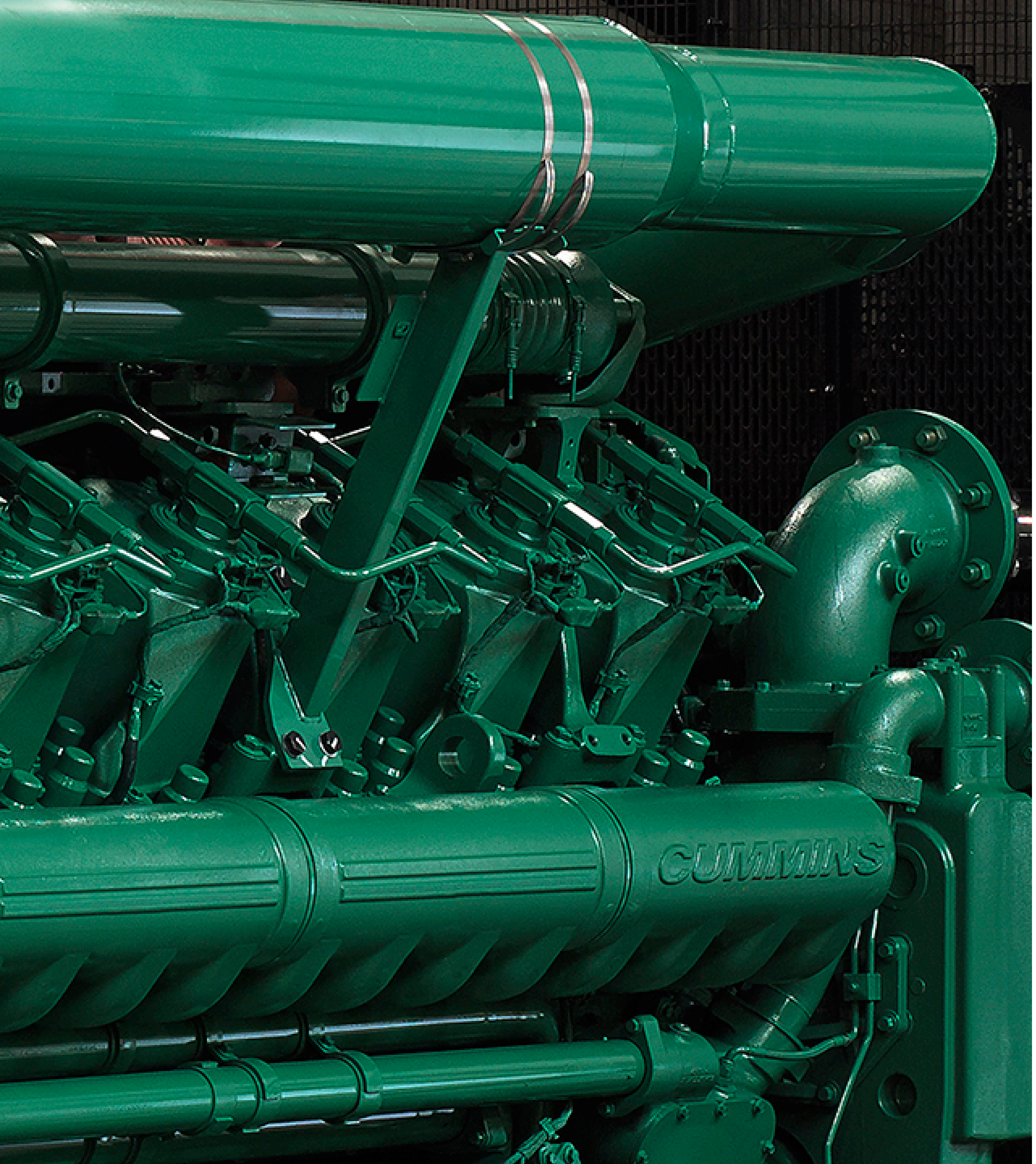

Power
Systems

Specifying Power System Equipment for Water and Wastewater Applications

PowerHour webinar series for consulting engineers

Experts you trust. Excellence you count on.

January 28, 2021 12:00pm Eastern Time / 9:00am Pacific Time
(1 PDH issued by Cummins Inc.)

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- Interact with Cummins experts and gain access to ongoing technical support
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Meet your panelists

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Disclaimer

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Participants are encouraged to refer to the entire text of all referenced documents. In addition, when it doubt, reach out to the Authority Having Jurisdiction.

Course Objectives

Emergency Standby Power Systems Requirements/Recommendations for Water and Wastewater Facilities:

This course is designed to discuss requirements/recommendations of Emergency Standby Power Systems for Water and Wastewater Treatment applications. After completing this course, participants will be able to:

- Understand the vast amount of power it takes to process water and the critical nature of providing reliable backup power systems for Water and Wastewater facilities, as well as, the potential consequences if these systems fail.
- Determine which generator set rating should be specified for an application, based upon its intended uses.
- Identify important design considerations when specifying power systems for Water and Wastewater Treatment applications.

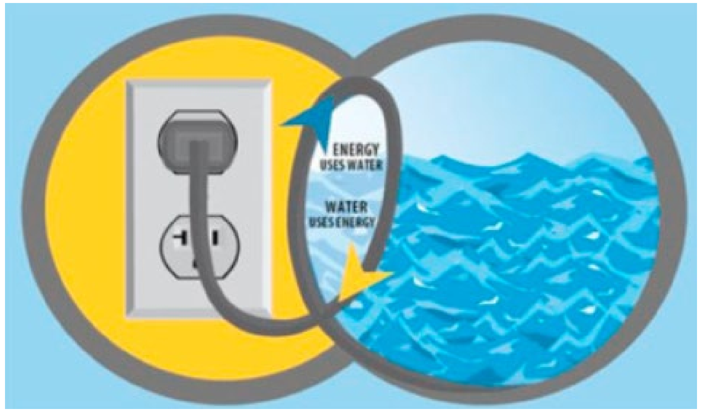
Agenda

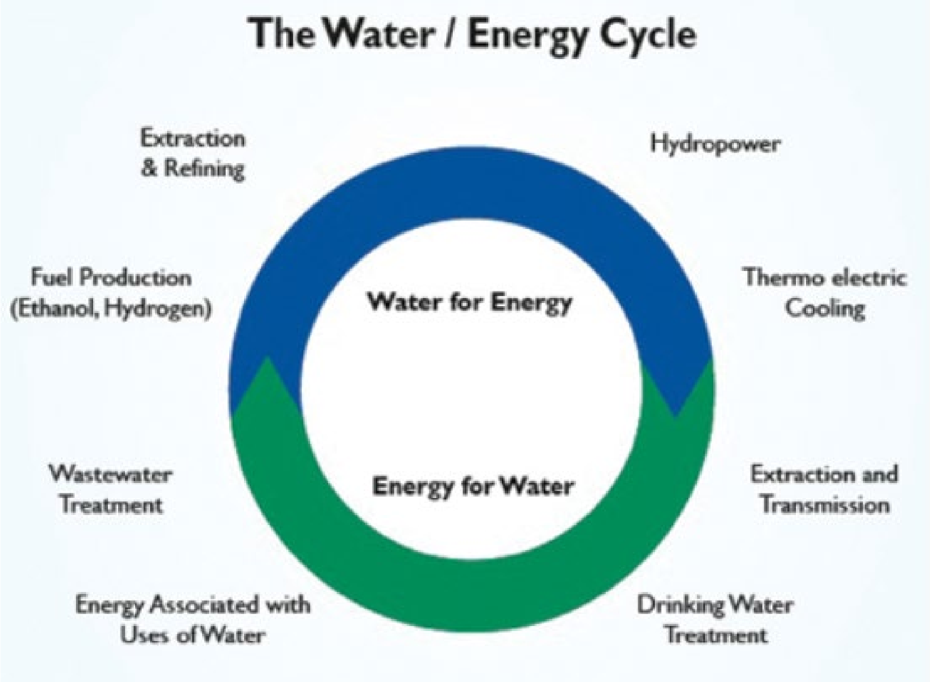
- Brief Water and Wastewater Treatment Overview
- Generator Sizing and Solution Options
- Important Design Considerations
- Installation Examples
- Q&A

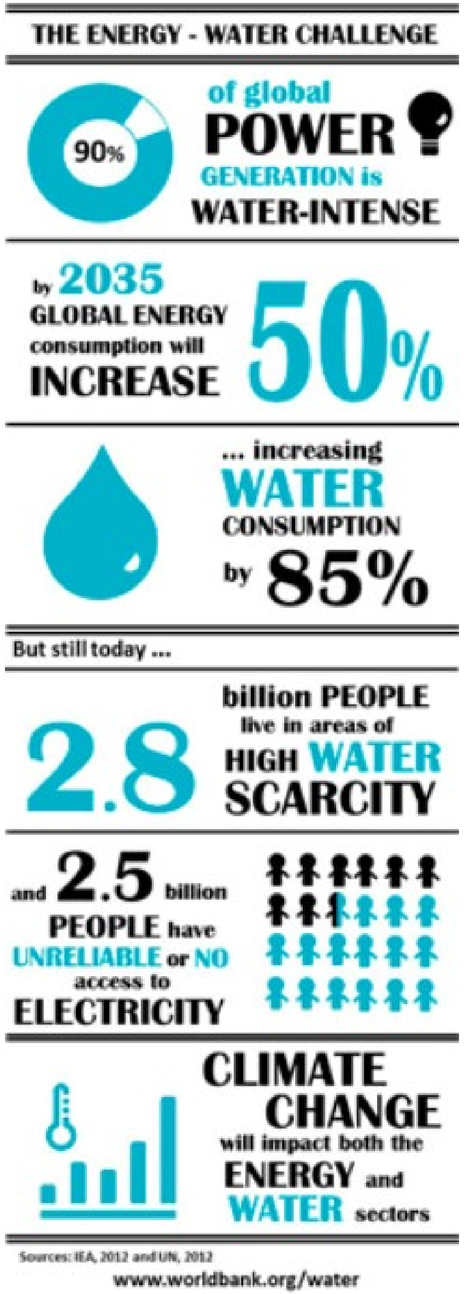
Background and Overview

Water and Energy

- **Energy and water are intricately connected.**







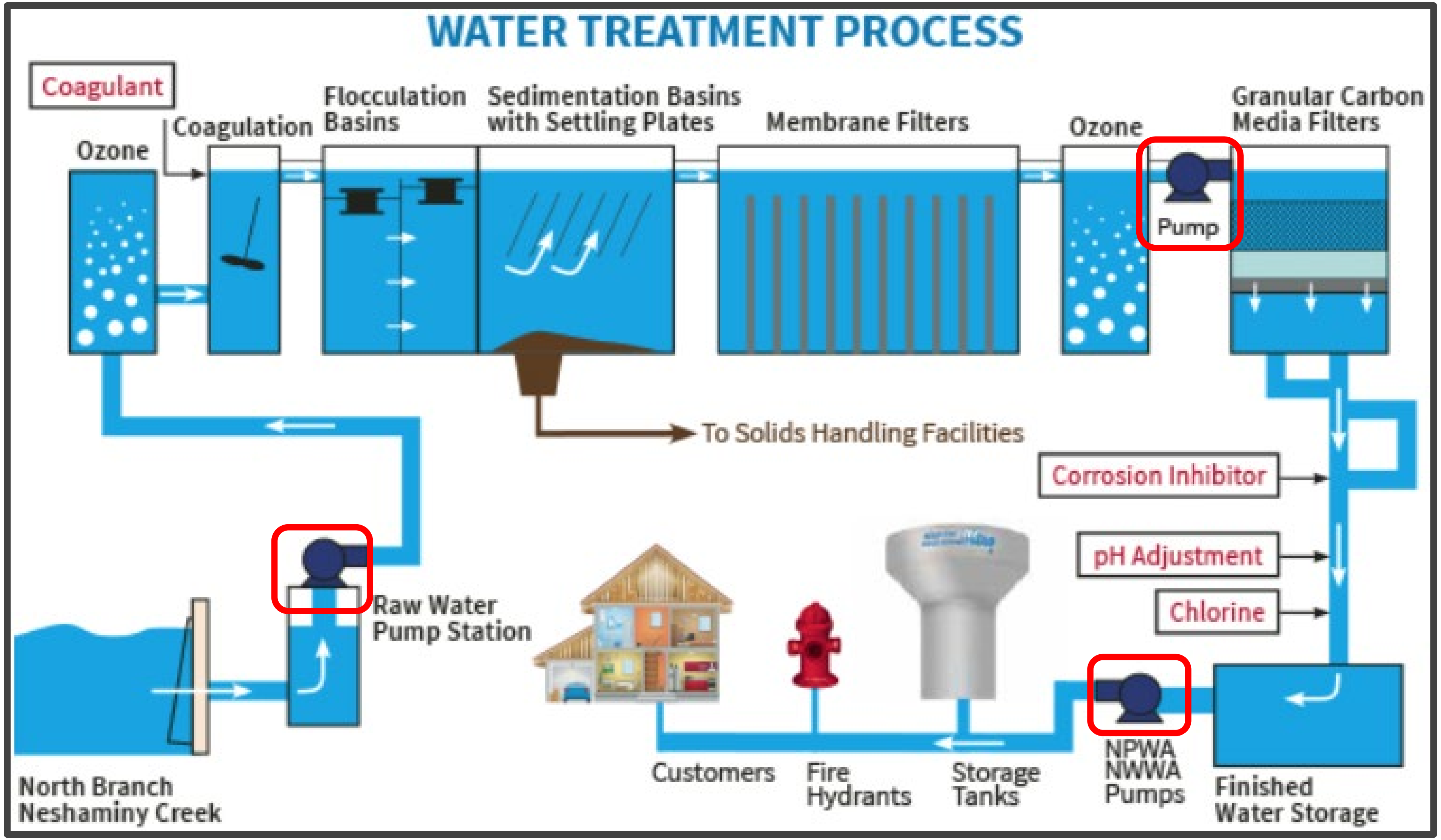
- **Energy availability is the pillar for social and economic progress in a society. Water holds the Key!**

- **Energy is of primary importance for water management and developments.**

Water Treatment

- Water and wastewater treatment plants produce water for consumption and recycling.
- Municipalities rely upon their water network to provide efficient distribution of precious water resources at the lowest cost to local stakeholders.
- Water treatment facilities treat surface or groundwater to provide a steady stream of potable water and move waste waters via a network of pumping stations.
- According to studies conducted by the EPA, water and wastewater utilities are the largest consumers of energy in municipalities, accounting for 30-40% of the total energy consumed. EPA estimates 3-4% of all national electricity consumption, equivalent to approximately 56 billion kilowatts, is used to provide drinking water and waster water services each year in the United States.

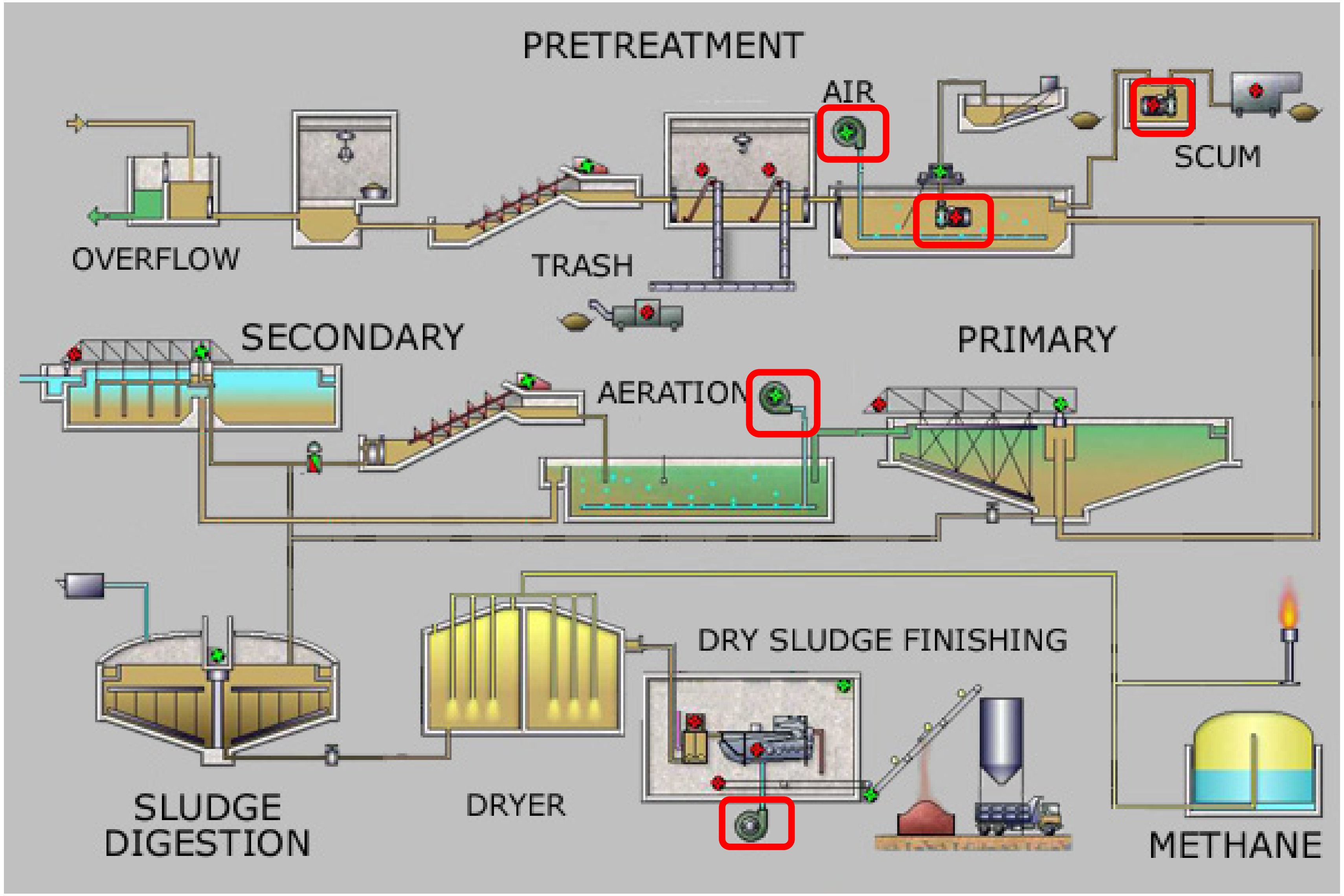
Supply Water Treatment



Pumps highlighted In RED

http://northpennwater.org/Forest-Park-Water-Treatment-Plant

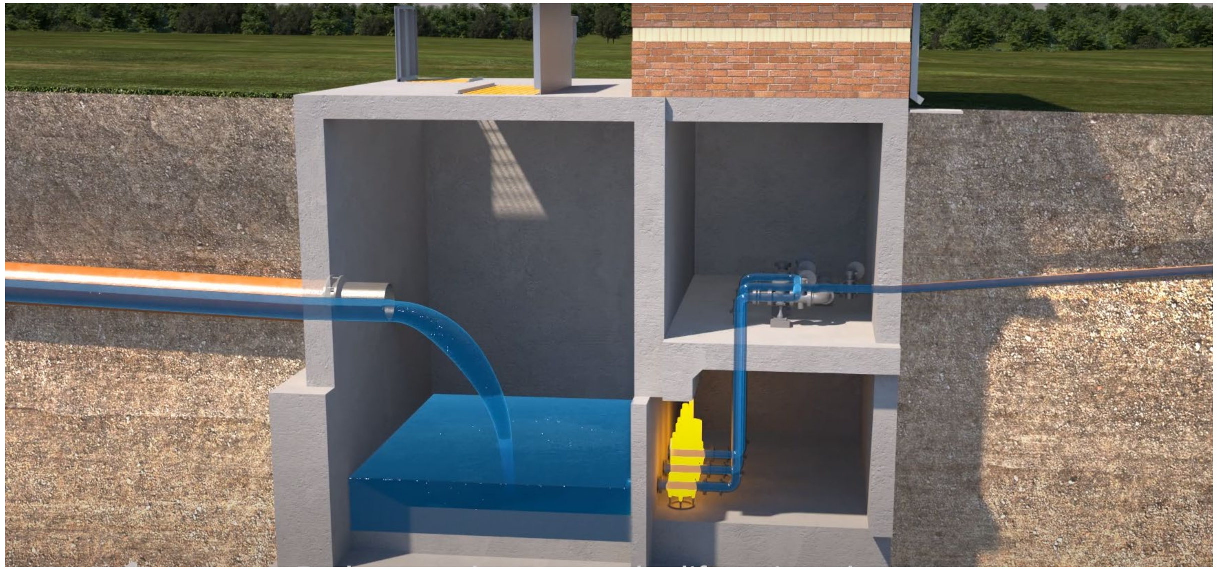
Wastewater Treatment Overview



Pumps highlighted
In RED

https://commons.wikimedia.org/w/index.php?curid=39975544

Wastewater Flow Path (Lift Stations)



Metropolitan Council
https://www.youtube.com/watch?v=Z9-DXl028-Y

Supply Water Treatment Outage Consequences

- When pumps go offline due to power outages, these processes are halted and water distribution ceases.
- In the case of large municipalities, returning all plant systems to normal operations and resuming the distribution of water can be a daunting task.
- During prolonged outages under-treatment may occur, and the penalties both in terms of financial and environmental damage can be severe.

Water Treatment Outage Consequences (Cont'd)

- Water distribution facilities are the heart of the water network, responsible for pumping water through the system.

- A power outage that disrupts pumping or lifting stations can put a significant strain on the network, potentially leading to flooding or discharge of untreated wastewater, negatively impacting local water quality.

- Fail-safe power systems ensure that critical pumps remain operational during power outages.

Power System Sizing and Solution Options

Power System Options

Generator	Pros	Cons
On-site (stationary or mobile)	• You know you have one • Reduced time to respond	• Could be costly • You perform the maintenance • The disaster that strikes your utility could also damage your generator
Off-site (rented or borrowed)	• Multiple sources to get one – EOC, WARN, vendor • 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

Generator Selection

Spec Note: As highlighted on the right and earlier in the presentation, pumps comprise a large portion of the electrical loads at WT and WWTP facilities. Motor starting capability should be carefully considered when selecting a generator supplier.

How do I know what my backup power needs are?

1. **Classify** the electrical needs at your utility:

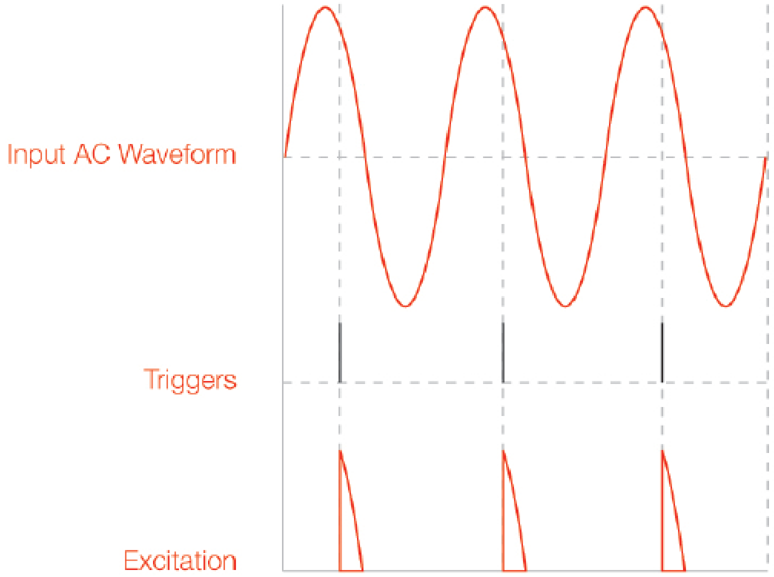
- *Critical need.* Equipment essential to maintain public health protection (e.g., pumps).
- *Secondary need.* Equipment that would enhance operation, but is not critical (e.g., SCADA components).
- *Noncritical need.* Equipment provided for convenience/comfort, but not essential (e.g., pumphouse lights).

Only consider needs critical to maintaining an acceptable level of service during power outages at your utility.

2. **Identify** the electrical equipment within the critical needs at your utility and determine their voltage, phase configuration, and horsepower/amperage requirements. Remember, electrical equipment starting power demands are usually two to three times higher than their running demands, which may dictate a larger generator.

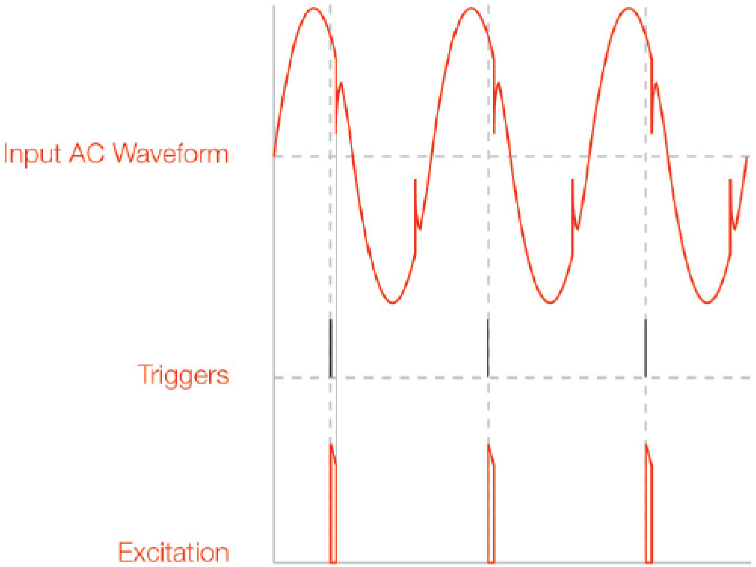
3. **List** all your critical electrical equipment and their starting order to determine your required starting power. At a minimum, your generator(s) must have the capacity to supply the maximum starting power demands and the running demands of the connected equipment.

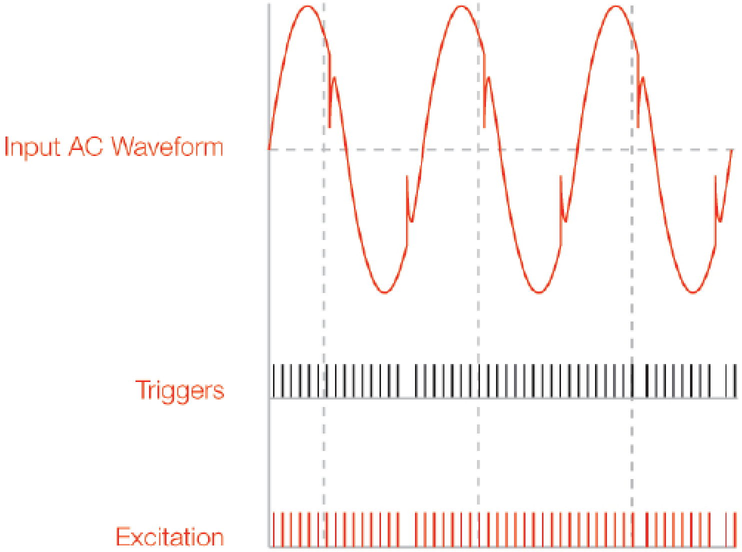
Generator Selection: Automatic Voltage Regulator (AVR)



SCR Controlled AVR
(Without Harmonics)

SCR Controlled AVR
(With Harmonics)





FET Controlled AVR
with Pulse Width
Modulation (PWM)
Excitation System

Spec Note: Specify 3-phase sensing, full wave rectified FET type AVR, with PMG

Related Content White Papers Search “GLPT-6008-EN”

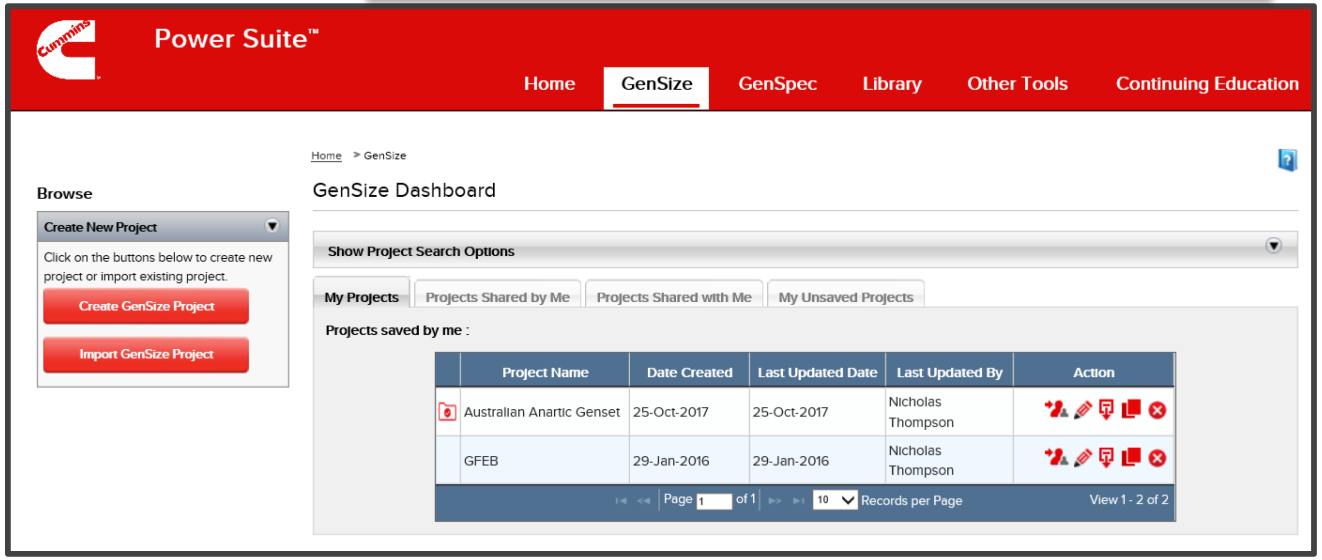
Generator Selection: Sizing

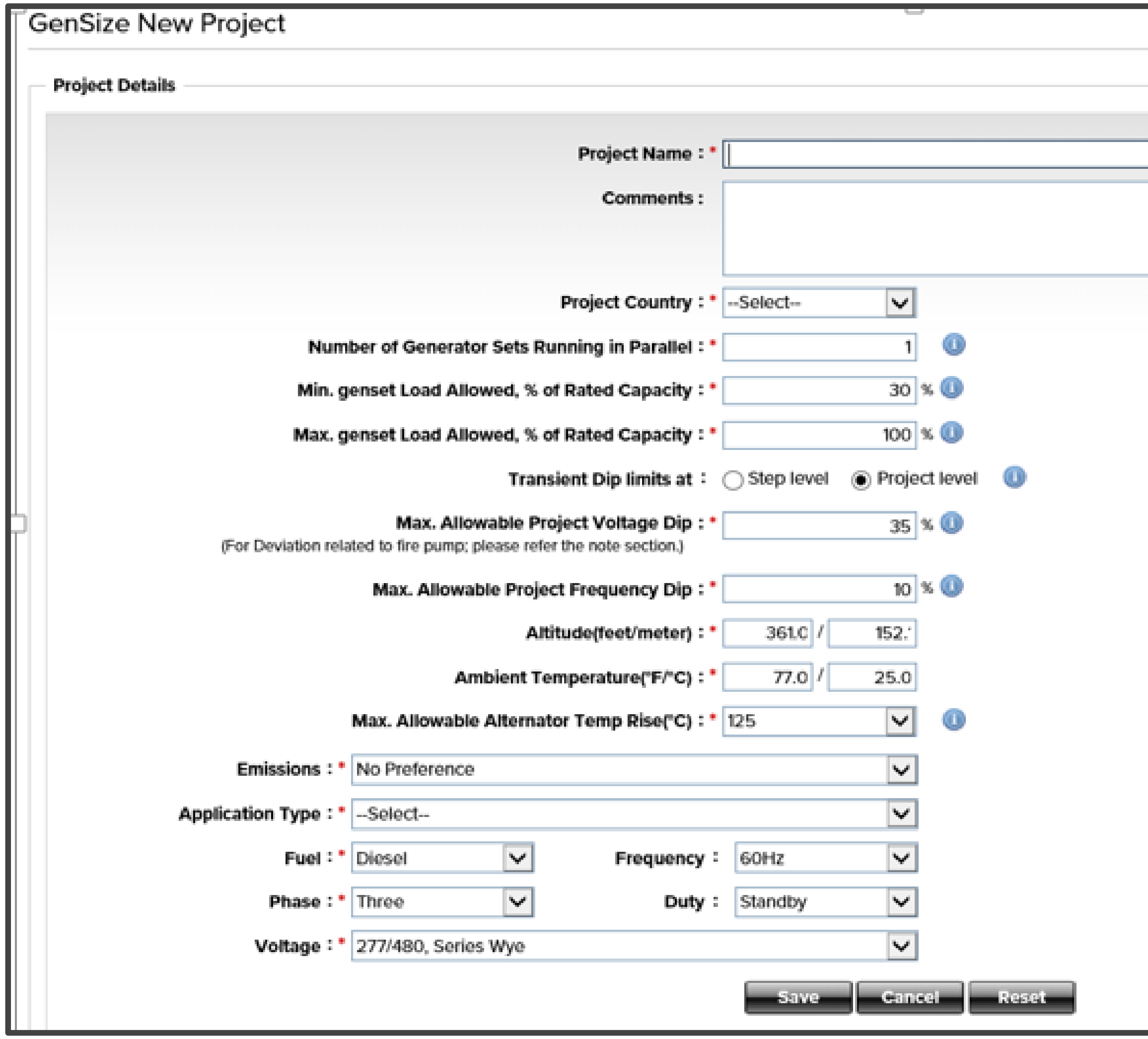
- Online sizing tools help to account for variables that impact generator sizing, such as:
  - Soft start capabilities
  - Variable frequency drives (VFDs)
  - Motor starting abilities

Related Content

Power Hour

- Introduction to Generator Set Sizing Software
- Advanced Generator Set Sizing Software: Transient Performance and





Concept Check

The following variable(s) should be included when utilizing a power system supplier's online sizing tool in order to ensure that the appropriate power system is selected:

A. Maximum Load

B. Soft Starting Capability

C. Variable Frequency Drives

D. Motor Starting Abilities

E. All of the Above

Concept Check

The following variable(s) should be included when utilizing a power system supplier's online sizing tool in order to ensure that the appropriate power system is selected:

A. Maximum Load

B. Soft Starting Capability

C. Variable Frequency Drives

D. Motor Starting Abilities

E. All of the Above

Generator Selection/Sizing: Fuel Choice

What other considerations are there?

1. Fuel Type - Fuel type greatly influences emergency generator(s) selection. Diesel generators are the most common, and offer the largest selection, availability, and power range (from 5 kilowatts [kW] to over 2,000 kW). To select an appropriate fuel supply, consider:

	Diesel[1]	Natural Gas[2]	Propane[3]	Gasoline
Fuel Storage	+	+	+	-
Fuel Delivery Method	-	+	-	-
Generator Availability	+	-	-	+
Generator Portability	-	-	-	+

[1] Assume a consumption rate of 0.07 gallons per hour for every 1kW of power generated.
[2] Assumes access to a pipeline. Can use propane as a backup fuel, but requires an adapter.
[3] Use the generator specification sheet to calculate expected runtime for a given load and propane tank capacity.

Also check any local or state regulations regarding air quality, as these may affect the generator(s) you select.

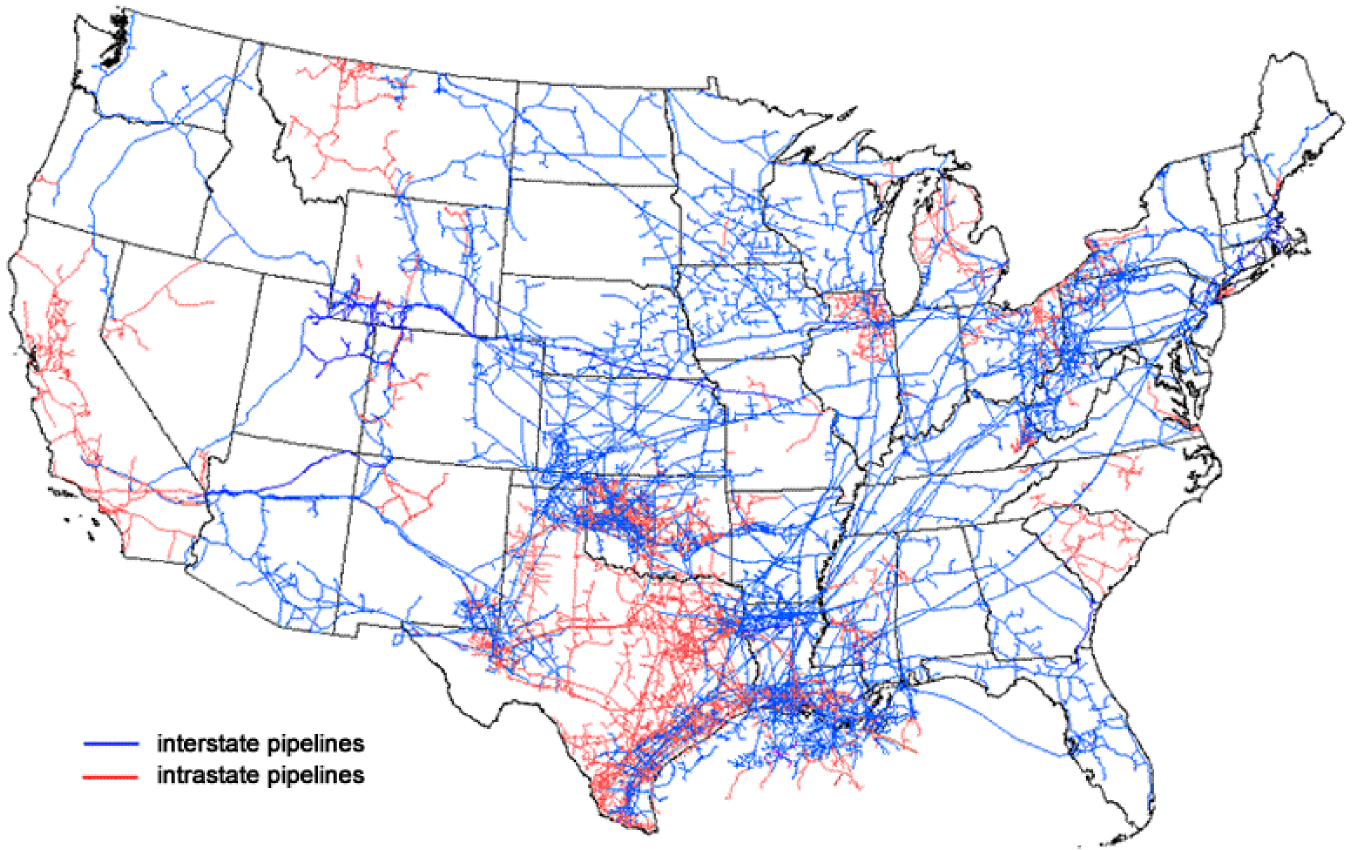
- Due to fuel shortages caused by extended outages that were the result of recent hurricanes, larger onsite fuel storage is now being required in some regions.
- Fuel testing requirements for diesel fuel tanks must also be considered.

Related Content
Power Hour
Considerations for Specifying Generator Set Fuel Sources

Generator Selection/Sizing: Fuel Choice (Cont'd)

- Natural gas generator sets may not be suitable for seismic regions
- Natural gas infrastructure has limitations, depending on location, however, it's important to note, natural gas infrastructure was not impacted during major recent storms Irene, Sandy, or even, Katrina.
- Space claim is another consideration. Due to higher power densities, diesel generators are capable of providing a smaller solution, versus, natural gas units.
- https://cummins365.sharepoint.com/sites/CS503/SitePages/Considerations-for-Specify.aspx

Map of U.S. interstate and intrastate natural gas pipelines



Source: U.S. Energy Information Administration, *About U.S. Natural Gas Pipelines*

Generator Selection/Sizing: Rating Types

What type of rating is appropriate for Water and Waste Water applications?

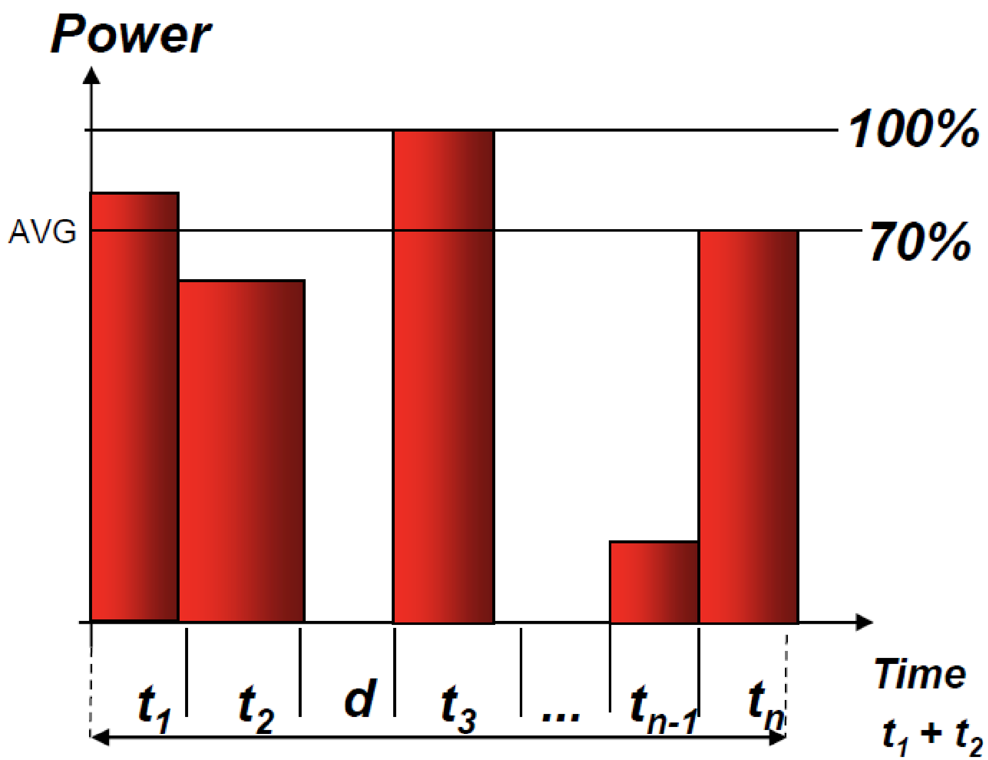
Industry Standard for Generator Set Ratings:

- ISO 8528: Standard for reciprocating internal combustion engine driven alternating current generator sets.
- Defines application, ratings and performance of generator sets.
- Sect. 13 defines these ratings:
  - **Emergency Standby Power (ESP)**
  - Limited Time Prime Power (LTP)
  - Prime Rated Power (PRP)
  - Continuous Operating Power (COP)
- Any manufacturer can go above and beyond the ISO ratings definitions.
  - Data Center Continuous (DCC)

Related Content

Power Hour
Generator Set Ratings for Data Centers and Other Applications

Emergency Standby Power (ESP)



$t_1 + t_2 + t_3 + \ldots + t_n = 24$ hours

- For supplying emergency power for the duration of a utility power failure
- Not to exceed **200 hrs/yr**
- **Average load factor of 70%** of the standby rating over 24 hour period
- No negotiated outage operations

$$P_{pa} = \frac{P_1 t_1 + P_2 t_2 + P_3 t_3 + \cdots + P_n t_n}{t_1 + t_2 + t_3 + \cdots + t_n} = \frac{\sum_{i=1}^{n} P_i t_i}{\sum_{i=1}^{n} t_i}$$

Spec Note: If a generator set is only utilized for emergency backup, not demand response or rate curtailment, then, a Standby rating should be specified. Prime and Continuous ratings are not properly suited for emergency backup applications as this can cause the generator set to be unnecessarily oversized.

Spec Note: If a generator set is also utilized for demand response, rate curtailment, or peak shaving, then Prime and Continuous ratings must be considered, NOT Standby ratings. NOTE: EPA T4 Certified Emissions Engines are required for these applications.

Why Customers Need or Want a Tier 4 Solution for Diesel?

Need

- to operate outside of the emergency standby limitations set forth by the EPA. (i.e. prime, peak shaving, rate curtailment, etc.)
- to comply with local requirements (BACT)

Related Content

Power Hour
Emissions and Air Permitting for Emergency Generator Sets

Want

- to be cleaner and better stewards of the local community and environment

"State and local agencies are not prevented from providing additional regulations beyond these regulations and such agencies may institute additional testing requirements independent of EPA related actions."

Response to Public Comments on Proposed Standards of Performance for Stationary Compression Ignition Internal Combustion Engines

Cummins Tier 4 Certified vs Tier 4 Compliant Products

EPA Tier 4 Certified

- Extended operation non-emergency
- "Inducement-shutdowns" (example: forced shutdowns if DEF fluid runs which would cause emissions to exceed limits.)
- No source testing
- Specific models
- As is – no modifications

Both

- Meets T4 emissions limits
- Identical hardware

Tier 4 Compliant

- Lower price point
- Not regulated by EPA
- Modifications are permitted, DEF tank size, etc.
- No Inducement shutdowns

Cummins Tier 4 Products

Certified

Generator Set Model	Standby Rating (kWe)	Engine Model
DQFAH	1000	QST30-G17
DQGAS	1500	QSK50-G8
DQKAM	2250	QSK60-G17
DQLH	2750	QSK78-G14

Compliant

Engine Model	Standby Rating (kWe)	T4 Compliant System
QST30	750kW – 1000kW	CA-45-1
QSK50, QSK60	1250kW – 2250kW	CA-45-2
QSK78	2500kW – 2750kW	CA-54-2

Portable

Generator Set Model	Standby Rating (kWe)	Engine Model
C70D2RE	70	QSB5-G11
C100D2RE	100	QSB5-G11
C150D2RE	150	QSB7-G9
C200D2RE	200	QSB7-G9
C275D2RE	275	QSL9-G9
C500D2RE	500	X15-G17

Concept Check

If a customer plans to use a backup power system only in emergency situations, totaling less than 200 hours per year, then the most effective rating choice, in terms of cost and space claim, would be:

A. Limited Time Prime

B. Prime

C. Emergency Standby

D. Continuous

Concept Check

If a customer plans to use a backup power system only in emergency situations, totaling less than 200 hours per year, then, the most effective rating choice, in terms of cost and space claim, would be:

A. Limited Time Prime

B. Prime

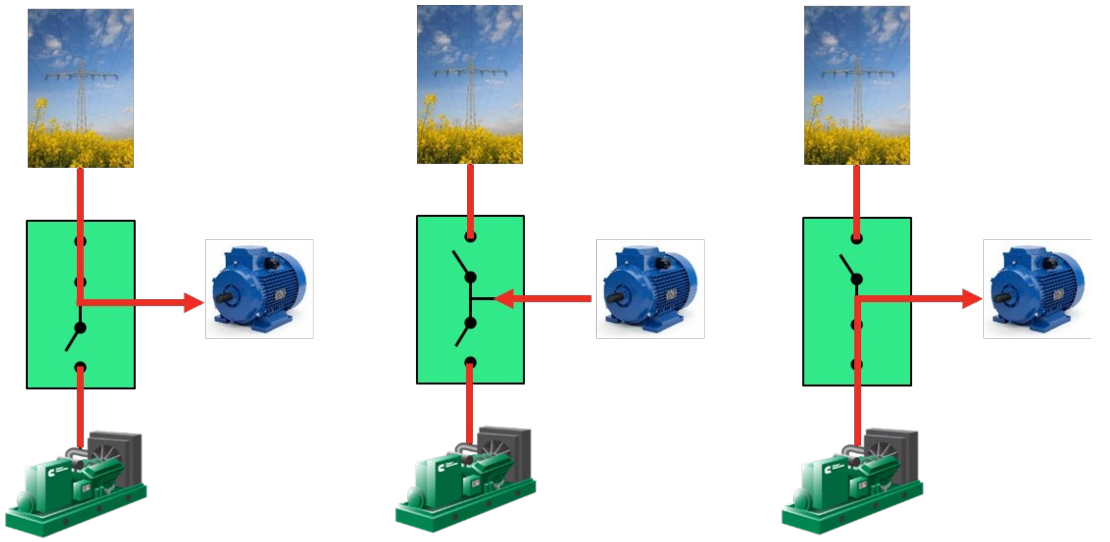
C. Emergency Standby

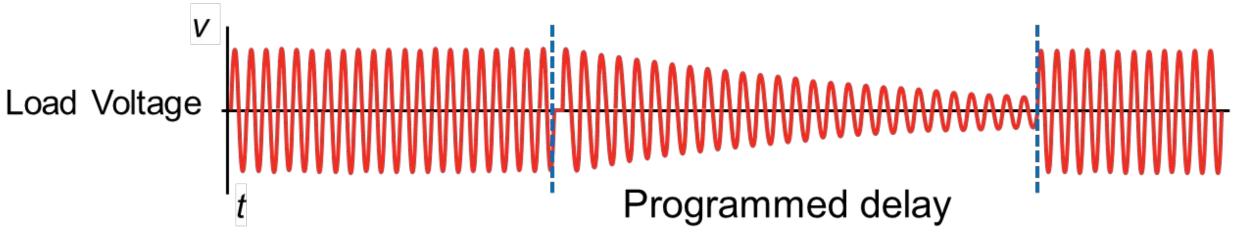
D. Continuous

Additional Design Considerations

Power Transfer Design Considerations (Open Transition)

- An Automatic Transfer Switch (ATS) or breaker pairs can be used for transferring power from one source to another.
- In applications where a significant portion of the loads are motors, the design must be cognizant when switching between two live sources because a motor, essentially, becomes a generator, for a short amount of time, and we need to allow the motor's residual voltage to decay prior to reenergizing the motor.
- An ATS or breaker pair controls can be ordered with a programmed transition time delay.





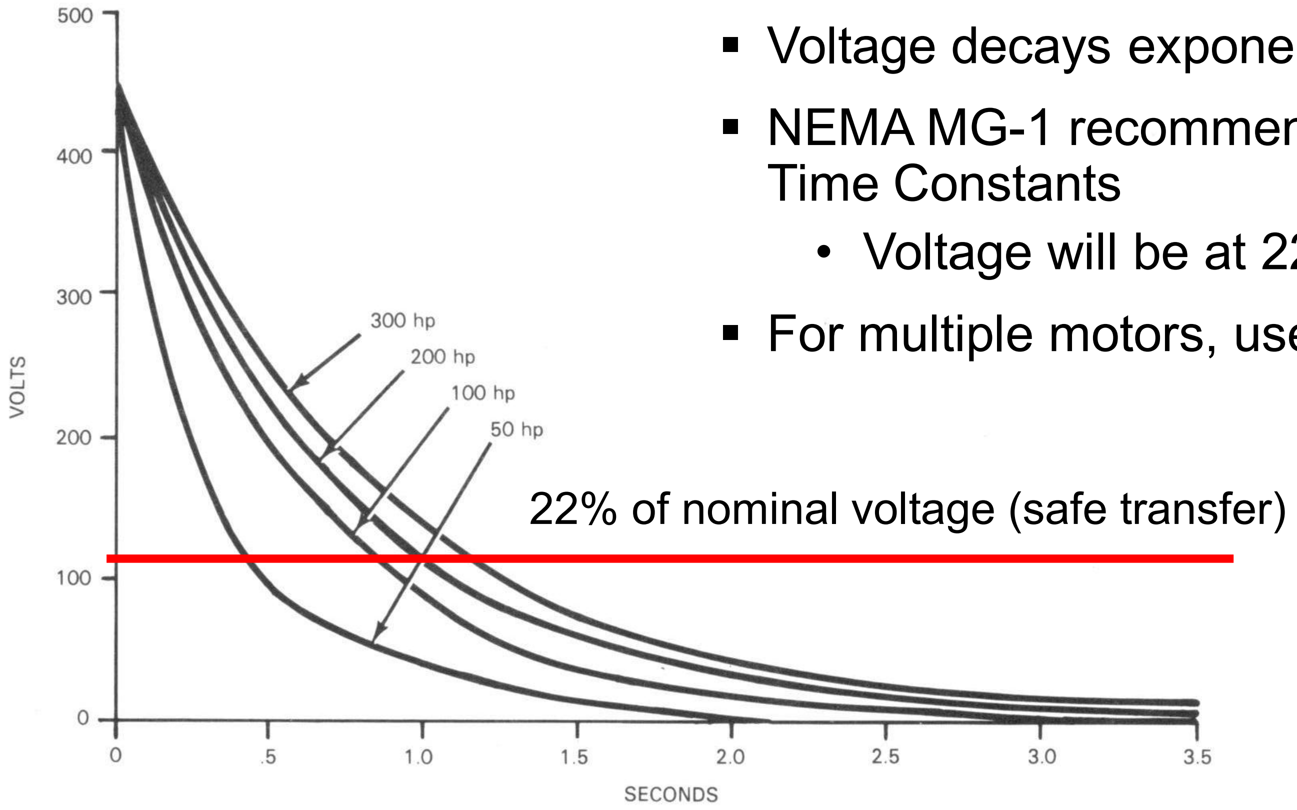
Spec Note: Specify open, programmed transition in order to allow voltage decay to protect equipment and prevent nuisance breaker trips or motor torque stress.

Related Content

Power Hour
Transfer Switches Made Easy: A Step-by-Step Guide for Selecting the Right Transfer Switch for your System

Residual Voltage Decay

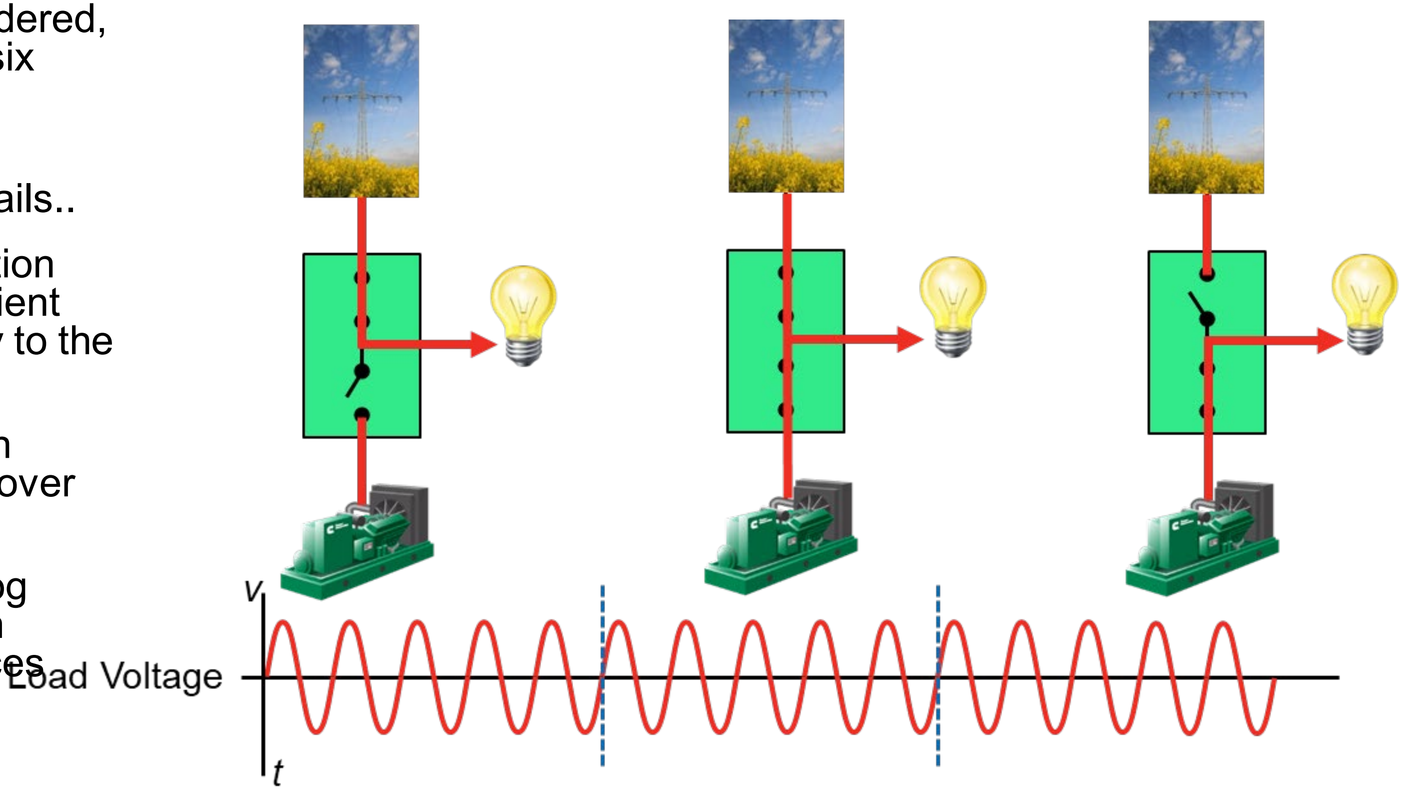
- Voltage decays exponentially (independent of motor speed)
- NEMA MG-1 recommends a delay of 1.5 Motor Open Circuit Time Constants
  - Voltage will be at 22% of nominal
- For multiple motors, use the time delay for the largest motor



Residual Voltage Decrement
Source: IEEE Orange Book

Design Considerations (Closed Transition Transfer)

- If closed transition (make-before-break) is being considered, be sure to verify acceptability with local utility at least six months in advance.
- ATSs cannot anticipate a power failure. The site will experience a power outage if the utility unexpectedly fails..
- With the fast-closed transition method of closed transition transfer you can expect a voltage and frequency transient event(dips) when the load is transferred from the utility to the genset during system testing.
- Transients can be minimized by a soft closed transition where the load is shifted from one source to the other over several seconds (<10 sec.)
- Most Utilities will require a Fail to Disconnect (watchdog timer) protective function to trip the utility breaker open should the equipment hang in the closed to both sources position.



Spec Note: For smooth closed transition switching, specify synchronizers that match phase, frequency, and voltage in order to protect equipment.

Design Considerations (ATSs / Switchgear)

- If transfer switches or gear will be located outdoors, be sure to verify site environmental requirements. Often, NEMA 3R or 4X enclosures with anti-condensation heaters are required.
- Ensure that switchgear busses are plated with a material compatible with corrosive environments, if used in a WWTP application (Tin vs. Silver plated).
- If a mobile generator is chosen for backup power, then, consider specifying a single purpose exterior connection box with overcurrent protection and CamLok style connectors.

Design Considerations (Switchboard/Switchgear)

- Switchboard/Switchgear/Metal-Clad Switchgear size and accessibility are important factors when designing installations.
- Specifying front access only ATSs and switchboards provide an advantage by not requiring rear access, which will allow the gear to be set against a wall saving interior floor space, reducing installation complexity.
- Arc Resistant Switchgear will require arc-blast ducting or an arc-blast shutter. Both options require additional space requirements.

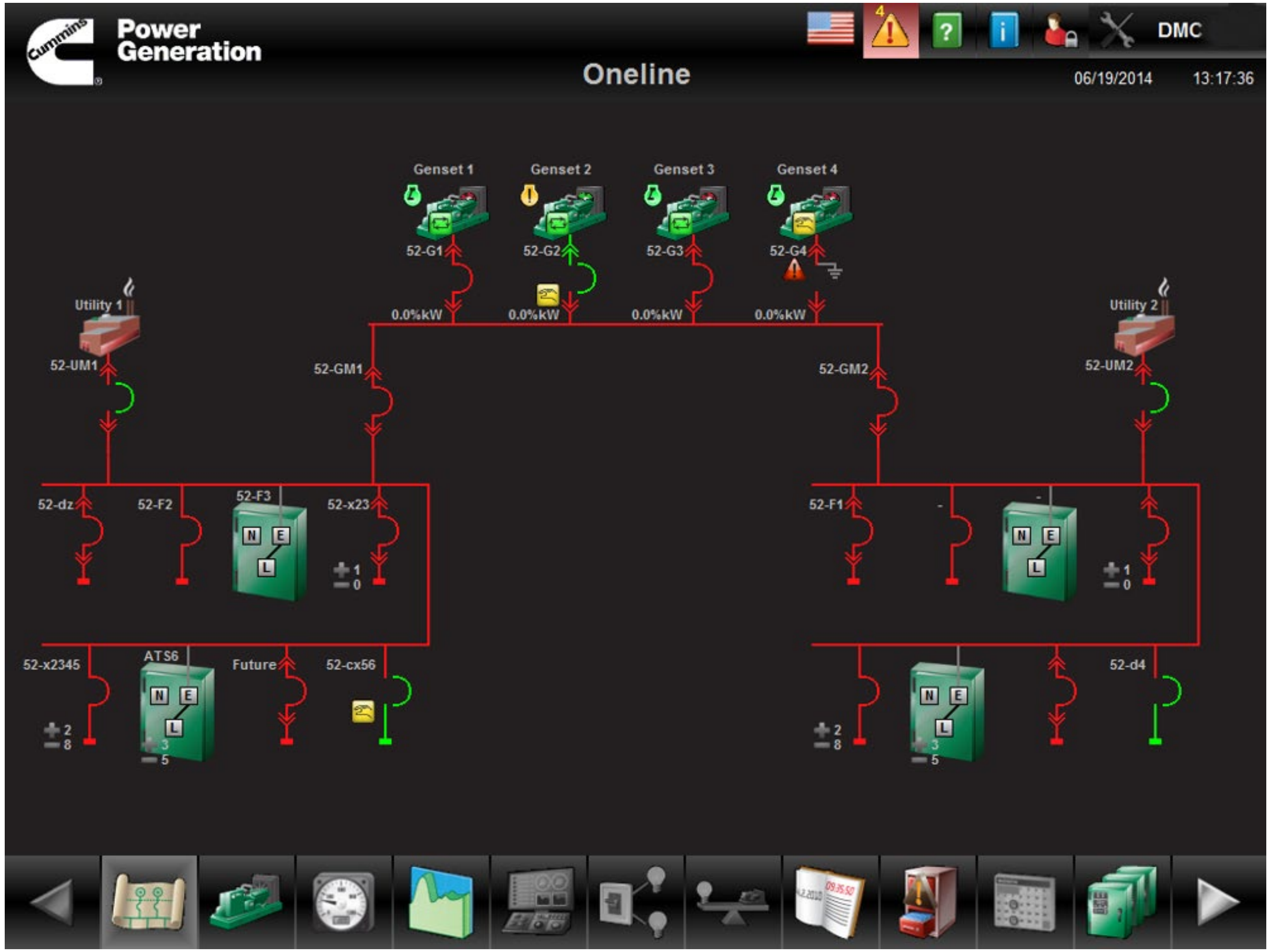
Design Considerations (Pre-configured equipment)

- Generator vendors often offer a wide selection of preconfigured switchboard sections for:
  - Generator paralleling
  - Utility and generator main breakers
  - Transfer breaker pairs
  - Molded case and insulated case feeder breakers .
- Preconfigured Digital Master Controls with selectable configurations offer time proven control sequences with years of operational experience.
- Both offer readily accessible outline and interconnection drawings reduce design time, lead time, and overall cost.

Spec Note: Specify predesigned, preconfigured switchboards and Digital Master Control solutions in order to reduce lead time, engineering work, and, consequently, overall system cost.

Digital Master Control

- Provides added functionality beyond what is available from engine/genset and ATS controls
- Examples of when a digital master control may be necessary:
  - Load addition and load shedding sequence.
  - Monitoring the plant's power flow.
  - Perform load transfer between multiple utility sources.
  - Multiple generators running in parallel with a utility.
  - Specific sequence of operations required for process control.
  - Real time and historical trending.
  - Time stamped, system's alarms and events.
  - Redundant supervisory controls (hot standby processors).



Concept Check

Specifying predesigned, preconfigured switchgear/ATS solutions can lead to the following benefits:

A. Reduce Lead Time

B. Reduce Engineering Work

C. Increase Overall Cost

D. Answers A & B

Concept Check

Specifying predesigned, preconfigured switchgear/ATS solutions can lead to the following benefits:

A. Reduce Lead Time

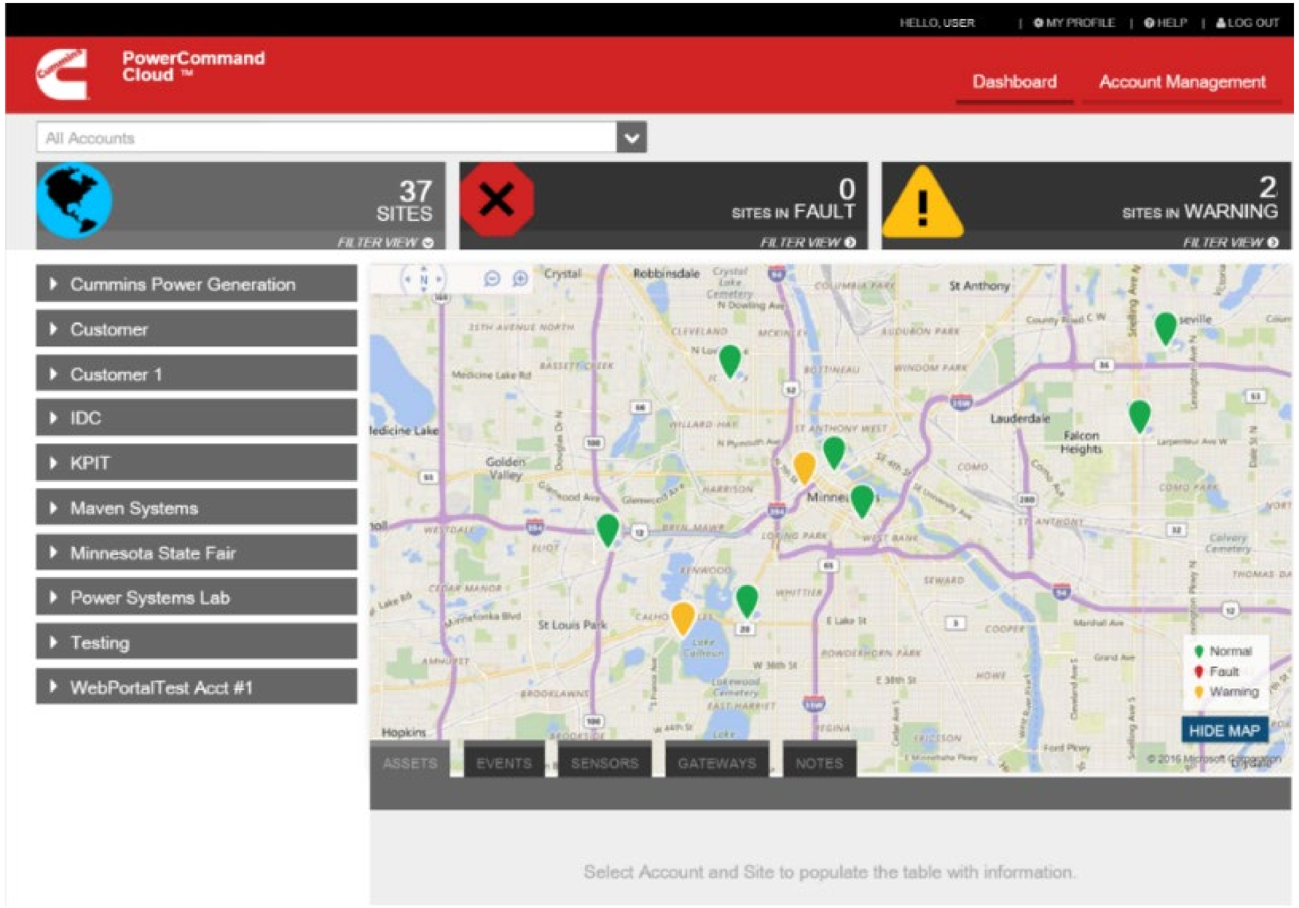
B. Reduce Engineering Work

C. Increase Overall Cost

D. Answers A & B

Design Considerations (Monitoring)

- Remote monitoring can provide valuable benefits to the power system. Monitoring the system will enable the operator to check the health and functionality of the system. This can provide a significant benefit for operators such as service response time and reducing equipment down time.
- Single or multiple discrete condition/alarm contacts for a trouble light or site telemetry.
- Cloud based remote monitoring enables the operator to view information from a single or multiple sites anywhere with internet connectivity. Monitoring systems for local area networks are also available.
- Network communications from the Genset, ATS, and Digital Master Controls directly interfacing with the site's Building Automation system or SCADA System.



Design Considerations (Service)

Confirm that the selected generator, ATS, and switchgear supplier can provide necessary service support. This includes:

- Service capability and distance from the service location to the equipment.
- Number of factory-trained technicians.
- Local, on-hand, parts inventory .
- Planned maintenance services.

Spec Note Require backup power system vendors to maintain an inventory of replacement parts and employ factory trained field service technicians and field service engineers capable of servicing the complete generator system.

Installation Examples

Example: Water Treatment Plant, Oklahoma, USA

The Broken Arrow Water Treatment Plant has a rated capacity of 20 million gallons to support most of the population of Broken Arrow, a major Tulsa suburb. The backup power system includes three 2 MW medium-voltage generator sets along with a DMC paralleling system and switchgear. The Digital Master Control is designed to directly interface with the genset controls on the generators for seamless system integration.

Example: Sewage Lift Station, Washington, USA

Where:
Camas, Washington, USA

What:
Seven standby diesel generators from Cummins Power Generation, ranging from 20 kW to 200 kW, for new critical sewage lift stations

Purpose:
To prevent sewage from backing up and causing an ecological disaster in the event of an extended utility outage

At sites with permanently installed standby generators, factory enclosures provide high security in addition to sound-attenutation.

Pre-engineered sewage lift stations include submersible pumps, an underground valve vault, a standby generator and controls.

Course Summary

Course Objectives:

- Understanding the criticality of providing reliable backup power systems for Water and Wastewater installations, as well as, the potential consequences if these systems fail.
- Determining which generator set rating should be specified for an application, based upon its intended uses.
- Identifying important design considerations when specifying power systems for Water and Wastewater Treatment applications.

Important Spec Notes:

- Motor starting capability should be carefully considered when selecting a generator supplier.
- A Standby rating should be specified if a generator set is only utilized for emergency backup.
- Emissions considerations:
  - if use is other than strictly emergency backup
  - Local AHJ/municipality requirements above current EPA requirements
- In order to reduce lead time, engineering work, and overall system cost, specify predesigned, preconfigured switchgear/ATS solutions.
- To protect downstream equipment, specify synchronizers that match phase, frequency and voltage .
- Specify programmed transitions to allow voltage decay to protect equipment and prevent nuisance breaker trips.
- Require generator set vendors to maintain an inventory of replacement parts and employ factory trained service technicians and field engineers capable of servicing the complete emergency power system.

Q&A

Please type your questions, comments and feedback in the Zoom Q&A window.

After the PowerHour, a complete list of questions and answers will be published on powersuite.cummins.com.

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