How to Approach Gaseous Fueled Generator Set Applications

PowerHour webinar series for consulting engineers

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Dec 16, 2021 12:00 Eastern / 9:00 Pacific

(1 PDH issued by Cummins Inc.)

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Q&A Button:

- For technical questions on today's topic
- Ask at anytime
- We'll do our best to answer your questions!

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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.

Meet Your Cummins Experts

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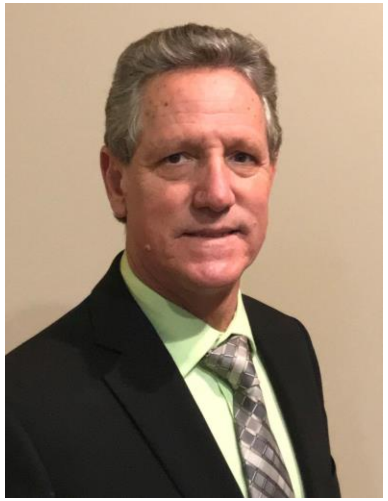

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Course Objectives

How to Approach Gaseous Fueled Generator Set Applications

Gaseous-fueled generator sets continue to see increased use throughout North America due to a number of market forces and evolving customer requirements. Manufacturers have, in turn, been heavily investing in these products. It can be challenging to keep up with these trends; we're here to help! This course will provide an overview of the strengths and special considerations of gaseous-fueled generator sets within a variety of applications. We'll equip you with the awareness and resources to successfully respond to your customers' questions on these products.

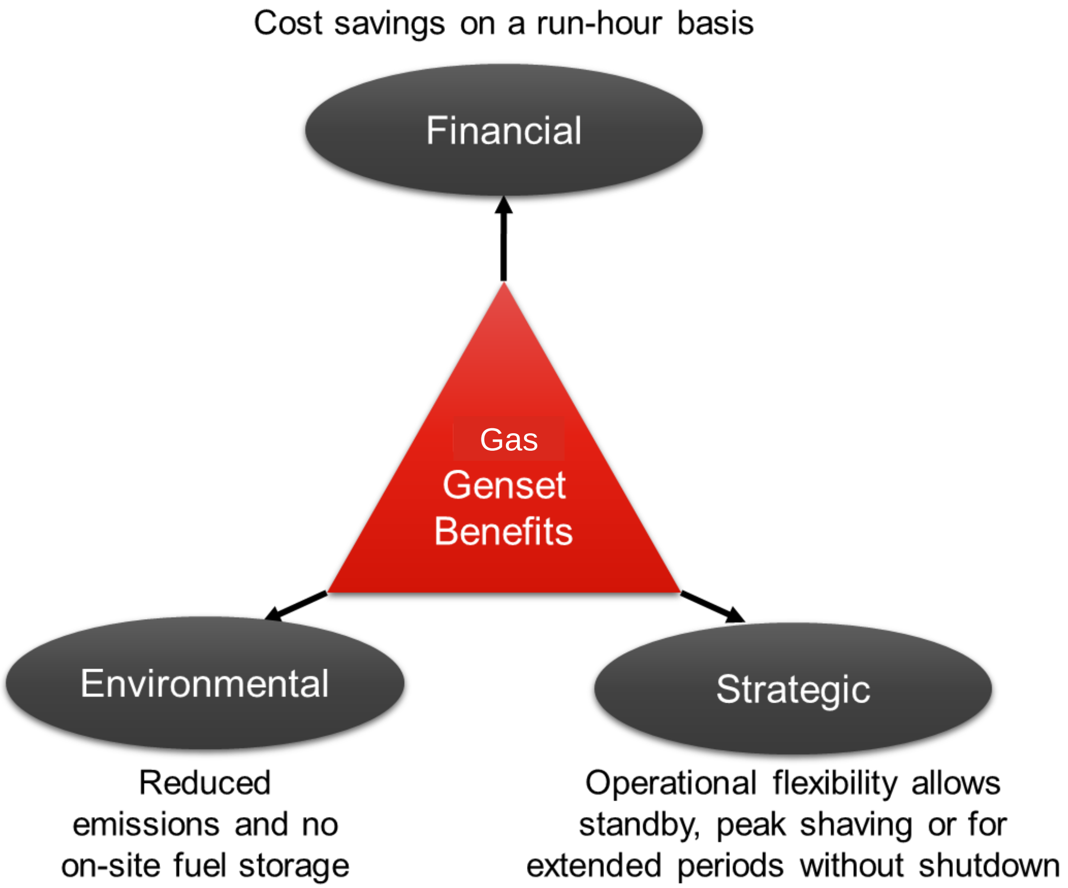
After completing this course, participants will be able to:

- Identify appropriate applications that could be well-suited for gaseous-fueled generator sets.
- Describe the typical application design requirements and how they align with key features and capabilities of gaseous generator sets.
- List key and unique specification items to cite when addressing applications outside of the typical emergency-standby space, such as in combined heat and power (CHP), demand response, or with non-standard gas applications.

Natural Gas for Power Generation

Growing need for natural gas generator sets driven by

- Energy costs
  - Natural gas exploration and extraction
- Availability
  - Gas fuel infrastructure (abundancy)
  - No storage and delivery considerations
- Exhaust emissions
  - Capability to meet regulations without aftertreatment
- Reliable, practical and proven technologies



Cost savings on a run-hour basis

Financial

Gas Genset Benefits

Environmental

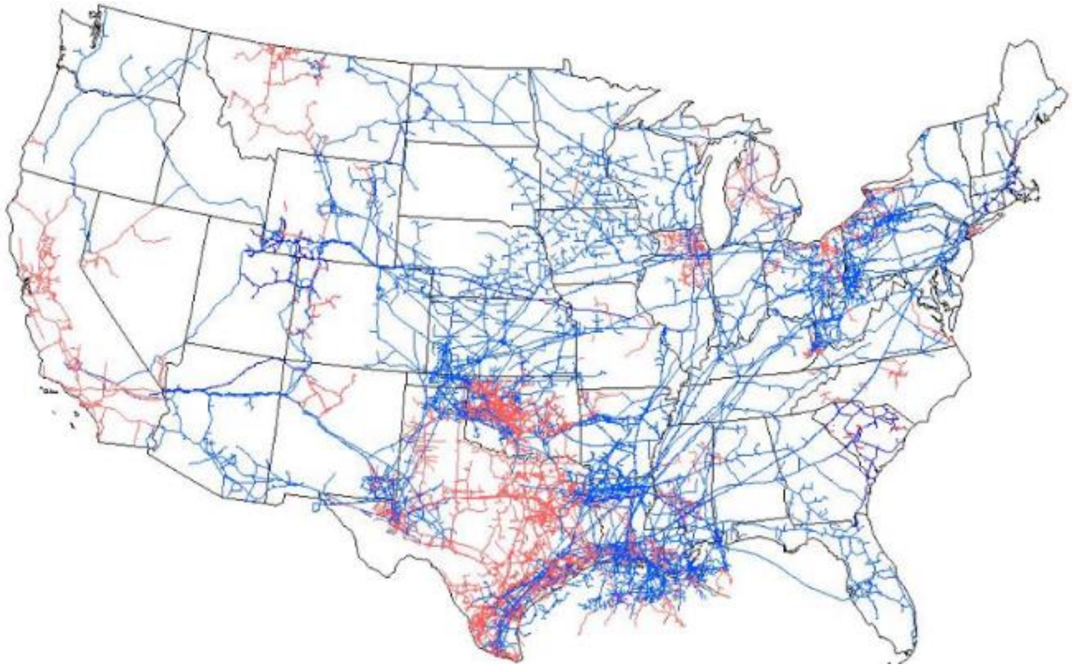
Strategic

Reduced emissions and no on-site fuel storage

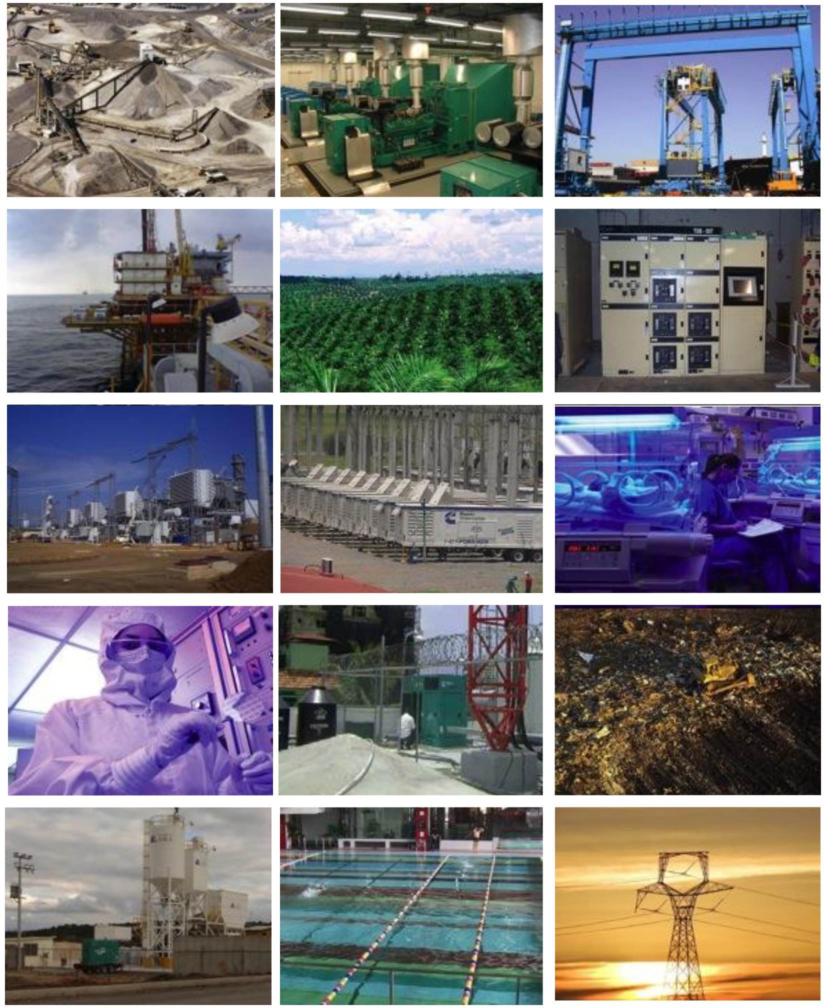
Operational flexibility allows standby, peak shaving or for extended periods without shutdown

Natural Gas – Fuel Availability & Flexibility

- Natural gas available through extensive pipeline network
  - Avoid fuel transportation, handling, and storage issues
- No fuel processing necessary
  - No fuel tank cleaning required
  - No fuel degradation over time
  - On skid fuel filter serviced every 3000 hours (or 6 months)
- Various gaseous fuels can be used in SI engines; Natural gas most often used
- Combination – Gas & Diesel – Provides Life Safety plus Long Duration Operation



Applications



Standby Power

Clean, reliable and cost-effective standby gas power when you need it

Peaking Power

Economical, adaptable and reliable solutions to meet your peak demands

Prime Power

Reliable continuous power for any location, day or night

Cogeneration

Combined heat and power solutions for a sustainable future

Waste-to-Energy

Converting wasted gaseous fuels into profitable and sustainable power

Standby Applications

Clean, reliable and cost-effective standby gas power when you need it

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)

Compliance to Codes and Standards

Fuel Source for Emergency Systems

NFPA 110-2019

5.1.1 The following energy sources shall be permitted to be used for the emergency power supply (EPS):

(1) Liquid petroleum products…

(2) Liquified petroleum gas…

(3) Natural or synthetic gas

Exception: For Level 1 installations in locations where the probability of interruption of off-site fuel supplies is high, on-site storage of an alternate energy source sufficient to allow full output of the EPSS to be delivered for the class specified shall be required, with the provision for automatic transfer from the primary energy source to the alternate energy source.

Natural Gas Council

Natural gas is a secure, reliable and resilient choice for customers

- Operational reliability
  - 2017 survey of 51 interstate pipelines – 99.97% of contractual commitments
  - Geographic dispersion of production reduces vulnerability to local weather
  - Transportation network interconnected, offering multiple pathways for rerouting
- Contractual continuity of service
  - Firm or interruptible contracts

Standby Application Definitions

Legally Required and Life Safety (i.e. NEC 700, 701, 708) Emergency Standby Power (ESP) to conform with NFPA 110 Type 10 suitable for Life Safety, or critical loads

Not legally required Emergency Standby Power (ESP) may not need to conform with NFPA 110 Type 10 to support **non-Life** Safety, or critical loads

Compliance to Codes and Standards

Fuel Source for Emergency Systems

NFPA 70 – NEC Article:	Diesel	Gaseous (utility & on-site fuel source)	Gaseous (utility source only)
708 "COPS"	✓	✓	×**
700 "Life Safety"	✓	✓	✓*
701 "Legally Req'd"	✓	✓	✓
702 "Optional"	✓	✓	✓

* Follow exemption process w/ AHJ per NFPA 110 Level 1 Systems

** **NEC Article 708:** *Prime movers shall not be solely dependent on a public utility gas system for their fuel supply… Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided…*

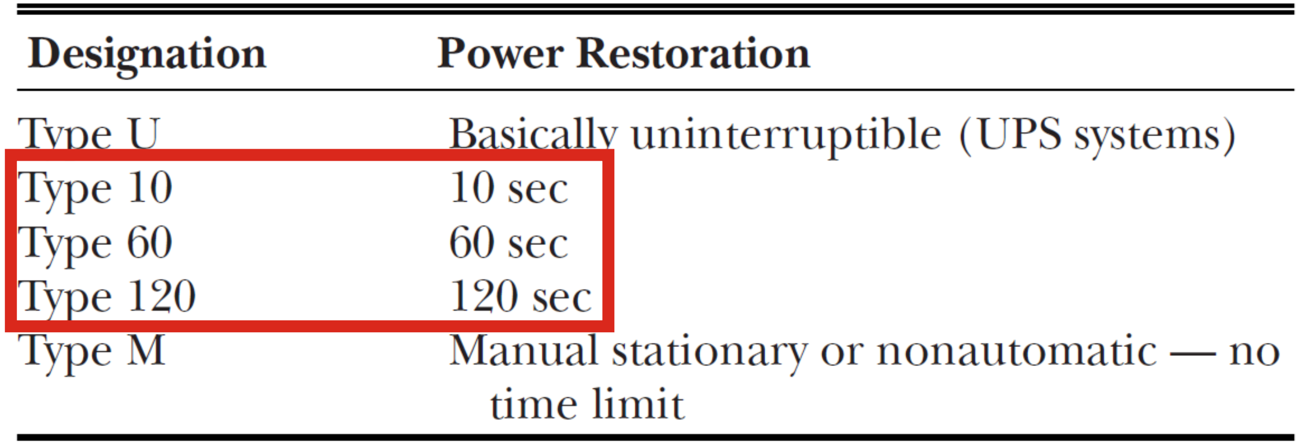
Spec Note Consider specifying natural-gas fueled generator sets for emergency power systems where permitted by the local Authority Having Jurisdiction. (Perform a Hazard Analysis or Risk Assessment with the utility and AHJ early in the design phase.)

Compliance to Codes and Standards

NFPA 110 Type Requirements

4.3 Type. The type defines the maximum time, in seconds, that the EPSS will permit the load terminals of the transfer switch to be without acceptable electrical power.

Table 4.1(b) Types of EPSSs



Designation	Power Restoration
Type U	Basically uninterruptible (UPS systems)
Type 10	10 sec
Type 60	60 sec
Type 120	120 sec
Type M	Manual stationary or nonautomatic — no time limit

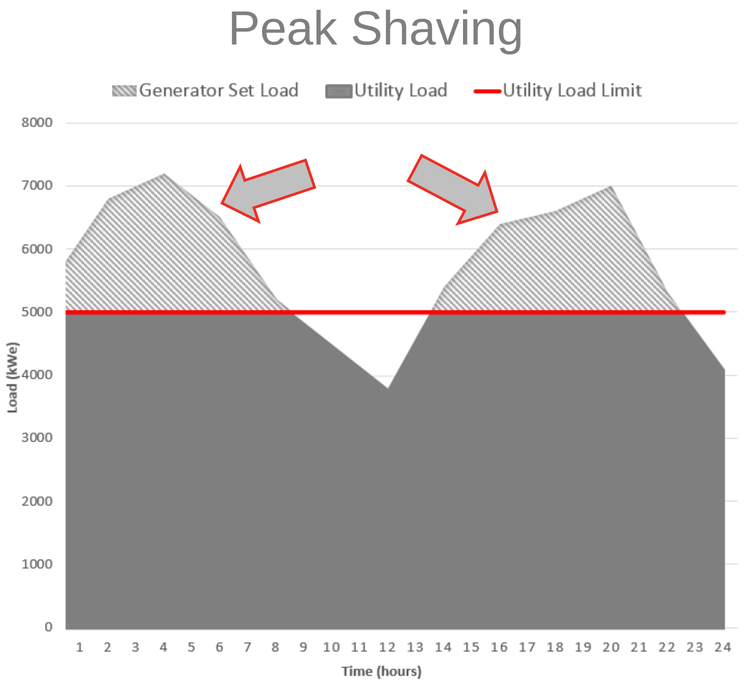
Spec Note Specify NFPA 110 Type requirement for Emergency Power Supply System based on application requirements and loads served. Many times stringent limits are specified when not required limiting product offering

Peak Shaving / Demand Response Applications

Relatively low-hour operation for economic benefit

Demand Response

- Demand Response is an energy solution that helps customers reduce energy consumption during periods of high stress on the electric grid and generate savings for using less during peak demand
- Also referred to as peak shaving or rate curtailment
- Some applications will request a genset to start when asked by the utility or when the electricity cost/demand is predicted to increase



Demand Response

- Grid-parallel or isolated operation at varying run hours per year (i.e. <24 hr/yr; >250 hr/yr)
- Emissions requirements vary by local AHJ
- Resiliency → Back-up power in the event of utility outage
- Applicability and savings programs vary by Independent System Operator (ISO) and utility companies
  - More beneficial in deregulated markets

Independent System Operator (ISO)	ERCOT	COMED
Example Savings Programs	Emergency Response Service (ERS) 30	Demand Response – Capacity Performance
	Commercial Load Management (CLM)	Economic Demand Response
	Four Coincident Peaks (4CP)	Sync Reserve
	Other	Peak Load Management

Spec Note Specify application and expected annual hours of operation. State emissions limits to be met by the engine for the site

Compliance to Codes and Standards

Emissions Requirements

US EPA New Source Performance Standards (NSPS)

- **Stationary Emergency Part 60 Subpart JJJJ – "Unplanned operation"**
  - 2.0/4.0/1.0 (g/bhp-hr) NOx / CO / VOC
- **Stationary Non-Emergency Part 60 Subpart JJJJ – "Planned operation"**
  - 1.0/2.0/0.7 (g/bhp-hr) NOx / CO / VOC
- **Non-road** – mobile, non-propulsion without operational limitation

State/Province	NOx Limit
Massachusetts	0.05 g/bhp-hr
New Jersey	0.15 g/bhp-hr
Delaware	0.2 g/bhp-hr
Ontario	0.4 kg/MWh

**Contact local AHJ for applicable limits*

Local Air Quality Management Board

May mandate more stringent emissions limits requiring exhaust aftertreatment

Spec Note Require generator set vendor to provide documentation demonstrating compliance with specific emissions level requirement and applicable test methodology.

CHP Solution

Cogeneration Overview

CHP: Combined Heat and Power

- The utilization of both heat and electric energy from a single source
- Also known as Co-generation or Co-Gen
- US EPA uses the term Co-generation

Cogeneration systems can provide hot water, steam, chilled water, or all 3 simultaneously

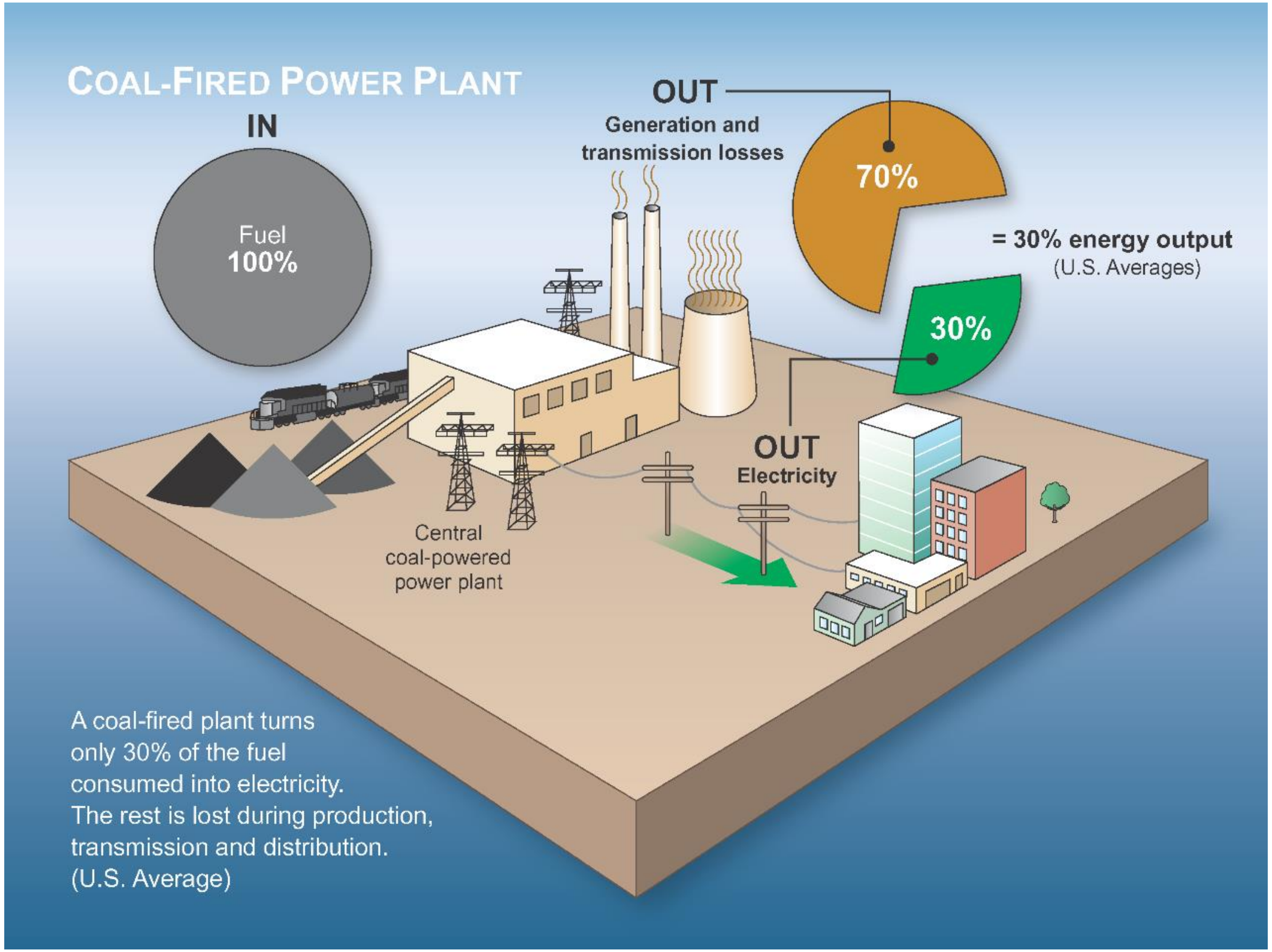
Types:

- Combined-cycle power plant
- Steam turbine CHP Plant
- **Internal Combustion Engine CHP**
- Gas Turbine CHP

Fuel **Heat + Electricity**

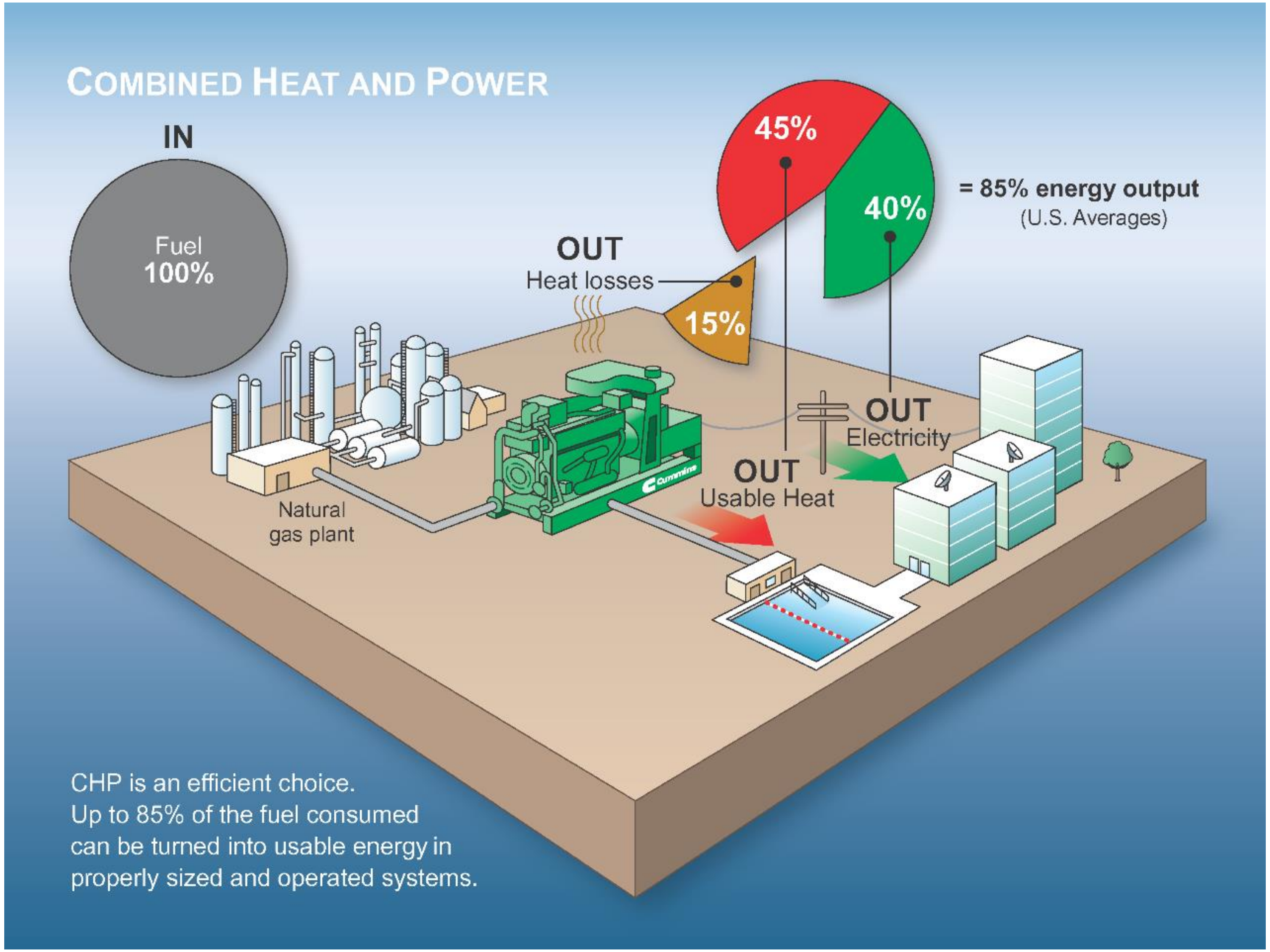
Transformation Process

Traditional Generation



A coal-fired plant turns only 30% of the fuel consumed into electricity.
The rest is lost during production, transmission and distribution.
(U.S. Average)

Generation with CHP



CHP is an efficient choice.
Up to 85% of the fuel consumed can be turned into usable energy in properly sized and operated systems.

CHP Benefits

- Energy efficiency
  - Over 85% overall efficiency
- Financial savings
  - Energy cost savings
  - Attractive return on investment (ROI)
    - Spark spread – Fuel Cost (on-site generation) vs Electric Cost (energy purchase)
  - Incentives for fuel efficiency and emissions reduction benefits of CHP
- Environmental
  - Reduced environmental footprint
    - Reduction in CO_2, NO_x, and particulates compared to central power plant
  - Higher efficiency means better conservation of natural resources

Heat Energy Sources

When to use each heat source: LT, HT, Exhaust?

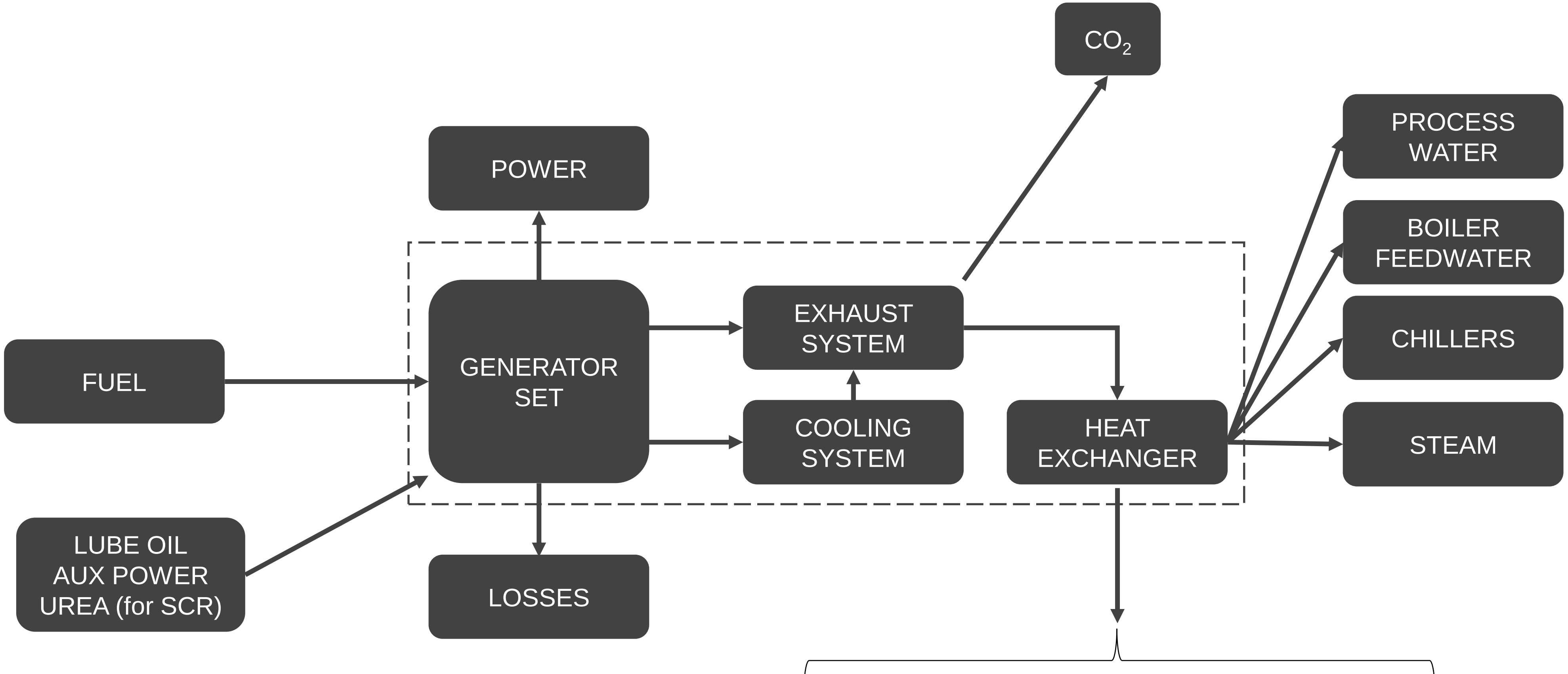
Heat source (% of fuel input based on Cummins C1100N6C generator)

- Engine After cooler circuit or Low Temperature (LT) circuit (3.6%): >104 F
- Engine Jacket water circuit or High Temperature (HT) circuit (22.9%): >184 F
- Engine Exhaust (22.4%): >765 F

Typical heat uses and components

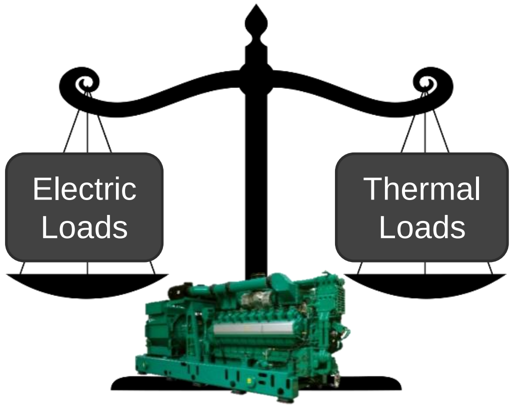
- Steam production → Boiler (exhaust)
- Hot water → Exhaust Gas Heat Exchanger, Engine Cooling HX (exhaust and/or HT, LT)
- Cold water → Chiller (exhaust and/or HT)

CHP Flow Schematic



Generator Model	Heat Recovery (BTU/hr)
1100 kW (QSK60G)	3,640,300
2000 kW (HSK78G)	7,073,900

Application Considerations



- Electrical loads
    - Sufficient base electrical load or export capability
- Thermal loads
    - Sufficient equipment or process that can use the heat energy
- Balance between electrical and thermal loads is critical for optimum CHP performance
    - Available heat energy is dependent on the electrical output
    - If not balanced, either the excess heat must be rejected or the excess electrical power exported, if allowed

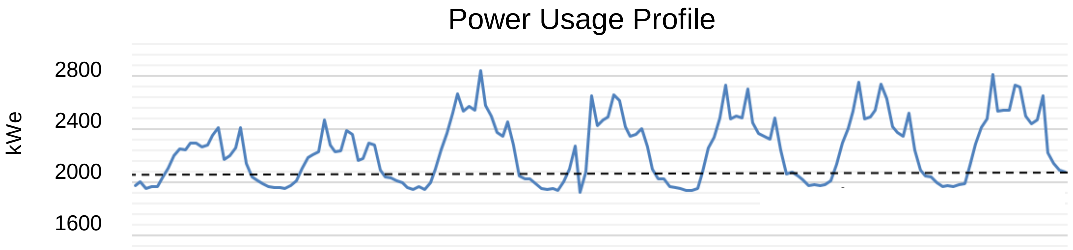
Required Information

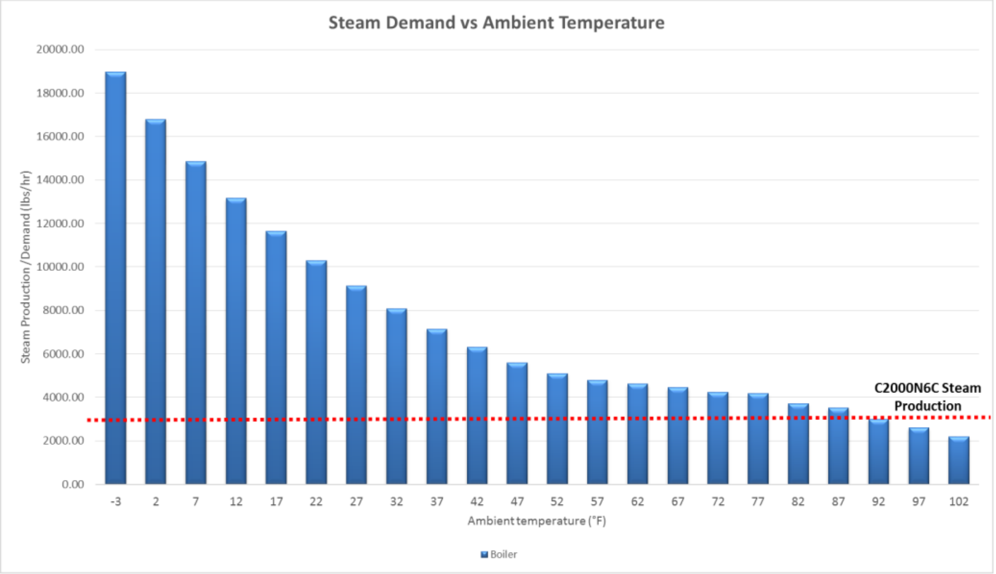
Customer

- Electrical load profile
- Thermal load profile
  - Type of process (i.e. food grade)
  - Heat transfer media
    - Steam, water, oil, etc.
  - Process temperatures
    - Input and output
  - Process flowrates

Generator Set Datasheet

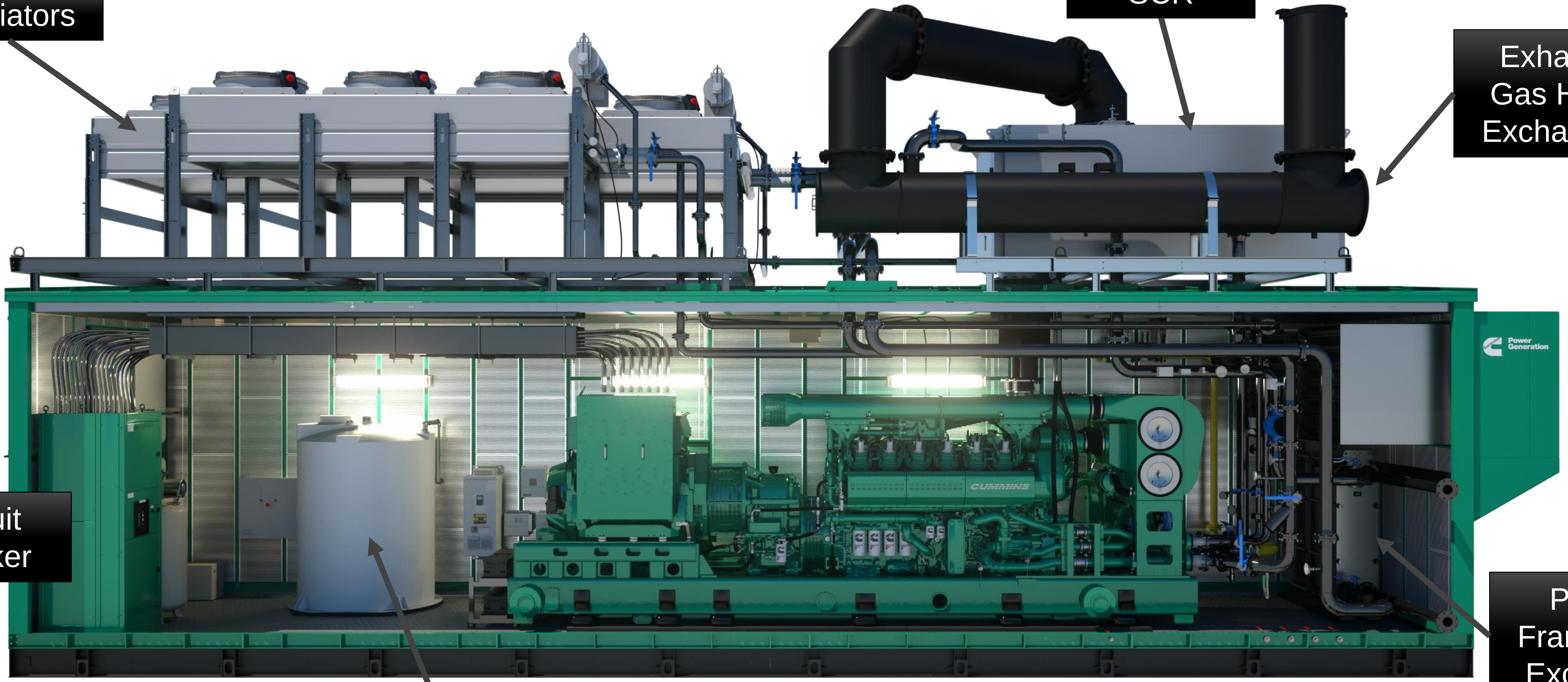
- Genset kW rating
- Thermal energy from each heat source
- Heat source flowrates and temperatures





Spec Note Process heat transfer media, temperatures, and flow rates are key specification inputs. Work with manufacturer to determine best approach for heat recovery if necessary.

CHP Representation



Radiators

SCR

Exhaust Gas Heat Exchanger

Circuit Breaker

Plate & Frame Heat Exchanger

Urea Tank

Waste-to-energy

Fuel Quality

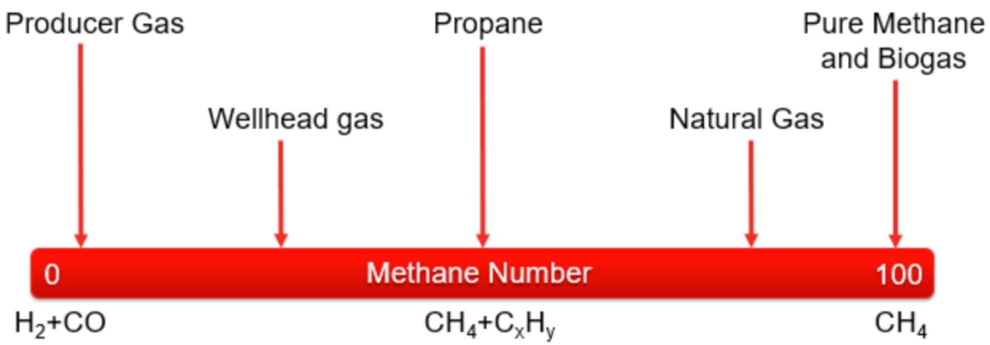
Heating Value:

- **Lower Heating Value (LHV):**
  - Net energy available in the fuel for combustion
  - Excludes heat of vaporization
- **Higher Heating Value (HHV):**
  - Gross energy in fuel
  - Includes heat of vaporization

Methane Index Number (MN):

- Higher MN will be less likely to auto-ignite (knock) and may be suitable for high power density applications.
- High quality pipeline natural gas is typically 80-90 MN

Classification	SI Units	Imperial Units
Pipeline	≥ 30 MJ/Nm^3	≥ 805 BTU/scf
Low BTU	16-30 MJ/Nm^3	429-805 BTU/scf
Ultra Low BTU	≤ 16 MJ/Nm^3	≤ 429 BTU/scf



Note: Gas analysis is <u>always</u> required to review whether gas is compatible to operate on selected genset.

Spec Note Conduct a fuel sample analysis, include the results and contaminants in the specification and require manufacturers to provide documentation demonstrating capability with the on-site fuel. Critical for low MN and low BTU fuels. Manufacturers may calculate MN differently.

Fuel Quality - Contaminants

Potential Contaminants by Fuel

	Siloxanes	Hydrogen Sulfide	Halogens	Ammonia	Tar
Landfill	✓	✓	✓	✓	
Wastewater Digester	✓	✓		✓	
Manure Digester		✓			
Syngas (Pyrolysis)					✓
POME Digester		✓			

Fuel Quality

- On-site Fuel Availability:
    - Site must have enough gas volume and pressure available at rated load
    - Be aware of gas pressure drop from the fuel source to the generator set
    - Provide a dedicated fuel line to generator set
- Consult generator set manufacturer for specific engine fuel quality requirements
- A pressure regulator is typically required upstream of the generator to provide stable pressure to the generator set
- Gas compressor/booster may to required if on-site gas pressure is not enough
- Applicable local and national codes for fuel systems: NFPA 37 and 54
- Provisions for gas leak space monitoring (methane) and/or other concerns might be required

Spec Note Indicate fuel pressure available on-site. Require generator set vendors to provide documentation indicating engine minimum fuel pressure at rated load.

Aftermarket Considerations

Aftermarket Considerations

Warranty

- Standard generator warranty period is typically 1 or 2 years depending on the application
- Extended warranty options to 5 or 10 years

Long-Term Service Agreements

- Scheduled maintenance
- Generator set
- Major accessories like radiator, heat recovery, exhaust aftertreatment and switchgear
- Length and scope of coverage can be customized to specific customer requirements

Protect the Investment

- Combination of extended warranty and scheduled service agreement helps assure up-time and keep the equipment in top working order for the life of the equipment

Spec Note

- Desired warranty coverage in years and expected annual hours of operation for desired application
- Desired length of planned maintenance agreement in number of years and expected annual hours of operation
- Describe desired scope of coverage
  - Equipment covered, level of support, consumables, etc.

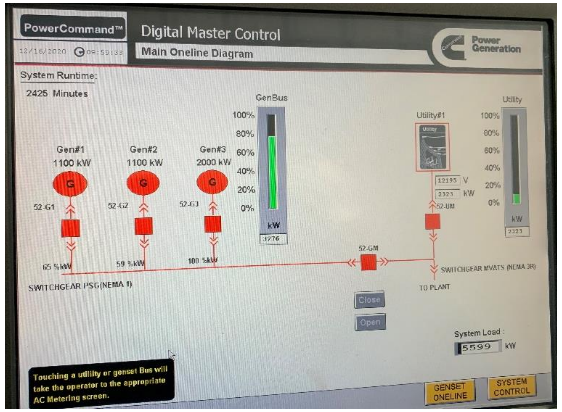
Application Examples

Hybrid: Diesel & Gas

- Examples:
  - Hospital Baton Rouge, LA
  - Naval Air Station, San Diego, CA
  - Correctional Facility in Louisiana
  - Laboratory in Chicago
- Summary:
  - Combine NG and diesel generators in parallel to extend operation and provide flexibility
  - Emergency standby and supplemental power
  - Diesel generator – designated for life safety backup power
  - Lean-burn natural gas generators provide supplemental power should it be needed in an event
    - Can be used in some instances to offset the costs of energy during peak periods

Biogas & CHP

- Where: New Castle, DE
- End user: Chemical manufacturer
- Generators: 2 x C1100N6C & 1 x C2000N6CD
- Summary:
  - Fueled by nearby Cherry Island landfill gas
  - Utility parallel or island mode operation in base load to facility's electric demand
  - Cummins switchgear and Digital Master Controller
  - Combined heat and power recovering heat to produce steam and hot water
    - Steam and hot water are used in facility's production and offsets natural gas and oil usage



PowerCommand™ Digital Master Control

Main Oneline Diagram

12/16/2020 09:59:33

System Runtime: 2425 Minutes

System Load : 5599 kW

Touching a utility or genset Bus will take the operator to the appropriate AC Metering screen.

Gaseous Generator Sets

Key Takeaways

Natural gas fueled generator sets can provide:

- Reliable power generation in emergency and non-emergency applications
- Low emission solutions to various application requirements
- High efficiency options for high-hour operations, especially combined heat and power
- Compliance with applicable codes and standards
- Low total cost of ownership

Next Steps

- Write specifications based on performance and application requirements such as hours of operation, loads, transient limits, emissions, start-time and other code-driven requirements.
- Consider generator performance in line with customer requirements
- Inquire about product performance – start times, transient performance, rating, efficiency
- Review model-specific data sheets, manuals and drawings for consideration in site design

Q&A

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

Copy of the presentation, and link to the recording will be provided in a follow up email within a 1-2 business days.

Please complete the brief survey upon exiting the webinar!

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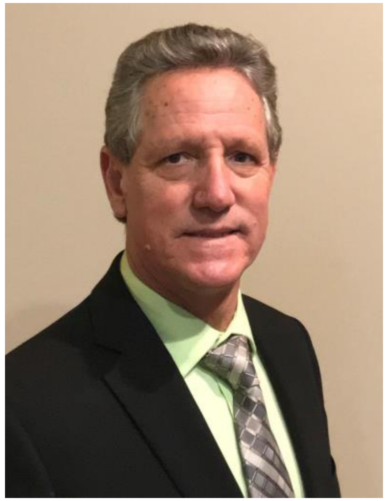

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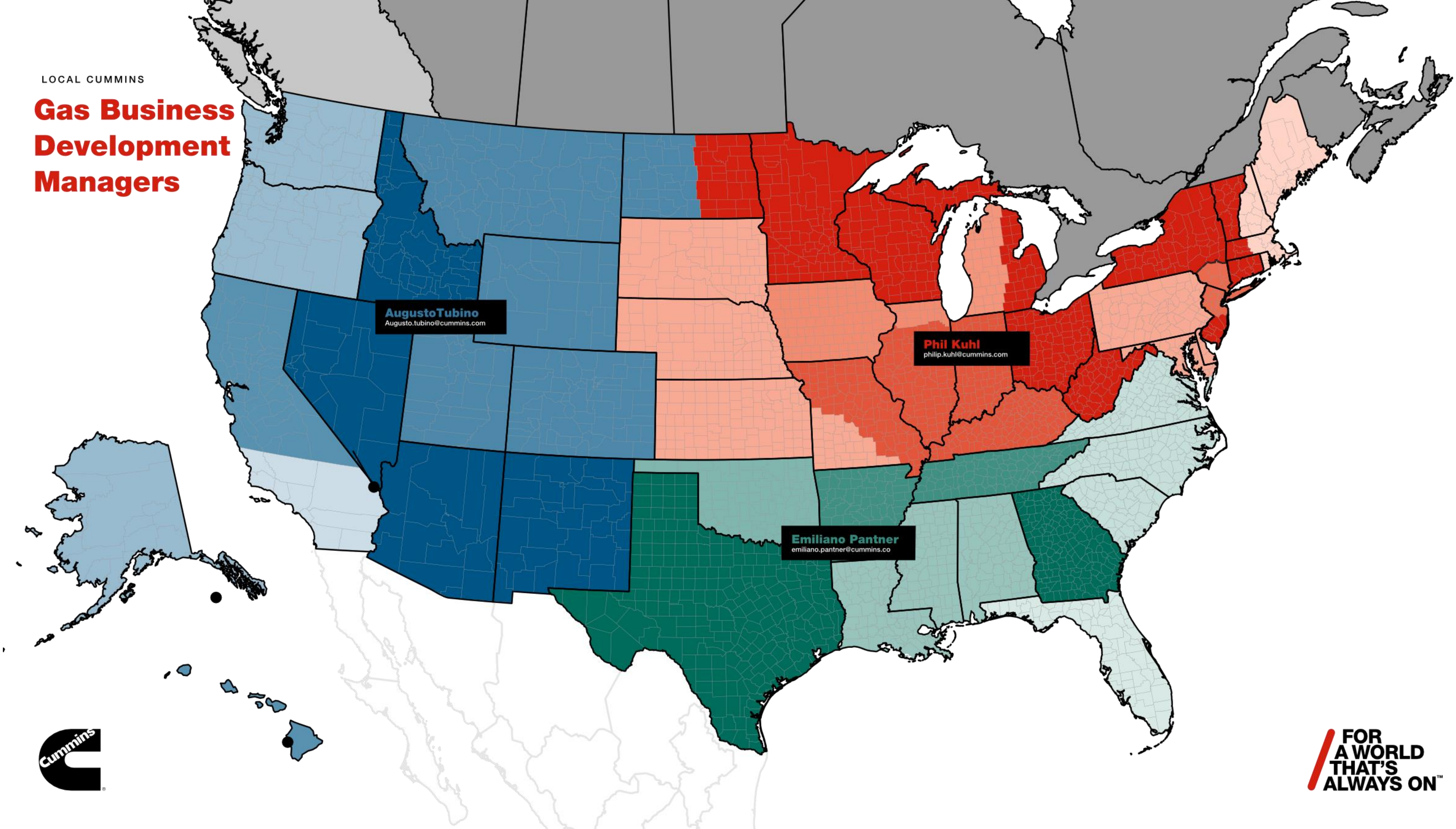

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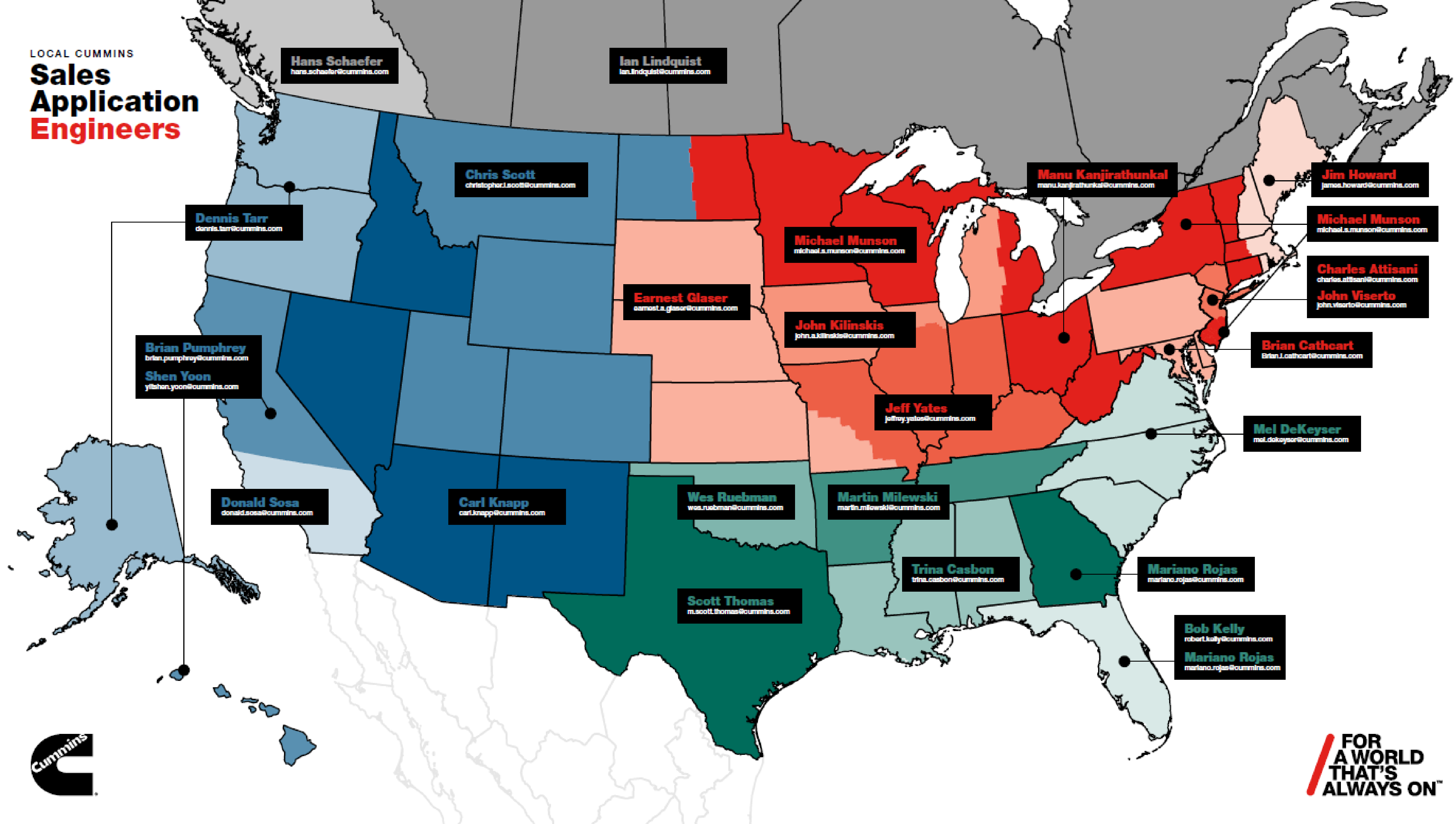

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