Utility Perspectives on Backup Power Design

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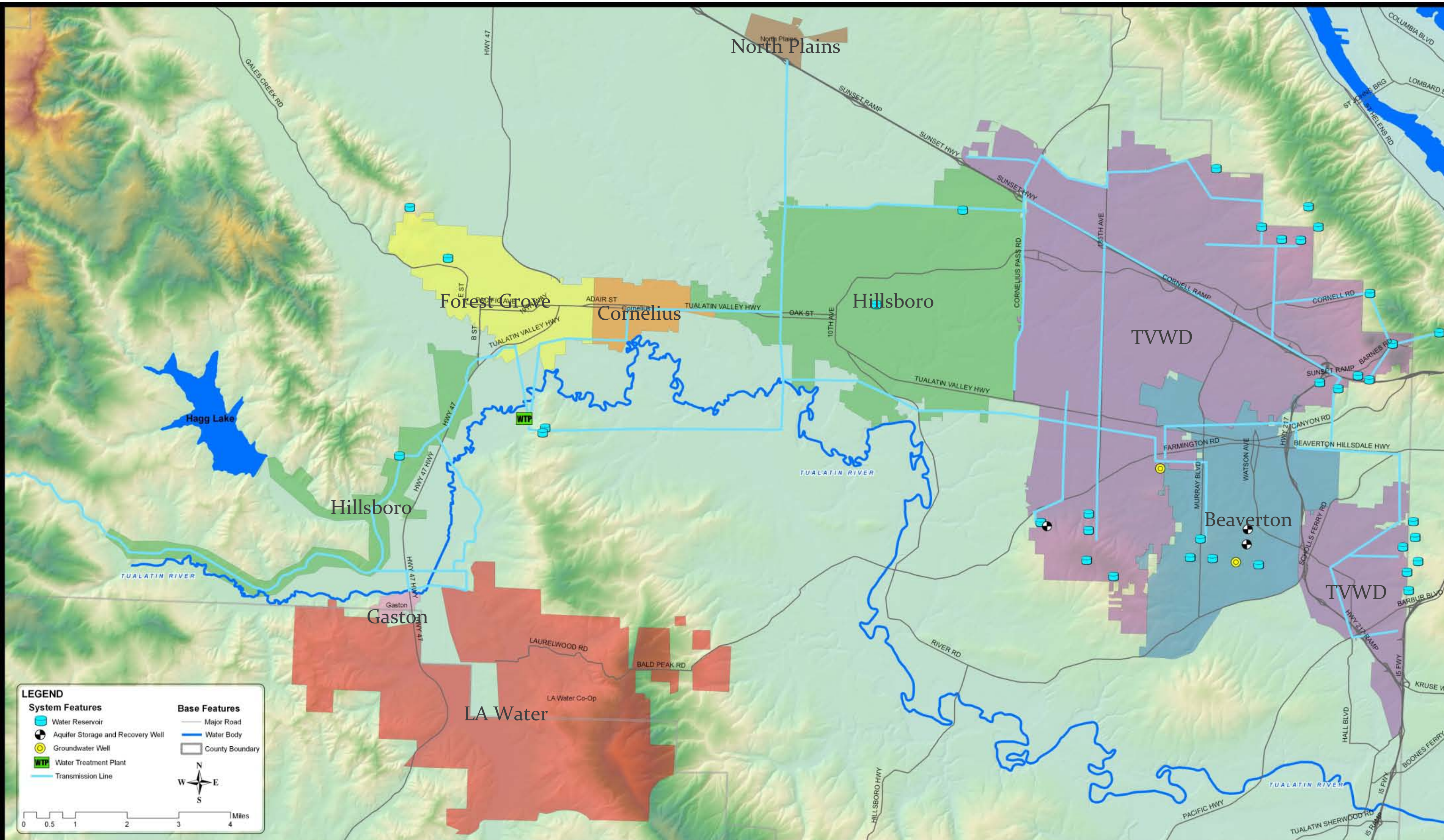
City of Hillsboro, Engineering Manager

May 4, 2012

Joint Water Commission (JWC)

- The JWC is a collective water supply agency formed under an Oregon Revised Statute (ORS) 190 agreement
- Primary drinking water supplier in Washington County, Oregon
- Treat, transmit and store potable water for more than 400,000 customers
- Treat up to 75 million gallons of water per day



North Plains
Forest Grove
Cornelius
Hillsboro
TVWD
Hagg Lake
Hillsboro
Beaverton
TVWD
Gaston
LA Water
LA Water Co-Op
WTP
TUALATIN RIVER
TUALATIN VALLEY HWY
SUNSET HWY
CORNELL RD
FARMINGTON RD
BEAVERTON HILLSDALE HWY
CANYON RD
MURRAY BLVD
WATSON AVE
SCHOLLS FERRY RD
HWY 47
GALES CREEK RD
LAURELWOOD RD
BALD PEAK RD
RIVER RD
PACIFIC HWY
HILLSBORO HWY
HALL BLVD
I5 FWY
TUALATIN SHERWOOD RD
BOONES FERRY RD
KRUSE WAY
BARBUR BLVD
COLUMBIA BLVD
LOMBARD ST
ST HELENS RD
OAK ST
10TH AVE
CORNELIUS PASS RD
185TH AVE
ADAIR ST
B ST
LEGEND
System Features
Water Reservoir
Aquifer Storage and Recovery Well
Groundwater Well
Water Treatment Plant
Transmission Line
Base Features
Major Road
Water Body
County Boundary
N
W
E
S
0 0.5 1 2 3 4 Miles

Vulnerability and Need

- JWC facilities are susceptible to long- and short- term power outages
- 2009 Master Plan identified a need
- Existing backup power 100kW
- 5 facilities need backup power capacity
  - Intake PS, treatment, telemetry, facility, and finished water PS
- Project goal to meet power needs for 50% of plant capacity
- Master Plan estimated 5 MW to meet this objective

UASI Grant

- JWC Applied for and received a Urban Area Security Initiative (UASI) grant
- Grant of $225,000 with matching funds provided by the JWC for a project total of $450,000
- City of Portland Office of Emergency Management (POEM) is the contract administrator
- Provides for Phase I services only (through 60 percent design)

Regional Benefits

- Project ensures emergency water supply to the JWC partners
  - City of Hillsboro
  - City of Forest Grove
  - Tualatin Valley Water District
  - City of Beaverton
- Emergency water supply to other wholesale water providers
  - Cities North Plains, Cornelius, and Gaston and the LA Water Co-op

JWC Project Objectives

- Inclusive, stand alone facility
- Participate in Portland General Electric's Dispatchable Standby Generation (DSG) Program
- Tier 4i emission control strategies
- Accommodate growth

Two Distinct Location Needs

Springhill Pump Station

JWC WTP

Figure 1: Aerial photo of the Water Treatment Plant

Springhill Pump Station

Early Decisions

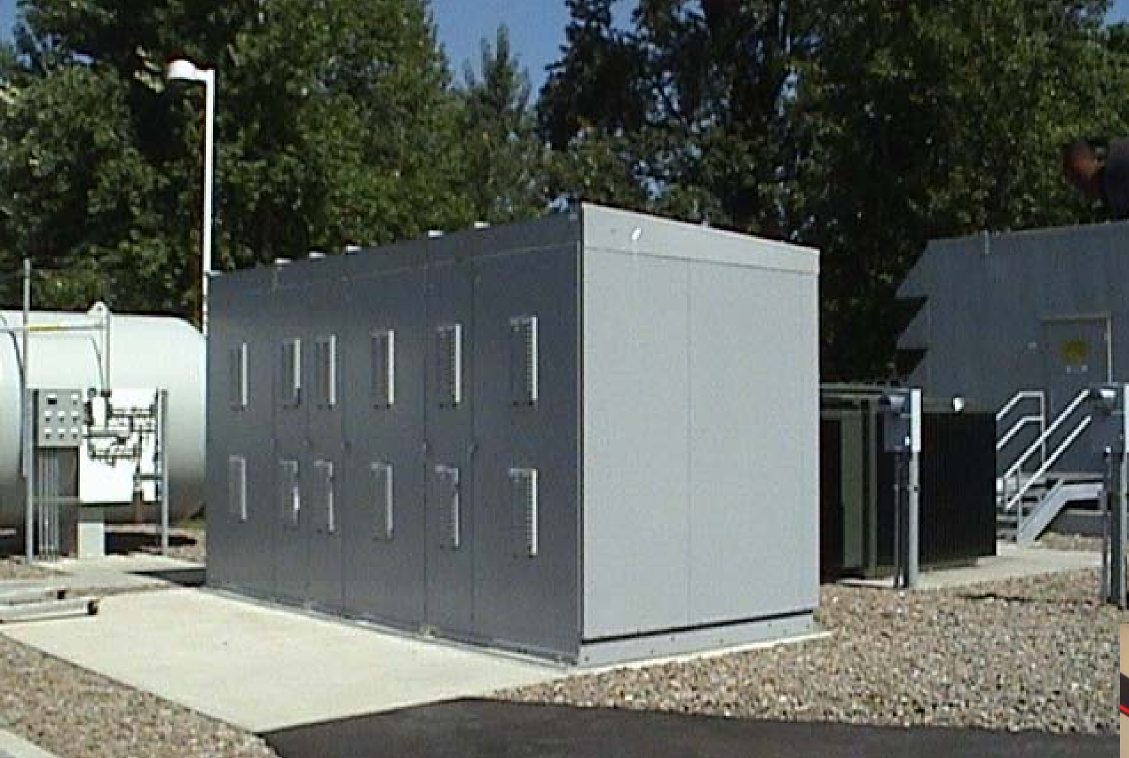
- Interior/Exterior installation of generators and electrical gear: *Interior installation*
- Generator Cooling Systems: *Closed cooling*
- Participate in Portland General Electric's Dispatchable Standby Generation (DSG) Program: *If costs and other benefits seem reasonable*
- Accommodate expansion at WTP: *Yes*
- Project Contracting: *Competitive procurement of generator and major equipment*

Enclosure vs. Building

Enclosure Type	Integral	Constructed
Noise Mitigation	Sufficient	Sufficient, easy to add additional noise mitigation
Access	Easy access but exposed to the weather	Easy access regardless of weather
Aesthetic	Functional	Custom architecture allows for a variety of options
Footprint	Small	Slightly larger
Expandability	No modifications to existing facilities are required	May require demolition
PGE Requirements for DSG	None	None
Pros	Easy expansion, small foot print	More aesthetically pleasing, better protection from weather, increased security
Cons	Exposed to weather, less aesthetically appealing	More difficult expansion

Interior Installation of a 1.0 MW Generator

Outdoor Installation of SWA 1.25 MW Generator

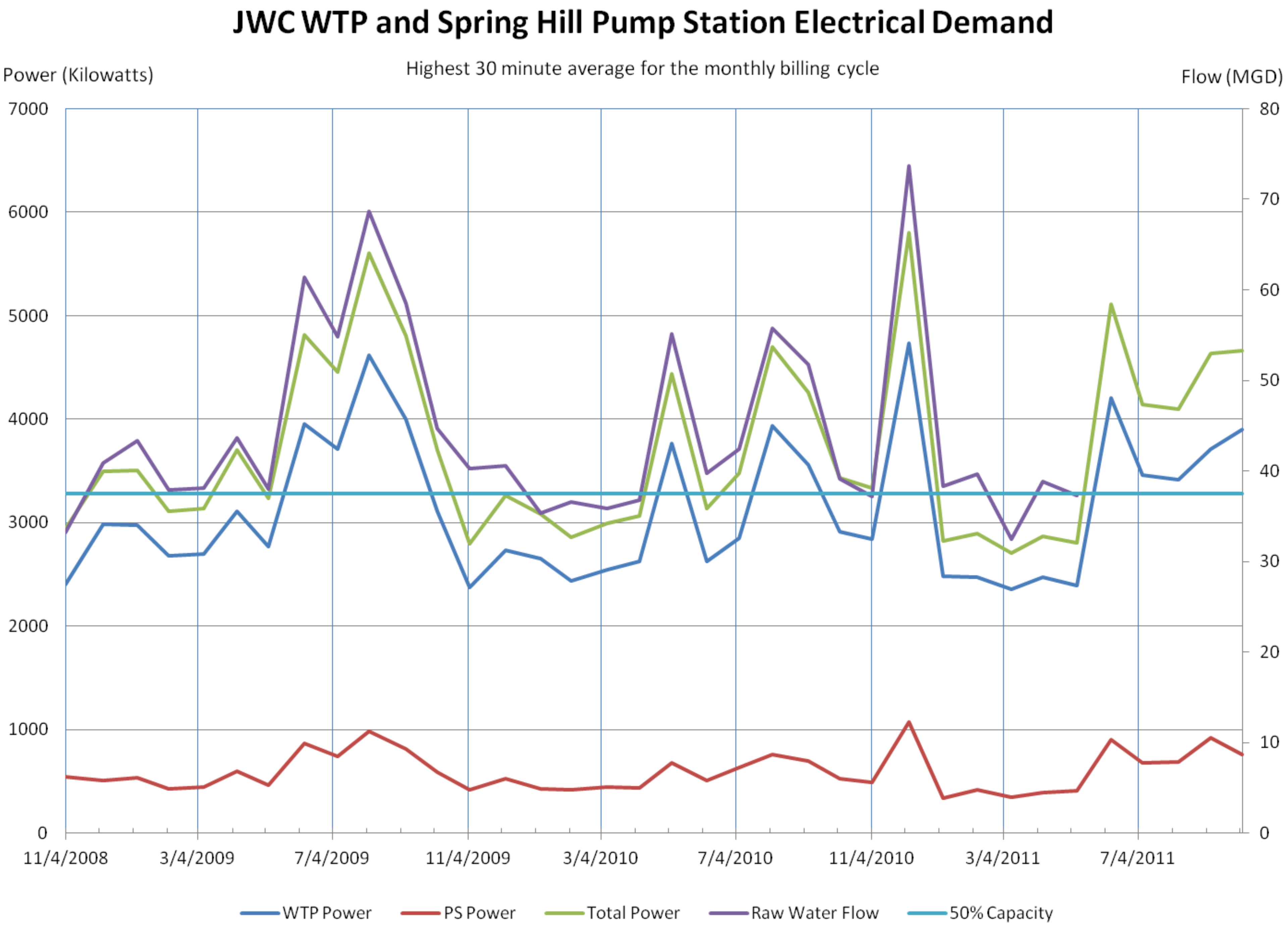


Outdoor Install of Parallel Switchgear

Interior Installation of Paralleling Switchgear

Generator Cooling

- Radiator (Closed) Cooling
  - Pros – Conventional system, self contained
  - Cons – Moderate impact to power output, additional noise source
- Heat Exchanger
  - Pros – eliminates some noise, reduces the size of louvers/penetrations
  - Cons – Does not eliminate all noise, uses moderate amounts of water for cooling that requires disposal



JWC WTP and Spring Hill Pump Station Electrical Demand
Highest 30 minute average for the monthly billing cycle
Power (Kilowatts)
Flow (MGD)
7000
6000
5000
4000
3000
2000
1000
0
80
70
60
50
40
30
20
10
0
11/4/2008
3/4/2009
7/4/2009
11/4/2009
3/4/2010
7/4/2010
11/4/2010
3/4/2011
7/4/2011
WTP Power
PS Power
Total Power
Raw Water Flow
50% Capacity

One versus Two

- Two distinct load locations:
  - Water Treatment Plant (treatment, telemetry, facility, and finished water PS)
  - Springhill Pump Station
- Separated by 2,500 ft
- Springhill Pump Station is owned by the Bureau of Recreation
- May be reconstructed in the future

Two Distinct Location Needs

Springhill Pump Station

JWC WTP

Table 3.5 Estimated Construction Costs

	2 x 2,500 kW Engine at WTP	3 x 1,500 kW Engine at WTP	3 x 1,500 kW Engine at WTP and 1 x 700 kW Engine at SHPP
Generators, Electrical Equip., Electrical Building(1)	$2,785,000	$2,727,000	$2,950,000
Fuel System(2)	$150,000	$150,000	$220,000
Fuel Polishing System	$25,000	$25,000	$50,000
Civil Work(3)	$115,000	$120,000	$130,000
Contingency (30%)	$923,000	$907,000	$1,005,000
Contractor Overhead & Profit (15%)	$600,000	$590,000	$654,000
TOTAL ESTIMATED CONSTRUCTION COST WITHOUT DSG PARTICIPATION(6)	**$4,598,000**	**$4,519,000**	**$5,009,000**
Added Cost for DSG Participation(4)	$1,033,000	$1,039,000	$1,039,000
PGE Contribution (Avg.)(5)	-$1,095,000	-$982,500	-$982,500
TOTAL ESTIMATED CONSTRUCTION COST WITH DSG PARTICIPATION(6)	**$4,536,000**	**$4,575,500**	**$5,065,500**

Consolidated Facility Options

Separate Facilities

Notes:

(1) Includes constructed enclosure for generators. Base cost is for Tier 2 generators.

(2) The fuel system includes one 10,000 gallon storage tanks and foundations, yard piping, and circulation pumps.

(3) Civil work includes a new driveway, landscaping, and fencing.

(4) This is the added equipment cost of complying with the DSG program. This includes upgrading the generators from Tier 2 to Tier 4i, and all additional electrical equipment/controls. This also includes a 30% contingency and 15% markup for contractor overhead and profit. This does not include the cost of DSG participation at the SHPP for a separate facility.

(5) PGE's contribution only applies if participating in the DSG program. The level of contribution from PGE is currently unknown. It has been between $200/kW and $250/kW on past projects. This estimate assumes an average contribution of $225/kW, and that PGE has costs of $30,000 per site, which is subtracted from their contribution.

(6) Conceptual Design level opinions of the estimated construction costs are provided for comparison of alternatives consistent with Association for the Advancement of Cost Engineering (AACEI), Class 4 (30 percent over to 15 percent under) estimates based on main process systems, facility conceptual layouts, and preliminary generator sizing requirements.

Consolidated Backup Power Location at WTP

- Lower Cost
- Availability of existing utility corridor for conductors
- Project need for intermediate voltage (4,160 volt)
- Consolidated location provided benefits for security, maintenance, fueling and other related activities
- Greater return for PGE DSG participation

Does the JWC Participate in PGE's DSG Program?

- Portland General Electric's (PGE) Dispatchable Standby Generation (DSG) Program:
  - Use of a Client's Generator by PGE to Meet Peak Power Needs in exchange for owner benefits
- Larger More Sophisticated Paralleling Switch Gear Required (versus an automatic transfer switch)
- Monthly Full-Load Testing of Generator by PGE
- 24-hour Monitoring by PGE

What are the Utility Benefits?

- Partial Reimbursement of Capital Costs
- All Fuel Supplied by PGE (after 1st fill)
- All Maintenance Performed by PGE
- Extensive Startup Testing
- Extensive Generator Integration Knowledge
- Power Used through Generator Charged at Market Rate

Requirements of DSG Participation

- Installation of Parallel Switchgear (vs. standard ATS)
- Additional footprint for Switchgear
- Space for communications equipment
- 10 Year contract with PGE
- New requirements for Tier 4i emission standards

ATS for a 1.0MW Generator

Parallel Switchgear for a 1.25MW Generator

Partner with PGE DSG Program: Yes*

- One Power Loss Instead of Two
- Monthly Full-Load Testing.
- No Fuel or Annual Maintenance Costs
- Increased Confidence of Problem Trouble Shooting
- Partnership in Community
- Initial capital costs are generally offset by PGE program grant

Project Contracting

- Traditional design, bid, build; or
- Owner procured equipment through competitive proposal
  - Reduce lead time for equipment delivery
  - Select generator manufacturer based on price and qualifications
  - Finalize the facility design based on a final equipment selection
  - Save project cost by reducing equipment markup
- Moving forward with the assumption of competitive proposal of generator equipment

Finalizing the Options:

- Option 1: Two (2) 2.5 MW Generators
  - Slightly smaller facility size
  - Larger overall load capability
- Option 2: Three (3) 1.5 MW Generators
  - Offers slightly better motor starting capabilities, but slightly lower total load capabilities
  - Better reliability with one generator out of service
- Both options meets 50% of existing plant capacity criteria (37.5 MGD)

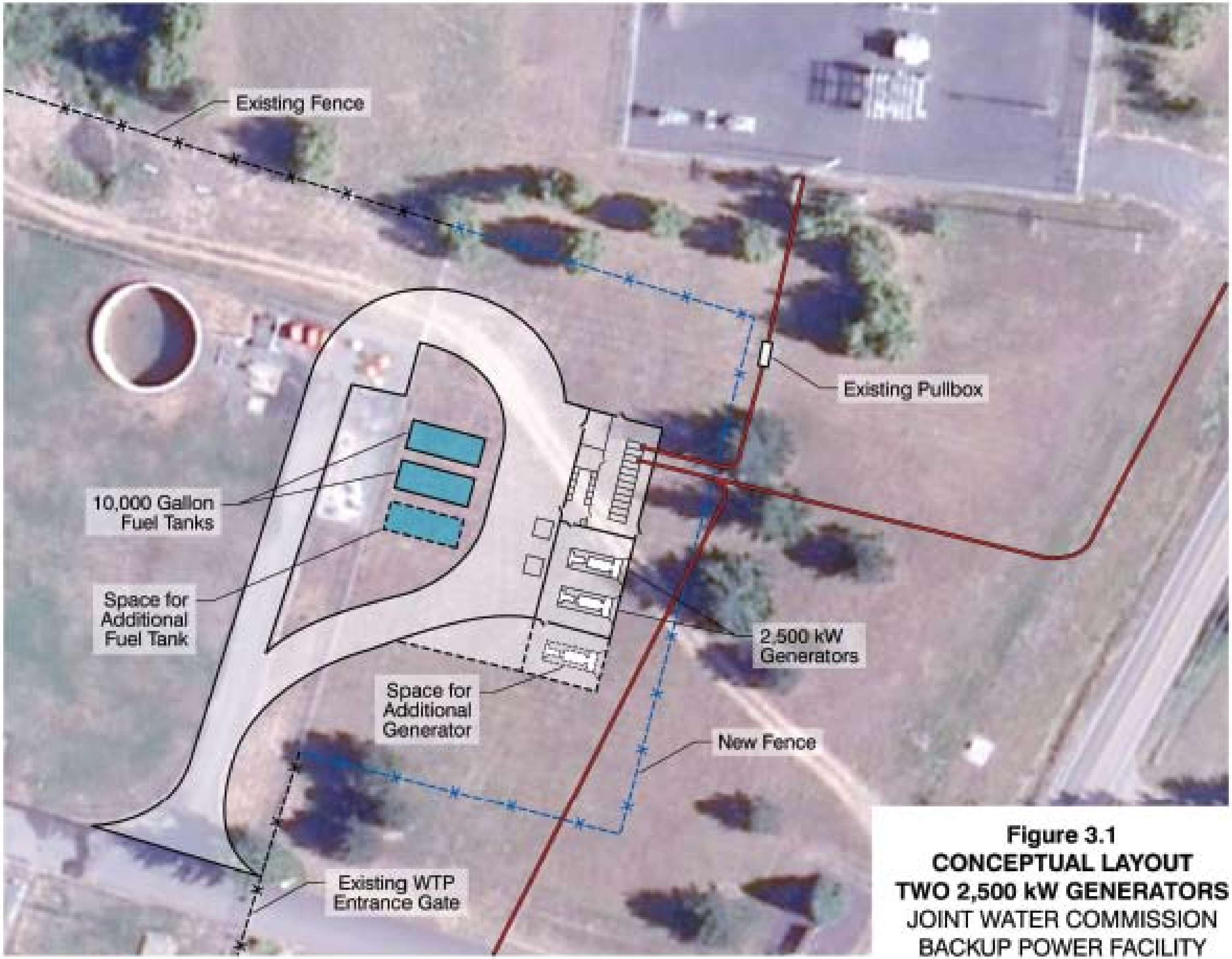
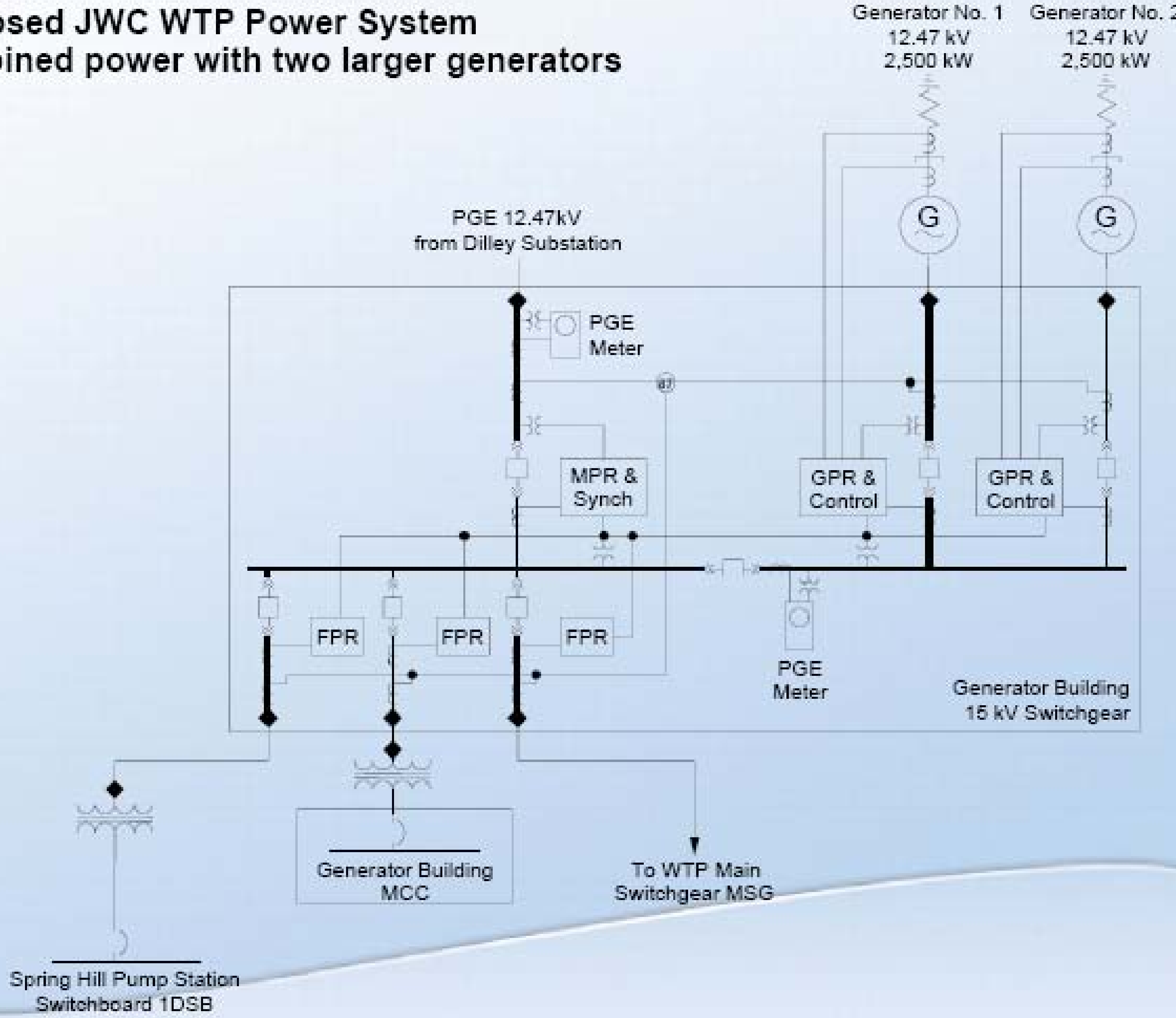
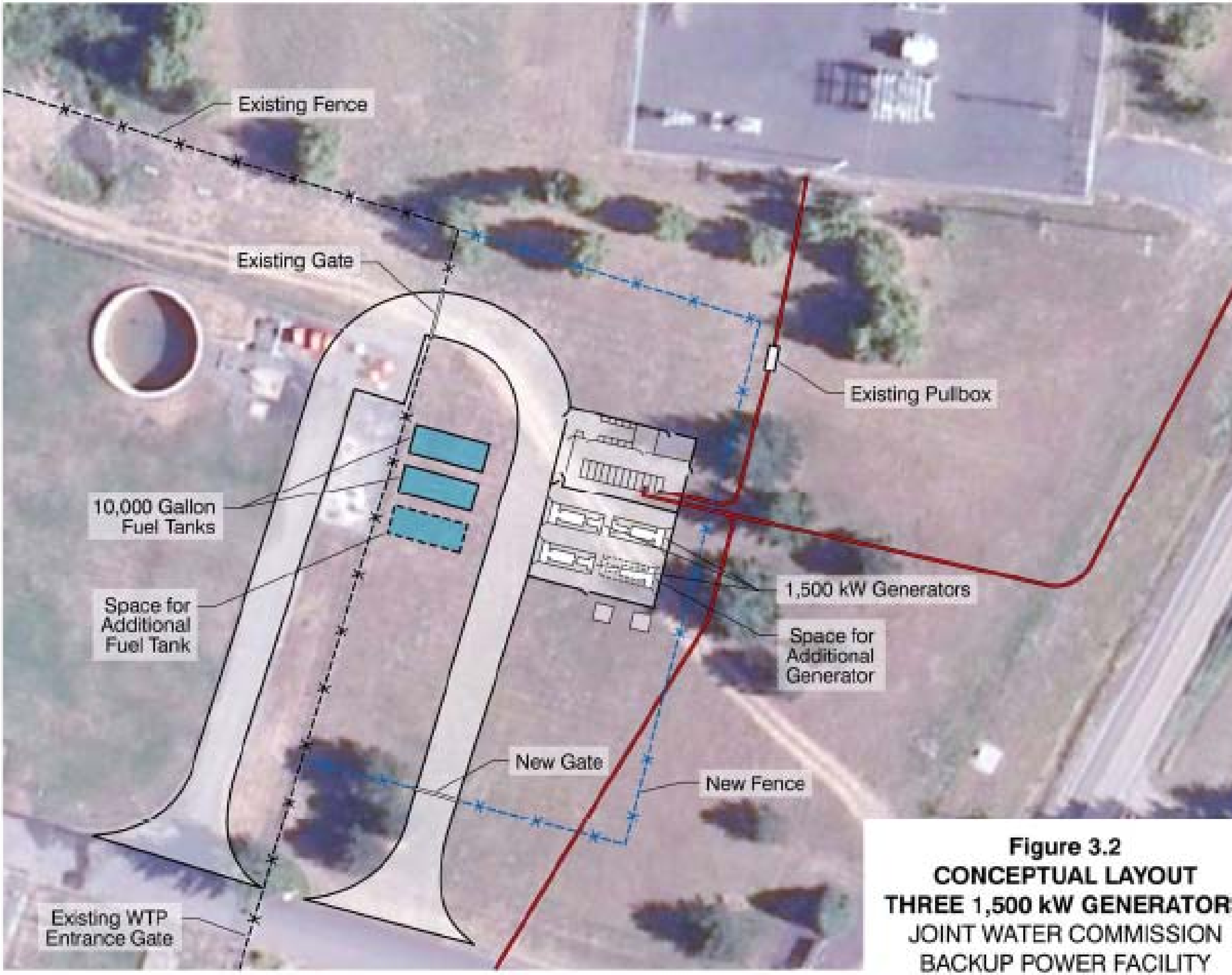


Figure 3.1
CONCEPTUAL LAYOUT
TWO 2,500 kW GENERATORS
JOINT WATER COMMISSION
BACKUP POWER FACILITY

carollo

Proposed JWC WTP Power System
Combined power with two larger generators





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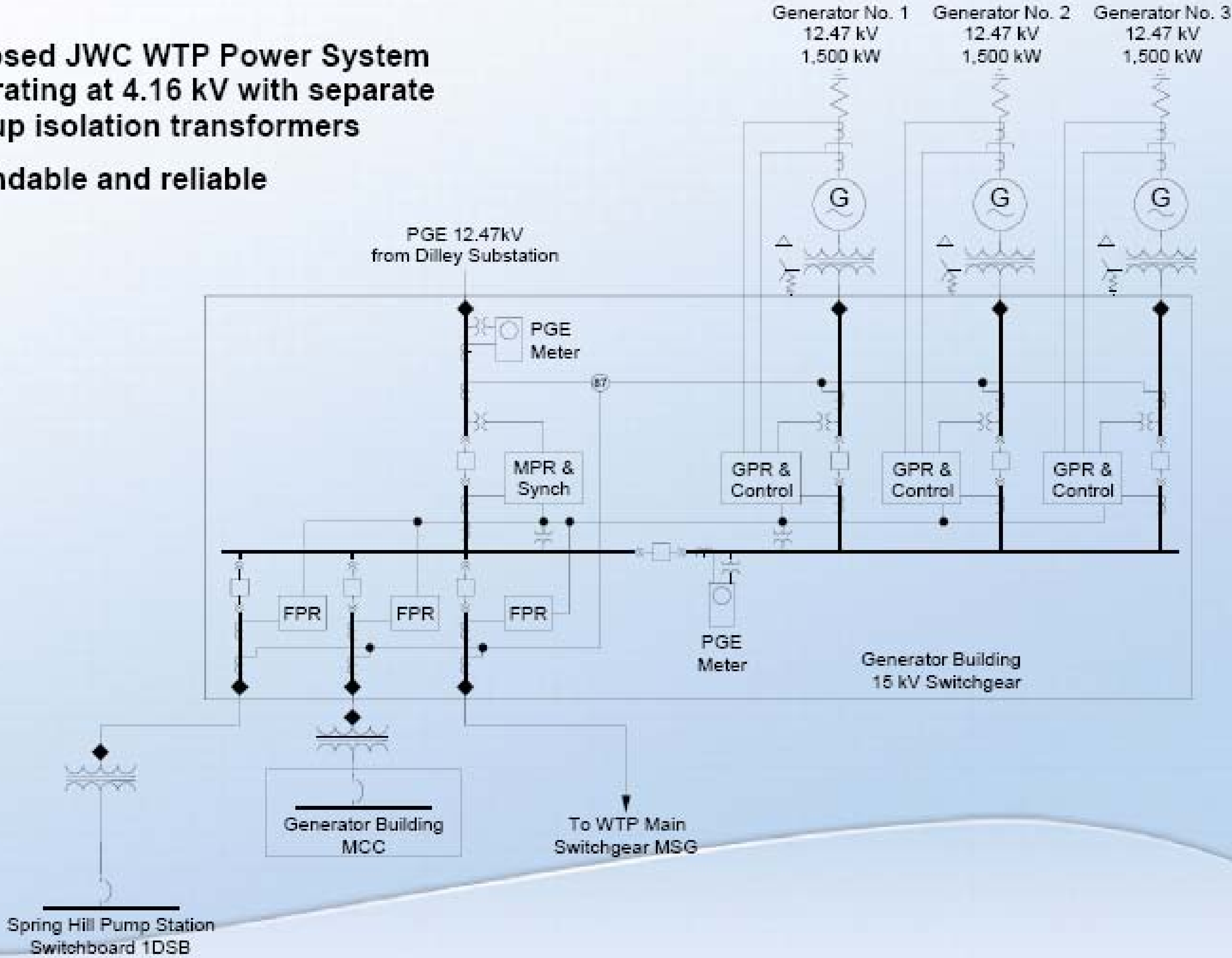
Preliminary Design Preferred Option

Proposed JWC WTP Power System Generating at 4.16 kV with separate step-up isolation transformers

Expandable and reliable



Budget Realities and JWC Needs

- Preferred option (3 x 1.5MW) cost estimate: $5,065,000
- Budget based on 2009 JWC Master Plan: $2,500,000
- Cost savings UASI grant from design costs applied to construction: $250,000
- Shortfall approximately $2,000,000

Potentials for Cost Reduction

- Reduce generator capacity:
  - Plant capacity for $3 M, $3.5 M, & $4 M cost points
- Reduce number of generators to two:
  - 2 vs 3 estimated to save $550,000
  - Facility cost $4 M
- Reduce size & number of generators

Table 1 Opinion of Probable Construction Cost for Generator Alternatives

Plant Capacity Using Backup Power	**7.2 MGD**	**20 MGD**	**25 MGD**	**32 MGD**	**37.5 MGD**
Generator Configuration	**1 x 1,250 kW**	**1 x 2,500 kW**	**2 x 1,500 kW**	**2 x 2,000 kW**	**3 x 1,500 kW**
Finished Water Pumps Powered	**1 – 700 HP**	**1 – 700 HP 3 – 400 HP (700 HP starts first or is put on a VFD)**	**2 - 1,000 HP**	**2 - 1,000 HP 1 – 700 HP**	**2 – 1,000 HP plus other pumps as needed**
Generators, Electrical Equip., Electrical Building (with DSG Participation)	$1,700,000	$2,160,000	$2,610,000	$2,990,000	$3,645,000
Bay for Future Generator	$115,000	$115,000	$0	$0	$0
Fuel System	$42,000	$84,000	$100,000	$134,000	$220,000
Fuel Polishing System	$25,000	$25,000	$25,000	$25,000	$50,000
Civil Work	$130,000	$130,000	$130,000	$130,000	$130,000
Subtotal	**$2,012,000**	**$2,514,000**	**$2,865,000**	**$3,279,000**	**$4,045,000**
Contingency (30%)	$604,000	$754,000	$860,000	$984,000	$1,213,000
Subtotal	**$2,616,000**	**$3,268,000**	**$3,725,000**	**$4,263,000**	**$5,258,000**
Contractor Overhead & Profit (15%)	$392,000	$490,000	$559,000	$639,000	$789,000
TOTAL ESTIMATED CONSTRUCTION COST	**$3,008,000**	**$3,758,000**	**$4,283,000**	**$4,902,000**	**$6,047,000**
PGE Contribution (average)	$252,000	$533,000	$645,000	$870,000	$982,000
TOTAL ESTIMATED CONSTRUCTION COST w/ PGE CONTRIBUTION	**$2,756,000**	**$3,225,000**	**$3,638,000**	**$4,032,000**	**$5,065,000**

Project Status

- Met the obligations of our UASI grant
- Reassessing the budget priorities and construction timing vs. WTP backup needs and priorities
- Addressing potential WTP plant expansion needs with the facility design
- Reviewing architectural styling of backup power facility to set the 'theme' of future plant expansion and buildings

Summary:

- The larger backup power need, the greater care and attention towards project decisions needs to be given
- Large motors will greatly influence generator sizing
- Outside partnerships (PGE DSG) can provide great benefits to your utility
- A experienced consultant in large backup power systems is essential

Summary: Backup Power Reliability

- What are you needs? Have you truly defined them?
  - House loads (lights, HVAC), computer & SCADA system?
  - Do you need all of your plant capacity?
  - Is this a critical facility? (A nexus facility)
  - Do alternative sources or internal storage affect the need?

Thank You

Questions?

Tyler Wubbena, PE
City of Hillsboro, Engineering Manager

May 4, 2012

Portland General Electric Dispatchable Standby Generation

Bruce Barney, PE

5/4/2012

AWWA

Today’s Discussion

- About PGE
- Dispatchable Standby Generation goals
- Why Customers like DSG
- Why the Utility likes DSG
- Why the regulators like DSG
- How it works
- Summary
- Q and A

PGE - Oregon's Largest Utility

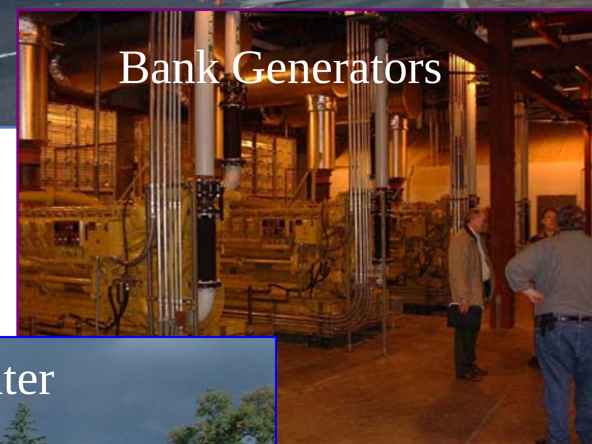
- 756,109 retail accounts
- Service territory population 1.5 million, 44% of state's population
- 51 cities served – Portland and Salem are the largest
- 4,105 square-mile service area
- 26,000 miles of T&D lines
- 1,979 MW of generation
- Average annual demand of 2,270 MW
- 4,000 MW 1 in 2 expected peak load
- 2,680 employees

PGE Goals

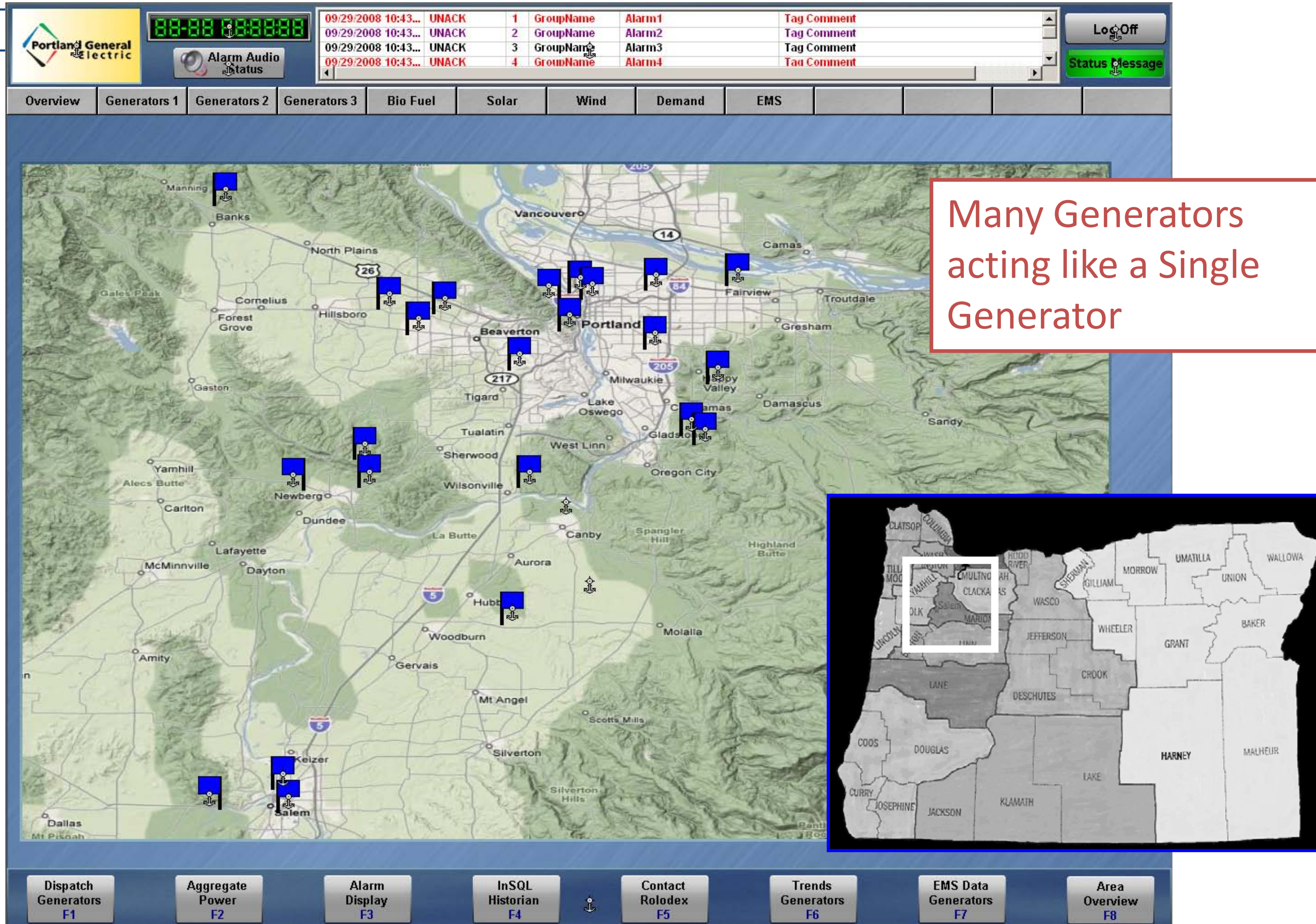
Dispatchable Standby Generation

- Build 150 MW DSG Virtual Peaking Plant
  - Utilize Our Customer’s Backup Diesel Generators
  - Provide Operating Reserves to Support Thermal & Hydro Plants
  - Currently: 70 MW On-line – 30 MW Under Development
- Provide the Least-cost Peaking Resource in IRP
- Enhance Services for Customers
  - With Operations, Maintenance & Fuel for Backup Power
  - *plus* PQ Monitoring for Facility Operations

Dispatchable Standby Generation



GenOnSys Site Aggregation



Many Generators acting like a Single Generator

Customer Benefits

- Greater Reliability
  - High Quality “Seamless Paralleling” Equipment
  - State of the art Relay Protection System
  - Power Quality Monitoring
- Reduced Operations & Maintenance
  - Preventive Maintenance on Switchgear & Gens
  - Repairs & Replacement
  - Oregon DEQ Permit Modifications & Renewals
  - Fuel & Fuel System Maintenance

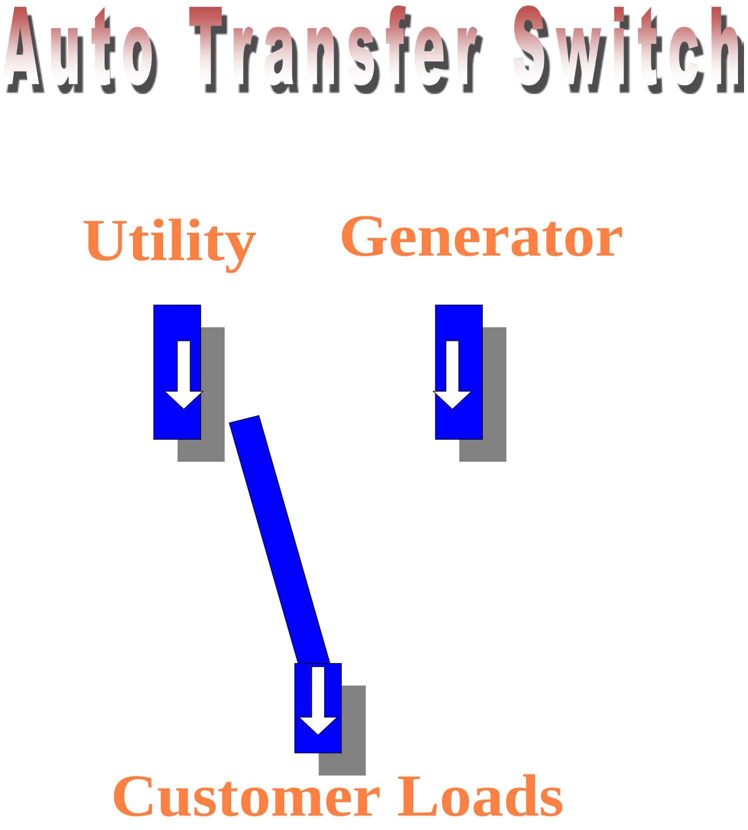
Utility Benefits

- Paralleling switchgear, communications and controls
  - Cheaper than a Peaker ($200-$300/kW vs. $650-$750/kW)
- Reliable & Dispatchable
  - We can start, operate, and monitor standby generators up to 400 hours per year
- Liquid Fuel Stored on Site - Gas Shortage Hedge
- Avoids transmission congestion at peak times

DSG Reliability Improvements

- Storm Avoidance Mode, seamlessly transfer Customer's facility to generator power ahead of a wind or ice storm
- 24/7 Support & upgraded monitoring of the diesel engine/switchgear helps facility operators and DSG operations to identify issues before they become problems
- Running under full load in parallel mode avoids costly load banks – Generators are run monthly at 90% load, preventing wet-stacking & providing longer engine life and higher engine reliability
- Sophisticated power quality monitoring and data collection can identify potential problems both with main facility power quality and with the generator system

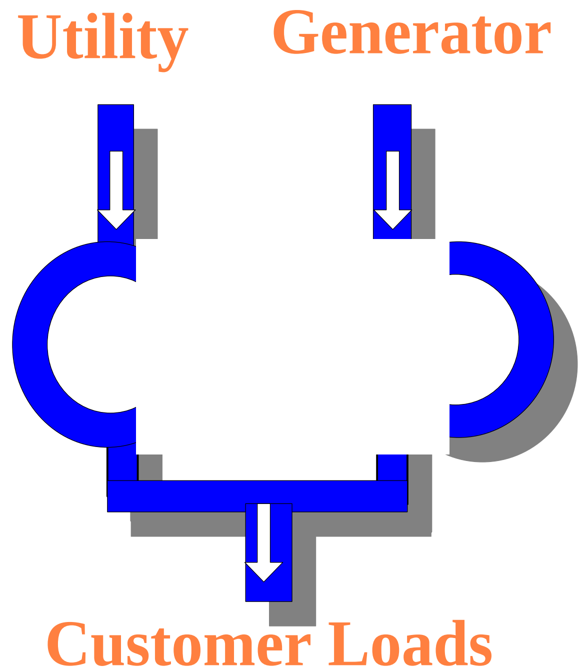
Conventional Generator Connection



More Reliable DSG System

Is this Generation or Demand Response?

Dual Electrically Operated Breakers

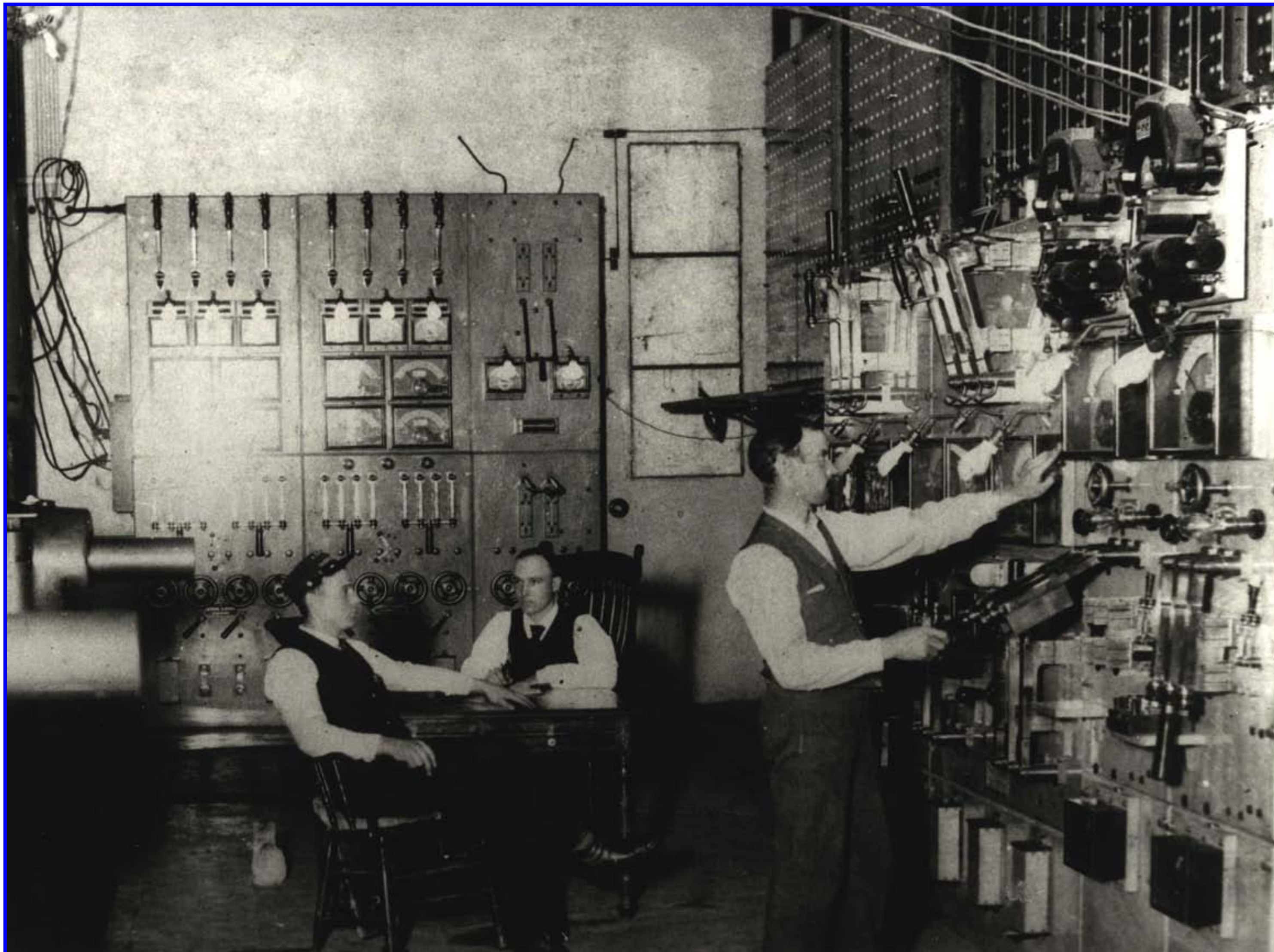


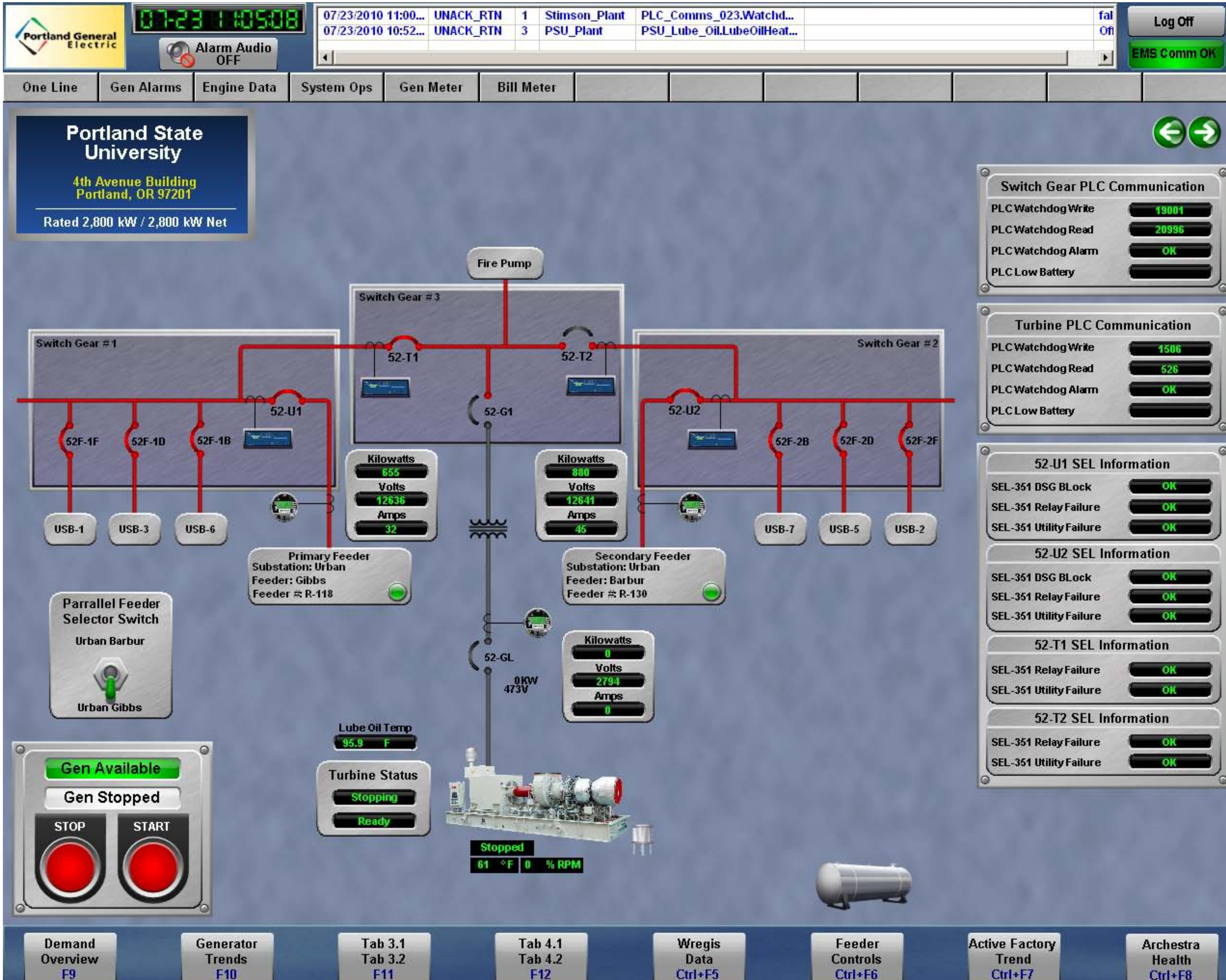
Equipment

- Customer Owned Equipment (Aid in Construction)
  - Paralleling Switchgear with Relay Protection
  - Diesel Backup Generator Controls
  - Fuel System Upgrades
  - Transformer Upgrades, medium & low voltage cables

- PGE Capital Equipment with installation
  - Engine Exhaust Catalyst for emission reduction
  - Revenue Metering for site and generators
  - Communications: router, switch & fiber runs
  - Substation upgrades: relays, PTs, feeder modifications

System Control Center - Starts Generators




Portland General Electric
07-23 11:05:08
Alarm Audio OFF
07/23/2010 11:00... UNACK_RTN 1 Stimson_Plant PLC_Comms_023.Watchd...
07/23/2010 10:52... UNACK_RTN 3 PSU_Plant PSU_Lube_Oil.LubeOilHeat...
Log Off
EMS Comm OK
One Line
Gen Alarms
Engine Data
System Ops
Gen Meter
Bill Meter
Portland State University
4th Avenue Building
Portland, OR 97201
Rated 2,800 kW / 2,800 kW Net
Fire Pump
Switch Gear # 3
Switch Gear # 1
Switch Gear # 2
52-T1
52-T2
52-G1
52-U1
52-U2
52F-1F
52F-1D
52F-1B
52F-2B
52F-2D
52F-2F
USB-1
USB-3
USB-6
USB-7
USB-5
USB-2
Kilowatts 655 Volts 12636 Amps 32
Kilowatts 880 Volts 12641 Amps 45
Primary Feeder
Substation: Urban
Feeder: Gibbs
Feeder #: R-118
Secondary Feeder
Substation: Urban
Feeder: Barbur
Feeder #: R-130
Parrallel Feeder Selector Switch
Urban Barbur
Urban Gibbs
52-GL
0KW
473V
Kilowatts 0 Volts 2794 Amps 0
Lube Oil Temp
95.9 °F
Turbine Status
Stopping
Ready
Stopped
61 °F 0 % RPM
Gen Available
Gen Stopped
STOP
START
Switch Gear PLC Communication
PLC Watchdog Write 19001
PLC Watchdog Read 20996
PLC Watchdog Alarm OK
PLC Low Battery
Turbine PLC Communication
PLC Watchdog Write 1506
PLC Watchdog Read 526
PLC Watchdog Alarm OK
PLC Low Battery
52-U1 SEL Information
SEL-351 DSG BLock OK
SEL-351 Relay Failure OK
SEL-351 Utility Failure OK
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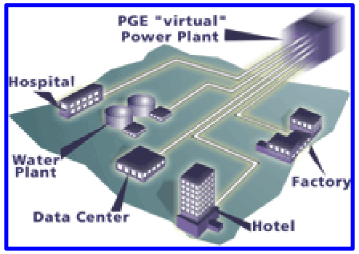
SEL-351 Relay Failure OK
SEL-351 Utility Failure OK
Demand Overview F9
Generator Trends F10
Tab 3.1 Tab 3.2 F11
Tab 4.1 Tab 4.2 F12
Wregis Data Ctrl+F5
Feeder Controls Ctrl+F6
Active Factory Trend Ctrl+F7
Archestra Health Ctrl+F8



- Dispatchable Standby Generation Summary:
  - Award Winning Program
  - 70 MWs Virtual Peaking for PGE
  - 30 MWs Additional Under development
  - 50 MWs More Proposed in new IRP

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Tier 4 Emissions Regulations for Electric Power

Joel Martin, Caterpillar Electric Power North America

PNWS-AWWA Conference: Yakima, WA
May 4, 2012

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Presentation Objectives

- Retrace the evolution of emissions regulations from Tier 1 to the current Tier 4 regulations facing the electric power industry.
- Understand the timeline for emissions regulations and how their effective dates & regulated limits vary by engine application and power output.
- Explain the difference between Tier 4 Interim and Tier 4 Final emission standards.
- Understand the difference between non-road mobile & stationary regulations.
- Understand the US EPA definition of “emergency use” for generator applications
- Provide example of Tier4 certified system and the impact on design & installation

Air Quality Basics

- Emissions Restricted by EPA Standards
  - Carbon Monoxide (CO)
  - Hydrocarbons (HC)
  - Particulate Matter (PM)
  - Oxides of Nitrogen (NOx)
- Federal Regulations (EPA)
  - Establishes the minimum standard for the US
- State Regulations
  - Can be more stringent than Federal Regulations under some circumstances

EPA Non-Road Regulations - History

- 1970: Clean Air Act places EPA in charge of emissions reductions.
- 1990: Clean Air Act includes regulations for off-road diesel emissions.
  - 1996-2000: Tier 1 regulations implemented.
  - 2001-2006: Tier 2 phased-in.
  - 2005-2008: Tier 3 phased-in.
  - 2008-2015: Tier 4 is the next step …….

EPA Nonroad Emissions Limits and Timing

NOx, HC / CO, PM g/kW-hr ***OR*** NOx+HC / CO, PM g/kW-hr

kW	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
<8																					
≥8 <19																					
≥19 <37																					
≥37 <56																					
≥56 <75																					
≥75 <130																					
≥130 <225																					
≥225 <450																					
≥450 ≤560																					
>560 Non Genset																					
>560 ≤900 Genset																					
>900 Genset																					

EPA Non-Road Regulations

- This is what the majority of industry is thinking about when it talks about “EPA” or “Tier 4” regulations
- Applies to non-road <u>mobile</u> machinery
  - includes gensets   (ie portable rental units)

BUT

- Engines in <u>stationary</u> applications are regulated separately

EPA Stationary Regulations

- In 2006 EPA began to regulate engines in stationary applications, much later than non-road regulations
- Known today as the New Source Performance Standards (NSPS)
- Beginning April 2006, Tier 1 standards were mandated
    - No factory certification was required
- Beginning Jan 2007, NSPS harmonized emissions limits & timing with EPA's non-road regulations with engine certification required

EPA Stationary Diesel Genset Emissions Limits and Timing (engines <10 litres per cylinder)

NOx, HC / CO, PM g/kW-hr ***OR*** NOx+HC / CO, PM g/kW-hr

bkW	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
<8											10.5 8.0, 1.0	7.5 8.0, 0.80	7.5 8.0, 0.40[2]		7.5 8.0, 0.60[3]						
≥8 <19											9.5 6.6, 0.80	7.5 6.6, 0.80	7.5 6.6, 0.40								
≥19 <37											9.5 5.5, 0.80	7.5 5.5, 0.60	7.5 5.5, 0.30					4.7 5.5, 0.03			
																		Emergency Applications Only			
≥37 <56											9.2, ---- ----, ----	7.5 5.0, 0.40	Option #1	4.7 5.0, 0.30				Option #1	4.7 5.0, 0.03		
													Option #2	4.7 5.0, 0.40			Option #2	4.7 5.0, 0.03			
																	Emergency Applications Only				
≥56 <75													4.7 5.0, 0.40				3.4[1], 0.19 5.0, 0.02			0.40, 0.19 5.0, 0.02	
																	Emergency Applications Only				
≥75 <130											9.2, ---- ----, ----	4.0 5.0, 0.30					3.4[1], 0.19 5.0, 0.02			0.40, 0.19 5.0, 0.02	
																	Emergency Applications Only				
≥130 <225											9.2, 1.3 11.4, 0.54	4.0 3.5, 0.20				2.0[1], 0.19 3.5, 0.02			0.40, 0.19 3.5, 0.02		
																Emergency Applications Only					
≥225 <450											9.2, 1.3 11.4, 0.54	4.0 3.5, 0.20 >300 hp <750 hp per CD				2.0[1], 0.19 3.5, 0.02			0.40, 0.19 3.5, 0.02		
																Emergency Applications Only					
≥450 ≤560											9.2, 1.3 11.4, 0.54					2.0[1], 0.19 3.5, 0.02			0.40, 0.19 3.5, 0.02		
																Emergency Applications Only					
>560 ≤900											9.2, 1.3 11.4, 0.54	6.4 3.5, 0.20				3.5, 0.40 3.5, 0.10				0.67, 0.19 3.5, 0.03	
																Emergency Applications Only					
>900 ≤2237											9.2, 1.3 11.4, 0.54					0.67, 0.40 3.5, 0.10				0.67, 0.19 3.5, 0.03	
																Emergency Applications Only					
>2237											9.2, 1.3 11.4, 0.54					0.67, 0.40 3.5, 0.10				0.67, 0.19 3.5, 0.03	
																6.4 3.5, 0.20	Emergency Applications Only				
Fuel Sulfur	5000 ppm												500 ppm		15 ppm						

Tier 1	Tier 2	Tier 3	Tier 4 Interim	Tier 4 Final

Tier 4 Regulation & Impact

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What changes with Tier 4?

- Tier 4 calls for such dramatic reductions in emissions that introduction is divided into two phases
  - Interim – focuses primarily on PM reduction for engines ≤900 bkW
    - Began in 2008 for engines <56 bkW
    - Main impact is in 2011 & 2012 for engines ≥56 bkW
    - Up to 90 % PM reduction & up to 50% NOx reduction vs Tier 3
    - 90% NOx reduction for gensets >900 bkW (from prior Tier)
  - Final – focuses primarily on NOx reduction
    - Does not affect engines <19 bkW
    - 2013 introduction for engines ≥19 <56 bkW
    - Main impact is in 2014 & 2015 for engines ≥56 bkW
    - Up to 80% NOx reduction & further PM reductions (gensets ≥56 bkW ≤560)
    - 70% further PM reduction for gensets >900 bkW (from Tier4 Interim)

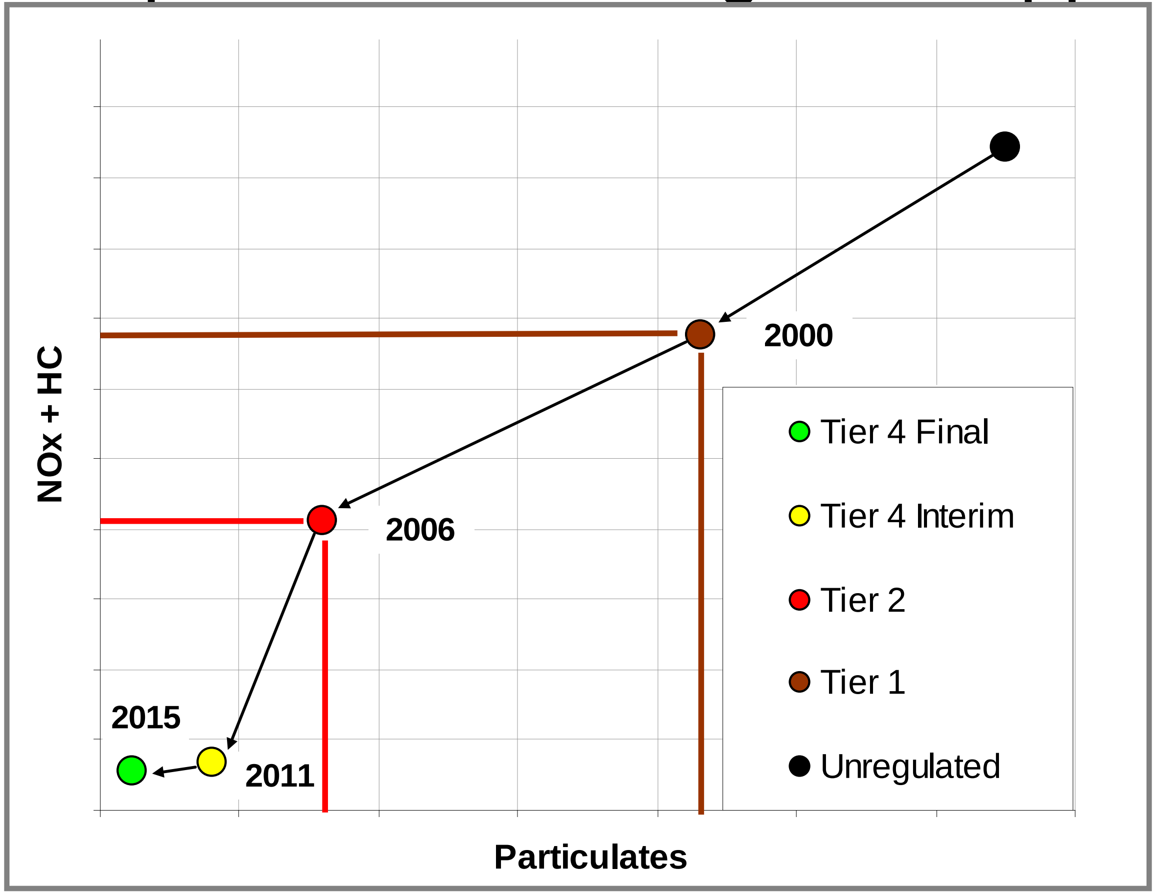
What changes with Tier 4?

- Regulated levels are so low that other technology solutions are needed, including the use of aftertreatment devices

- Significant engine development required
    - NOx : PM ratio is critical to optimizing aftertreatment cost / size / performance

EPA Non-Road Regulatory Impact

Example - >900 bkW genset applications



What changes with Tier 4?

- Emissions standards vary based on the power category
  - optimum technology varies by power category
- Reliant on introduction of ULSD (<15 ppm)
  - High sulfur content in fuel is incompatible with aftertreatment devices – specifically catalysts
  - Gensets using Tier 4 aftertreatment cannot be sold / operated in territories where ULSD is unavailable
- Engine & aftertreatment must be certified as a complete system

What changes with Tier 4?

- Affects mobile diesel generator sets in U.S. & Canada
- Affects stationary diesel generator sets in U.S.
- Stationary engines ≥10 liter / cylinder & <30 liter / cylinder must be certified to Marine Tier 2 limits defined in 40 CFR 94 Subpart C.
- Stationary Emergency engines do not need to meet Tier 4 emission standards.

What changes with Tier 4?

- Different emissions standards for generators above 560 bkW

EPA Nonroad Emissions Limits and Timing >560 kW

NOx, HC
CO, PM g/kW-hr

kW	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
>560 Non Genset										3.5, 0.19 3.5, 0.04	
>560 ≤900 Genset	6.4 3.5, 0.20					3.5, 0.40 3.5, 0.10				0.67, 0.19 3.5, 0.03	
>900 Genset						0.67, 0.40 3.5, 0.10					
		Tier 2			Tier 4i			Tier 4f			

- >900 bkW - NOx limits are very severe at Interim
  - followed by significant PM reduction at Final

- >560 bkW ≤900 - same limits as Industrial at Interim
  - same severe limits as >900 bkW at Final

Tier 4 – Stationary Emergency Definition

- Engines in installations which meet the definition of “emergency” are not required to meet Tier 4 emissions standards
- Engines must be certified to prior (Tier 2/3) requirements
- Emergency standby engines >3000 bhp (<10 liters / cylinder) are required to be certified to Tier 2 emissions standards on Jan 2011 and clearly labeled as “emergency use only”

Tier 4 – Stationary Emergency Definition

- “Emergency” (EPA) effectively means no running except when normal source power fails
- No limit to actual emergency running time
- Maintenance & testing limited to 100 hours per year
- Operator must record and report actual use time

Proposed Tier 4 Regulation Changes

Beginning in 2010, there were a number of proposals & changes affecting Tier 4 regulations for Electric Power engines:

1. Proposed changes to the EPA's definition of stationary emergency engines.
2. CARB alignment with 2006 EPA NSPS regulation

Proposed Tier 4 Regulation Changes

Emergency-use Provisions

2011 Revision

- In August 2011, EPA published a final rule which includes adjustments to the non-emergency running hour allowance for stationary emergency engines:
  - Up to 50 hours per year of storm avoidance, facility maintenance, etc.
    - Hours run under this allowance count towards the annual limit of 100 hours for engine maintenance & testing.

Proposed Tier 4 Regulation Changes

Emergency-use Provisions

- Early 2012 a settlement agreement between industry petitioners and the EPA regarding hours of use for emergency engines was published.
  - There may be 60 hours allowed for "demand response" use - this 60 hours will still be a part of the 100 hours per year of maintenance and testing.
- Settlement agreement precedes an EPA Notice of Proposed Rule Making (NPRM) which will include EPA's proposed changes to allowable use and hours of operation for emergency engines.
- The NPRM is anticipated mid 2012 & will open a public comment period followed by final action by the EPA.
- The final EPA rulemaking will occur after the comment period closes and the EPA has time to consider comments (late 2012 early 2013).

Proposed Tier 4 Regulation Changes

- EPA & CARB regulatory changes will allow a greater proportion of the stationary Electric Power market to utilize emergency engines.
- However ………
  - Emergency engines have less operational flexibility than Tier 4 certified.
  - Emergency engines cannot be “upgraded” to Tier 4 certification.
  - Local air boards <u>may</u> mandate tougher emergency standards than EPA & CARB.

Tier 4 for Electric Power

- Tier 4 certified generator sets will be required for the following applications:
    - Non-emergency standby units
    - Prime Power applications
    - Load management / peak shaving
    - Electric Power Rental units
    - Storm Avoidance

- In addition, there are potential state and local regulations that may drive the use of Tier 4 generator sets.

Tier 4 for Electric Power

- California
- Local Regulations

California

- The US Clean Air Act prohibits individual states from setting their own emissions standards with the exception of any state that had emissions standards prior to March 30, 1966.
- Severe air quality issues prompted California to enact emissions standards before the federal government passed the Clean Air Act and thus California is the only US state that meets this criterion.
- EPA must approve California’s "waiver" request for each new California emissions standard before the standard may be implemented.
- EPA will not permit a California emissions standard that is less stringent than EPA's own standards.

California

- ATCM For Stationary Engines (Airborne Toxic Control Measures)
  - uses g/bhp-hr limits – beware conversion
  - more restrictive than EPA regulations
  - local districts may adopt even tighter limits
  - Historically focused on PM reduction
  - applies to stationary engines >50 bhp

- ATCM For Portable Engines
  - aligns with EPA Non-Road emissions standards

US Local Regulations

- Generally, EPA emission standards must be met before an engine can legally be sold in the US.
- However, once a standard is implemented by California, other states may adopt California's emissions standards.

Regulations Summary

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Tier 4 Regulations Summary

- EPA is the starting point
- Understanding local requirements is vital
  (i.e. California and non-attainment areas)
- Understanding if an installation falls within the EPA definition of "emergency" is critical
- Minimum requirement will be a factory certified solution
  - Tier 2 or 3 engine for emergency (dependent on horsepower)
  - Tier 4 engine / aftertreatment for non-emergency application

Packaging Considerations

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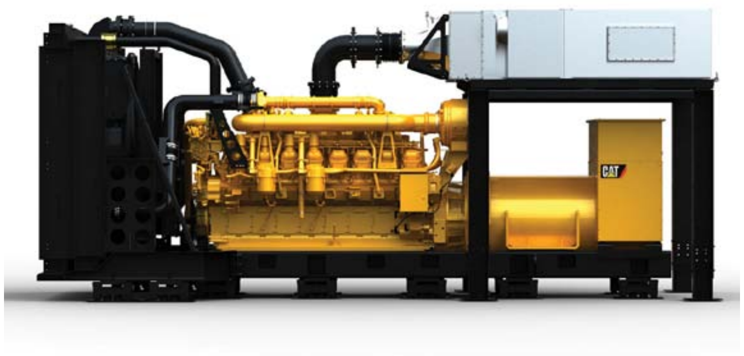
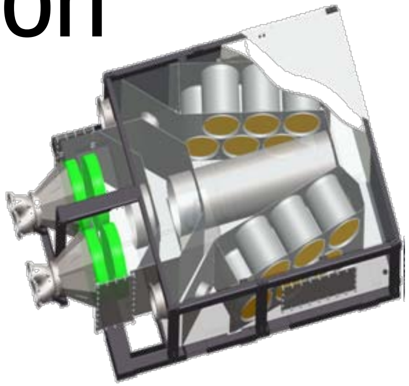
Technology ► 900+ bkW

- SCR application
  - Engine + PM and NO_x Aftertreatment (DOC and SCR)
  - Uses Diesel Exhaust Fluid (DEF) and air injection system
  - Optimized for Cat generator sets - designed specifically for Cat engines (catalyst size, exhaust flow, noise characteristics)
  - Reliable, compact, light weight – designed with mobile applications in mind



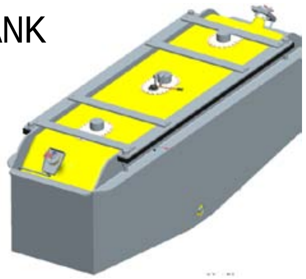
SCR System Integration

ENGINE / GENSET



AFTERTREATMENT
MODULE

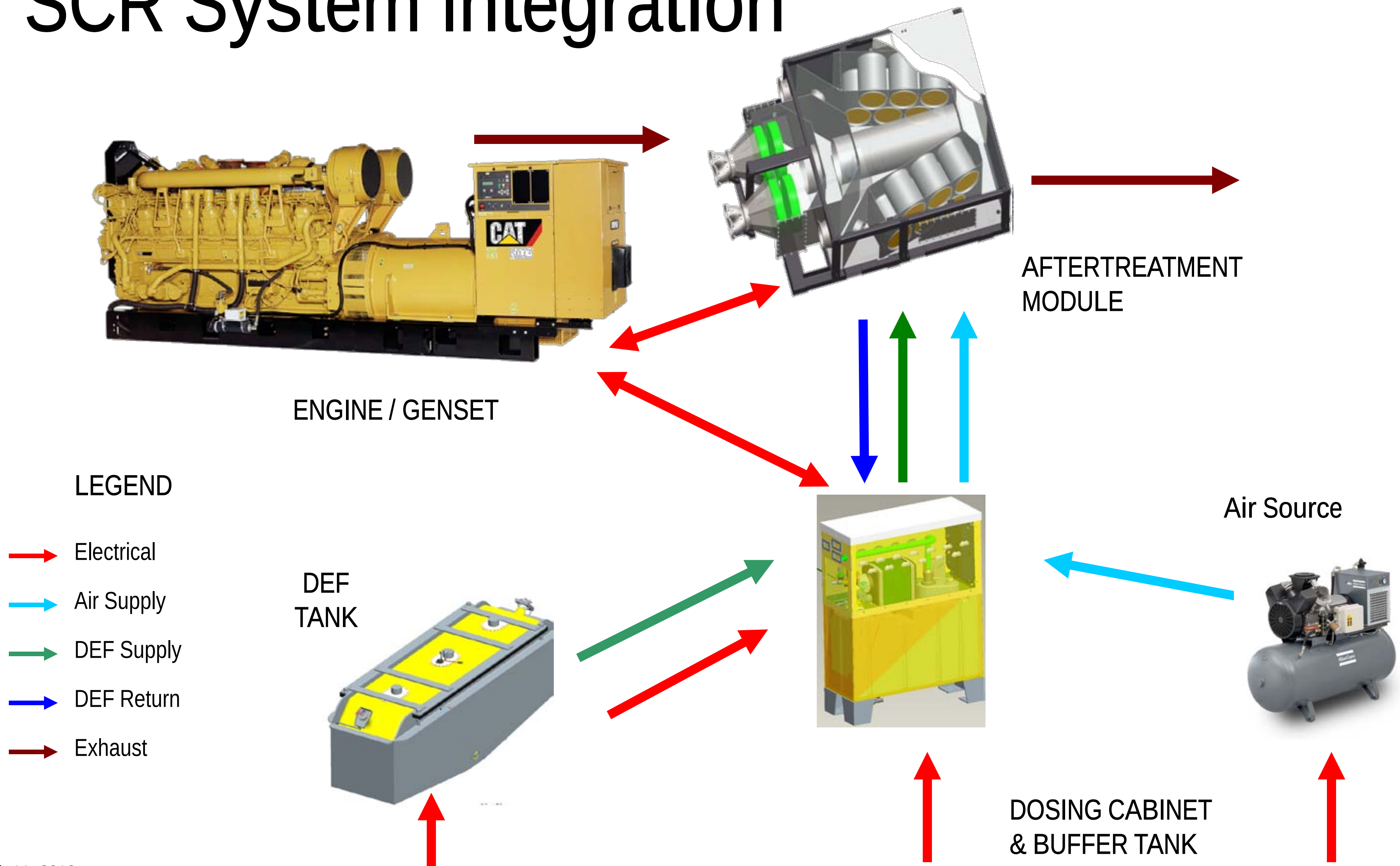
DEF
TANK

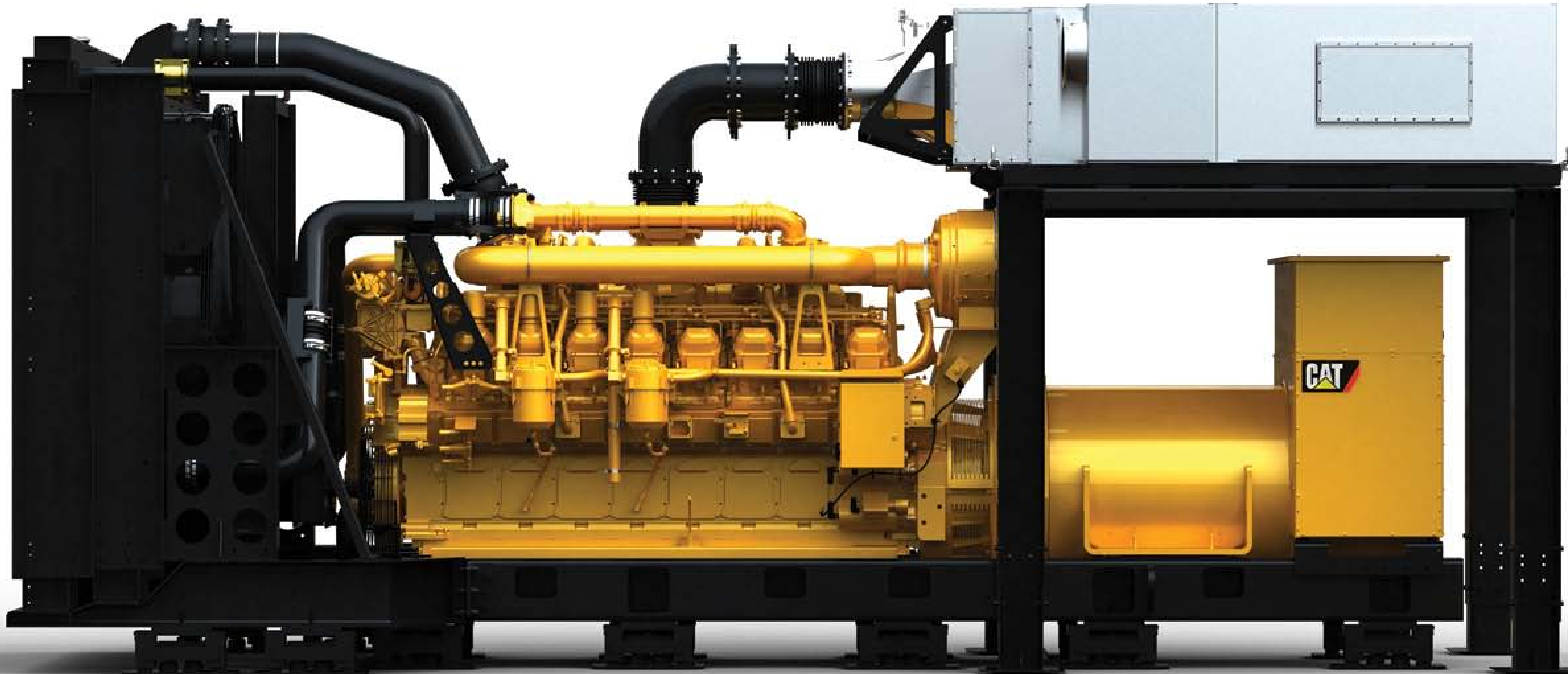


DOSING CABINET
& BUFFER TANK

Air Source

SCR System Integration





Cat 3516C-HD 2.5MW EPA Tier4 Interim

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Tier 4 Product Availability

Tier 4 Generators from Caterpillar

	Cat EPA Emissions Certification	
	60 Hz	
	EPA Emergency	EPA Tier 4i Certified
4 MW: C175-20	**X**	**Tier 4F** (Future)
3 MW: C175-16	**X**	**X** (July '12)
2.5 MW: 3516C-HD	**X**	**X**
2 MW: 3516C	**X**	**X**
800 kW: C27	**X**	**X**
500 kW: C15	**X**	**X**

Questions?

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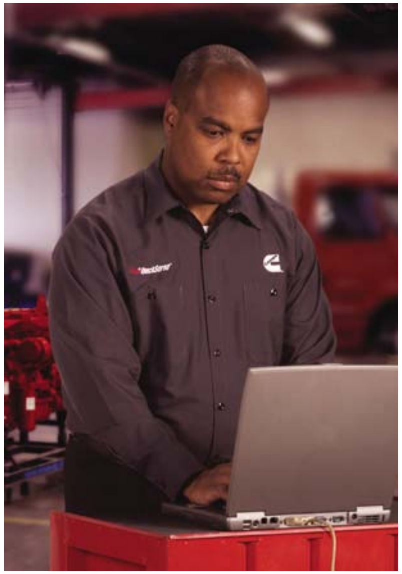
Cummins Northwest

Generator System Preventive Maintenance

2012 PNWS-AWWA ANNUAL CONFERENCE

YAKIMA, WA



TEN COMMON REASONS GENERATOR FAIL TO PROVIDE POWER.

Cummins Northwest

1. BATTERY SYSTEM PROBLEMS

- Over-Extending Battery Service Life.

Most battery failures are attributed to the buildup of Crystalline lead sulfate on the battery's lead plates. (aka "sulfation"). MAX Service life 3 years.

2. CONTROL SYSTEM PROBLEMS

CONTROLLS NOT

IN AUTO

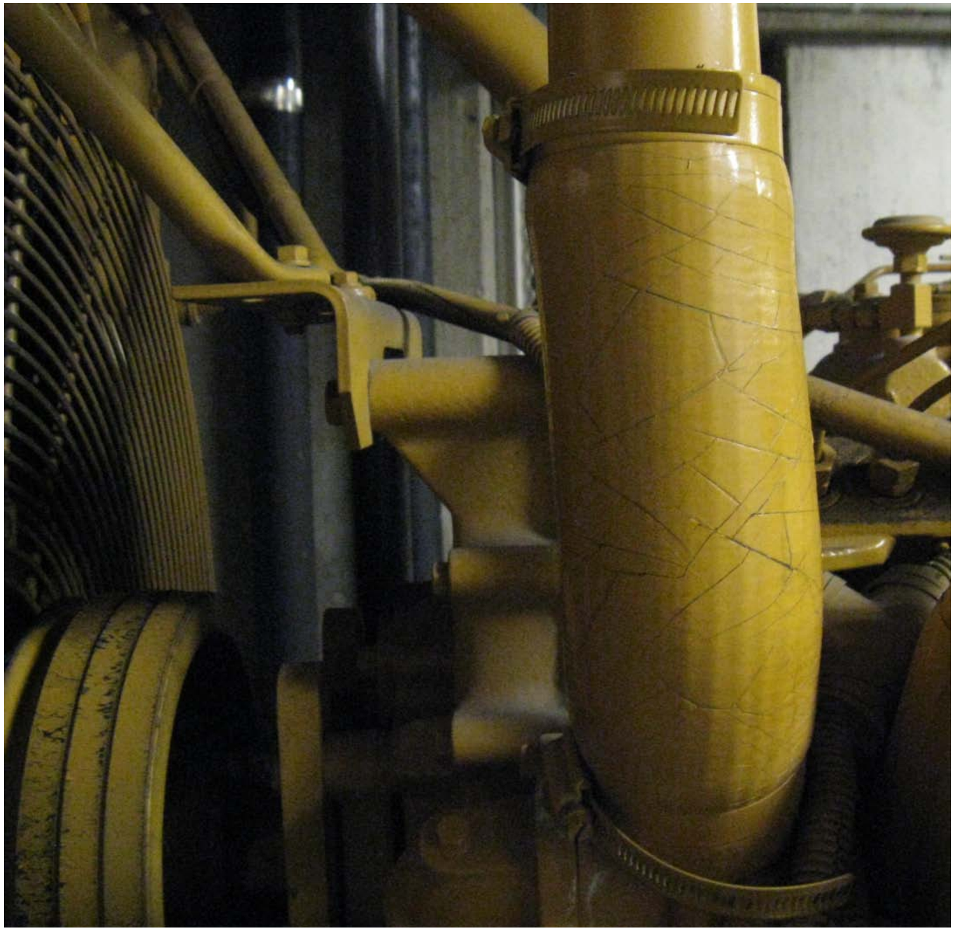
Cummins Northwest

3. COOLING SYSTEM PROBLEMS

3 SERVICE LIFE FOR COOLANT AND HOSES

4 YEARS FOR BELTS

GENERATOR OVER 10 YEARS IN SERVICE



Northwest

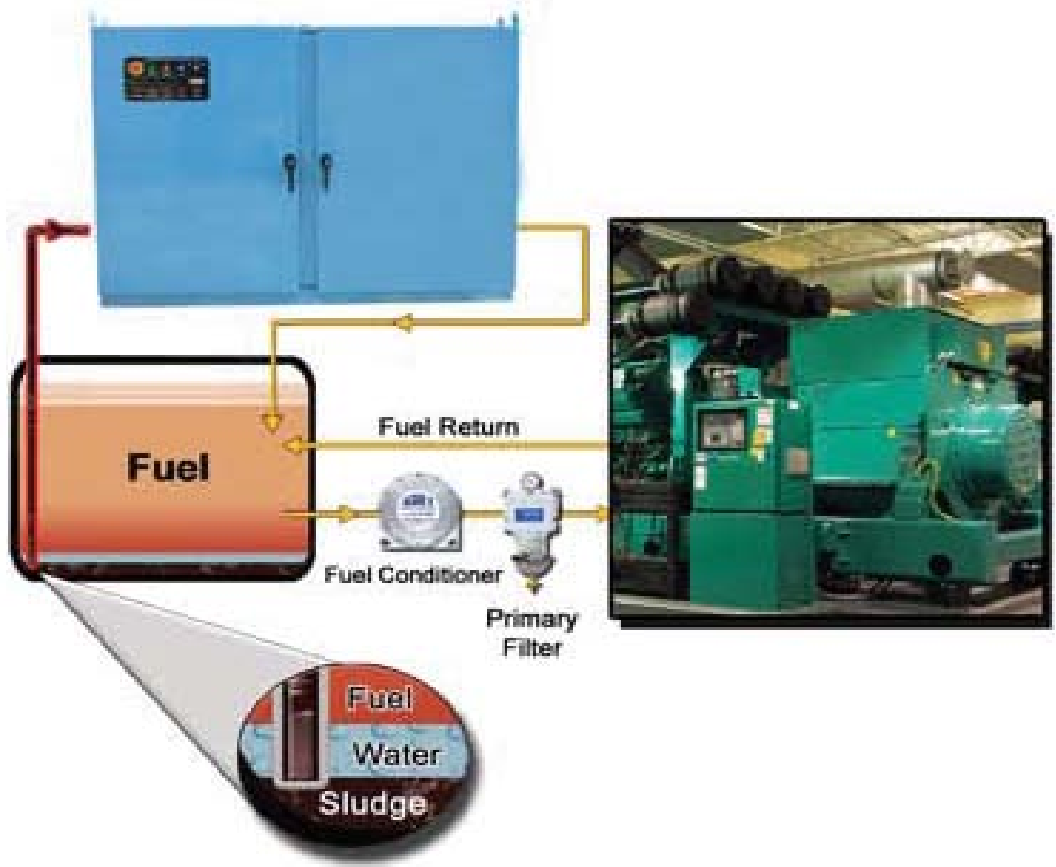
4. FUEL SYSTEM PROBLEMS

Contaminated Fuel:

"It takes only six short months for diesel fuel to become jeopardized.

Northwest

Annual fuel polishing and tank cleaning are recommended to reverse the degradation process and restore and stabilize the overall quality of the fuel.

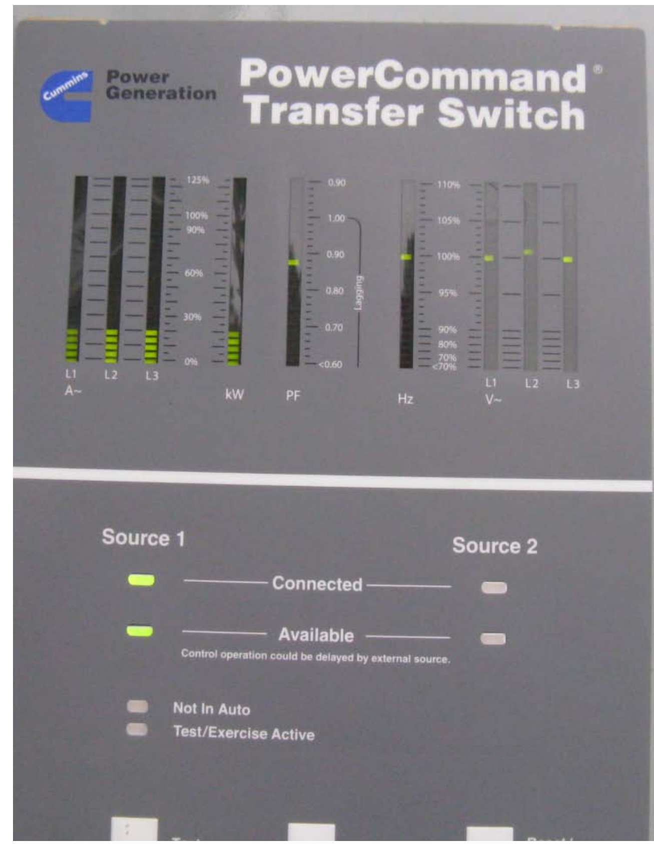


5. AUTOMATIC TRANSFER SWITCH (ATS) OR SWITCHGEAR PROBLEMS

CONFIDENCE TEST

ONCE A YEAR

CAN IDENTIFY PROBLEMS



Northwest

6. CIRCUIT BREAKER PROBLEMS

MOST COMMON

BREAKER IS OPEN

Cummins Northwest

7. INTAKE/EXHAUST VALVE PROBLEMS

CARBON BUILD UP

AND OIL BREAK DOWN

PREVENTION!

CHANGE OIL

AND

LOAD BANK

8. GENERATOR WINDING PROBLEMS

LOAD BANKING HELPS TO KEEP WINDINGS DRY

9. LUBRICATION PROBLEMS

OIL SHOULD BE CHANGED 12 MONTHS OR 250 HOURS

Lube oil analysis

Wear Metals: The product of friction, corrosion, and/or deterioration of components within a given unit:

Metal	Engines	Transmissions	Gears	Hydraulics
Iron	Cylinder liners, rings, gears, crankshaft, camshaft, valve train, oil pump gear, wrist pins	Gears, disks, housing, bearings, brake bands, shaft	Gears, bearings, shaft, housing	Rods, cylinders, gears
Chrome	Rings, liners, exhaust valves, shaft plating, stainless steel alloy	Roller bearings	Roller bearings	Shaft
Aluminum	Pistons, thrust bearings, turbo bearings (Cat)	Pumps, Thrust washers	Pumps Thrust washers	Bushings, thrust plates
Nickel	Valve plating, steel alloy from crankshaft, camshaft, gears from heavy bunker type diesel fuels	Steel alloy from roller bearings and shafts	Steel alloy from roller bearings and shafts	
Copper	Lube coolers, main and rod bearings, bushings, turbo bearings, lube additive	Bushings, clutch plate (auto/powershift) lube coolers	Bushings, thrust plates	Bushings, thrust plates, lube cooler
Lead	Main and rod bearings, busings, lead solder	Bushings (bronze alloy), lube additive supplement	Busings (bronze alloy), grease contamination	Busings (bronze alloy)
Tin	Piston flashing, bearing overlay, bronze alloy, babbit metal along with copper and lead	Bearing cage metal	Bearing cage metal, lube additive	
Cadmium	N/A	N/A	N/A	N/A
Silver	Wrist pin busing (EMDs), silver solder (from lube coolers)	Torrington needle bearings (Allison transmissions)	N/A	Silver solder from lube coolers
Titanium	Gas turbine bearings/ hubs/blades, paint (white lead)	N/A	N/A	N/A
Vanadium	From heavy bunker type diesel fuel	N/A	N/A	N/A

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10. WET STACKING & CARBON BUILDUP PROBLEMS

LOAD BANKING TESTING

- • Detects potential deficiencies in system which may appear during extended operation.
- • Insures full rated output capacity
- • Removes potentially damaging deposits commonly referred to as “wet stacking” in the combustion chamber and exhaust system which may have accumulated under lightly loaded operation.
- • Re-seat piston rings in the cylinders and liners.
- • May be required once each year per local code or regulations.

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Renton, WA 98057-3000
(425) 235-3400 fax: (425) 235-8202

Generator Start-Up Report

Job Name ____________________

Date: ________ RO #: ________ HR Meter: ______ CPL #: ______

Engine Model #: ____________ Serial #: ____________

Gen/Set Model #: ____________ Serial #: ____________

Spec #: ________ System Voltage: ________ Phase: ______

PCCII "RTOP" Calibration File: ____________

ATS 1 Model #: ____________ Spec #: ________
ATS Serial #:

ATS 2 Model #: ____________ Spec #: ________
ATS Serial #:

ATS 3 Model #: ____________ Spec #: ________
ATS Serial #:

ATS 4 Model #: ____________ Spec #: ________
ATS Serial #:

ATS 5 Model #: ____________ Spec #: ________
ATS Serial #:

ATS 6 Model #: ____________ Spec #: ________
ATS Serial #:

Type of Installation (*Indoor or Outdoor*) ____________

START-UP PERFORMED BY: ____________

START-UP COMPLETION DATE: ____________

CONTRACTOR NAME: ____________

OWNER'S REPRESENTATIVE: ____________

[illegible] Page 1

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F - Failed

A - Acceptable

NA - Not Applicable

Comment if Failed or Corrected

OIL SYSTEM

______ Engine Oil Checked and Full ____________________

FUEL SYSTEM **Type** ____________________
(Diesel / Propane / L-Propane / Natural Gas / Gasoline)

______ Manual Shut Off Valve ____________________
______ Primary Gas Pressure Regulator ____________________
______ Gas Meter Flow Adequate ____________________
______ Fuel Strainer ____________________
______ Solenoid Valve ____________________
______ Check Valve on Fuel Supply ____________________
______ Check Valve on Fuel Return ____________________
______ Flexible Fuel Connections ____________________
______ Fuel Available ____________________
(Quantity)
______ Day Tank Installation ____________________
______ Primary Fuel (If Dual Fuel) ____________________
______ Fuel Transfer Pump ____________________
______ Fuel Return to Main Tank ____________________
(One Size Larger Pipe Required)
______ Fuel Tank Vent ____________________

#070505-7

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EXHAUST SYSTEM

_____ Seamless Tubing or Black Pipe _______________
_____ Muffler _______________
_____ Proper Mounting & Support _______________
_____ Exhaust Condensation Trap _______________
_____ Correct Exhaust Pipe Size _______________
_____ Exhaust Flex Connection _______________
_____ Exhaust Thimble _______________
_____ Rain Cap _______________

COOLING SYSTEM **Type** _______________
(Radiator / Remote Radiator / Air Cooled)

_____ Proper Radiator Installation _______________
_____ Proper DCA & Coolant Level _______________
(DCA Level and Freeze Point)
_____ Proper Discharge Opening _______________
_____ Proper Intake Opening _______________
_____ Louvers _______________
_____ City Water Cooling _______________
(Stand Pipe / Heat Exchanger / Direct)
_____ Flexible Water Connections _______________
_____ Water Solenoid Valve _______________
_____ Water Available _______________
_____ Hose Clamps Tight _______________

MOUNTING

_____ Secured to Level Surface _______________
_____ Vibration Isolators (Installed) _______________
_____ Vibration Isolators (Adjusted) _______________

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ENGINE

______ Belt Tension ______________________
______ Fan ______________________
______ Alternator ______________________
______ Governor Operation ______________________

BATTERY

______ Size / Model ______________________
______ Electrolyte ______________________
______ Correct Polarity ______________________
______ Post Type ______________________
(Automotive Posts / Marine Posts)
______ Number of Batteries ______________________

ENGINE

______ Block Heater Wired to Normal ______________________
______ Block Heater Model ______________________
______ Block Heater Wattage ______________________
______ Block Heater Voltage ______________________
______ Fuel Solenoid Valve ______________________
(Wired to What Location)
______ Remote Start Wires Terminated ______________________
______ Interconnect Wiring Stranded ______________________
______ Remote Annunciator Wiring ______________________
______ Generator Set Grounded ______________________
______ Location of Generator Ground ______________________
______ Neutral Bonded ______________________
______ Location of Neutral Bond ______________________
______ Correct Voltage Configuration ______________________

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TRANSFER SWITCH

	#1	#2	#3	#4	#5	#6
______ Proper Voltage						
______ Utility Terminated Properly						
______ Gen. Terminated Properly						
______ Load Terminated Properly						
______ Phase Rotation (Utility and Generator)	/ Utility/Gen.	/ Utility/Gen.	/ Utility/Gen.	/ Utility/Gen.	/ Utility/Gen.	/ Utility/Gen.
______ Battery Charger						
______ Time Delay Start (Set at ?? Seconds)						
______ Time Delay Transfer (Set at ?? Seconds)						
______ Time delay Retransfer (Set at ?? Minutes)						
______ Program Transition (Set at ?? Seconds)						
______ Time Delay Cool Down (Set at ?? Minutes)						
______ Exercise Clock Set						
______ OTPC Real Time Clock Set						

OTPC DATA:

Software Version: ____________________

Software Update: ____________________

Network Options: ____________________

Capture File Name: ____________________

____

____

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Corrective Modifications made to OTPC:

REMOTE ANNUNCIATOR

______ Termination's with Stranded Wire ______________

______ Operation ______________

OPERATION TESTING

______ Site Load (Available?) A)______ (AMPS) B)______ (AMPS) C)______ (AMPS)

______ Voltage ______________ (Volts)

______ Frequency ______________ (Hertz)

______ Oil Pressure ______________ (PSI)

______ Water Temperature ______________ (Degrees F)

______ Oil Pressure Shutdown ______________ (Yes / No)

______ High Water Temp. Shutdown ______________ (Yes / No)

______ Overspeed Shutdown ______________ (Yes / No)

______ Overcrank ______________ (Yes / No)

GENERATOR SET LEFT IN AUTOMATIC ______________ (Yes / No)

CIRCUIT BREAKER CLOSED ______________ (Yes / No)

SYSTEM OPERATIONAL & IN STANDBY ______________ (Yes / No)

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Items Not Finished or Needing Attention

Date: ____________ *Project#* ____________ *Job Name:* ______________________________

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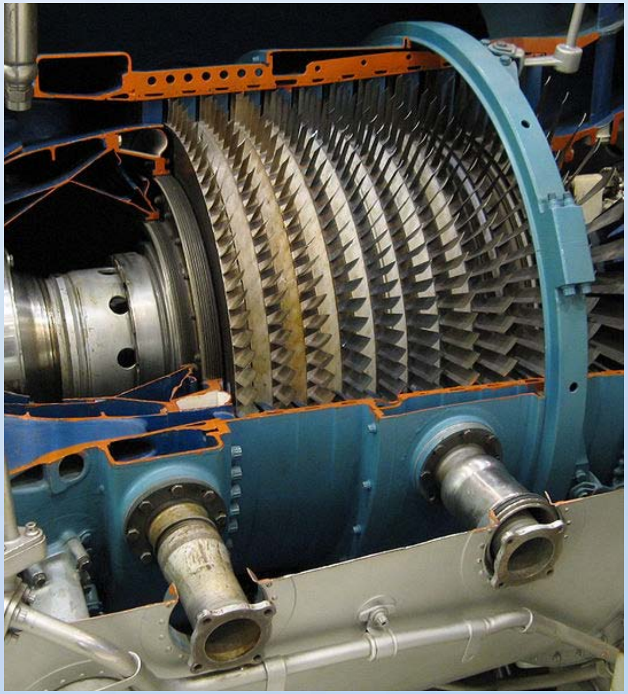
Northwest

Backup Generator System Equipment Selection

Presented by Todd Hackett
Senior Electrical Engineer with Carollo Engineers

Prime Movers

Gas (Natural Gas, LPG, etc.)
Spark Ignition Engine



Turbine (Gas or Dual Fuel)
Compression Ignition Engine

Diesel
Compression Ignition Engine

Prime Movers

Prime Mover	Advantages	Disadvantages	Best Application
Turbine	Clean and efficient when operating on gas. Low operating cost. Stable with sudden changes in load.	High initial cost. Requires power to start. Requires Diesel or other on-site fuel.	Cogeneration or other frequent or continuous operation.
Gas Engine	Lower fuel cost than Diesel.	Poor stability with sudden load change.	Small scale cogeneration.
Dual Fuel Diesel	Reduced fuel cost by blending gas into Diesel.	Fuel cost savings not significant for standby duty. Higher initial cost. Emissions.	Peak shaving or other extended operating use.
Diesel	Lowest initial cost. Stable with sudden changes in load. Reliable on-site fuel supply.	Higher fuel cost. Not as clean as equipment running on gas.	Standby power

Selecting the Right Generator

The right generator is the smallest one that can start the required loads effectively without adversely affecting other loads that are already running.

- An undersized generator will exhibit excessive voltage or frequency dip when starting large motors.
    - The problem is usually voltage dip due to high inrush current, which can cause motor starters and control relays to drop out, often resulting in chattering of the starter and repeated starts and starting inrush, overheating the motor and generator.
- An oversized generator will run well below its rating, and may not get hot enough for complete combustion, resulting in “wet stacking” and reduced engine life.

Specify capabilities – not kilowatts

Selecting the Right Generator

Several methods can be used to allow a smaller generator set to work effectively:

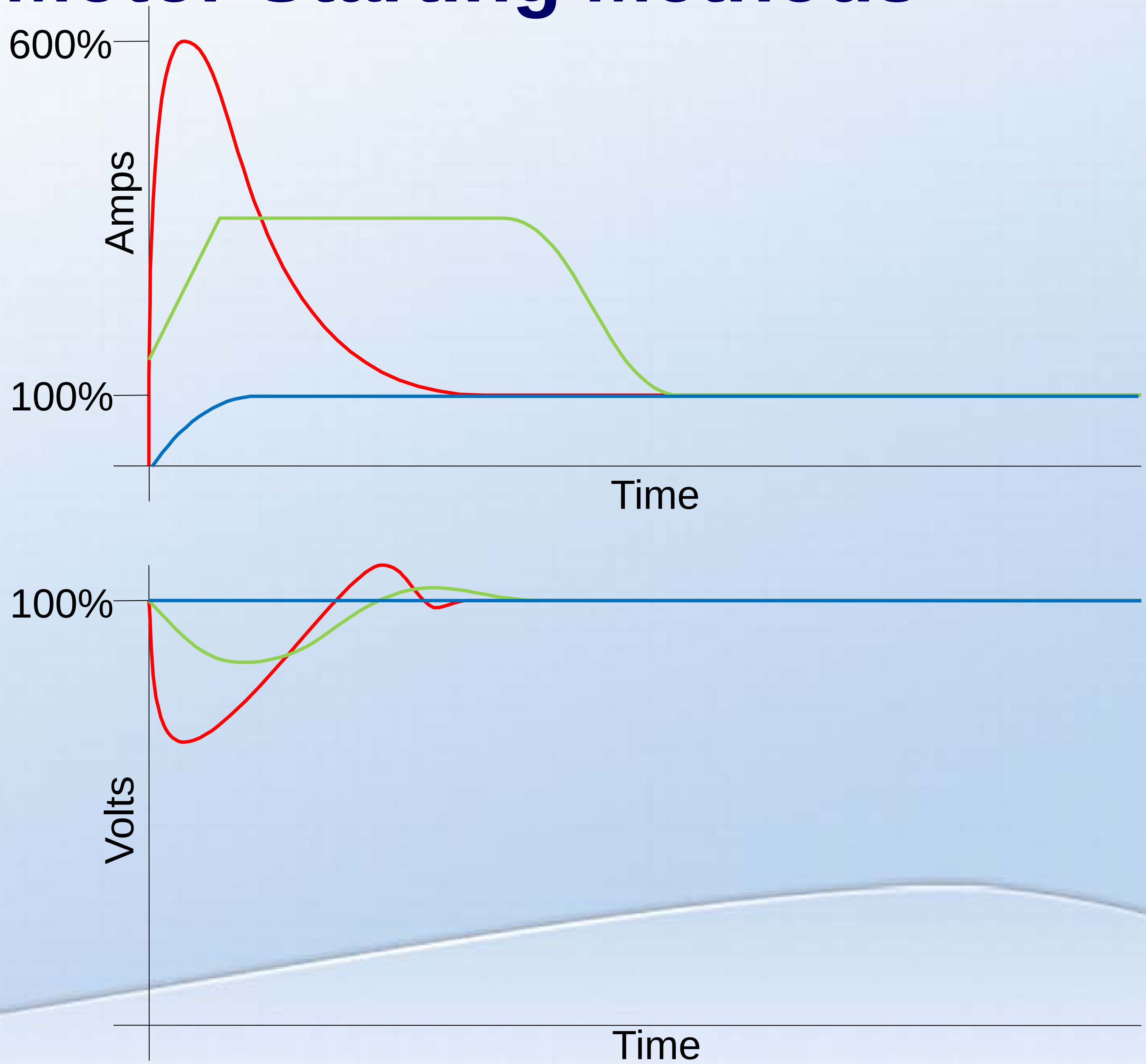
- Control of Load Steps
  - By only allowing one large motor to start at a time, the total inrush can be much less.
- Oversized Alternator
  - Voltage dip is caused by characteristics of the electrical generator (or alternator) and voltage regulator. The characteristics of the engine are not a major factor.
  - Generator sets with the same kW rating are available with several combinations of alternators and regulator to best match the loads.
- Sag-compensating power supply
  - For applications where the generator only operates one or a few motors, and no other loads sensitive to voltage dip, a UPS or sag-compensating power supply can prevent starter drop-out or chattering.
- Selecting the best starting method…

Motor Starting Methods

Across the Line

Soft Starter

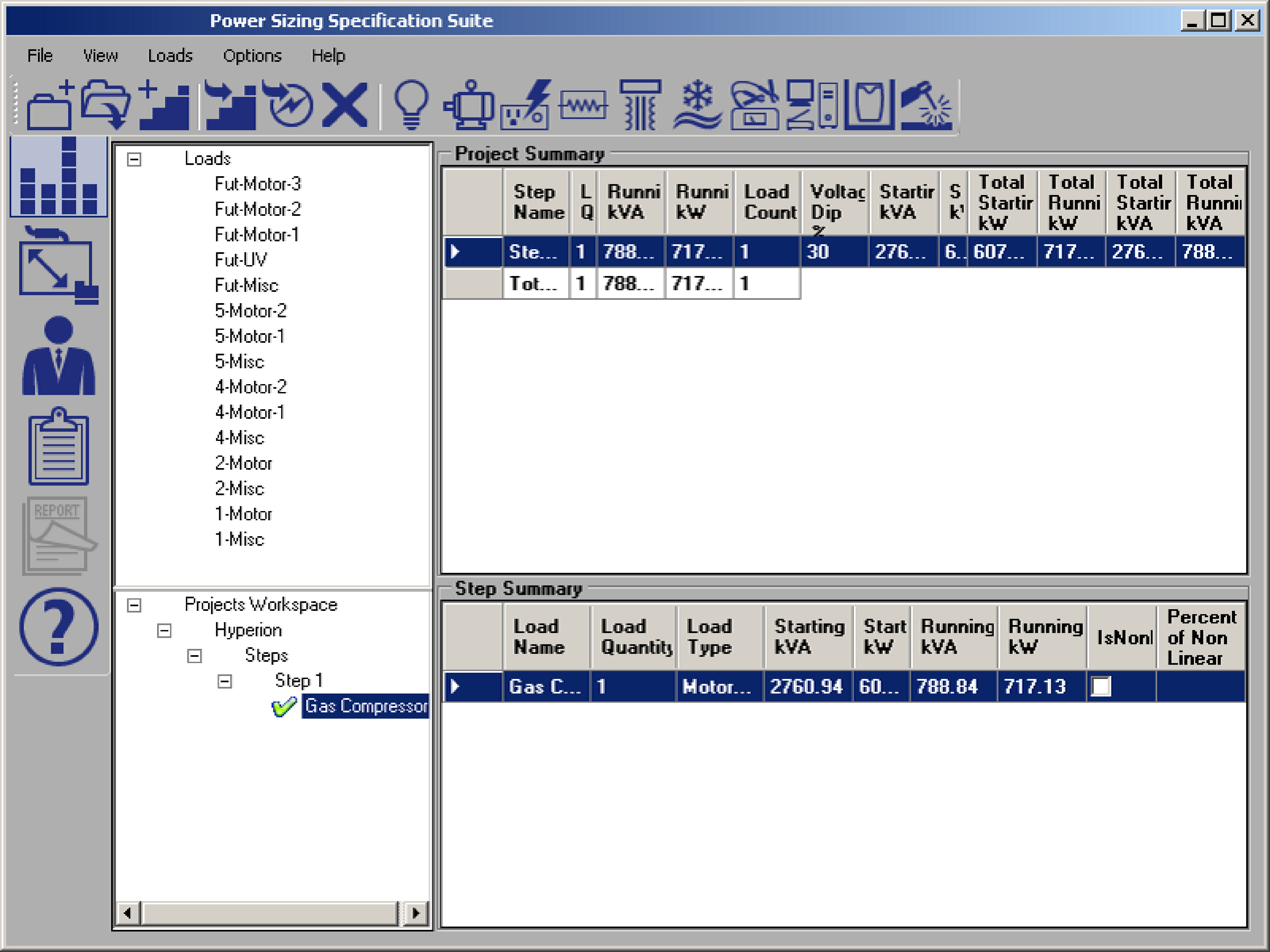
VFD

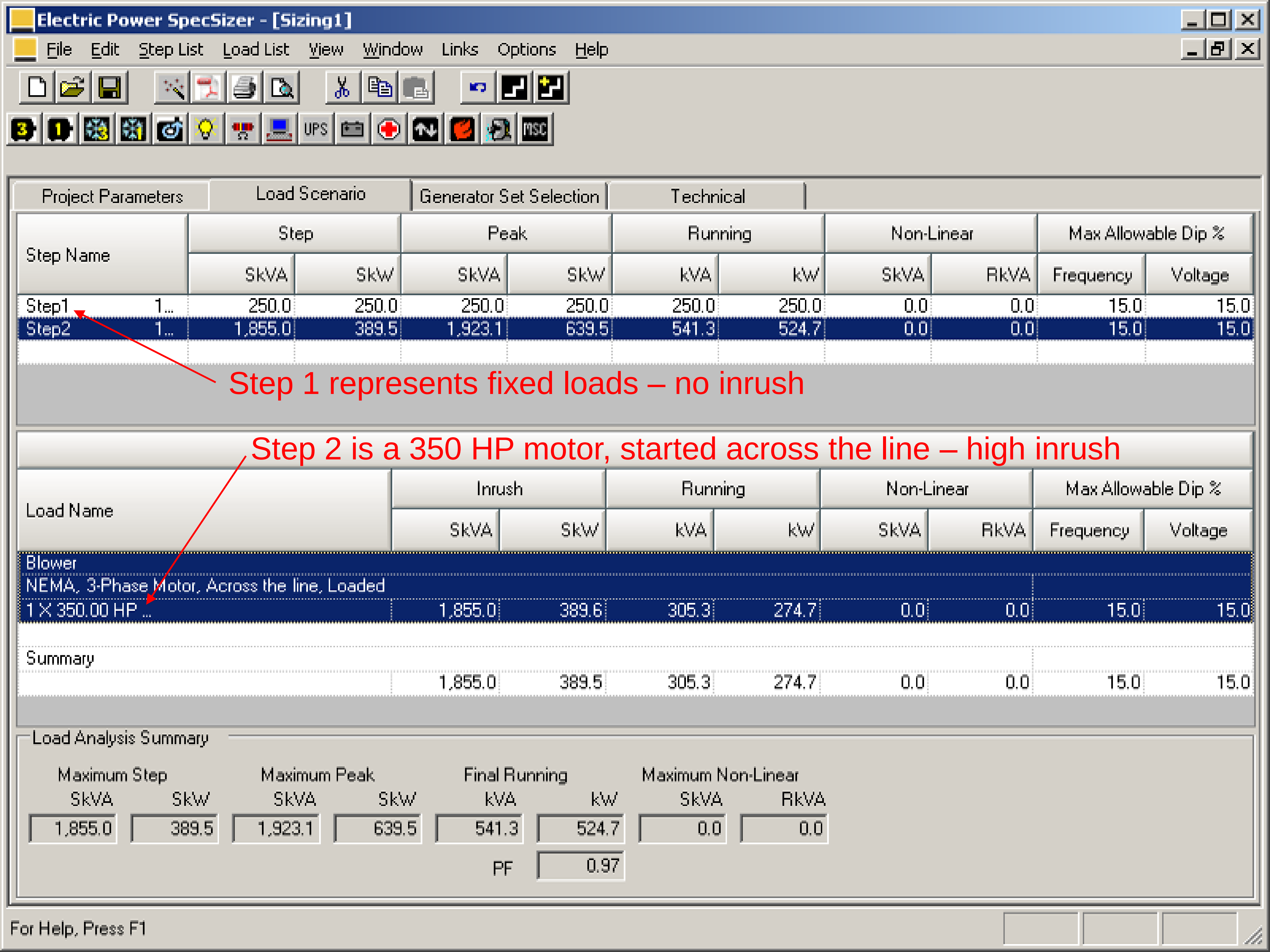


Generator Sizing Software

Each major diesel generator set manufacturer provides software to select the best generator set for a given application.

- They allow individual loads to be entered.
  - Characteristics that affect generator operation are modeled, such as motor starting method, and harmonic content.
  - Some software allows the actual running load of a motor to be entered.
    - Using motor nameplate power is required to model inrush, but also using actual running load more accurately models the characteristics.
- The loads are grouped into steps to identify which loads start at the same time.
  - Uncontrollable loads are usually grouped in step 1.
  - The hardest motor to start is usually entered as the last step to ensure that loads can be started in any sequence.


Power Sizing Specification Suite
File
View
Loads
Options
Help
REPORT
Loads
Fut-Motor-3
Fut-Motor-2
Fut-Motor-1
Fut-UV
Fut-Misc
5-Motor-2
5-Motor-1
5-Misc
4-Motor-2
4-Motor-1
4-Misc
2-Motor
2-Misc
1-Motor
1-Misc
Projects Workspace
Hyperion
Steps
Step 1
Gas Compressor
Project Summary
Step Name
L Q
Runni kVA
Runni kW
Load Count
Voltag Dip %
Startir kVA
S k'
Total Startir kW
Total Runni kW
Total Startir kVA
Total Runni kVA
Ste... 1 788... 717... 1 30 276... 6.. 607... 717... 276... 788...
Tot... 1 788... 717... 1
Step Summary
Load Name
Load Quantity
Load Type
Starting kVA
Start kW
Running kVA
Running kW
IsNonl
Percent of Non Linear
Gas C... 1 Motor... 2760.94 60... 788.84 717.13



Electric Power SpecSizer - [Sizing1]
File Edit Step List Load List View Window Links Options Help
Project Parameters
Load Scenario
Generator Set Selection
Technical
Step Name | Step SkVA | Step SkW | Peak SkVA | Peak SkW | Running kVA | Running kW | Non-Linear SkVA | Non-Linear RkVA | Max Allowable Dip % Frequency | Max Allowable Dip % Voltage
Step1 1... 250.0 250.0 250.0 250.0 250.0 250.0 0.0 0.0 15.0 15.0
Step2 1... 1,855.0 389.5 1,923.1 639.5 541.3 524.7 0.0 0.0 15.0 15.0
Step 1 represents fixed loads – no inrush
Step 2 is a 350 HP motor, started across the line – high inrush
Load Name | Inrush SkVA | Inrush SkW | Running kVA | Running kW | Non-Linear SkVA | Non-Linear RkVA | Max Allowable Dip % Frequency | Max Allowable Dip % Voltage
Blower
NEMA, 3-Phase Motor, Across the line, Loaded
1 X 350.00 HP ... 1,855.0 389.6 305.3 274.7 0.0 0.0 15.0 15.0
Summary
1,855.0 389.5 305.3 274.7 0.0 0.0 15.0 15.0
Load Analysis Summary
Maximum Step SkVA 1,855.0 SkW 389.5
Maximum Peak SkVA 1,923.1 SkW 639.5
Final Running kVA 541.3 kW 524.7
Maximum Non-Linear SkVA 0.0 RkVA 0.0
PF 0.97
For Help, Press F1

Electric Power SpecSizer - [Sizing1]

File View Window Links Options Help

Maximum Step SkVA	Maximum Step SkW	Maximum Peak SkVA	Maximum Peak SkW	Final Running kVA	Final Running kW	Maximum Non-Linear SkVA	Maximum Non-Linear RkVA
1,855.0	389.5	1,923.1	639.5	541.3	524.7	0.0	0.0

Project Parameters | Load Scenario | Generator Set Selection | Technical

Generator Set Selection

1,500.0 EkW / 1,875.0 kVA 60 Hz Standby, 480/277V, 3512 ATAAC EPA T2, 825 PM SR4B FORM, CDVR 2:1 slope

Number of Gensets: 1

Note: The selected genset is the BEST FIT for the site/load requirements.

Factory Genset EkW	Factory Genset kVA	Site Genset EkW	Site Genset kVA	Site Alternator kVA	Generator Set Duty	Genset Model	Aftercooler	Emissions / Certification	Alternator Frame	Alternator Excitation	Winding
2,000.0	2,500.0	2,000.0	2,500.0	2,500.0	Standby	3516 C	ATAAC	EPA T2	825	SE	RANDOM
1,500.0	1,875.0	1,500.0	1,875.0	2,500.0	Standby	3512 C	ATAAC	EPA T2	825	PM	FORM
1,500.0	1,875.0	1,500.0	1,875.0	2,500.0	Standby	3512 C	ATAAC	EPA T2	825	PM	RANDOM
1,500.0	1,875.0	1,500.0	1,875.0	2,188.0	Standby	3512 C	ATAAC	EPA T2	824	PM	FORM
1,500.0	1,875.0	1,500.0	1,875.0	2,188.0	Standby	3512 C	ATAAC	EPA T2	824	PM	RANDOM

Create Guide Spec | Go to Best Fit Genset | Customer Sales Support Links | Dealer Sales Support Links

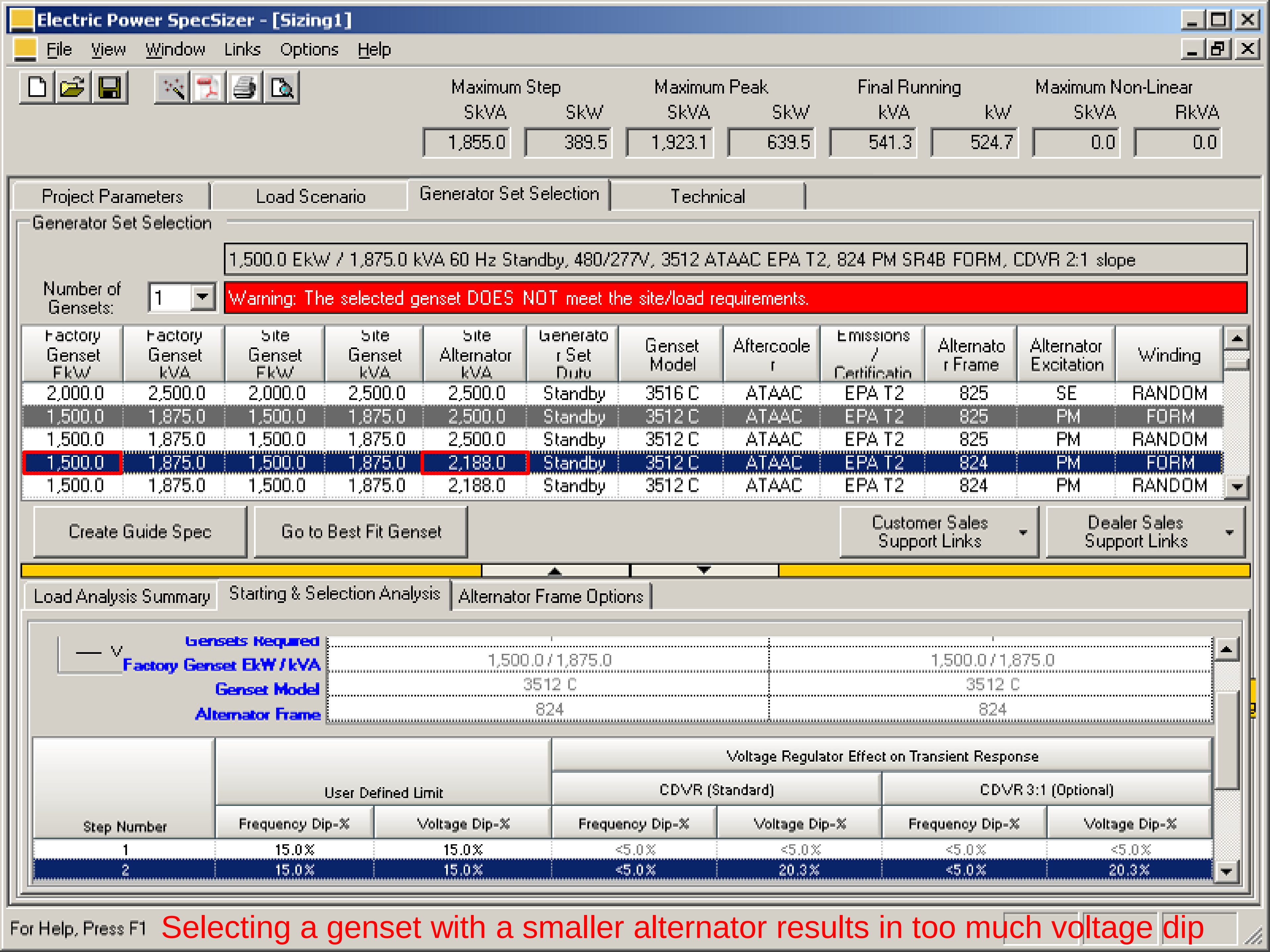
Load Analysis Summary | Starting & Selection Analysis | Alternator Frame Options

Gensets Required		
Factory Genset EkW / kVA	1,500.0 / 1,875.0	1,500.0 / 1,875.0
Genset Model	3512 C	3512 C
Alternator Frame	825	825

Step Number	User Defined Limit		Voltage Regulator Effect on Transient Response			
			CDVR (Standard)		CDVR 3:1 (Optional)	
	Frequency Dip-%	Voltage Dip-%	Frequency Dip-%	Voltage Dip-%	Frequency Dip-%	Voltage Dip-%
1	15.0%	15.0%	<5.0%	<5.0%	<5.0%	<5.0%
2	15.0%	15.0%	<5.0%	14.6%	<5.0%	14.6%

For Help, Press F1

The result is a 1,500 kW generator set with oversized alternator



Selecting a genset with a smaller alternator results in too much voltage dip

Electric Power SpecSizer - [Sizing1]

File Edit Step List Load List View Window Links Options Help

Project Parameters | Load Scenario | Generator Set Selection | Technical

Step Name		Step		Peak		Running		Non-Linear		Max Allowable Dip %	
		SkVA	SkW	SkVA	SkW	kVA	kW	SkVA	RkVA	Frequency	Voltage
Step1	1...	250.0	250.0	250.0	250.0	250.0	250.0	0.0	0.0	15.0	15.0
Step2	1...	1,068.4	224.4	1,186.7	658.3	541.3	524.7	1,068.4	0.0	15.0	15.0

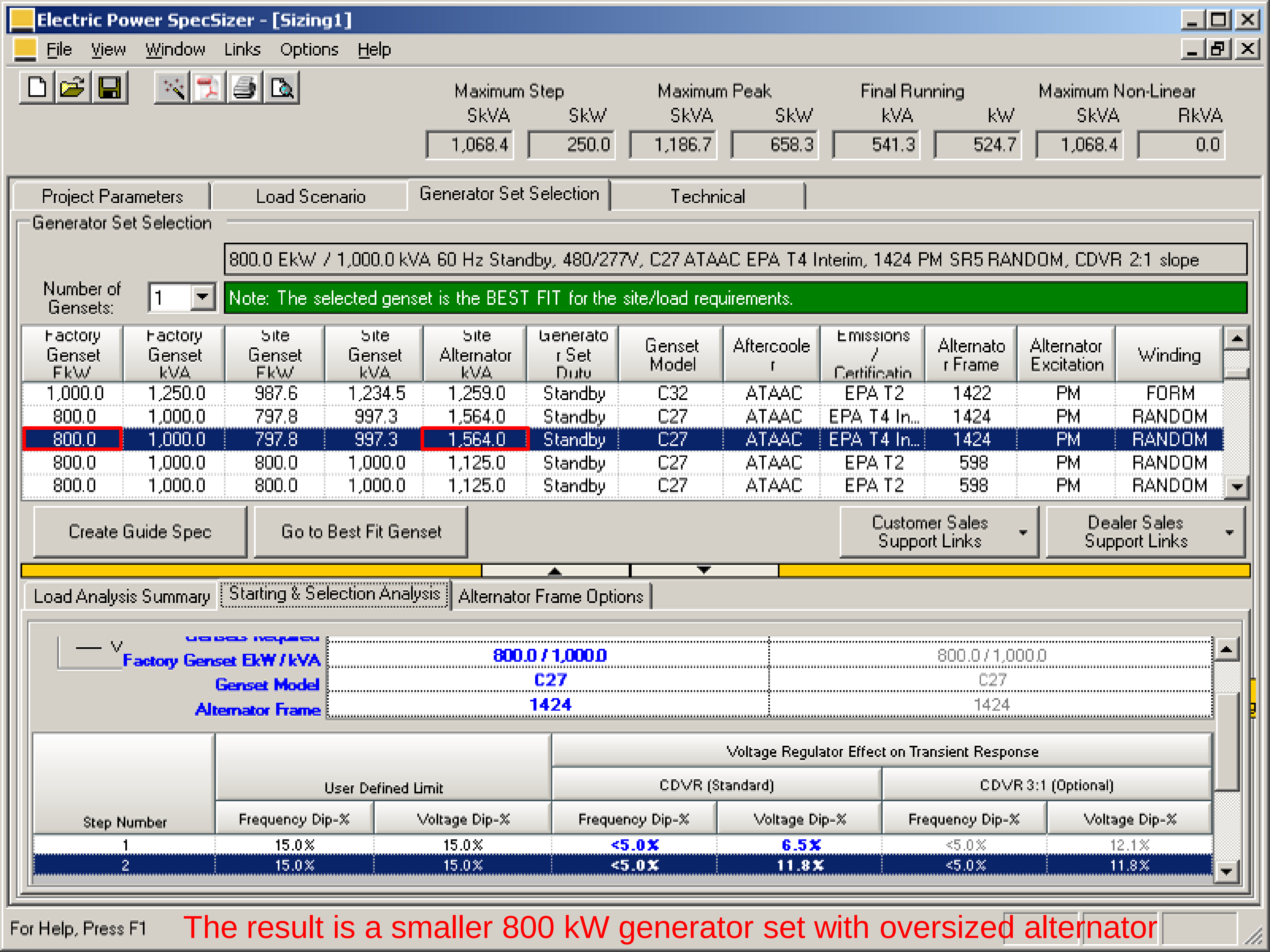
Step 2 now uses a soft starter – be sure to set the correct current limit

Load Name	Inrush		Running		Non-Linear		Max Allowable Dip %	
	SkVA	SkW	kVA	kW	SkVA	RkVA	Frequency	Voltage
Blower								
NEMA, 3-Phase Motor, Soft Starter, 350% Current Limit								
1 X 350.00 HP ...	1,068.4	224.4	305.3	274.7	1,068.4	0.0	15.0	15.0
Summary								
	1,068.4	224.4	305.3	274.7	1,068.4	0.0	15.0	15.0

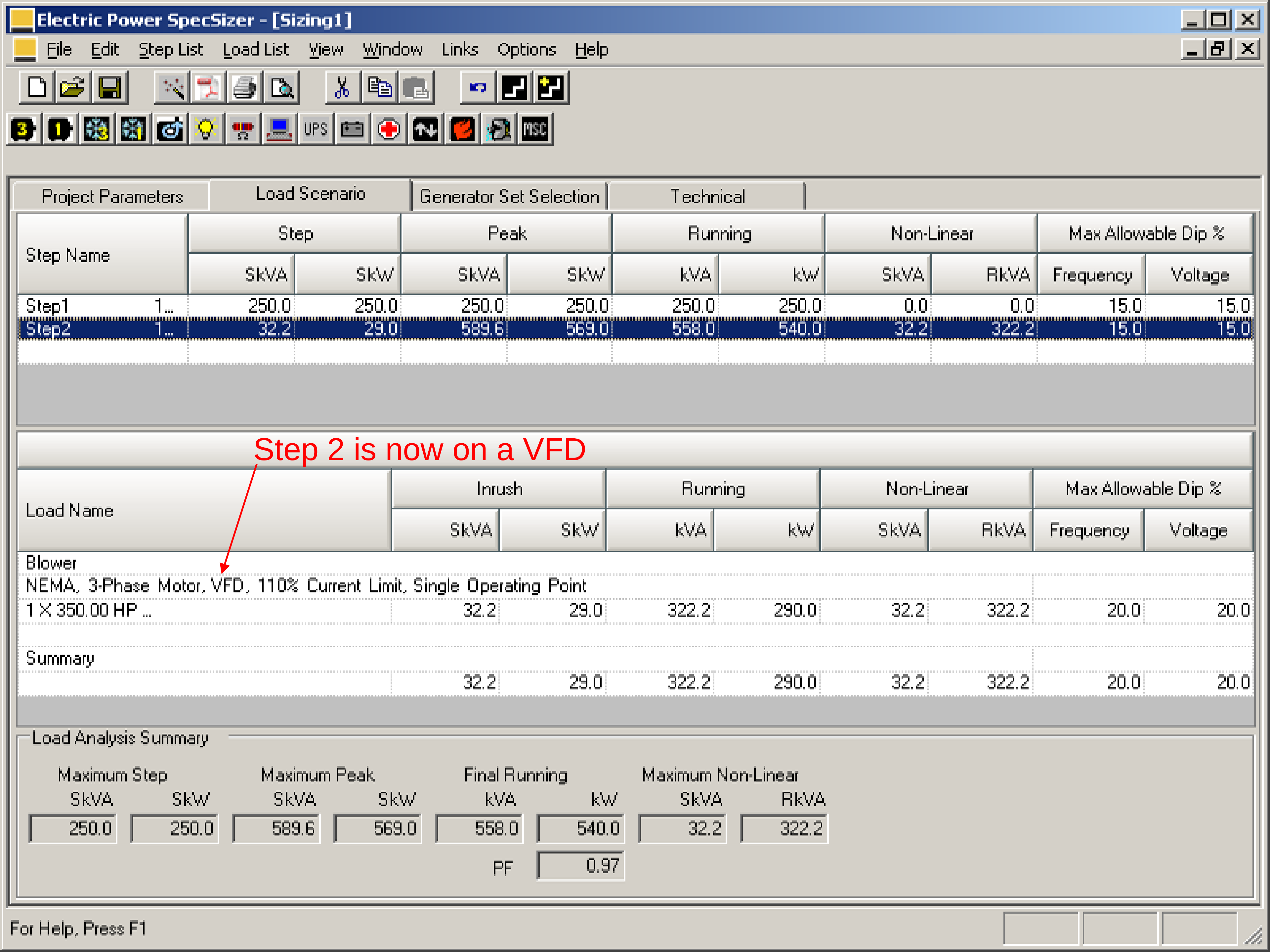
Load Analysis Summary

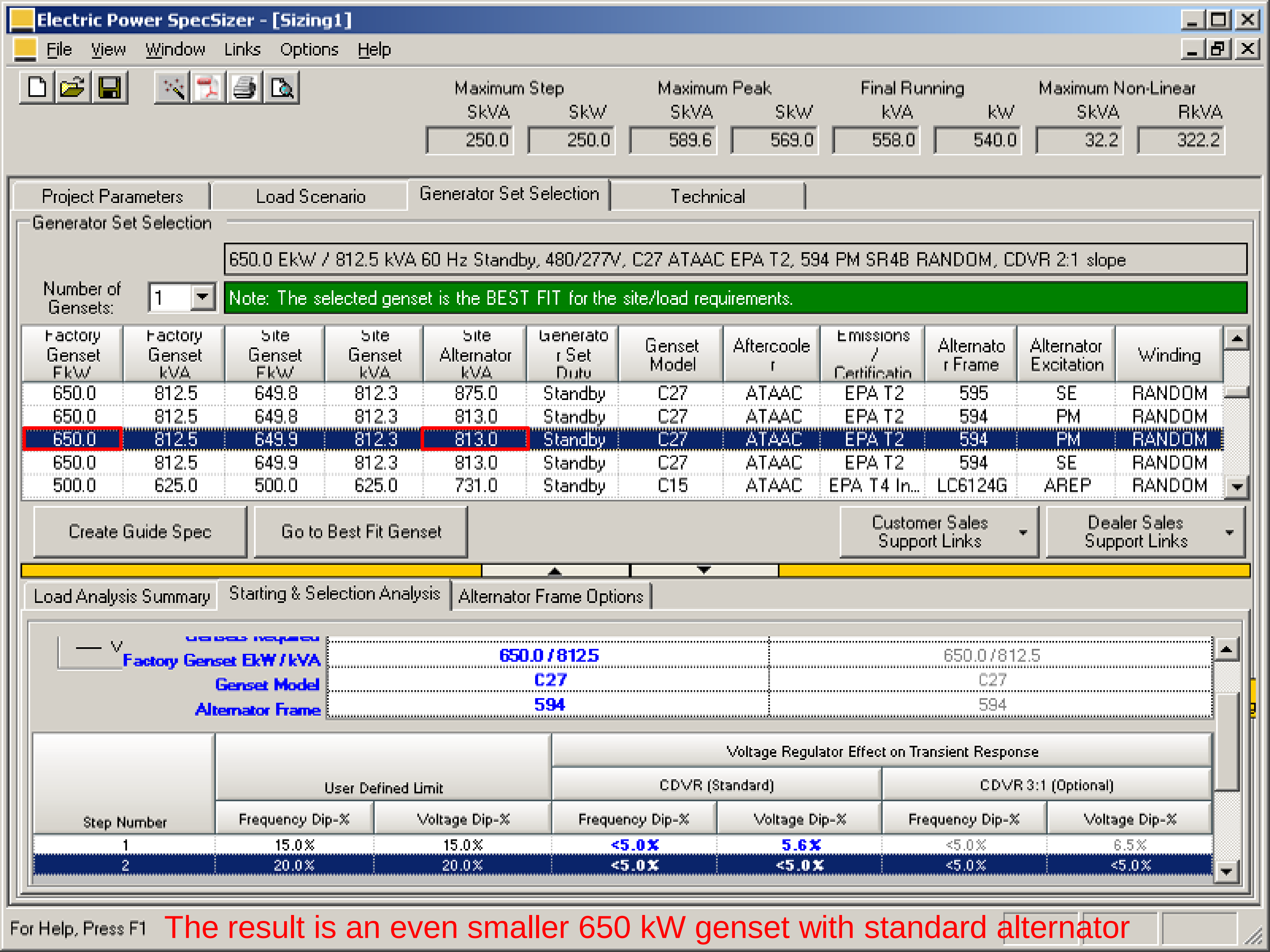
Maximum Step		Maximum Peak		Final Running		Maximum Non-Linear	
SkVA	SkW	SkVA	SkW	kVA	kW	SkVA	RkVA
1,068.4	250.0	1,186.7	658.3	541.3	524.7	1,068.4	0.0
				PF	0.97		

For Help, Press F1



The result is a smaller 800 kW generator set with oversized alternator


Electric Power SpecSizer - [Sizing1]
File Edit Step List Load List View Window Links Options Help
Project Parameters
Load Scenario
Generator Set Selection
Technical
Step Name
Step
Peak
Running
Non-Linear
Max Allowable Dip %
SkVA SkW SkVA SkW kVA kW SkVA RkVA Frequency Voltage
Step1 1... 250.0 250.0 250.0 250.0 250.0 250.0 0.0 0.0 15.0 15.0
Step2 1... 32.2 29.0 589.6 569.0 558.0 540.0 32.2 322.2 15.0 15.0
Step 2 is now on a VFD
Load Name
Inrush
Running
Non-Linear
Max Allowable Dip %
SkVA SkW kVA kW SkVA RkVA Frequency Voltage
Blower
NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point
1 X 350.00 HP ... 32.2 29.0 322.2 290.0 32.2 322.2 20.0 20.0
Summary
32.2 29.0 322.2 290.0 32.2 322.2 20.0 20.0
Load Analysis Summary
Maximum Step
Maximum Peak
Final Running
Maximum Non-Linear
SkVA SkW SkVA SkW kVA kW SkVA RkVA
250.0 250.0 589.6 569.0 558.0 540.0 32.2 322.2
PF 0.97
For Help, Press F1



The result is an even smaller 650 kW genset with standard alternator

Generator Operation
(Other than Standby)

EPA regulations for new diesel engines make a distinction between those used for emergency or standby generators, and those used for “beneficial use.” Any use other than Standby or Emergency power requires higher emissions compliance (typically Tier 4 or 4i).

- Standby or Emergency use includes:
  - Powering a facility when the normal utility power source fails.
  - Maintenance and exercising, not to exceed 100 hours per year.
- Beneficial use includes:
  - Peak Shaving
  - Storm Avoidance
  - Distributed Generation
  - Any other operation that does not qualify as Standby or Emergency

Integrating Generator Systems into the Plant

Locations of standby power

- Transfer switch at main service.
  - Backup whole plant, or use PLC/DCS or load shedding breakers to limit load on generators.
- Transfer switch at "Essential Power" bus – the rest of the plant not backed up.

Number of Generators

- One generator
  - Easiest, least costly installation
  - Limited capacity
- Two or more generators
  - Operating in parallel
    - Higher cost and complexity
    - Better motor starting capability
    - N+1 redundancy possible
  - Each generator powering a different plant area
    - Maintains simplicity and low cost of one generator, with the capacity of two or more generators

Integrating Generator Systems into the Plant

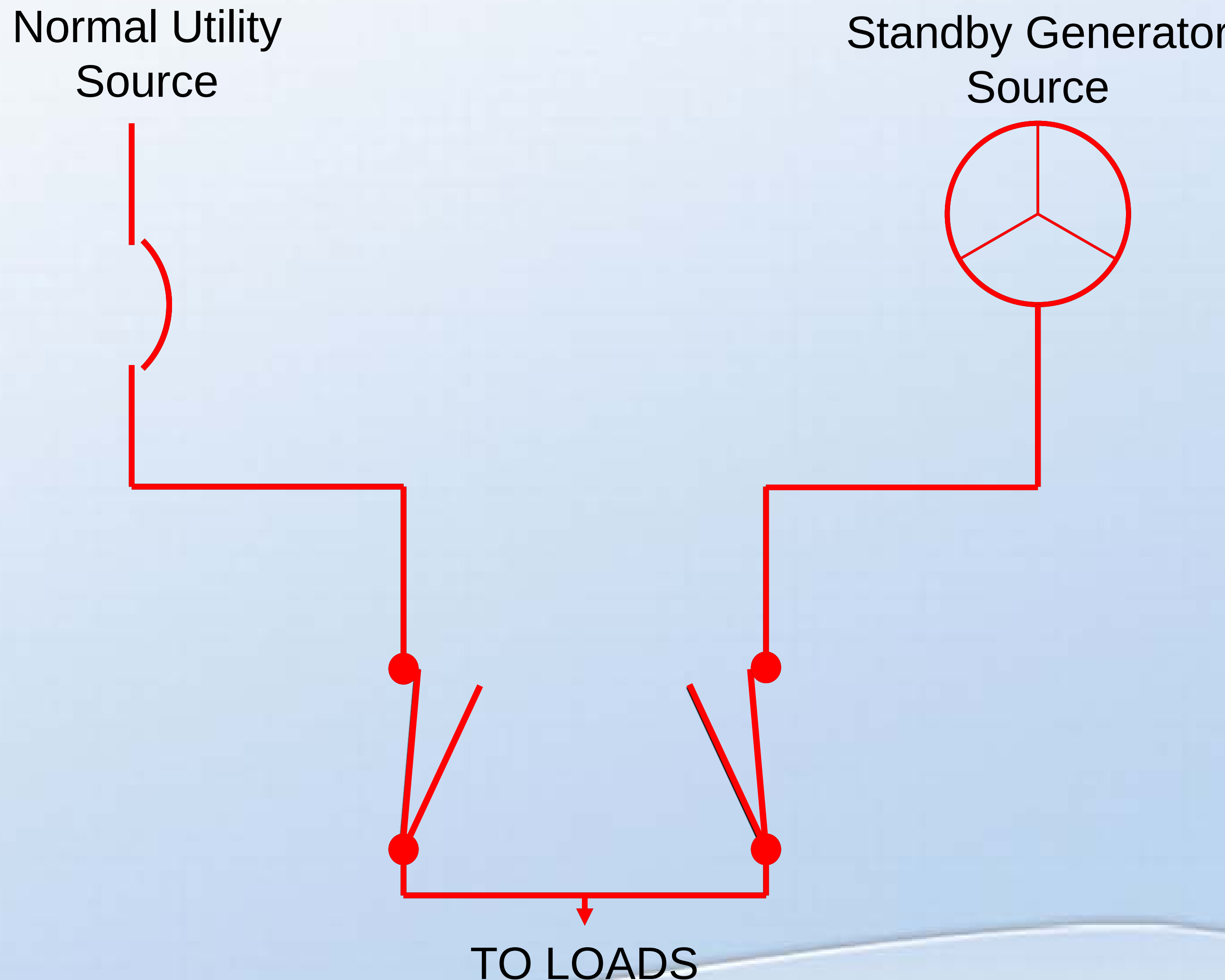
Transfer Equipment

- Manual Transfer Switch (MTS)
- Automatic Transfer Switch (ATS)
  - Using Automatic Transfer Controller (ATC)
- Transfer Switchgear
  - Using PLC or ATC

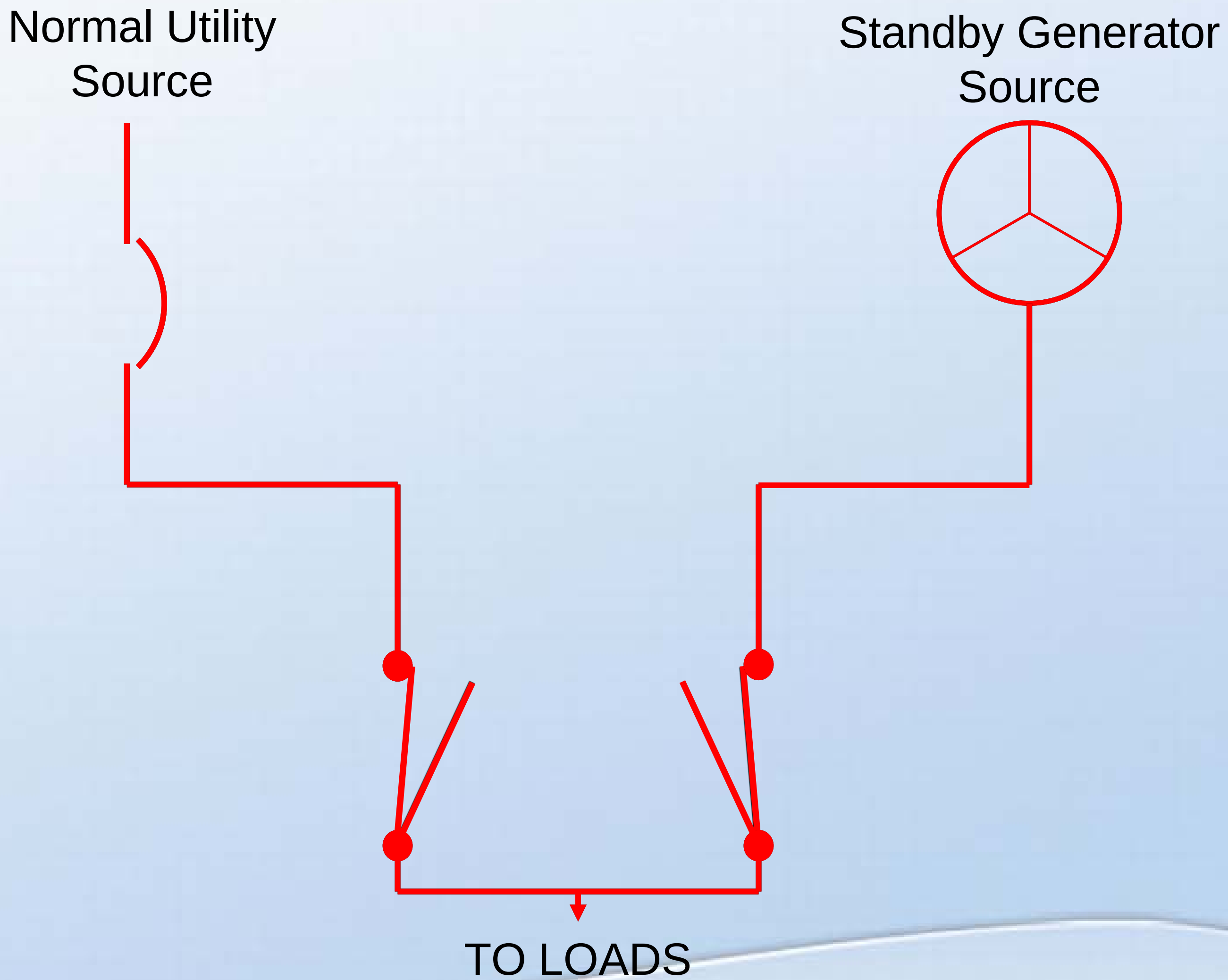
Transfer Methods

- Open Transition
  - Delayed
    - Allows motor field to decay
    - Does not require sources to be synchronized
  - Fast
    - Allows most loads to continue operation
    - Requires more complex ATC
- Closed Transition
  - Highest complexity
  - Must meet electrical utility requirements, including protective relaying
  - Not allowed by many electrical utilities
  - Operation beyond 100 milliseconds may result in different rate tariff

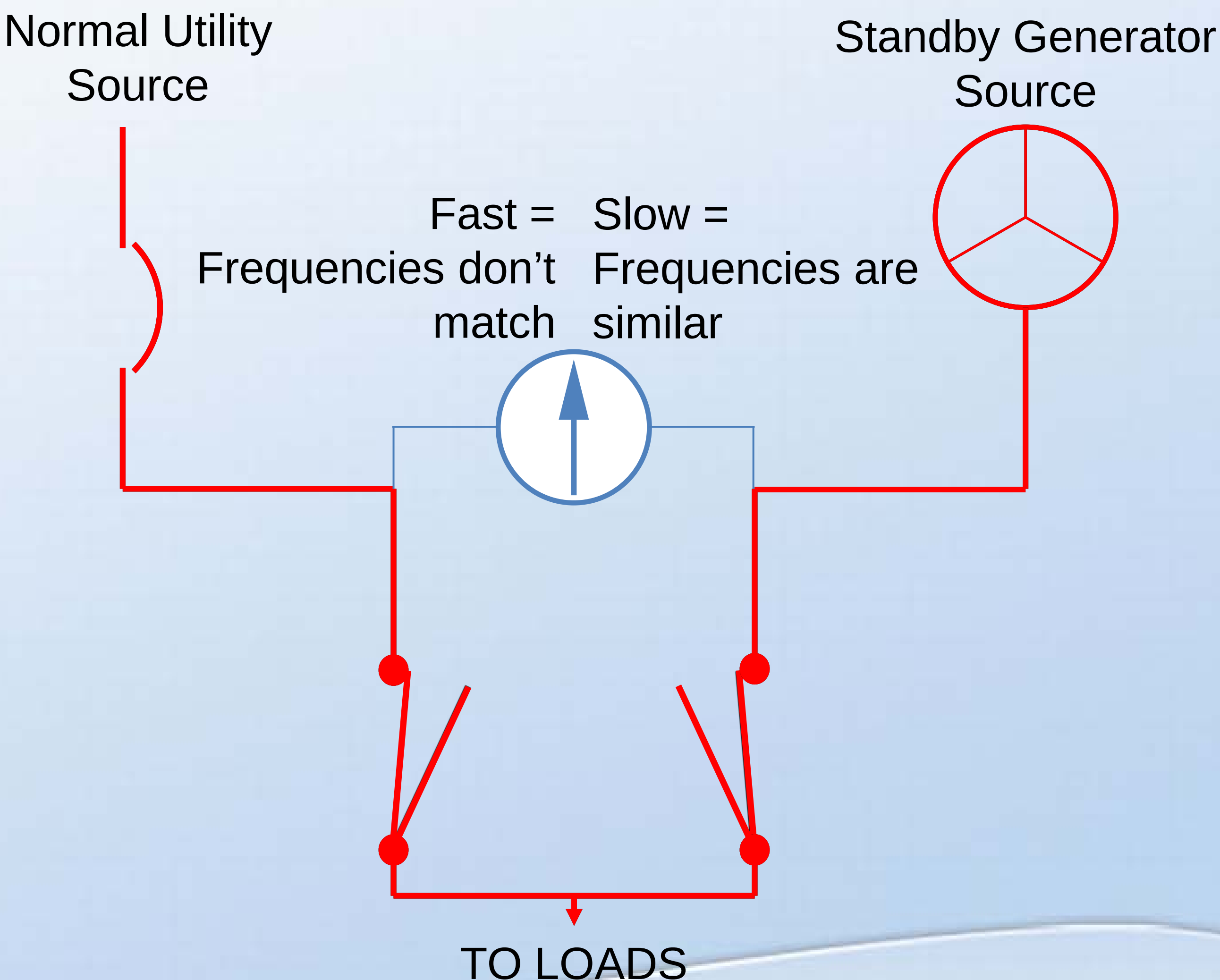
Open Transition Transfer
Normal to Standby



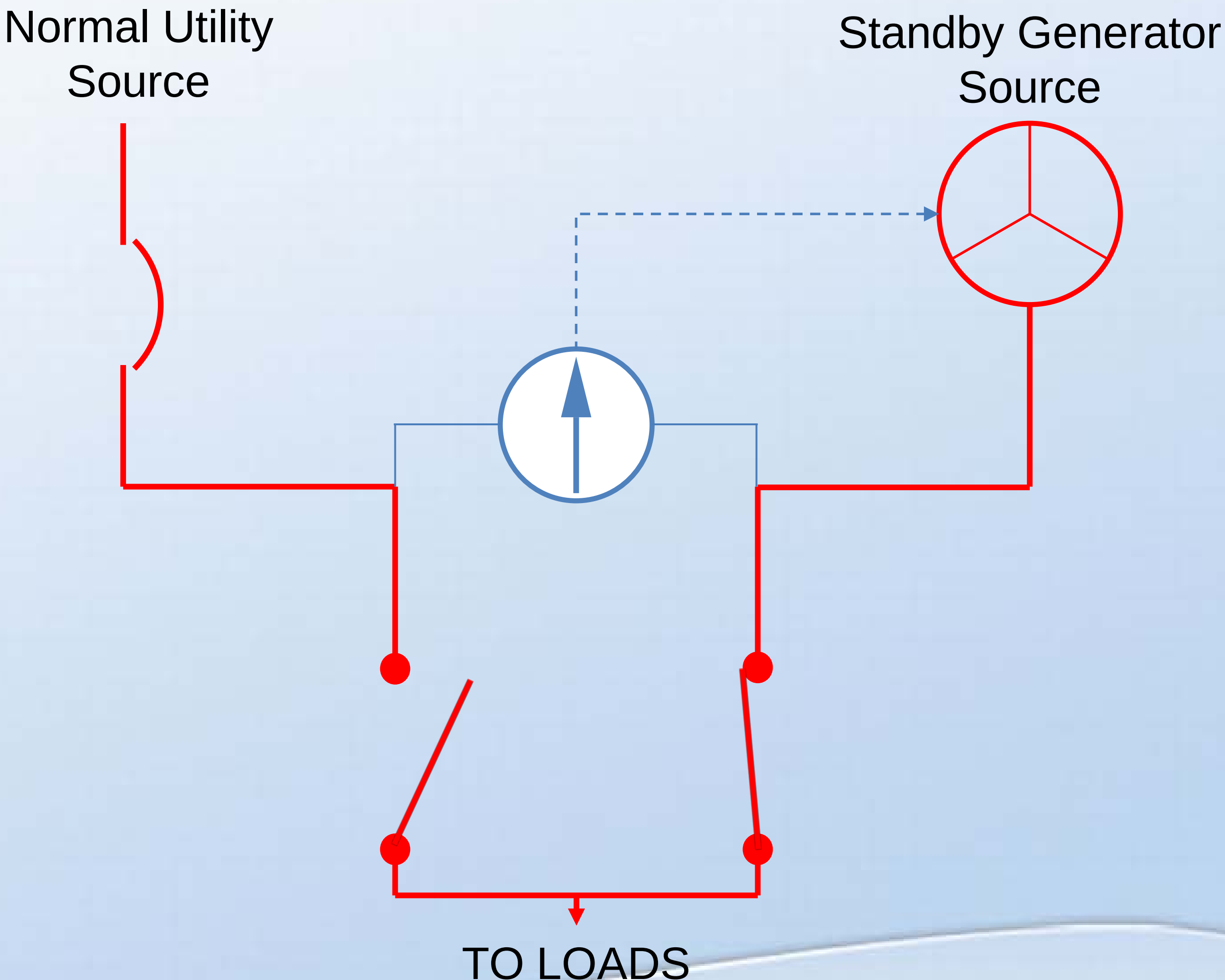
Open Transition Transfer
Standby to Normal



Fast In-Synch Open Transition Transfer Standby to Normal



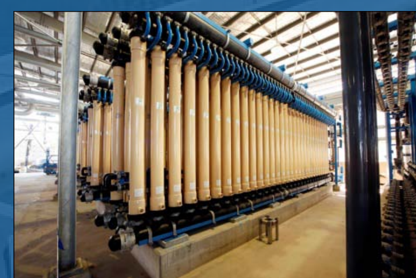
Synchronized Closed Transition Transfer
Standby to Normal



CH2MHILL®

Standby Generator Support Systems





AWWA Pacific Northwest Section Annual Meeting

May 2012

Standby Generator Support Systems

- Codes, Standards, & Regulations
- Impacts of Operation
- Engine Starting Methodology
- Fuel Oil
- Pollution Abatement

Review Local Code and Environmental Regulations

Standby Generator Support Systems

Codes and Standards

Standby Generator – Codes, Standards, & Regulations

- Local Building, Fire, and Mechanical Code

- Local Environmental Regulations
  - Air Pollution, chemical and particulate
  - Noise Pollution
  - Monitoring and Reporting

- NFPA
  - 30, *Flammable and Combustible Liquids Code*
  - 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*
  - 211, *Standard for Chimneys, Fireplaces, Vents, and Solid Fuel–Burning Appliances*

Standby Generator Support Systems

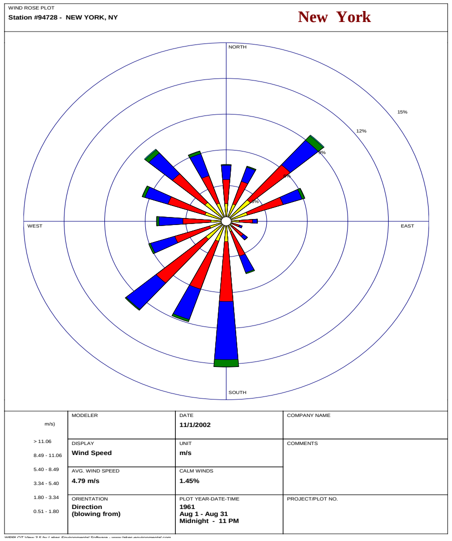
- Local Environmental Regulations
  - Air Pollution
    - NOx
    - Particulate
  - Noise Pollution
    - Property Boundary Limitations
    - Time of Day Limitations
  - Monitoring and Reporting
    - Fuel Oil Quantities
    - Emissions Rates
    - Leak Detection
    - Test Well Monitoring

Standby Generator Support Systems

Operational Impacts

Standby Generator –Operational Impacts

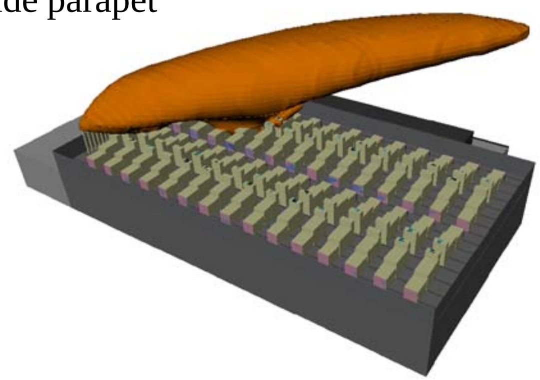
- Air Intake and Exhaust
  - Consider prevailing wind directions
  - Radiator fan pressure limitations
  - Engine back pressure limitations
  - Meeting code required separation for the locations of the air intake, radiator exhaust, and combustion exhaust does not necessarily mean there aren't potential problems.

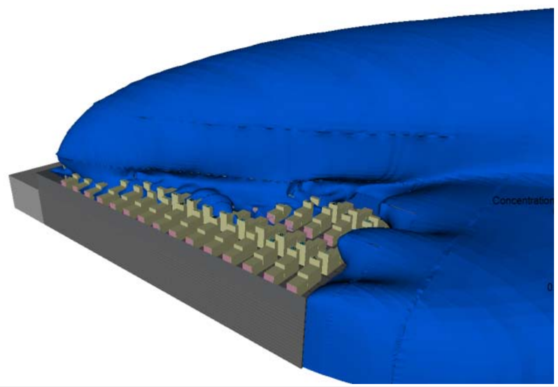


Standby Generator – Operational Impacts

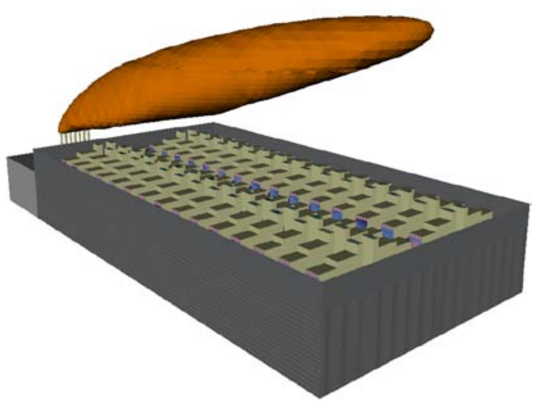
- Engine Exhaust – Code compliance is not a performance guarantee

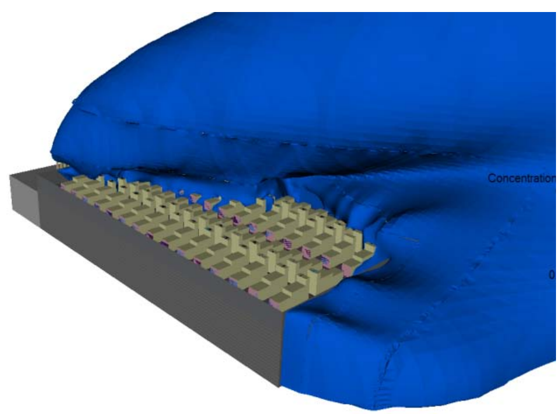
Stacks inside parapet





Stacks outside parapet





RED PLUME: NOx Short Term Exposure Limit (STEL): 5 ppm

BLUE PLUME: NOx Odor Threshold: 0.11 ppm

Standby Generator Support Systems

Engine Options

Standby Generator – Engine Starting Options

- Battery Powered Starter
  - Think "car battery" – same issues
  - Battery power and life is affected by ambient temperature
- Compressed Air Powered Starter
  - Backup air source
  - Dry air – keep water out of the system
  - Control interlocks – attempting to start with too low of air pressure may damage the starters.
  - Size system to allow multiple starts on stored compressed air

Standby Generator – Engine Cooling Options

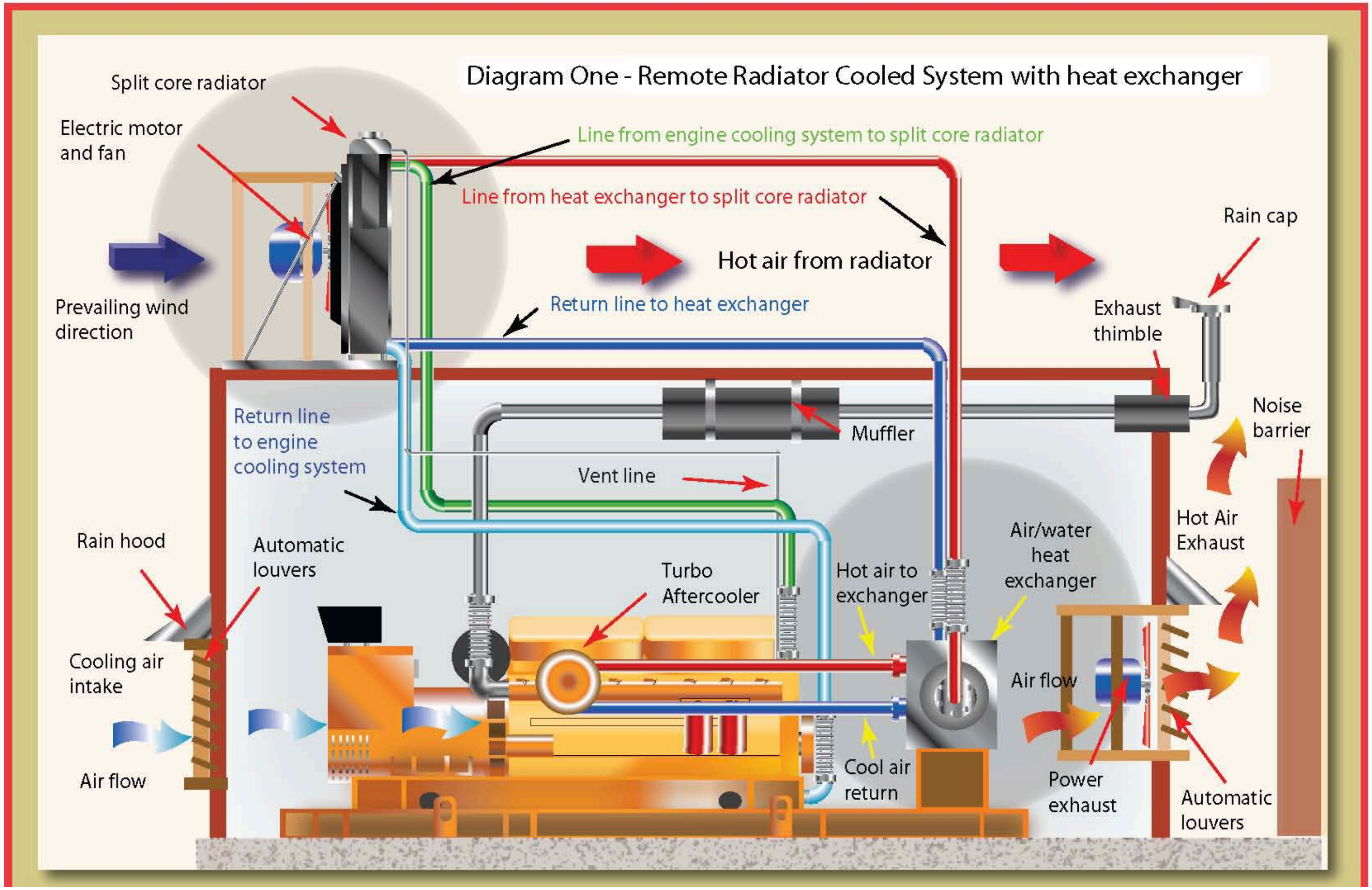
- Engine Mounted Radiator

Standby Generator – Engine Cooling Options

- Engine Mounted Radiator
  - Fan runs on engine shaft
  - No extra motor or motor control system required
  - Pre-piped radiator simplifies field installation
  - Requires large airflow (radiator + combustion) required in engine room
    - Provides cooling for electrical components in room.
    - Address uncontrolled recirculation
    - Radiator fan allowable pressure drop < 0.25” WC
    - Controlled recirculation may be desirable to heat space
    - May require heating of room when engine is off

Standby Generator – Engine Options

- Remote Mounted Radiator



Standby Generator – Engine Cooling Options

- Remote Mounted Radiator
  - Potentially fewer airflow engineering challenges than engine mounted
  - Considered less reliable than engine mounted due to additional components required to operate units.
    - Additional fan motor(s) and controls to operate radiator fan(s)
    - Field piping from engine to radiator
    - Address cooling of electrical components in engine room.
  - Distance from generators to radiators may impose complications.
  - Only combustion air need be drawn into engine room.

Standby Generator – Engine Cooling Options

- Water Cooled (Cooling Tower)
  - Potentially fewer airflow engineering challenges than engine mounted
  - Considered less reliable than engine mounted due to additional components required to operate units.
    - Requires pumps, cooling towers, and associated support systems
    - Address cooling of electrical components in engine room.
  - Distance from cooling towers to generators not limited.
  - Only combustion air need be drawn into engine room.

Standby Generator Support Systems

Fuel Oil

Standby Generator – Fuel Oil

- Types of Fuel Oil

  – No. 1 Fuel Oil
    - Lower temperature cloud point typically ~ -35°F
    - Lower heat content than No. 2 fuel oil

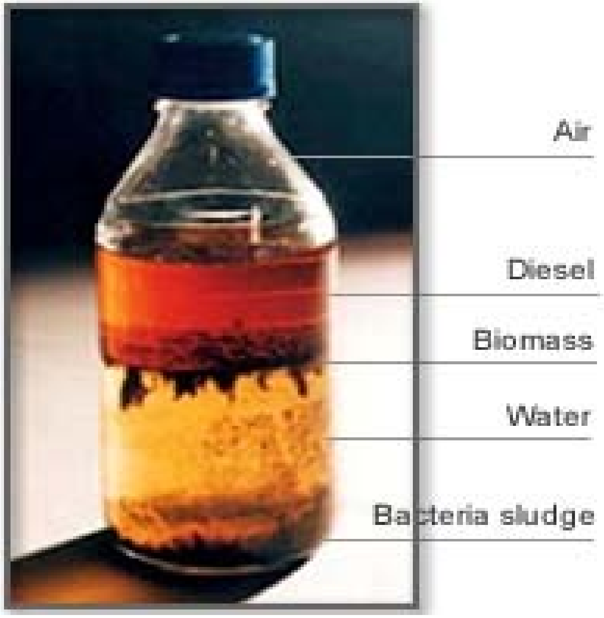
  – No. 2 Fuel Oil
    - Most commonly used
    - Cloud point for diesel is typically 10°F, paraffin wax in fuel oil clouds at 40°F
    - Cloud point is where wax crystallizes
    - Sometimes blended in No. 1 fuel oil for winter operation
      – Reduces cloud point making low temperatures less problematic
      – Reduces heat content thereby reducing engine output
      – Reduces lubricity of fuel
      – Blending not well defined in the industry – caution
      – Previous use of Kerosene and Jet A fuels were also common blending fuels

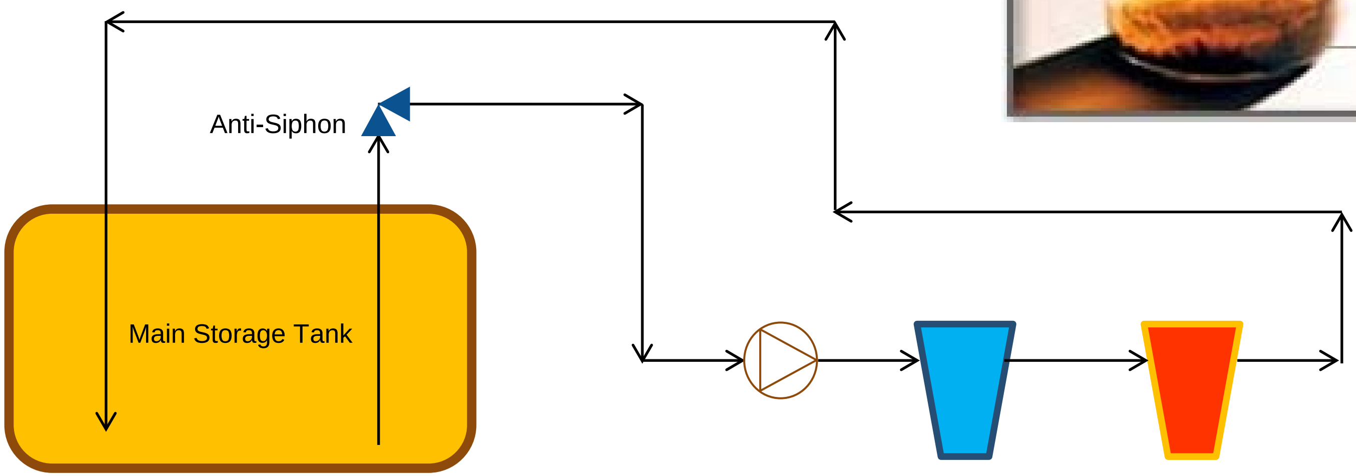
Standby Generator – Fuel Oil

- Fuel Oil Quality
  - Ultra-low sulfur (15 PPM) diesel fuels have been developed to comply with environmental regulations.
  - Reducing the amount of sulfur in diesel fuel renders the fuel vulnerable to microbial growth. The process of removing sulfur also removes oxygen and nitrogen and requires introducing water.
  - When fuel becomes contaminated, the water in diesel fuel becomes a breeding ground for bacteria and fungus, which may result in filter blockage, fuel pump wear, diesel engine damage or engine shut down.
  - Emergency and standby generators are at the greatest risk for bacterial contamination as they often go unused for extended intervals.

Standby Generator – Fuel Oil

- Fuel Oil Polishing
  - Removes particulate
  - Removes water





Standby Generator Support Systems

Fuel Oil Storage

Standby Generator – Fuel Oil Storage

- Fuel Oil Storage
  - All storage tanks require double containment and monitoring for leaks and fuel oil level. Double contained pipe is required for underground installations and may be desirable for aboveground pipe.
  - Type and location of tanks is dependent:
    - Available space
    - Required hours of operation prior to requiring a fuel delivery
    - Risks:
      - Natural (e.g.: floods, earthquakes)
      - Environmental (e.g.: leaking tank / pipes or an inadvertent release (spill))
      - Human risks (e.g.: vandalism, operational errors)
    - Governmental Regulations
    - Operational preferences

Standby Generator – Fuel Oil Storage

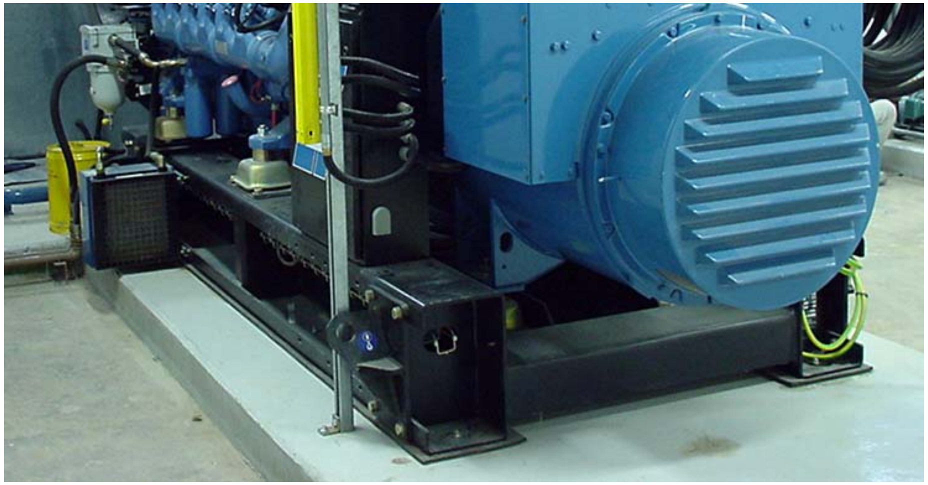
- Type of Fuel Storage Tanks
  - Above Ground Storage Tank (AST)
    - Requires space on site
    - Consider tank insulation and fuel heater if temperature may drop below 50°F
    - Less monitoring than compared to underground storage
    - May require pump for filling
    - Anti-Siphon device required
    - May not need double contained piping as long as the pipe is visible and in a contained location

Standby Generator – Fuel Oil Storage

- Type of Fuel Storage Tanks
  - Underground Storage Tanks (UST)
    - Less space when compared to AST
    - Gravity fill possible
    - May require tank insulation and fuel heating depending on location and depth
    - Double contain pipe with leak detection
    - Environmental monitoring wells
    - Transition sumps with leak detection between below and above ground piping may be required

Standby Generator – Fuel Oil Storage

- Type of Fuel Storage Tanks
  - Generator Base Tanks
    - Quantity of fuel oil storage may be limited by building code.
    - Fuel oil storage of 8 hours not uncommon
    - No external piping or controls required
    - Tank insulation and fuel oil heaters may be required
    - Fill may be require a pump depending on tank fill port height

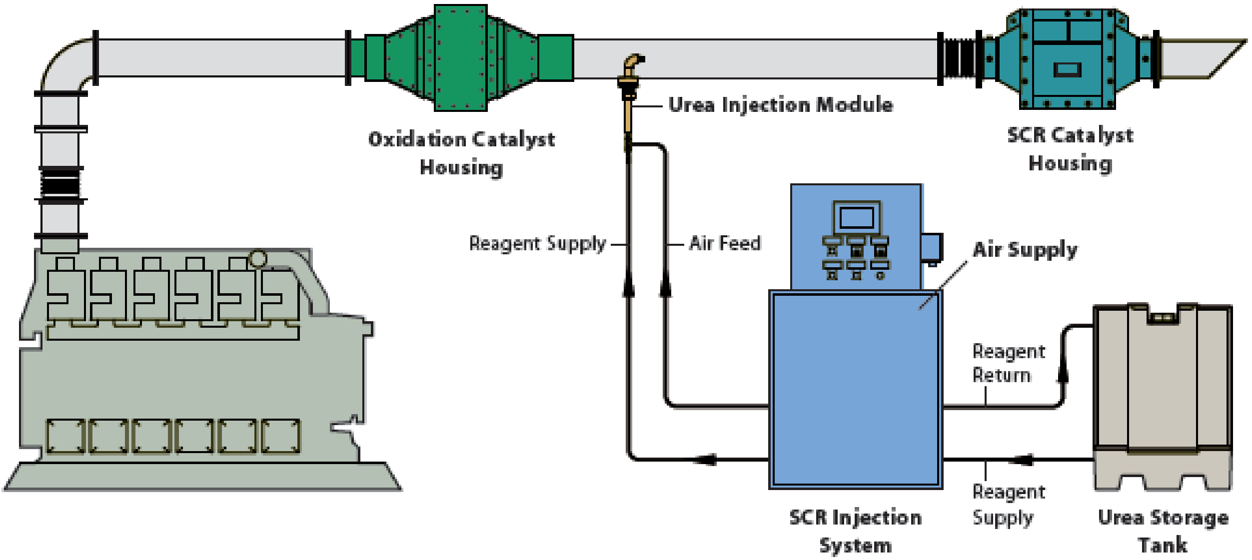


Standby Generator Support Systems

Pollution Abatement

Standby Generator – Pollution Abatement

- Federal EPA and State DEQ Regulations
  - Selective Catalytic Converters (SCR) for NOx Reduction
    - Support Systems
      - Urea Storage
      - Compressed Air



Standby Generator – Pollution Abatement

- Diesel Particulate Filters (DPF)

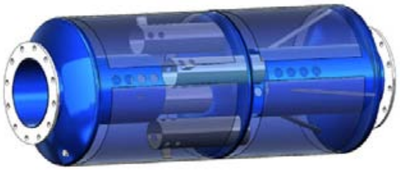
- Caution –abatement systems impose engine back pressure.
- Typical engines are limited to < 27” Hg back pressure.
- The engine exhaust system must account for the impact of any applied abatement (silencer, SCR, and/or DPF) system plus the exhaust stack.

Standby Generator – Pollution Abatement

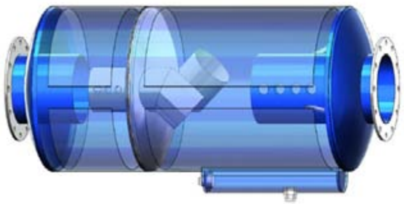
- Noise Abatement (i.e.: silencers or mufflers)

Application	Insertion Loss (dBA)
Industrial	14 – 20
Residential / School	25 – 32
Critical	30 – 38
Hospital	35 – 42
Hospital ICU / Super Critical	35 - 50

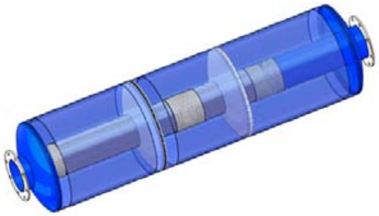
insertion loss ranges vary by manufacturer



CHAMBER



CHAMBER SPARK ARRESTING



RESONATOR

LOW PROFILE

Discussion