February 22, 2022

Mayor Bradshaw and City Councilors
City of Ketchum
Ketchum, Idaho

Mayor Bradshaw and City Councilors:

Recommendation To Approve PO #22057

Recommendation and Summary

Staff is recommending the council to contract with DC Engineering for their Professional Services and conceptual design engineering to provide backup power to our Northwood Well and Water Operations Building.

I recommend the council authorize the mayor to sign PO# 22057 and attached proposals with DC Engineering for their Professional Services, and conceptual design engineering work to provide backup power to our Northwood Well and Water operations building at a not to exceed price of $50,000.00.

The reasons for the recommendation are as follows:

- The Idaho Department of Environmental Quality Idaho Administrative Act (IDAPA) rules for public drinking water systems (IDAPA 58.01.08) requires sufficient on-site standby power or standby water storage so that water may be treated and supplied to pressurize the entire distribution system during power outages for a minimum of 8 hours at average day demand plus fire flow.
- The Northwood Well is our primary well and it has no backup power supply
- loss of power could impact firefighting capabilities
- Without backup power to our operations building our response time in the event of a power outage will be impacted.
- In case of an extended power outage, we would have no heat in our building due to the newly installed electrical boiler system and damage to our radiant heating could occur.

Introduction and History

The Northwood well came online in 1989 as part of the Bigwood PUD Development. With the configuration of our water system at that time, it was not considered to be critical to have back up power at this site. With the growth experienced over the life of the well, it has become our primary well making backup power critical.

The Water Operations Building was built in 2001. At that time, we had a natural gas fired boiler. In the spring of this year an electric boiler was installed. While the boiler works fine, in the event of an extended outage, it puts our building in possible jeopardy if our radiant heating were to freeze.

Analysis

Northwood Well

In the event of a normal utility outage or sustained power outage our ability to provide sufficient domestic water flows and fire protection would be severely compromised.

Water Operations Building

While the risk of such damage is probably small, backup power will allow us to put our service fleet on the street quickly. If for example there was an earthquake and power was disrupted, we would have to manually open and reclose our garage bay doors. This could also allow us to move our SCADA computerized well control system into our operations building from the Warm Springs wellhouse.

Sustainability

The recommended action will further the goals of the 2020 Ketchum Sustainability Action Plan in the following ways:

- Provide redundant power in event of a power failure
- Allow us to save in power costs by not having to double pump system water through booster pumps.

Financial Impact

This is a planned and budgeted expense that will be drawn from our FY 21-22 budget.

Respectfully submitted,

Gio Tognoni
Water Division Supervisor

Attachments:

Purchase Order# 22057
Proposal Agreements from DC Engineering

Memo

To: Pat Cooley/City of Ketchum
Copy:
From: John Barrutia/DC Engineering
Date: Friday, June 25, 2021
Subject: Northwood Well Standby Power

Overview and Project Objective

The City of Ketchum municipal water originates from six wells. Five wells (Northwood Well, Big Wood Well, Ketchum Well #1, Ketchum Well #2, and Parkwood Well) are located in close proximity to the Big Wood River and pump water from the Big Wood aquifer. The remaining sixth well (Trail Creek Well) is located near Sun Valley Resort and pumps water from the Trail Creek aquifer. Water is pumped into storage reservoirs daily, with a total capacity of approximately 3 million gallons available for domestic, irrigation, and fire protection needs.

Three of the system wells and the Warm Springs Booster Pump Station are the water system's most critical facilities to maintain adequate pressure and flow. Northwood Well (located at 100 Park Circle W.) is one of those critical wells, but unlike the other critical facilities, Northwood Well does not have a standby power source when normal utility power from Idaho Power fails. This could hinder water flow and fire-fighting operations without manual intervention by Operations personnel to curtail irrigation or isolating some sections of town during summer months. The project objective is, therefore, to install a standby power source at the Northwood Well.

Alternative Selection Criteria

Alternative selection criteria are influenced by project requirements and will be used as a basis to develop reasonable alternative solutions and as a shield against unreasonable alternative solutions to provide a balanced approach to costs, benefits, and risks. In the case of this project, code related requirements and community related requirements influence the alternative selection criteria.

Code Related Requirements

Three standby power system categories exist in the National Electrical Code (NEC) based on load classification as follows:

- Emergency Power Systems (NEC Article 700) – Installed when power interruption would compromise life safety or functions essential to maintain human life (e.g. fire detection, fire pumps, hospitals, etc.).
- Legally Required Standby Systems (NEC Article 701) - Installed when power interruption would create health hazards, hamper rescue, or fire-fighting operations (e.g. wastewater treatment plants, water supply systems, etc.).
- Optional Standby Systems (NEC Article 702) – Installed when power interruption would create discomfort, process interruption, damage to products, etc. (e.g. industrial and commercial facilities, farms, residences, etc.)

In addition, the U.S. Department of Homeland Security (DHS) identified public drinking water and wastewater infrastructure as part of the national infrastructure protection plan that require continuous operation for reasons of public safety, emergency management, national security, or business continuity. The DHS vision and goal of the plan are to secure this infrastructure through risk assessment, vulnerability and hazard identification (e.g. contamination, naturally occurring hazards, and human caused events such as physical and cyber-attacks), and development of a mitigation strategy using a layered defense of effective preparedness and security practices. At the request of DHS, the NEC developed the criterion for the critical electrical system elements intended to supply, distribute, and control electrical power to these facilities in the event of normal electric utility disruption in NEC Article 708 - Critical Operations Power Systems (COPS).

It is presently unknown if the Northwood Well electrical power system could be classified as COPS, and the risk assessment process is beyond the scope of this project. However, at a minimum, the proposed standby power system would likely be classified as a Legally Required Standby System due to its criticality and use for fire protection. The rules that classify the loads and associated standby power system category as either Emergency or Legally Required are found in locally adopted building codes, such as the International Building Code or National Fire Protection Agency (NFPA) 101 *Life Safety Code*, and enforced by the authority having jurisdiction (AHJ). The AHJ may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, building official, electrical inspector, or others having statutory authority.

The requirements for Legally Required Standby Systems are outlined in the NEC Article 701, NFPA 110 Standard for Emergency and Standby Power Systems; and NFPA 111 Standard for Stored Electrical Energy Emergency and Standby Power Systems, which only allow stored energy type power sources (i.e. 100% active power output availability within seconds) including storage battery, engine-generator, uninterruptible power supplies (UPS), fuel cells, and DC microgrid system with the following reliability requirements:

- The system must be permanently installed and be able to supply standby power within 60 seconds.
- Storage batteries and UPS's are required to maintain the total load for a minimum 90 minutes without the voltage falling below 87.5%.

- Engine-generator sets:
    - Required to be supplied with on-premises fuel supply sufficient for 2 hours of full-demand operation.
    - Shall not be solely dependent on an off-premises public utility gas system for fuel supply or municipal water supply for cooling unless approved by the AHJ when there is a low probability of a simultaneous failure of both the off-site fuel delivery system and power from the electric utility.
- Fuel cells and DC microgrid systems are required to maintain the total load for a minimum 2 hours of full demand operation.
- Periodic testing in a manner approved by the AHJ, maintenance per manufacturer's instructions, and written records of testing/maintenance are required.

Community Related Requirements

The Northwood Well is funded with municipal customer water rates and is situated in a neighborhood that backs up to the Big Wood River and its associated riparian habitat. As such, the standby power system will need features acceptable to the stakeholders including the nearby neighbors and community.

The assumed community related alternative selection criteria in order of priority are as follows:

- Minimize initial construction costs
- Maximize surface power density (ratio of power output per unit area) to minimize physical size to limit disruption of riparian habitat
- Minimize noise
- Minimize maintenance costs
- Minimize environmental impact

Existing Loading Conditions

The load at the Northwood Well Pumphouse consists of a 150HP pump controlled via variable frequency drive (VFD) and other miscellaneous pumphouse loads such as lighting, receptacles, heating, etc. The peak electrical demand at the Idaho Power meter (meter #46013506) occurred during the June 2019 billing period and was measured at 124-kW. As such, a standby power system will need to be sized at 175-kW (minimum) to accommodate both the pump induction motor starting requirements and carry the 124-kW peak electrical demand for the environmental conditions (i.e. elevation, temperature, etc.) of Ketchum, Idaho.

Alternative Analysis

A UPS system is an advanced version of a storage battery system, so both are considered similar technologies that need a properly sized source of energy (i.e. electric utility, solar, wind, etc.) to keep the batteries effectively charged and maximize battery life. Only storage battery systems with a battery charger connected to the electric utility will be evaluated.

Alternative energy sources such as solar (~10,000 square feet of panels) and wind (tall windmills) can be used to supply power to storage batteries as part of a DC microgrid system. However, alternative energy sources are dependent on the weather, available sunlight, and time of day – no wind, darkness, cloud cover, or snow-covered solar panels keeps power production to near zero, which may not be acceptable to the AHJ. In addition, adding properly sized solar arrays or windmills in the nearby riparian habitat around the well site to effectively charge the batteries is likely an undesirable choice among nearby residents and community. As such, storage batteries that are charged only from the electric utility will be evaluated from a reliability, cost, and physical size perspective.

Fuel cell performance capabilities are not well understood or widely used for Legally Required Standby Power systems to serve 124-kW of motor loading, nor are the associated hydrogen production, storage, and efficiency costs readily available. As such, fuel cells are not included in this alternative analysis.

Engine-generator considerations for this application type typically include diesel fueled generators and propane/natural gas generators with on-premises fuel storage tanks. The three main fuel related considerations are as follows:

- Electric utility power outages often exceed the code required minimum 2 hours of fuel supply. Fuel supplies of 24 hours or more are often recommended for similar applications.
- The break-even cost point between diesel fueled generator installations and propane/natural gas generator installations occurs at approximately 100-kW. Propane/natural gas generator installations start to become 2-3 times more expensive than similarly sized diesel generators at sizes larger than 100-kW.
- Separately mounted fuel storage tanks require area in addition to that required by the engine-generator. Diesel fueled generators are often built-in “subbase” fuel tanks installed under the engine that can store fuel up to 24 hours using the same surface area as the generator; whereas, propane/natural gas generators require a separately mounted storage tank.

As such, only a diesel fueled generator with a will be evaluated from a cost and physical size perspective.

In summary, two alternatives will be evaluated in this preliminary engineering report as follows:

- Diesel fueled engine-generator
- Storage batteries charged from the electric utility (Idaho Power)

Both alternatives have their advantages and disadvantages as discussed below.

Alternative 1: Diesel Engine Generator

Advantages

- Reliability – Widely used across the world because of the proven reliability and availability.
- Surface Power Density and Physical Size – Approximately 1,200 watts/square foot using an average of 150 square feet to produce the of continuous power necessary to supply the connected load. Most practical application for running large loads (i.e. >30kW).
- Initial Construction Costs - Range from $400/kW - $500/kW.

Disadvantages

- Maintenance Costs – Approximately $1,500 - $2,500 per year.
  1. Requires regular oil, fuel, air intake, and filter maintenance.
  2. A lightly loaded diesel generator will not reach operating temperature, which leads to unburnt fuel and carbon buildups in the exhaust system (wet stacking) that can cause engine damage. Regular operation that brings the unit up to operational temperature (i.e. minimum 75% of full load) is required.
- Environmental – Burns fossil fuels and creates pollutants.
- Noise - The surrounding area is predominantly residential so sound attenuation is critical. Noise can be mitigated with sound attenuating enclosures that increase the generator physical footprint.

Alternative 2: Storage Batteries Charged from Idaho Power.

Advantages

- Reliability – Reliable when battery inverter is not direct coupled to motor loads. The Northwood Well uses a VFD to control the pump motor, so the battery inverter will not be direct coupled to the motor (e.g. via full voltage motor starters).
- Maintenance Costs – Approximately $750 per year. Batteries must be regularly inspected, connections verified, and routinely tested (typically annually). However, battery system maintenance is less rigorous and costs are generally less than engine-generators.
- Noise - Silent

Disadvantages

- Surface Power Density and Physical size –
  1. Deep-cycle lead acid batteries are more suitable because of their ability to supply sustained loads for longer periods, and because they can be deeply discharged and recharged on a regular basis. Other battery types are generally less effective at meeting NEC performance requirements.

2. Batteries are a more practical application when running smaller loads (i.e. <30kW). Battery size for Northwood Well load is estimated at 300,000 amp-hours (approximately 1,500 batteries sized at 200 amp-hours each at 12V each) to serve the load for 90 minutes without the voltage falling below 87.5%. Battery size becomes even larger when serving loads for longer than 90 minutes.
3. A new building (estimated to be approximately 4,000-5,000 square feet) is required to contain the batteries (freeze protection) and associated battery charger, inverters, acid containment, and heating/ventilation equipment.
4. Surface power density is approximately 35 watts/square foot.

- Initial Construction Costs – 300,000 amp-hours equates to 3600 kWh. Battery prices range around $400 to $750 per kilowatt-hour (approximately $1.4M - $2.7M) plus the cost of a building system (approximately $1,000,000) to contain and ventilate the battery system.
- Environmental –
  1. Battery production (e.g. mining of battery metals and minerals, associated energy and chemical use to produce, etc.) and disposal are substantial.
  2. Lead acid batteries produce hydrogen gas when charging, and a 4% mixture of hydrogen in air is an explosive mixture when ignited. Battery rooms therefore require sufficient ventilation to prevent accumulation of an explosive mixture.

Other Considerations

Some utility customers consider offsetting their energy usage by installing onsite clean energy sources such as wind and solar in parallel with the load to offset energy costs. Idaho Power allows customers to connect a generation facility to the electrical grid in this configuration with certain constraints, and as long as the total nameplate capacity of the generation facility is 100kW or less. Projects in the 175-kW range similar to this project fall under Idaho Power's generation interconnection process and requires special contracts, additional electrical protection and metering infrastructure, and energy pricing structure that makes paralleling standby generation with Idaho Power for this project less attractive from a cost, operations, and administrative perspective.

Recommended Solution

- Reliability – Both alternatives meet NEC and NFPA reliability requirements.
- Minimize initial construction costs – Diesel engine generator is most attractive.
- Maximize surface power density to minimize physical size – Diesel engine generator is most attractive.
- Minimize noise – A properly designed sound attenuating enclosure make a diesel engine generator alternative similarly attractive to a battery alternative.
- Minimize maintenance costs – Battery is most attractive.

- Minimize environmental impact – Neither option is attractive.

Our recommended solution for this particular application is a diesel engine generator. They are dependable, long-lasting, and widely available. They have been proven many times over in similar installations with their heavy-duty build, high energy density, and efficient operation.

Budget-Level Opinion of Probable Installed Cost

Assumptions:

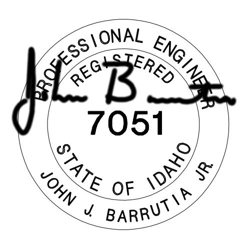
- 175-kW generator with sub-base fuel tank and sound-attenuated enclosure installed in grass area northeast of the pump station.
- Wood fence installed around generator to screen.
- Automatic transfer switch installed on exterior wall of pump station.
- Existing harmonic filter needs addition of auxiliary contact to disconnect internal capacitor when connected to generator.
- Approximately 75 feet of underground circuit and raceway (power and control) between generator and automatic transfer switch.
- Generator alarm contacts connected to SCADA.

Budget-level cost:

Engineering*:	$28,000
Construction:	$150,000
Contingency:	$27,000
Total:	$205,000

*Engineering services include preparation of design drawings, specifications, contract documents, and representing the Client during bidding and construction.

Installing a generator in an architectural building adds costs and can still use the sub-base fuel tank inside the building if less than 660 gallons of fuel. Assume the building will add approximately $130,000 to the above total cost (includes engineering, construction, and contingency).



Memo

To: Pat Cooley/City of Ketchum
Copy:
From: John Barrutia/DC Engineering
Date: Friday, June 25, 2021
Subject: Water Department Operations Building Standby Power

Overview and Project Objective

The City of Ketchum municipal Water Department Operations Building is located within the same fenced area as the Ketchum wastewater treatment plant (WWTP) and is the main office for Water Department operations personnel, fleet vehicles, and equipment maintenance. The WWTP and Operations Building area is situated between the Big Wood River on the west side, and residential housing and Wood River trail system along the north and east side. The Operations Building has its own Idaho Power electrical utility service and is not electrically connected to any of the WWTP normal utility power and standby power electrical infrastructure. More specifically, the Operations Building is served via separately metered Idaho Power service through an Idaho Power owned 50-kVA, single-phase, 240/120-volt transformer and does not have standby generation in the event normal utility power from Idaho Power fails. The WWTP has a standby generator that supports the wastewater process in the event of an Idaho Power outage as required by Environmental Protection Agency reliability requirements, but that generator is not sized to accommodate the Operations Building loading.

Near-Term Objective: Failure of normal utility power hinders operations personnel from safely accessing their trucks, tools, and inventory, and repairing failed equipment. In addition, the Operations Building uses a 40-kW electric boiler to heat the building and an extended power outage during winter months can cause plumbing damage due to frozen pipes. Standby generation will mitigate these issues in the near-term.

Long-Term Objective: The U.S. Department of Homeland Security (DHS) identified critical public drinking water and wastewater infrastructure as part of the national infrastructure protection plan that require continuous operation for reasons of public safety, emergency management, national security, or business continuity. The DHS vision and goal of the plan are to secure this infrastructure through risk assessment, vulnerability and hazard identification (e.g. contamination, naturally occurring hazards, and human caused events such as physical and cyber-attacks), and development of a mitigation strategy using a layered defense of effective preparedness and security practices. Because the wastewater treatment plant is fenced and has a security camera and gate at the entrance, the Water Department would like to leverage these features to better align with the DHS vision and goal, and make the water system main SCADA control panel more secure by relocating it from the Warm Springs Booster Pump Station to the Operations Building. Warm Springs Booster Pump Station doesn't have the same degree of physical and electronic security as the wastewater treatment plant, but it does have a higher degree of reliability due to the presence of standby generation. Providing standby generation at the Operations Building provides the needed reliability and helps facilitate the long-term plan to relocate the SCADA control panel.

Alternative Selection Criteria

Alternative selection criteria are influenced by project requirements and will be used as a basis to develop reasonable alternative solutions and as a shield against unreasonable alternative solutions to provide a balanced approach to costs, benefits, and risks. In the case of this project, code related requirements and community related requirements influence the alternative selection criteria.

Code Related Requirements

Three standby power system categories exist in the National Electrical Code (NEC) based on load classification as follows:

- Emergency Power Systems (NEC Article 700) – Installed when power interruption would compromise life safety or functions essential to maintain human life (e.g. fire detection, fire pumps, hospitals, etc.).
- Legally Required Standby Systems (NEC Article 701) - Installed when power interruption would create health hazards, hamper rescue, or fire-fighting operations (e.g. wastewater treatment plants, water supply systems, etc.).
- Optional Standby Systems (NEC Article 702) – Installed when power interruption would create discomfort, process interruption, damage to products, etc. (e.g. industrial and commercial facilities, farms, residences, etc.)

The rules that classify the loads and associated standby power system category as either Emergency or Legally Required are found in locally adopted building codes, such as the International Building Code or National Fire Protection Agency (NFPA) 101 Life Safety Code, and enforced by the authority having jurisdiction (AHJ). The AHJ may be a federal, state, local, or other regional department or individual such as a fire chief, fire marshal, building official, electrical inspector, or others having statutory authority.

The proposed Operation Building standby power system would likely be classified as an Optional Standby System to meet near-term objective requirements. However, it would likely be classified as a Legally Required Standby System to meet long-term objective requirements.

The NEC Article 702 requirements for Optional Standby Systems are considerably less stringent than those for Emergency or Legally Required systems. Optional Standby Power system considerations:

- Allows either permanently installed or portable alternate power supplies. For example, a portable vehicle-mounted generator can be brought to the Operations Building and manually connected to the optional standby system in the event of an Idaho Power outage.
- Does not limit energy power sources to only stored energy power sources. For example, renewable energy sources such as solar and wind are allowed.
- The facility user is permitted to select which load is connected to the standby power system. For example, Operations Building personnel could decide to only connect the boiler to a standby power source.
- The loads can be connected to the standby power system either automatically or manually.

The requirements for Legally Required Standby Systems are outlined in NEC Article 702; NFPA 110 Standard for Emergency and Standby Power Systems; and NFPA 111 Standard for Stored Electrical Energy Emergency and Standby Power Systems, which only allow stored energy type power sources (i.e. 100% active power availability within seconds) including storage battery, engine-generator, uninterruptible power supplies (UPS), and fuel cells with the following reliability requirements:

- The system must be permanently installed and be able to supply standby power within 60 seconds.
- Storage batteries and UPS's are required to maintain the total load for a minimum 90 minutes without the voltage falling below 87.5%.
- Engine-generator sets:
  - Required to be supplied with on-premises fuel supply sufficient for 2 hours of full-demand operation.
  - Shall not be solely dependent on an off-premises public utility gas system for fuel supply or municipal water supply for cooling unless approved by the AHJ when there is a low probability of a simultaneous failure of both the off-site fuel delivery system and power from the electric utility.
- Fuel cells are required to maintain the total load for a minimum 2 hours of full demand operation.
- Periodic testing in a manner approved by the AHJ, maintenance per manufacturer's instructions, and written records of testing/maintenance are required.

Community Related Requirements

The Operations Building is funded with municipal customer water rates and is located adjacent to residential housing and the Wood River trail system. As such, the standby power system will need features acceptable to the stakeholders including the nearby neighbors and community.

The assumed community related alternative selection criteria in order of priority are as follows:

- Minimize initial construction costs
- Minimize space encroachment on WWTP operations
- Minimize noise
- Minimize maintenance costs
- Minimize environmental impact

Existing Loading Conditions

The load at the Operations Building presently consists of an electric boiler, HVAC, lighting, welding, receptacles, and other miscellaneous loads. The peak electrical demand at the Idaho Power meter was 43-kW.

If it is desired to provide standby power for the entire building, the system will need to be sized at approximately 90-kW to accommodate the loading and environmental conditions (i.e. elevation, temperature, etc.) of Ketchum, Idaho.

Alternative Analysis

The average lifespan of standby power systems is approximately 20-25 years, which is likely within the timeline of when the Operations Building standby power system is classified as Legally Required. As such, only Legally Required Standby Systems are included in this alternative analysis.

A UPS system is an advanced version of a storage battery system, so both are considered similar technologies that need a properly sized energy source to keep the batteries effectively charged and maximize battery life. As such, only storage batteries are included in this alternative analysis.

Alternative energy sources (i.e. solar, wind, etc.) can be used in Legally Required Standby Systems when included with properly sized storage batteries. The weather in Ketchum, as well as the location of the Operations Building in the valley along the Big Wood River makes alternative energy sources less attractive than other alternatives due to less sunlight and wind exposure, trees, snow, etc. In addition, windmills are not a viable alternative for consideration due to city structure height restrictions. However, it may be possible to install enough roof-mounted solar panels used in conjunction with storage batteries to make solar energy a viable alternative only if electrical loading can remain at 5-kW or less due to cost.

Fuel cell performance capabilities are not well understood or widely used, nor are the associated hydrogen production, storage, and efficiency costs readily available. As such, fuel cells are not included in this alternative analysis.

Engine-generator fuel considerations for this application type typically include diesel, propane, and natural. The main fuel related considerations are as follows:

- Propane and natural gas generator installations are generally less expensive than diesel generators at approximately 50-kW and less. Diesel generators are generally more cost effective when larger than 50-kW.
- The NEC does not allow Legally Required Standby Systems to be solely dependent on a public utility gas system for the fuel supply unless there is a low probability of public fuel supply failure and approved by the AHJ. This prevents (or limits) the use of natural gas for Legally Required Standby Systems.
- Fuel supplies of 24 hours or more are often recommended for similar applications because electric utility power outages often exceed the code required minimum 2 hours of fuel supply.
- Separately mounted fuel storage tanks require area in addition to that required by the engine-generator. Diesel fueled generators are often built-in “subbase” fuel tanks installed under the engine to save space; whereas, propane generators require a separately mounted storage tank.

In summary, three alternatives will be evaluated in this preliminary engineering report as follows:

- Storage batteries charged from solar panels.
- Diesel fueled engine-generator.
- Propane fueled engine-generator.

Each alternative has their advantages and disadvantages.

Alternative 1: Storage batteries charged from solar panels

Advantages

- Practical application for running smaller loads (i.e. <5-kW). Some utility customers consider offsetting their energy usage by installing onsite clean energy sources such as solar in parallel with the load to offset energy costs. Idaho Power allows customers to connect a generation facility to the electrical grid in this configuration with certain constraints, appropriate microgrid interconnect device, and as long as the total nameplate capacity of the generation facility is <25kW.
- Reliability – Very reliable for Operations Building load types and where battery inverter is not directly coupled to large motor loads.
- Maintenance Costs – Approximately $500 per year. Equipment must be regularly inspected, connections verified, and routinely tested (typically annually). However, battery system maintenance is less rigorous and costs are generally less than engine-generators.

- Noise – Silent

Disadvantages

- Space -
  1. Battery size becomes very large when serving loads greater than 5-kW or for longer than 90 minutes. For reference, battery size to serve a 5-kW load for 90 minutes without voltage falling below 87.5% is estimated at 11,000 amp-hours at 12V (approximately 55 batteries sized at 200 amp-hours each).
  2. Indoor building space (e.g. Operations Building or new building) is required to contain the batteries (freeze protection) and associated battery charger and inverters. Acid spill containment is required if more than 100 gallons of electrolyte.
  3. Roof space on the Operations Building and possibly the adjacent building is likely required for loads approaching 10-kW. More space is required for loads larger than 10-kW.
- Initial Construction Costs –Approximately $25,000/kW. Installations larger than 5-kW start to become prohibitively costly.
- Environmental –
  1. Battery production (e.g. mining of battery metals and minerals, associated energy and chemical use to produce, etc.) and disposal are substantial.
  2. Lead acid batteries produce hydrogen gas when charging, and a 4% mixture of hydrogen in air is an explosive mixture when ignited. Battery rooms therefore require sufficient ventilation to prevent accumulation of an explosive mixture.

Alternative 2: Diesel Fueled Engine Generator

Advantages

- Reliability – Widely used across the world because of the proven reliability and availability. Most practical application for serving larger loads (i.e. >30kW).
- Space - Approximately 50 square feet for generator and fuel tank.
- Initial Construction Costs – Diesel units cost less than propane or natural gas in this size application. Approximately $500/kW.

Disadvantages

- Maintenance Costs – Approximately $750 per year for testing and requires regular oil, fuel, air intake, and filter maintenance. A lightly loaded diesel generator will not reach operating temperature, which leads to unburnt fuel and carbon buildups in the exhaust system (wet stacking) that can cause engine damage. Regular operation that brings the unit up to operational temperature (i.e. minimum 75% of full load) is required.

- Environmental – Burns fossil fuels and creates pollutants.
- Noise - The surrounding area is residential so sound attenuation is critical. Noise can be mitigated with sound attenuating enclosures that increase the generator physical footprint.

Alternative 3: Propane Fueled Engine Generator

Advantages

- Reliability – Widely used because of the proven reliability and availability. Most practical application for running smaller loads (i.e. <30kW).
- Space - Approximately 90 square feet for the generator and fuel tank.
- Initial Construction Costs – Approximately $550/kW.

Disadvantages

- Maintenance Costs – Approximately $500 per year for testing and regular oil, fuel, air intake, and filter maintenance.
- Environmental – Burns fossil fuels and creates pollutants.
- Noise - The surrounding area is residential so sound attenuation is critical. Noise can be mitigated with sound attenuating enclosures that increase the generator physical footprint.

Recommended Solution

- Reliability – All alternatives meet NEC and NFPA reliability requirements.
- Minimize initial construction costs – Diesel engine generator is most attractive.
- Space – Diesel engine generator is most attractive.
- Minimize noise – A properly designed sound attenuating enclosure make both engine generator alternatives similarly attractive to a solar/battery alternative.
- Minimize maintenance costs – Solar/battery is most attractive. However, the WWTP also uses a diesel engine generator which offers economies of scale when considering ongoing fueling costs for a diesel engine generator.
- Minimize environmental impact – None of the options are attractive.

Our recommended solution is a diesel engine generator. They are dependable, long-lasting, and widely available for this application.

Budget-Level Opinion of Probable Installed Cost

Assumptions:

- 90-kW generator with sub-base fuel tank and sound-attenuated enclosure installed near the building.
- Automatic transfer switch installed on exterior wall of building.
- Approximately 75 feet of underground circuit and raceway (power and control) between generator and automatic transfer switch.

Budget-level cost:

Engineering*:	$12,000
Construction:	$90,000
Contingency:	$13,500
Total:	$115,500