The microgrid should ensure full compliance with the Texas Commission on Environmental Quality regulatory requirements for water treatment facilities and will provide greater operational reliability during maintenance and grid outage periods than traditional backup power supplies.

Case Study: Rialto Water Services, Rialto, California

Rialto Water Services provides water and wastewater services to 100,000 people in the Inland Empire. As part of a unique, 30-year concession agreement, the water utility intends to design and install an $8 million microgrid by 2024. The city of Rialto currently spends more than $800,000 a year in electricity and natural gas purchases. Partially funded with a $1.56 million grant from the California Energy Commission, the project aims to save ratepayers $350,000 to $550,000 of that amount and cover its own cost of design and construction. Benefits include:

- *The facility will no longer need to flare excess biogas waste which involves purchasing natural gas to mix with the biogas, as well as creating unwanted carbon emissions. Instead, a reciprocating engine will convert the waste gas into electricity for plant operation. It will also provide heat to the digesters.*
- *The facility will have a small-scale solar power installation which, combined with the reciprocating engine, will convert the plant from a net user of electricity to a net producer.*
- *The facility will also use lithium-ion batteries. The batteries will allow for the storage and potential sale of energy back to the grid during peak demand and provide the facility with much needed backup and redundancy for secure and reliable operation.*

The microgrid will be able to "island" during power outages and supply power to the plant for at least three days. During normal operation, the microgrid will enable more efficient energy management by minimizing electrical draw, exporting renewable energy, and participating in demand response. As a result, the microgrid will minimize energy costs at the facility, and help reduce the need for the water utility to start high-cost peaking plants when the grid is under strain. Besides the positive impact the project will have on energy efficiency and resilience, it will also contribute to protecting natural resources in the area. The wastewater treatment plant is located near an environmentally sensitive waterway which supports a population of endangered Santa Ana suckerfish. Once the new microgrid is in place, the plant will be less vulnerable to power outages that could cause the plant to shut down and potentially spill wastewater into nearby waterways.

Case Study: Greater Lawrence Sanitary District (GLSD), Massachusetts

GLSD augments its Combined Heat and Power (CHP) fuel source digestion facilities with food waste at its 52 MGD treatment plant. This greatly boosts methane production and the ability to power the District's treatment processes and net meter power to the grid for its off-site pumping station. GLSD benefits from a Massachusetts law that does not allow producers of one ton or more of food waste per week to use landfills or incinerators to dispose of that waste. A Waste Management CORe® facility creates an engineered bioslurry from food waste and delivers three to five truckloads of slurry to GLSD each day.

Based on this project, GLSD can:

- *Fuel its cogeneration engines with natural gas*
- *Fuel its cogeneration engines with biogas*
- *Produce 3.2 MW of power, enough to sustain full wastewater treatment plant (WWTP) operations during an extended power outage*

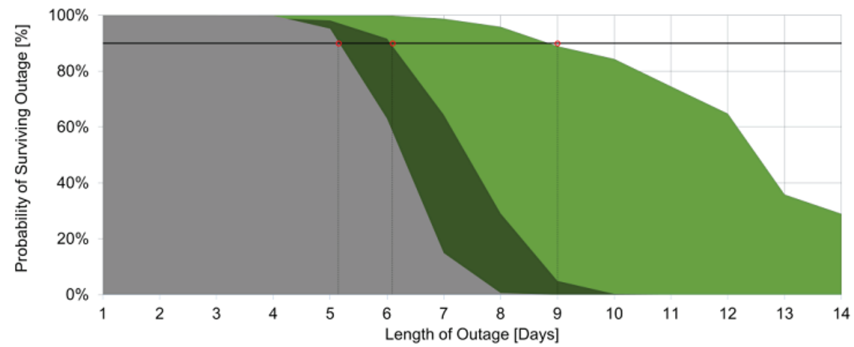
In the event of a power outage, the CHP shuts down, but can then be restarted by GLSD in island mode using natural gas. This has been done successfully during electrical utility maintenance on the District's service lines. GLSD is currently investigating programming changes that would allow switching from natural gas to biogas during island mode operations. These abilities provide operational reliability and flexibility and demonstrate that continued WWTP operations during a long-duration power outage with a clean energy source is possible. Off-site pumping stations still require backup diesel generators in the event of a power outage, but GLSD is well on its way to net zero operations.

Case Study: *Atlantic County Utilities Authority (ACUA), New Jersey*

ACUA serves 14 municipalities and a population of over 230,000 residents. Its wastewater treatment plant has a capacity of 40 MGD and currently treats about 26 MGD. The treatment plant has an energy demand of approximately 2.5 MW. The 7.5 MW Jersey Atlantic Windfarm provides about 60% of the utility's electricity through a fixed purchase agreement. ACUA also has 500-kW of solar onsite, including ground mount, canopy, and rooftop systems. ACUA has a land lease agreement with Viridity Energy, who installed, owns, and operates a one MW battery energy storage at ACUA. Viridity uses the frequency regulation market to get a return on its investment and shares in the savings ACUA sees from a reduction in peak load charges on its electric bills. The one MW battery storage could provide 15 minutes of back-up power to the entire treatment plant. ACUA plans to obtain additional batteries so it can operate as an island, independent of the grid.

ReOpt Web Tool: *Renewable Energy Integration and Optimization (ReOpt) is a techno-economic decision support platform used by DOE's National Renewable Energy Laboratory researchers to optimize energy systems for buildings, water utilities, communities, and microgrids. ReOpt recommends the optimal mix of renewable energy, conventional generation, and energy storage technologies to meet cost savings, resilience, emissions reductions, and energy performance goals (see graphic). Water utilities can use the free, publicly available ReOpt web tool.*

	Generator	Solar PV	Storage	Life Cycle Cost	Outage
Base case	2.5 MW	-	-	$20 million	5 days
Lowest cost solution	2.5 MW	625 kW	175 kWh	$19.5 million	6 days
Proposed system	2.5 MW	2 MW	500 kWh	$20.1 million	9 days



Storage and PV extend probability of surviving outage at little to no added cost

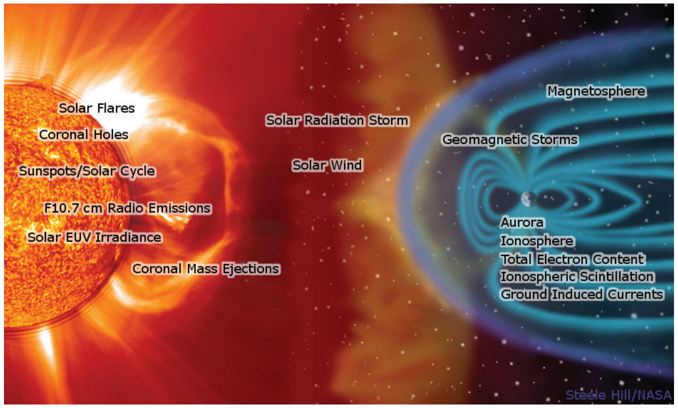
The Distributed Energy Resources Customer Adoption Model (DER-CAM) is a powerful and comprehensive decision support tool that primarily serves the purpose of finding optimal distributed energy resource (DER) investments in the context of either buildings or multi-energy microgrids. Researchers at Lawrence Berkeley National Laboratory developed DER-CAM and it is publicly available and free to use.

EPA's RE-Powering America's Land Initiative encourages renewable energy development on current and formerly contaminated lands, landfills, and mine sites (RE-Powering sites) when such development is aligned with the community's vision for the site. As they are often located within or near population centers, RE-Powering sites also offer opportunities for meeting the specific energy demands of nearby off-takers, such as wastewater treatment plants (WWTPs), drinking water treatment plants, hospitals, or emergency shelters.

7. Black Sky Planning

TOP TIP: Consider how your utility could sustain operations during a power outage lasting several weeks or longer.

A black sky incident is generally defined as a long duration power outage, lasting at least 30 days, that impacts a large region including several states. Hazards that could cause a black sky incident include a cyber-attack, high altitude electromagnetic pulse (EMP), coordinated kinetic attack (e.g., physical attacks on key elements of power grid), geomagnetic disturbance (i.e., space weather), large-scale earthquake, and extreme terrestrial storm (e.g., Hurricane Maria). The National Oceanic and Atmospheric Administration issues alerts, watches, and warnings for space weather, which may provide you some time to take pre-planned actions in advance. Learn more at www.swpc.noaa.gov/alerts-watches-and-warnings.



Many utilities that are prepared for power outages lasting two to three days may not be able to maintain full operations during an outage lasting one week or longer. Fuel, treatment chemicals, transportation and other critical interdependencies could be a challenge for water utilities due to disruption of supply chains and extreme resource competition. The Electric Infrastructure Security (EIS) Council published the free EPRO Handbook II Volume 2: Water Sector Resilience for Black Sky Events. Some key planning considerations identified in the book as well as recent EPA Black Sky Exercises are outlined below.

Step 1 – Define Top Level Goals

- ☐ What are the basic, overarching goals your utility wants to achieve during a black sky incident?
- ☐ What are the threats to public health and safety due to long-term disruption of drinking water or wastewater services that you wish to avoid?

Long-term Backup Generator Use

During Superstorm Sandy in 2012, the Bay Park Sewage Treatment Plant on Long Island, New York lost all power. The utility produced its own power with on-site generation units, and the flooding from Sandy damaged multiple secondary systems on which those units relied. Bay Park was effectively left without primary power for more than one year. The plant operated with backup power from two pods of two diesel generators each, each pod capable of producing three MW. Based on Bay Park's experiences post-Sandy, the following are some considerations for long-term operation of standby generators:

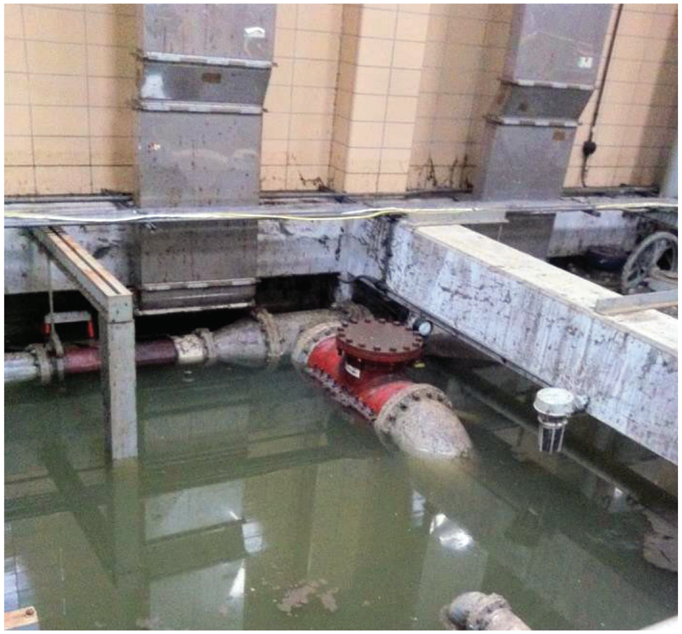
- *Despite having 5,000 gallons of diesel fuel storage at each standby generator pod, fuel deliveries were required every 24 hours. Fortunately, the roads around Bay Park were passable within one week after Sandy made landfall.*
- *Frequent load shedding to perform maintenance on the standby generators was challenging. Therefore, the two MW generators in each pod were replaced with two one MW generators each to make maintenance easier.*
- *Diesel generators are noisy, and since the generators were used long-term, there were numerous community complaints. Bay Park regularly conducted public meetings on the progress and timeline to restore primary power.*
- *"Emergency" use of the generators was allowed for 500 hours before state air quality standards applied. Therefore, Bay Park eventually replaced their standby diesel generators with natural gas generators to meet emission requirements.*
- *FEMA reimbursement for the rental charges of the standby generators became difficult because Bay Park had used them so long. In this case, purchasing the generators would have cost less than renting them.*
- *The flooding and noise issues led Bay Park to reconsider its standby generator placement. Bay Park's generators are now on the roof (out of a flood's reach), shielded by a building for noise abatement and as far as possible from residential neighbors.*

Long-term Backup Generator Use (continued)

- *Continuous run or prime power rated backup generators, not standby rated, can typically provide up to full power for your utility for extended durations. Standby or emergency generators are not designed to run continuously for long periods of time. They need to be frequently taken offline for maintenance and if used for longer periods of time, need to be de-rated, or run below their full power rating*
- *Continuous run or prime power rated backup generators, not standby rated, can typically provide up to full power for your utility as long as you need it. Standby or emergency generators are not designed to run continuously for long periods of time. They need to be frequently taken offline for maintenance and if used for longer periods of time, need to be de-rated, or run below their full power rating.*

Step 2 – Establish Minimalist Sustainable Service Levels

- ☐ What are the "bare minimum" goals for meeting customer needs as your fuel and treatment chemical supplies dwindle during an extended wide area blackout?
- ☐ Will you reduce treatment and/or stop serving some pressure zones?
- ☐ Have you discussed or developed plans on your expected levels of treatment and service during a prolonged power outage with your local EMA, critical customers, and your state regulatory authority so that they can plan appropriately?
- ☐ Have you segregated the electric loads to their own breaker boxes so that the facility could have the option for dedicated on-site electric renewable or generator systems?



Step 3 – Develop Internal Requirements

☐ Make carefully prioritized investments in backup power, onsite fuel storage and other necessary infrastructure to support your goals and minimum service levels.

- What alternative and temporary emergency power resources do you have at your treatment plant(s) and pumping stations?
- How much fuel do you have onsite? How many days will it last? How will you source and deliver it?
- How many days of treatment chemicals do you need to store?
- Obtain renewable energy resource assessments on what the facility has available on-site: waste heat, solar, wind, methane, biomass (for biogas), and water.

☐ Develop the specific procedures within your utility's emergency response plan to achieve minimum service levels.

- What is your plan for pumping and treating water, based on your available alternative and temporary emergency power resources, fuel and chemicals? Does this correspond with your goals for providing services during an extended power outage?
- Do you have plans to ensure that your employees can work (e.g., do they have transportation, do their families have the support they need?) during extended power outages?
- What is your plan for restoration of service following a prolonged outage of the electric grid, especially when you have not been able to operate for an extended period of time (e.g., reactivating wastewater treatment, transitioning a contaminated distribution system from "Do Not Use" to "Boil Water Notice" to "Potable")? What are your requirements for additional resources? Have you incorporated risk into your activities, supply chain for resources, etc.?

☐ Evaluate the opportunities, challenges, benefits, and risks of expanded onsite fuel and chemical storage.

☐ Procure black sky-secure communications capabilities that can operate for over 30 days without satellite, cell service and grid power.

Step 4 – Develop External Requirements

- ☐ What are the support requirements your utility will need to achieve black sky service levels?
  - Do you have contracts to rent generators if you do not own them? Have you installed transfer switches?
  - Who will repair and maintain your emergency generators during a prolonged period of use?
  - Does your electric provider know which of your facilities are the highest priorities for power restoration?
  - Do you have contracts to provide fuel during an emergency? Is your vendor prepared to pump and move fuel without grid power?
  - Have you worked with your local EMA to establish a local and regional emergency fuel plan and to coordinate fuel deliveries to generators from multiple agencies in the most efficient manner possible?
  - How resilient are your chemical vendors and their supply chains? EPA's Supply Chain Resilience Guide for Water and Wastewater Utilities offers guidance on this topic.
  - How will you communicate with your local EMA during a widespread power outage when landlines, cell phones, and the Internet do not work?
  - How will you communicate information about water advisories, reductions in service and emergency disinfection to the public during a widespread power outage when landlines, cell phones, and the Internet do not work?
- ☐ What are the policy changes your utility will need to achieve black sky service levels?
  - Clean Air Act waivers
  - Other local air quality regulation waivers
  - Fuel storage and transportation waivers
  - Water quality waivers from primacy agencies
  - Regional level emergency fuel planning

7
Black Sky Planning

Step 1
Define Top Level Goals

Step 2
Establish Minimalist Service Levels

Step 3
Develop Internal Requirements

Step 4
Develop External Requirements

Step 4 – Develop External Requirements (continued)

- ☐ What are your ongoing activities with key external service providers?
  - Coordination and contact information exchange
  - Collaboration regarding planning and resilience investments
  - Mutual conduct of workshops and exercises
- ☐ Compile a list of resilience investments that address specific black sky events
  - Differentiate from gray sky resilience investments but leverage them as much as possible

8. Funding

TOP TIP: Use EPA's Fed FUNDS website to determine your eligibility for funding power resilience projects.

There are numerous funding mechanisms water utilities can use to increase their power resilience, ranging from government loans and grants to private sector financing. Some utilities can implement energy efficiency and power resilience projects with internal funding. Other efforts may require capital investment through the water or wastewater utility's capital improvement plan or government funding. Renewable Energy Credits (RECs) may also help. RECs are issued when one megawatt-hour (MWh) of electricity is generated and delivered to the electricity grid from a renewable energy resource. These can be a useful element of a renewable energy investment strategy for water and wastewater utilities as a source of revenue to offset capital/operating costs, since RECs associated with your utility's renewable energy project's electricity output can be sold to another party (EPA, 2022).

Examples of power resilience projects that have been funded successfully through external sources include:

- Energy efficiency measures
- Installation of solar panels and other renewable energy technologies
- Purchase or subsidized costs of microgrid technology
- Purchase, rental, or upgrade of emergency generators and fuel supply facilities
- Electric connections (transfer switches) to receive emergency generators
- Elevation or protection of electric panels and generators from hazards
- Flood protection around an electric substation and transformers

Private Sector Financing and Resources

On-site renewable energy, energy storage, and energy efficiency have unique sources of financing that attract private sector dollars to pay for installation. Most of these approaches are common throughout the United States, and some are explicitly supported by state laws or regulations:

1. Energy Savings Performance Contracting (ESPC) is a financial mechanism in which energy efficiency and renewable options are financed and installed by a private company, for a price competitive to what would be paid to the electric utility. Companies that perform this kind of work are called Energy Service Companies (ESCO).
2. Energy Leases are offered routinely by renewable energy and energy storage companies (e.g., battery banks). Usually, leases are for three to seven years, sometimes longer. At the end of the lease the system is retrieved or may be able to be acquired for a nominal fee.
3. A Power Purchase Agreement (PPA) is an arrangement in which a third-party developer installs, owns, and operates an energy system on a customer's property. The customer then purchases the system's electric output for a predetermined period. A PPA allows the customer to receive stable and often low-cost electricity with no upfront cost, while also enabling the owner of the system to take advantage of tax credits and receive income from the sale of electricity. Though most used for renewable energy systems, PPAs can also be applied to other energy technologies such as CHP.
4. Electrical Resiliency-as-a-Service with a private provider is a newer funding option. For example, a microgrid may be able to be installed at your utility that uses generators and/or DERs. These microgrids are managed around the clock by the private provider and come with design, installation, operation, maintenance, warranty, and support services at an ongoing and predictable expense. The expense is typically offset by the provider aggregating the generators/DERs and selling power back to the grid when the microgrid is not being used in an emergency.

Case Study: *Wastewater Treatment Center, Becker, Minnesota*

This case study shows how Becker leveraged a PPA to lower the city's energy cost and free up cash for other needs. First, in consultation with an energy firm, the city's utility bills were analyzed across multiple locations. Based on the analysis, the city decided to complete a renewable energy project to help reduce the energy demand at one of the city's largest electrical loads, the wastewater treatment center. The selected solar solution consisted of:

- *704-kW solar system consisting of 1,900 solar panels.*
- *Four power system inverters*
- *Single axis tracking for better sun angle throughout the day*

By using a PPA, the city received their solar array with no upfront costs. After six years the city has the option to purchase the array. In addition, the city locked in their electric utility rate with a 1% escalator. Based on current costs, the city will save thousands of dollars and the initial cash flow savings projected should be exceeded. Additionally, the city will receive the PV Demand Credit on their electric utility bill, which will credit them approximately seven cents per kWh produced during peak business hours. The system will deliver over 1,000,000 kWh per year, representing about $100,000 in cost savings each year. The array will supply approximately 40% of the plant's electricity requirements and will reduce carbon emissions by over 1,600,000 pounds each year.

Many water and wastewater utilities use private sector options as it places the burden for equipment upgrades and maintenance on entities other than the utility. Also, depending on the solution or resource chosen, initial costs can be partially or fully paid for by the technology itself over time.

State Resources

State resources vary but many states have grant programs and other incentives for energy efficiency and renewable energy projects. For example, Oregon's 1999 electric-utility restructuring legislation (SB 1149) required Pacific Power and Portland General Electric (PGE) to collect a 3% public-purpose charge from their customers to support renewable energy and energy efficiency projects through January 1, 2012. Of the funds collected by the electric utilities, 56.7% was allocated towards energy efficiency programs and 17.1% to renewables. The remaining funds support low-income housing energy assistance and K-12 school energy-conservation efforts. The Oregon Public Utility Commission (OPUC) authorized the Energy Trust of Oregon, an independent non-profit organization, to administer these programs beginning in 2002, which results in numerous energy efficiency and renewable energy projects at water utilities.

The Database of State Incentives for Renewables & Efficiency (DSIRE) is a comprehensive source of information on incentives and policies that support renewable energy and energy efficiency in the United States. Funded by the U.S. Department of Energy, DSIRE finds local and state programs and resources that can help you attain your energy goals.

Case Study: *McKinleyville Special Community District (MSCD), California*

MSCD provides water, wastewater, parks, and recreation services to the town's 17,000 residents. Using a California State Water Resources Control Board Energy Efficiency Grant, the District is installing a $2 million microgrid at the wastewater treatment plant. The project combines a 580-kW solar array, a 500-kW battery energy storage system that can produce 1,340 kWh in a single discharge, and an existing diesel generator. Although backup generators are in place for critical water infrastructure, the batteries will be able to run the District's Ramey Water Pump Station and Fischer Wastewater Lift Station for over a day if grid power is lost. As an added benefit, the batteries can also be used to shave power during the electric utility's peak periods. The peak power shaving should result in savings of around $30,000/year. All told, the microgrid will save the District about $10,000 in electrical costs every month.

Federal Resources

The EPA tool Federal Funding for Utilities – Water/Wastewater – in National Disasters (Fed FUNDS) provides comprehensive information on funding programs from various federal agencies including FEMA, the EPA, the U.S. Department of Agriculture (USDA), the U.S. Department of Housing and Urban Development (HUD), and the Small Business Administration (SBA). For example, the state-administered Drinking Water State Revolving Fund (SRF) and Clean Water SRF support a wide range of infrastructure projects. Eligible projects could include resilience components such as energy efficient upgrades and alternative power sources. States establish priorities for using SRF funds and assistance is typically in the form of low-interest loans.

The Water Infrastructure Finance and Innovation Act (WIFIA) accelerates investment in America's water infrastructure by providing long-term, low-cost supplemental loans for regionally and nationally significant water and wastewater infrastructure projects. The WIFIA program can fund development and implementation activities for eligible projects such as but not limited to wastewater conveyance and treatment projects that are eligible for the Clean Water SRF, drinking water treatment and distribution projects that are eligible for the Drinking Water SRF, and enhanced energy efficiency projects at drinking water and wastewater facilities. WIFIA works separately from, but in coordination with, the SRF programs to provide subsidized financing for large dollar-value projects.

Following the passage of the historic Infrastructure Investment and Jobs Act (IIJA), EPA will be making significant investments in the health, equity, and resilience of American communities. IIJA delivers more than $50 billion to EPA over five years to improve the nation's drinking water, wastewater, and stormwater infrastructure. This is a historic investment that includes $11.7 billion each to both the Drinking Water and Clean Water SRFs. Green projects are eligible for funding under the SRFs. Drinking Water SRF green projects include energy efficiency projects that use improved technologies and practices (e.g., wind, solar, geothermal, micro-hydroelectric) to reduce energy consumption of water projects and use energy in a more efficient way. The Clean Water SRF can fund a wide range of green energy efficiency and conservation activities that reduce energy consumption.

Federal Resources (continued)

In addition to traditional funding resources such as the SRF, new federal programs have become available in recent years. Since the Disaster Recovery Reform Act of 2018 was signed into law, FEMA's Building Resilient Infrastructure and Communities (BRIC) supports states, local communities, tribes, and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. In 2017, The Blue Lake Rancheria (BLR), a Native American reservation, constructed a $6.3 million, low-carbon community microgrid to bolster its resilience to frequent power outages caused by heavy rainstorms and forest fires. When a nearby wildfire caused a power outage in October 2019, the microgrid successfully islanded and kept tribal facilities running.

The Inflation Reduction Act marks the largest federal investment in climate and clean energy in American history. With a mix of federal funding and tax credits, the law includes a new mechanism for tax-exempt entities, such as cities, towns, and villages, to leverage many of the new clean energy tax incentives included in the law. Historically, only taxpaying entities were able to take advantage of renewable energy tax incentives, but this legislation opens the door for local governments to access these incentives.

The Inflation Reduction Act provides non-taxable entities participating in clean energy incentives with a direct payment option in lieu of tax credits. This provision is applicable for tax years starting after December 31, 2022, and ending before January 1, 2033. Tax-exempt entities will be able to claim a refund for the excess taxes they paid or deemed to have paid. Effectively, this provision makes the applicable tax credits as "refundable" tax credits. Under the Inflation Reduction Act, the amount of the credit will be paid to the tax-exempt entity when they make an election to receive the credit on a tax filing for tax return in the year in which the project is placed in service (NLC, 2022).

Sample Projects and Funding Sources

To assist you in locating potential funding sources, the table below has been completed based on a broad interpretation of funding eligibility and policy. Individual water utility projects will need evaluation on a case-by-case basis. Talk to your supervisor, local emergency manager, town manager, and state hazard mitigation officer and revolving fund program to determine the availability of funding opportunities for your power resilience project.

Sample Power Resilience Project	Possible Funding Sources						
	SRF/ IIJA	FEMA PA	FEMA HMG	FEMA BRIC	HUD CDBG	USDA WEP	WIFIA
Repair generator or fuel tank		X				X	
Elevate existing generators, electric equipment etc.	X	X	X	X		X	X
Purchase generators and fuel storage	X		X	X	X	X	X
Install electric wiring hookups (e.g., transfer switches) to accept generators	X		X	X		X	X
Develop and implement emergency power plan	X		X	X		X	X
Harden grid link or multiple independent feeds	X		X	X		X	X
Replace damaged equipment with energy efficient versions	X	X	X	X	X	X	X
Perform energy efficient audits and upgrade to energy efficient equipment	X						X
Add renewable energy resources (e.g., cogeneration, solar, wind)	X	X	X	X	X	X	X
Install a microgrid	X		X	X	X		X

Table Key: *SRF = State Revolving Fund; IIJA = Infrastructure Investment and Jobs Act; PA = Public Assistance; HMG = Hazard Mitigation Grant; BRIC = Building Resilient Infrastructure and Communities; CDBG = Community Development Block Grant; WEP = Water and Environmental Programs; WIFIA = Water Infrastructure Finance and Innovation Act*

References

Congressional Research Service (CRS). *Energy-Water Nexus: The Water Sector's Energy Use*. 24 January 2017. Available: https://sgp.fas.org/crs/misc/R43200.pdf.

Department of Energy. *Fuel Cells*. Accessed November 2022. Fuel Cells | Department of Energy.

Department of Energy. *How does solar work?* Accessed November 2022. How Does Solar Work? | Department of Energy.

Department of Energy. *Hydropower Basics*. Accessed November 2022. Hydropower Basics | Department of Energy.

Department of Energy. *Solar Energy in the United States*. Accessed November 2022. Solar Energy in the United States | Department of Energy.

Department of Energy. *Top 10 Things You Didn't Know About Wind Power*. Accessed November 2022. Top 10 Things You Didn't Know About Wind Power | Department of Energy.

Electric Power Research Institute (EPRI) and Water Research Foundation (WRF). *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries*. November 2013. Electricity Use and Management in the Municipal Water Supply and Wastewater Industries.

National League of Cities. Inflation Reduction Act: Clean Energy Project Eligibility for Local Governments. Accessed November 2022. Inflation Reduction Act: Clean Energy Project Eligibility for Local Governments - National League of Cities (nlc.org).

National Public Radio. *One Florida community built to weather hurricanes endured Ian with barely a scratch*. October 6, 2022. A Florida community built to weather hurricanes endured Ian barely scratched: NPR.

References

National Renewable Energy Laboratory. *Microgrids*. Accessed November 2022. Microgrids | Grid Modernization | NREL.

Oak Ridge National Laboratory. Assessing U.S. *Conduit Hydropower Potential*. Accessed November 2022. Assessing U.S. Conduit Hydropower Potential | ORNL.

Oak Ridge National Laboratory. *Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities*. March 2013. Available: Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities.

U.S. Energy Information Administration. *Biomass explained: Landfill gas and biogas*. Accessed November 2022. Biogas-Renewable natural gas - U.S. Energy Information Administration (EIA).

U.S. Energy Information Administration. *Geothermal explained*. Accessed November 2022. Geothermal explained - U.S. Energy Information Administration (EIA).

U.S. Energy Information Administration. *Battery Storage in the United States: An Update on Market Trends*. Accessed November 2022. EIA - U.S. Battery Storage Market Trends.

U.S. Environmental Protection Agency. *Renewable Energy Certificates*. Accessed 2022. Renewable Energy Certificates (RECs) | US EPA.

Water Research Foundation. Battery Storage System Guidance for Water and Wastewater Utilities – Report 4718. February 2020. Available: Battery Storage System Guidance for Water and Wastewater Utilities | The Water Research Foundation (waterrf.org).

Appendices

Appendix A: Existing Generator Information Sheet

1. Facility Information

Site Name: ______________________ Address: ____

Latitude (N):_____________________________ Longitude (W): _____________________________

Major motors, in starting order, used for facility operations (*e.g., 75 HP 2 Quantity 460 Volts 3 Phase*):

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

2. Generator Information

Power (kW): __________ Voltage (V):__________ Phase(s): __________

Configuration: ☐Wye ☐Delta

Transfer Switch: ☐Auto ☐Manual

Generator Location: ☐Inside ☐Outside

Generator Type: ☐Portable ☐Stationary

Cable Length (ft): ___________ Cable Size (MCM or AWG): __________

3. Engine Information

Engine Make: _________________ Engine Model: ___________________

Engine Serial Number: _________________ Battery Voltage: ______________________

Primary Fuel Filter: __________ Secondary Fuel Filter: __________ Coolant Filter: __________

Oil Filter: __________ Oil Type: __________ Oil capacity: __________

Air Filter: __________ Fuel Type: ___________ Fuel Capacity: __________

Gallons per hour: ________ Max Run Hours (100% load)*: __________

Diesel Emissions Fluid (DEF) Tank Capacity: __________

4. Additional Notes (e.g., hitch requirements for portable generator, site specific directions, clearance issues with overhead lines)

Facility Information

Site Name: site name for stationary generator or write “portable” for portable generator

Address: physical location for stationary generator; storage location for portable generator

Latitude and Longitude: provide six places to the right of the decimal point for latitude and longitude to indicate a more precise location. If presented in degrees-minutes-seconds, the seconds should be listed four decimal places to the right of the whole number of seconds for equivalent accuracy.

Major motors: provide the horsepower, quantity, volts, and phases of the major motors that will be powered by the generator, in starting order, and whether they are soft start or across the line start

Generator Information

Power: the power output of the generator in kilowatts (kW)

Voltage: voltage is a measure of pressure

Phase(s): generators can be single or three-phase

Configuration: 3-phased power can be in a wye configuration in the shape of a “Y” or a delta configuration in the shape of a triangle

Transfer switch: does the generator start up automatically or require a manual switch?

Generator Location: is the generator located inside or outside?

Generator Type: a portable generator can be moved between locations and a stationary one is at a fixed location

Cable Length: length of cable between generator and load

Cable Size: size of cable in Thousand Circular Mils (MCM) or American Wire Gauge (AWG)

Engine Information

Engine Make and Model: the manufacturer of the engine and the engine model number

Engine serial number: the serial number on the engine

Battery voltage: the size and number of batteries the engine requires

Filters: the type of filters each system requires; note – some engines do not have a secondary fuel filter

Oil: the type and capacity of oil

Fuel: the type and capacity of fuel (e.g., diesel)

Gallons per hour: the number of gallons of fuel needed per hour

**Max run hours:* for fuel planning only, the maximum number of hours the engine can run before refueling assuming 100% load (generators should run closer to 70% or 80% load)

Diesel Emissions Fluid (DEF) Tank Capacity: the capacity of DEF tank

Appendix B: Generator Request Form

1. Facility Information

Site Name: ______________________ Address: ____

Latitude (N):____________________________ Longitude (W): ____________________________

Contact Name: ___________________________ Phone: ____________ Email: ____________________

Major motors, in starting order, used for facility operations (*e.g., 75 HP 2 Quantity 460 Volts 3 Phase*):

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

_____ HP _____ Quantity _____ Volts _____ Phase ☐soft start ☐ACL (across the line)

2. Needed Generator

Power (kW): __________ Voltage (V): __________ Phase(s): __________

Configuration: ☐Wye ☐Delta Cable Length (ft): ___________ Cable Size (MCM or AWG): __________

On-site cable configuration: ___________________________ Preferred Fuel Type: _______________

3. Assessment Details

Main Breaker Current (Amps): __________

Service Drop Type: ☐Overhead ☐Underground

If overhead, is there sufficient clearance for trailer? ☐ Yes ☐No ☐N/A

Anticipated On-site Location of Temporary Generator: ____

4. Hitching Requirements

Trailer Hitch: ☐ Pintel ☐ Ball Trailer Height: _____________

Electrical connections: _________________________ Generator and Trailer Weight: ______________

5. Additional Notes (e.g., site specific directions, clearance issues with overhead lines)

Facility Information

Site Name and Address: location and address for requested generator

Latitude and Longitude: provide six places to the right of the decimal point for latitude and longitude to indicate a more precise location. If presented in degrees-minutes-seconds, the seconds should be listed four decimal places to the right of the whole number of seconds for equivalent accuracy.

Contact: name, email and phone number for a point of contact for the generator

Major motors: provide the horsepower, quantity, volts, and phases of the major motors that will be powered by the generator, in starting order, and whether they are soft start or across the line start

Needed Generator

Power: the power output of the generator in kilowatts (kW)

Voltage: voltage is a measure of pressure

Phase(s): generators can be single or three-phase

Configuration: 3-phased power can be in a wye configuration in the shape of a "Y" or a delta configuration in the shape of a triangle

Cable Length: length of cable needed to connect generator to load in feet

Cable Size: size of cable in Thousand Circular Mils (MCM) or American Wire Gauge (AWG)

On-site cable configuration: onsite cable connection for a generator (e.g, appleton, camlock, etc.)

Preferred Fuel Type: type of fuel (e.g., diesel) that is preferred

Assessment Details

Main Breaker Current: size of the circuit breaker in amps that controls all electric current in the building

Service Drop Type: are the electrical lines overhead or underground?

Transformer Mount Type: is the transformer mounted on a pad or a pole?

Anticipated On-site location: describe where the generator will be placed

Hitching Requirements

Trailer Hitch: type of hitch

Trailer Height: height of the trailer/hitch

Electrical connections: describe electrical connections needed for trailer

Generator and Trailer Weight: combined weight of generator and trailer