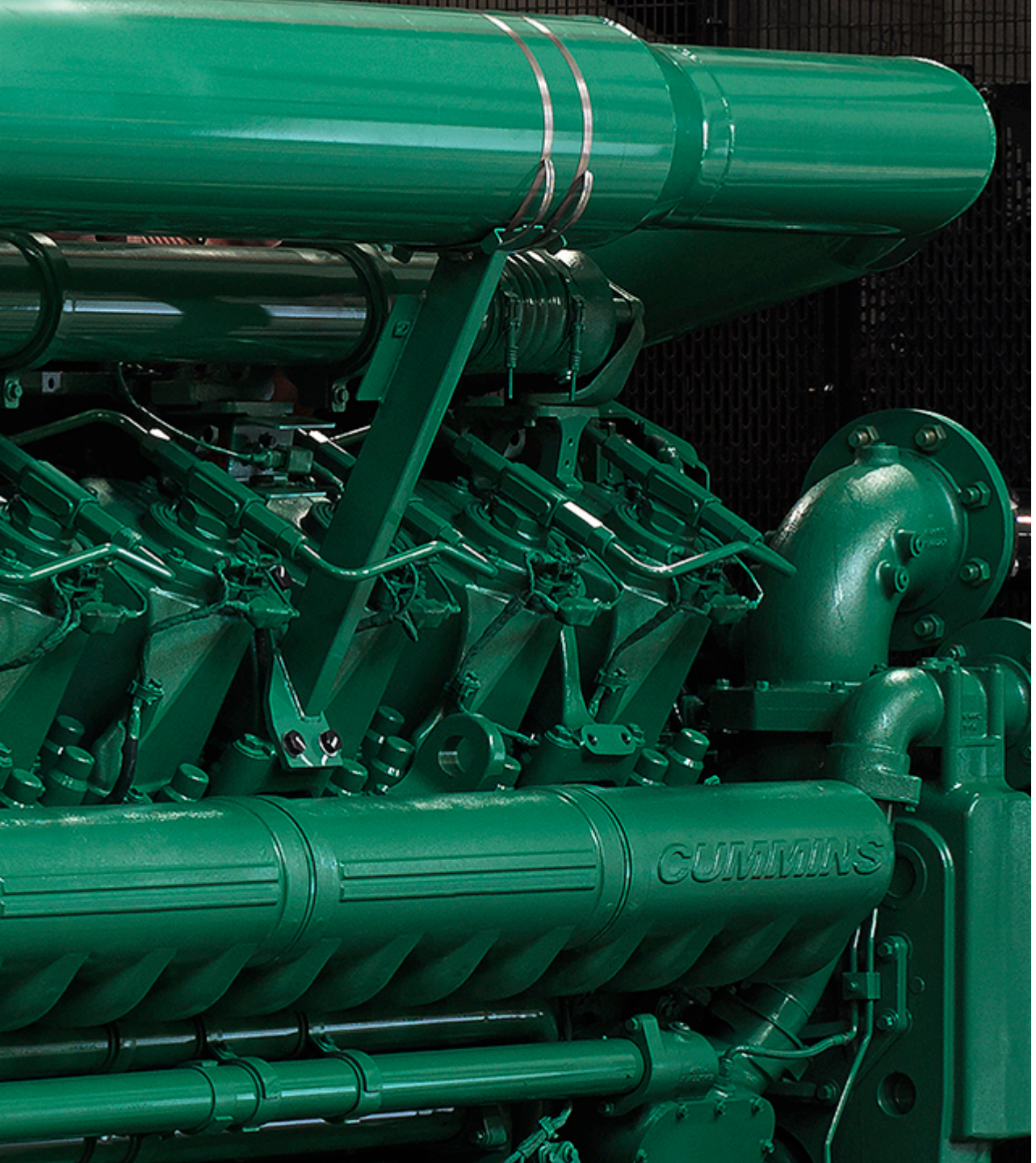

Power Systems

Lean Burn Natural Gas Generator Sets in Standby/ Peak Shaving Applications

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May 22, 2018

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The views and opinions expressed in this course shall not be considered the official position of any regulatory organization and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

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 Description

Course will expand on the application of LBNG gensets in standby application including peak shaving, and energy demand response. This is being driven by the increase demand on energy and the lack of infrastructure available to supply it.

It will also explore the shift from diesel to natural gas as the fuel choice for energy production while comparing the benefits.

Learning objectives:

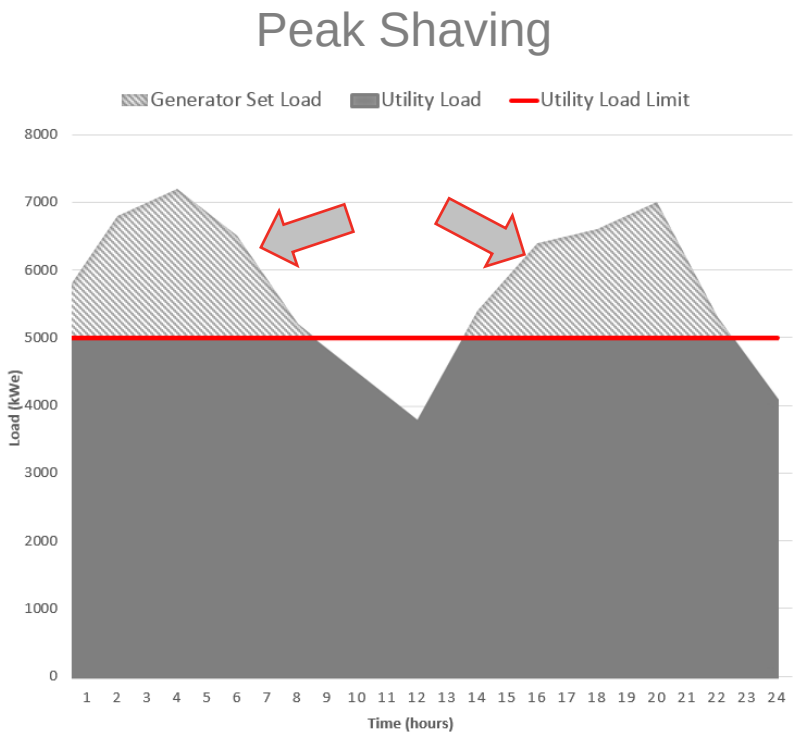
- Recognize the strengths and limitations of using spark ignited generator sets for standby, peaking, and energy demand response applications.
- Identify appropriate applications which may benefit from using a lean burn natural gas generator set.

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)

Standby Application Definitions

- **Standby**
  - Emergency Standby Power (ESP) conforms with NFPA 110 Type 10 suitable for Life Safety, legally required, or critical loads
  - **Non**-Emergency Standby Power (ESP) may not need to conform with NFPA 110 Type 10 to support **non** Life Safety, legally required, or critical loads
- **Demand Response**
  - Also referred to as peak shaving or rate curtailment
  - Applications that use on–site generation in lieu of a utility electricity supply
  - Some applications will request a genset to start when asked by the utility, or when the electricity cost is predicted to increase



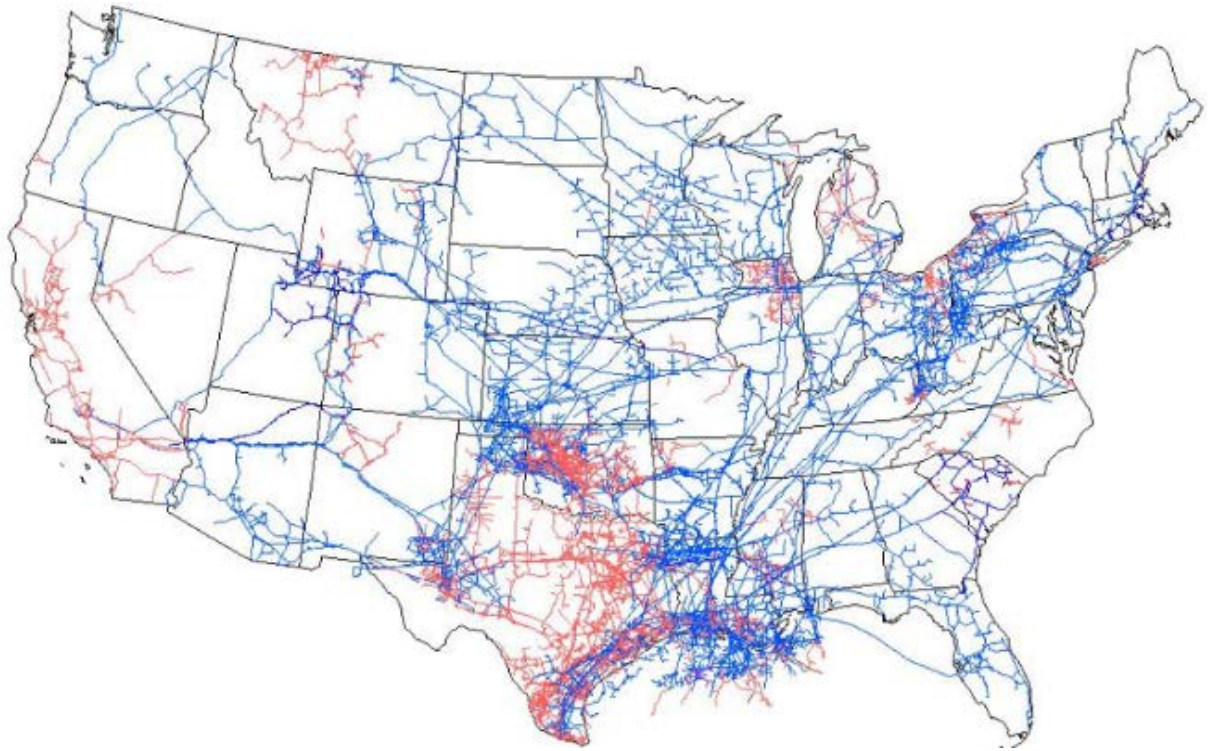
LBNG Gensets in Standby Application

Growing need for 1-2 MW Natural Gas Gensets driven by

- Energy costs
  - Natural gas exploration and fracking
- Availability
  - Gas fuel infrastructure (abundancy)
  - No storage and delivery considerations
- Exhaust emissions
  - Capability to meet regulations without aftertreatment

Advantages – Fuel Availability and Flexibility

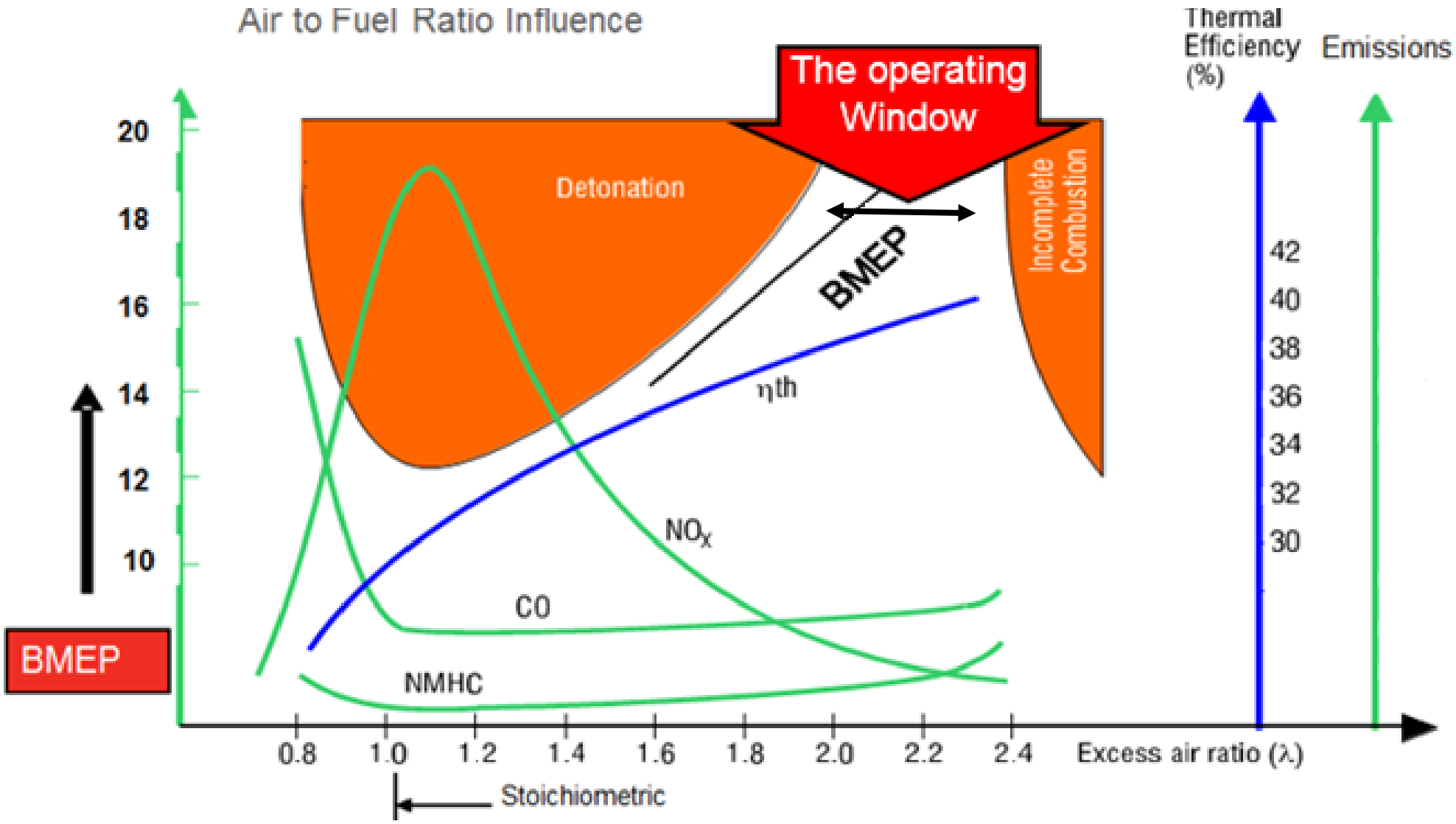
- Natural gas available through extensive pipeline network
  - Avoid fuel transportation, handling, and storage issues
- No fuel tank cleaning required
- No fuel processing necessary
  - On skid fuel filter serviced every 3000 hours (or 6 mos)
- No fuel degradation over time
- Various fuels can be used in SI engines; Natural gas most often used for standby
- Remote radiator allows for better temperature control in cold weather



Gas Combustion Technology

	Stoichiometric	Lean (Standard) Burn	Advanced Lean Burn
Lambda	1	1 to 1.5	> 1.5
Excess O2	0.2 to 0.8%	4 to 6%	> 6.5%
Applications	Fast start and can accept large block loads	Optimal power but high emissions	High efficiency but requires advanced controls
Emissions	Used when must meet emissions requirements but after-treatment may be required to reduce NOx and CO	Used when emissions are not a concern	Can often meet emissions requirements without after-treatment

Advantages – Emissions and Efficiency



Standby Power Node Offerings

1500 – 2000kWe

QSV91G

1000 – 1350kWe

QSK60G

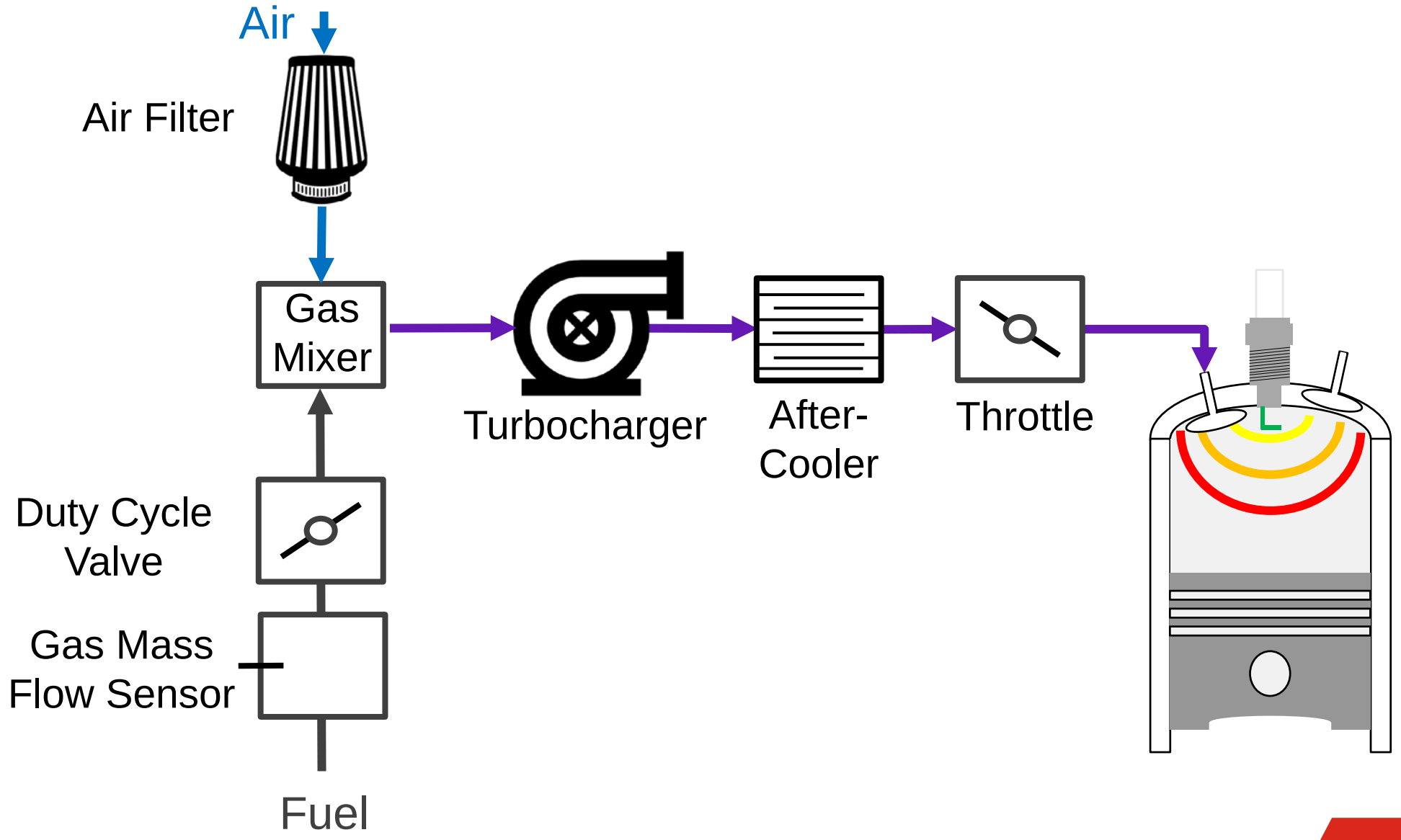
Standby Model Ratings

- Adaptation from continuous rating product
- Rated for improved transient response and load pickup necessities of standby application
- Ancillary options developed for “black start” readiness
- Packaged solutions can be configured
  - Flexibility for site specific needs

Performance

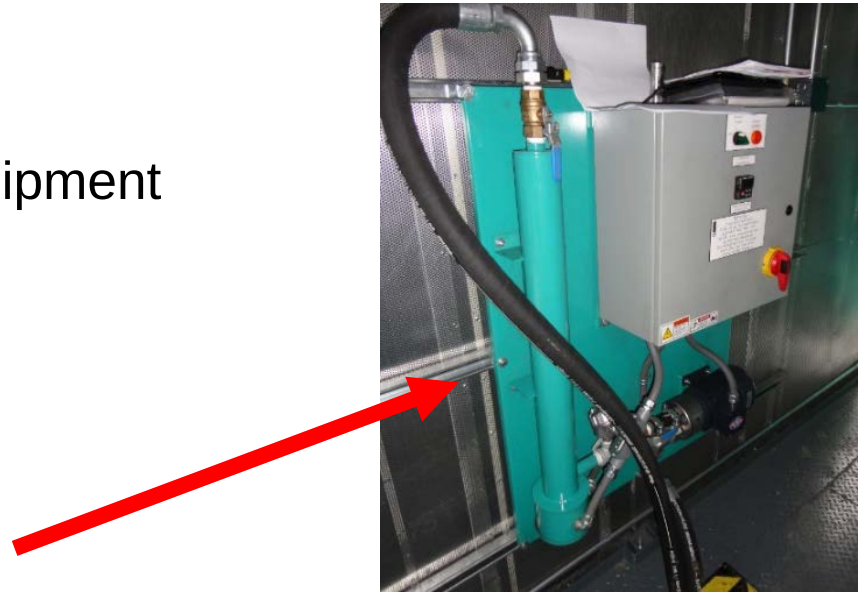
- Durability
  - Capable of operating up to 500 hours per year
  - Continuous duty core design
- Competitive efficiency
- Start to rated times
  - Load acceptance readiness
- Load step pickup and rejection
  - Transient response will differ from diesel genset

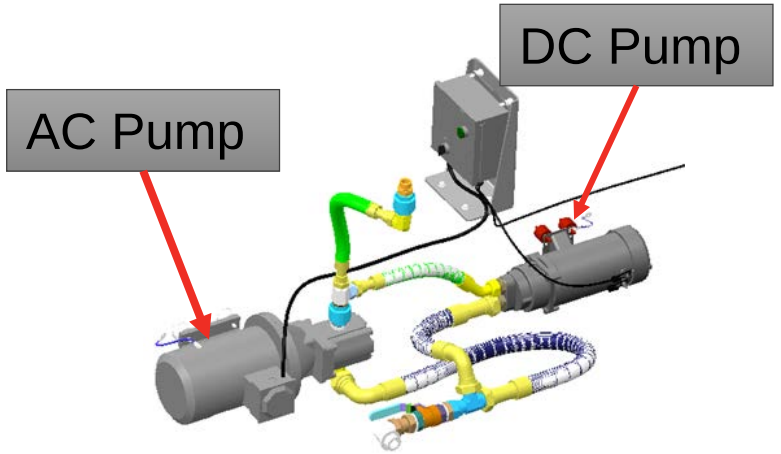
Fuel System Design



Installation Differences from Diesel Generator sets

- Ventilation - combustion air, engine/alternator, room equipment
- Coolant heater for improved start time
- Remote cooling (two loop system)
  - De-aeration components (cooling)
- Oil heater and prelubrication for improved start time
  - DC prelube pump required for “black start”
  - Engine must be pre-lubricated to start (oil pressure)
  - Oil must be up to temperature before engine can go to rated speed
- Oil level maintenance tank (optional in standby)
- Auxiliary power need (AC)
  - Cooling, ventilation, control batteries (30 min w/o charge)
- Starting battery charging (non-engine driven)
- Factory commissioning





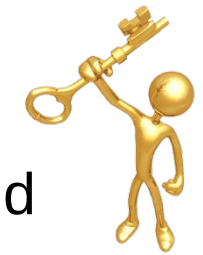
Balance of Plant (BOP) System Installations

Installation Similarities with Diesel Generator Sets

- Exhaust systems – mounting, insulation, expansion
- Foundation & isolators – mass, size, securing
- Starting system – batteries and charger
- Noise considerations – location external or in room/housing
- Service & maintenance access – planned maintenance
- Monitoring systems – requirements and capabilities
- Housing requirements

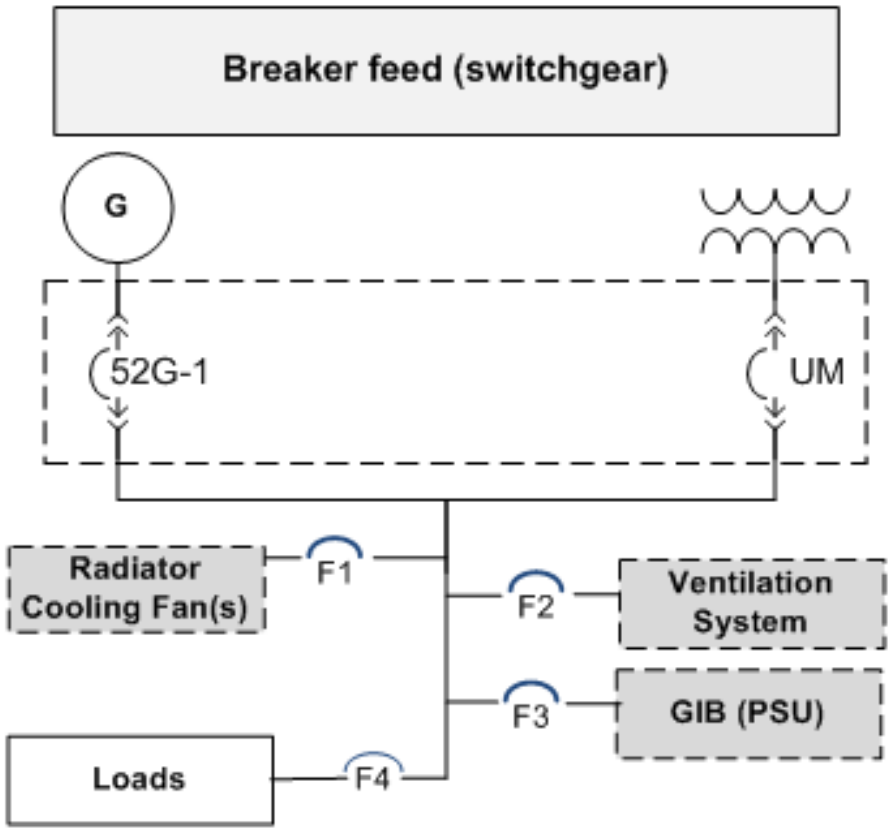
Load Step Performance

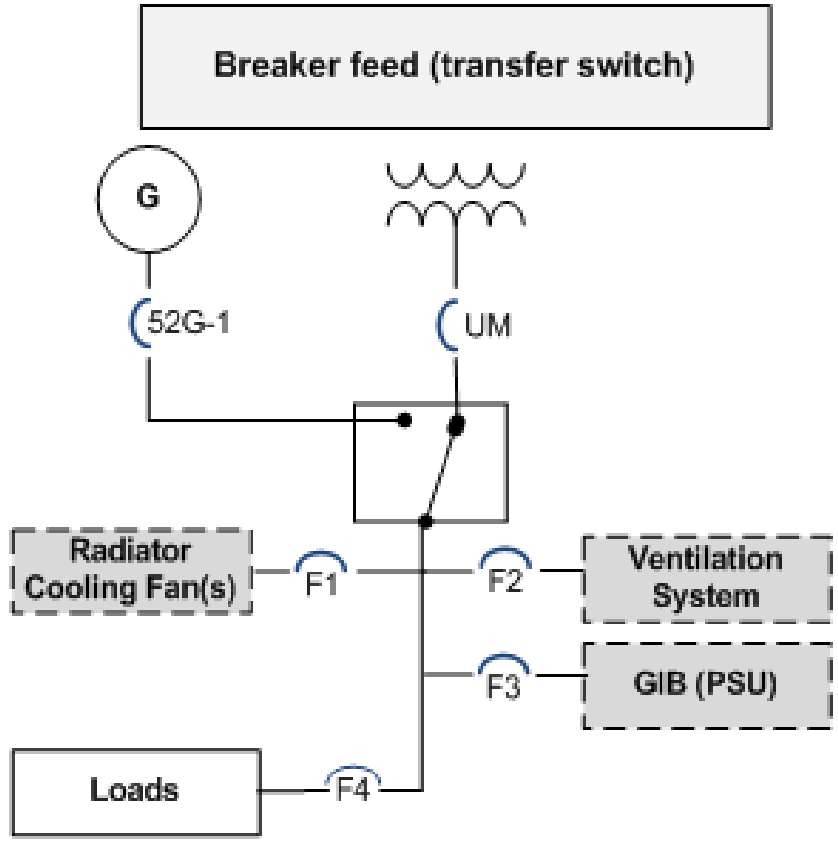
- Capability of 100% load step
  - Varies by genset model
  - Sizing tools applied to determine suitable load step
    - Parallel operation for improved load step capability
    - Sequences may be required to manage large load steps by add/shed and ramping schemes (motors, UPS's, etc.)



- "Emergency" (Level 1) systems require diesel genset in conjunction with gas genset to pick up critical "life and safety" load(s)
  - Transfer to the gas genset after critical start and load pickup

Auxiliary Equipment Electrical Connections





Codes and Standards

- Lean Burn Gensets are **NOT** certified to meet the requirements of NFPA 110 **Type 10** or CSA 282 standards
  - Capable of meeting NFPA 110 Type 60 requirements
  - Suitable for systems with 30 second or greater power restoration requirements
    - With functional coolant/oil heaters and suitable ventilation/aspiration air temperatures
- Rich Burn Gensets are capable of meeting NFPA 110 **Type 10** requirements
- Provisions for gas leak space monitoring (methane) and/or other concerns might be required
  - Standard on packaged gensets
  - Should be included in all indoor applications
  - Not suitable for defined *Hazardous* environment classifications
  - Include thermostat actuated VFD controlled ventilation fans

ALWAYS contact your local AHJ's early in project planning

Exhaust Emissions

- **Standby** exhaust emissions levels:
  - Suitable for US EPA NSPS Stationary "*Emergency*" and "*Non-Emergency*" installations
    - 1.0/2.0/0.7 (g/bhp-hr) NOx / CO / VOC

- Local authority may mandate lower values, particularly related to *non-emergency* applications
  - Exhaust aftertreatment (OC and/or SCR) may be required

Always consult with the local air quality board as enforced standards do vary widely by locality

Considerations

Standby	LBNG	Diesel
Genset and BOP	70%	55%
Fuel storage	0	5%
Enclosure	30%	20%
After-treatment	0	20%

Typical Fuel Cost Ratio:
~ **6 : 1** (Diesel : NG) @ 1MW-hr

Customer Criteria	Diesel	Spark Ignited
Transient Performance	●	◑
Reliability of Fuel Supply	◑	●
Exhaust Emissions	○	●
Fuel Cost	○	●

● - Good
◑ - Average
○ - Fair

Packaged Solution Option

- Genset
- Vibration isolators
- Natural gas fuel train
- Free standing alternator termination box w/ breaker
- Electric starter, batteries, cables and charger
- DC prelube pump kit
- Circulating oil heater kit
- Weatherproof, sound-attenuated enclosure
- Remote cooling package
- De-aeration components
- Exhaust silencer and optional after-treatment
- Paralleling control

Strengths

- Low emissions
- High efficiency
- Continuous duty design – high durability
- Standby single load step in excess of 75% per ISO8528
- Factory certified prototype test reports
- 100% load shed capable
- Low fuel pressure capability – Min 3 psi (post gas train)

Limitations

- Do not meet NFPA 110 Type 10 – 10 second start requirements
- Remote radiator and electric fans only
- Not factory emissions certified for all products

Summary

- LBNG Gensets are suitable for standby application
  - Do not assume LBNG models are direct substitutes for diesel units
  - Consider set performance against customer requirements
- Contact generator set manufacturer for additional details
  - Inquire about product performance – start times, transient performance, loads
  - Review dedicated data sheets, manuals and drawings for consideration in site design
- Consider pre-packaged solutions
- Additional references:
  - PowerSuite: Spec sheet, data sheet, drawings, etc
  - T-035, Application Manual for Liquid Cooled Gensets
  - Installation manual
  - LBNG Sample Specifications

Q&A

Type your questions, comments, feedback in the **WebEx Q&A box**. We will get to as many questions as we can

We will publish consolidated FAQ along with presentation and webinar recording on powersuite.cummins.com

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Q+A


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