United States
Environmental Protection
Agency

Auxiliary and Supplemental Power Fact Sheet: Viable Sources

INTRODUCTION

This fact sheet describes the use of Auxiliary and Supplemental Power Sources (ASPSs), which can provide Wastewater Treatment Plants (WWTPs) with a secondary power source in the case of a blackout or other problem resulting in a loss of power. In other cases the utility provider may use this power to supplement other sources of power on a continuous basis. In order to be effective, these ASPSs should provide the power necessary to run the WWTP efficiently and effectively, and should also have a short start-up time if they are to be used in an emergency.

Most WWTPs have electric power connections to at least two independent power substations, such that if power from one substation fails (i.e., due to a localized storm or the downing of a local power line), the WWTP could receive power from the other substation. However, if the entire grid fails (such as it did for much of the northeast and the Great Lakes states in August 2003), having power feeds from separate substations that are all connected to the same main grid will not meet the auxiliary power needs to keep many WWTPs operating during such a failure. Without an adequate reliable auxiliary power source, many WWTPs will discharge untreated sewage into the receiving waters.

There are a number of different types of ASPSs that can provide reliable power to WWTPs on either a continuous or emergency basis. These include:

- **Internal Combustion Engine Driven Generators (diesel, natural gas, or bio-gas)**
- **Microturbines**
- **Fuel Cells**
- **Solar Cells**
- **Wind Turbines**
- **Low Head Hydro Power**
- **Wastewater Heat Recovery**

Some of these technologies can also be used by the wastewater utilities to supplement their commercial power sources. Technologies such as fuel cells, solar cells, wind turbines, and bio-gas driven generators can provide renewable energy on a continuous basis, while diesel or natural gas power generators have been used to reduce peak energy demands on a short term basis.

Planning for auxiliary power must take into account the expected flow rates at the WWTP during the time of the power failure in order to ensure that sufficient auxiliary power will be available to meet the normal operating needs of the WWTP. Planners should also consider other factors that could affect the amount of power required by the WWTP to remain operational, such as potential weather conditions (wet weather can increase storm water flow to the WWTP in combined systems), collection system pump station operation, and whether drinking water is distributed during the power failure (this function requires increased pump capacity, and could be a factor for combined water/wastewater utilities). If the technology is planned to supplement commercial power, other considerations, such as continuous operating costs, energy market trends, and long range fuel price projections, may need to be factored in.

In addition to general considerations related to evaluating auxiliary and supplemental power sources, there are also technology specific considerations that must be evaluated. These include:

• **Reliability:** ASPSs must provide reliable auxiliary power under adverse conditions. ASPSs should be available for immediate service (i.e., warm up quickly) and be available for the time period for which they are needed without interruption. In some case, auxiliary power may be needed for extended periods of time (i.e., 48 hours or more), and sufficient fuel must be available for long term operation.

• **Cost:** ASPS technologies range widely in costs which will be a major factor in a utility's selection of the best options for providing auxiliary or supplemental power. Costs should be weighed against many other factors, including the expected life, annual maintenance, and reliability of the technology, as well as potential economic and environmental costs associated with an extended power failure at the POTW.

• **Appropriateness:** ASPSs should have sufficient capacity to operate primary treatment and disinfection for all wastewater flows for at least 24 hours after a power interruption. For discharges to sensitive water bodies, capacity to operate additional unit processes (i.e., advanced treatment) may be required by state regulatory authorities.

• **Security:** When possible, ASPSs should be located on-site, because it is easier for most wastewater utilities to protect on-site power supplies than it is to protect transmission lines and substations that feed the plant or remote pumping stations.

•**Environmental Factors:** The goal of insuring an adequate auxiliary power supply is to protect human health and the environment in the event of a power interruption. An auxiliary power supply should be adequate to prevent raw sewage from coming in contact with the public or discharging to sensitive receiving waters. However, spills or leaks from underground fuel tanks used to store fuel for ASPSs can create a risk to the ground water or the environment. In addition, some of the older gas or diesel engine driven generators produce air emissions that are harmful to public health.

• **Safety:** One significant obstacle to the installation of on-site electricity generation at WWTPs is the safety risk associated with the operation of such equipment. Operators must be trained to safely operate and maintain the equipment. There may also be concerns with fuel storage and handling. For example, large above ground fuel or gas storage may pose a risk to public health from an accident or terrorist attack.

Internal Combustion Engine Driven Generators

Electric generators can be furnished with engines that can run on diesel fuel, natural gas, or bio-gas. In many cases the engine can be provided with duel fuel capability. All of the engines currently being manufactured are required to meet Clean Air Act (CAA) emissions requirements as stated in sections 89-90, Chapter 40 of the Code of Federal Regulations. Some states have additional requirements that restrict the use of some auxiliary or supplemental power sources. States are required to be as strict in environmental regulations as the federal government, but can be more strict if needed to meet local air quality restrictions (like emissions in California). While older engines can contribute to air pollution problems, today high efficiency, low emission engines are available for most generators.

Microturbines

Microturbines are a new, innovative technology based on jet engines (more specifically the turbo charger equipment found in jet engines) that use rotational energy to generate power. Microturbines can run on bio-gas, natural gas, propane, diesel, kerosene, methane, and other fuel sources, making them suitable for a variety of applications. From an environmental standpoint, these new machines take up less space, have higher efficiencies, and generate lower emissions than reciprocating engines. If operated from a natural gas pipeline, no on site gas storage is needed, thus reducing safety concerns. Based on estimates by the Gas Research Institute and National Renewable Energy Laboratory, the total plant cost varies from ~$2600/kW for a 30 kW system to ~$1800/kW for a 100kW system. The 18.4 MGD Sheboygan Regional WWTP in Wisconsin has installed ten 30kW Capstone microturbines that provide an annual savings of close to $140,000.

Solar Cells

Solar cells, also known as photovoltaic (PV) cells, convert sunlight directly into electricity. They are often assembled into flat plate systems that can be mounted on rooftops or other open areas. Solar cells require only sunlight (a renewable energy source) as fuel, and have no emissions. They generate electricity with no moving parts and require little maintenance, making them ideal for remote locations. However, solar cells are dependant on weather. If there is no sun there is no energy generated. If used as an auxiliary source of power, some type of storage system (i.e., batteries) must be provided. In 2007, the cost of implementing a solar power project was $8/watt. Currently, solar power companies offer a "Power purchase Agreement" model wherein the wastewater treatment plants do not have to incur expenditure on implementing a solar power project. The project costs are borne by the solar power company which would then sell the solar power to the wastewater treatment plant. An ideal example would be that of City of Madera's WWTP in California. It has a solar installation that can produce 1.158 MW of electricity. This project would lower their energy costs by $250,000 annually.

Fuel Cells

A fuel cell is an electrochemical device similar to a battery. While both batteries and fuel cells generate power through an internal chemical reaction, a fuel cell differs from a battery in that it uses an external supply that continuously replenishes the reactants in the fuel cell. A battery, on the other hand, has a fixed internal supply of reactants. The fuel cell can supply power continuously as long as the reactants are replenished, while the battery can only generate limited power before it must be recharged or replaced. Most types of fuel cells can operate on a wide variety of fuels including hydrogen, digester gas, natural gas, propane, landfill gas, diesel, or other combustible gas. In some cases, such as in a WWTP, methane (sludge gas) from anaerobic digesters can be reused in the fuel cell instead of flaring off the excess gas. Other advantages of fuel cells include few moving parts, modular design and negligible emission of pollutants. Palmdale Water Reclamation Facility in Los Angeles County installed a 250kW molten carbonate fuel cell at a cost of $1.9 million. The reduction in the energy expenditure for the facility was calculated to be $227000 annually.

Wind Turbines

Wind turbines convert wind into mechanical energy and electricity. A generator is equipped with fan blades and placed at the top of a tall tower. The tower must be tall in order to harness the wind at a greater velocity, free of turbulence caused by interference from ground obstacles such as trees, hills, and buildings. Generally, individual wind turbines are grouped into wind farms containing several turbines. The power generated from wind farms can be inexpensive when compared to other traditional power production methods. The cost to generate the electricity from wind farms decreases as the size of the farm increases.

Wind turbines do not produce any harmful emissions nor do they require any fuel product for operation. However, wind turbines do require periodic maintenance, which can present a safety problem, since most turbines are mounted on tall towers. There is also concern about construction and other activities below each turbine, although the land can generally still be used for animal grazing or farming. Problems with birds flying into the turbine propellers have been reported, however newer designs have reduced this problem. The costs of implementing a wind power project vary with the size of the project. The City of Evansville's WWP installed a 100kW wind turbine at a cost of $594,000 which translates to $5940/kW. The Jersey Atlantic Wind Farm owned by the Atlantic County Utilities Authority has an installed capacity of 7.5 MW and the cost per kW is $1667.The Cost of wind generated at this facility is $0.076/kWh and the annual energy cost saving is around $350000.

Low Head Hydro Power

The electric energy that is harnessed from the force of moving water is termed as hydroelectric power. The two types of systems used for this purpose are run-of –the –river system and storage system. In either system, water is channeled through a pipeline to a turbine and the pressure at the end of the pipeline constitutes the net head. Hydroelectric power is renewable, clean and it is the largest source of renewable energy in the United States. According to the U.S. Energy Information Administration, about 60% of the renewable energy produced in the United States in 2010 was from hydroelectric projects.

Hydroelectric power systems that operate with a head water level of ≤ 66 feet are termed low head hydro power systems. In most cases, low head hydro is built as a run-of-the-river system and the power generation is dependent on having perennial flow in the river. Loss of head due to build up of debris is also an issue. When implemented in a WWTP, the low head hydro power system will not encounter the same problems as a run-of-the-river system because of the constant supply of debris-free water. The power that can be potentially produced at a site is roughly given by the following equation:

Make	Head (ft)	Flow (cfs)	Power (kW)	Cost
Energy System	10	2	1	$3k-$4k
Power Pal	5	5	1	$3k-$4k
Canyon Hydro-Kaplan	30–50	100-400	Varies	Varies
Hydro e-kid	Varies	Varies	2- 200	Varies
VLH	6.6-11	N/A	486-496	N/A

Low head Turbines

$$\text{Power} = \frac{H\,x\,F}{11.8}\ \text{x efficiency}$$

Where H is the head in feet and F is the flow rate in cubic feet per second

By harnessing the potential energy of effluent water contained in a 4.5 mile long outfall, Point Loma Wastewater Treatment Plant of San Diego is able to produce 1.35 MW of electricity. A hydroelectric turbine is operated by the effluent water before being discharged to the ocean. The head available from the plant to the outfall is 88.5 ft. The total cost of this project is $1.7 million out of which $419000 was provided by a California Energy Commission grant.

Wastewater Heat Recovery

An estimated 350 billion kWh of energy stored in hot water is drained annually from households and most of it is recoverable. Using municipal wastewater as a heat source in the winter and as a heat sink in the summer, considerable savings in HVAC costs can be achieved. Briefly, a heat exchanger is used to transfer heat from the municipal wastewater to the conveyance medium which is pumped to individual buildings. Heat pumps located at these buildings then extract heat from the conveyance medium and deliver energy for space heating/cooling. The conveyance medium is sent back into the loop where it exchanges heat with the municipal wastewater again. The first project of this kind was announced jointly by the East Division Reclamation Plant, Renton, WA and Boeing in 1992. Wastewater was pumped to one of Boeing's training facilities and used for space cooling purposes. The annual savings in energy costs, from this project was estimated to be $120,000. On a commercial scale, this system has been implemented at the Whistler Athletes' Village, British Columbia at a cost of $4.1 million. The incoming wastewater has an annual temperature range of 50 F to 64 F. The installed system is capable of generating up to 11000 mWh/year of heating energy that caters to an occupied space of 85000 sq m. Kent County, Delaware is implementing this system to provide heating/cooling solution for two buildings located in the Kent County regional Wastewater Treatment Facility. Sustainability and flexibility are among the key benefits of implementing this system.

REFERENCES

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