Microturbines

US DoE DER Roadshows

What Is A Microturbine?

- Microturbines: a new way to locally supply continuous energy to facility
- Installed inside or near a building to provide electricity and optionally, heat
- Similar to a placing a furnace, boiler, backup genset, or chiller in a facility

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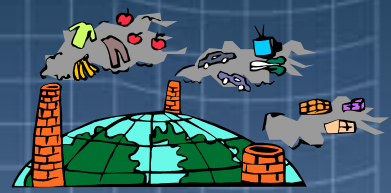
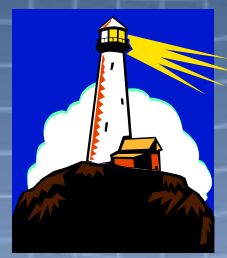
How Does It Help The Customer?

An opportunity to:

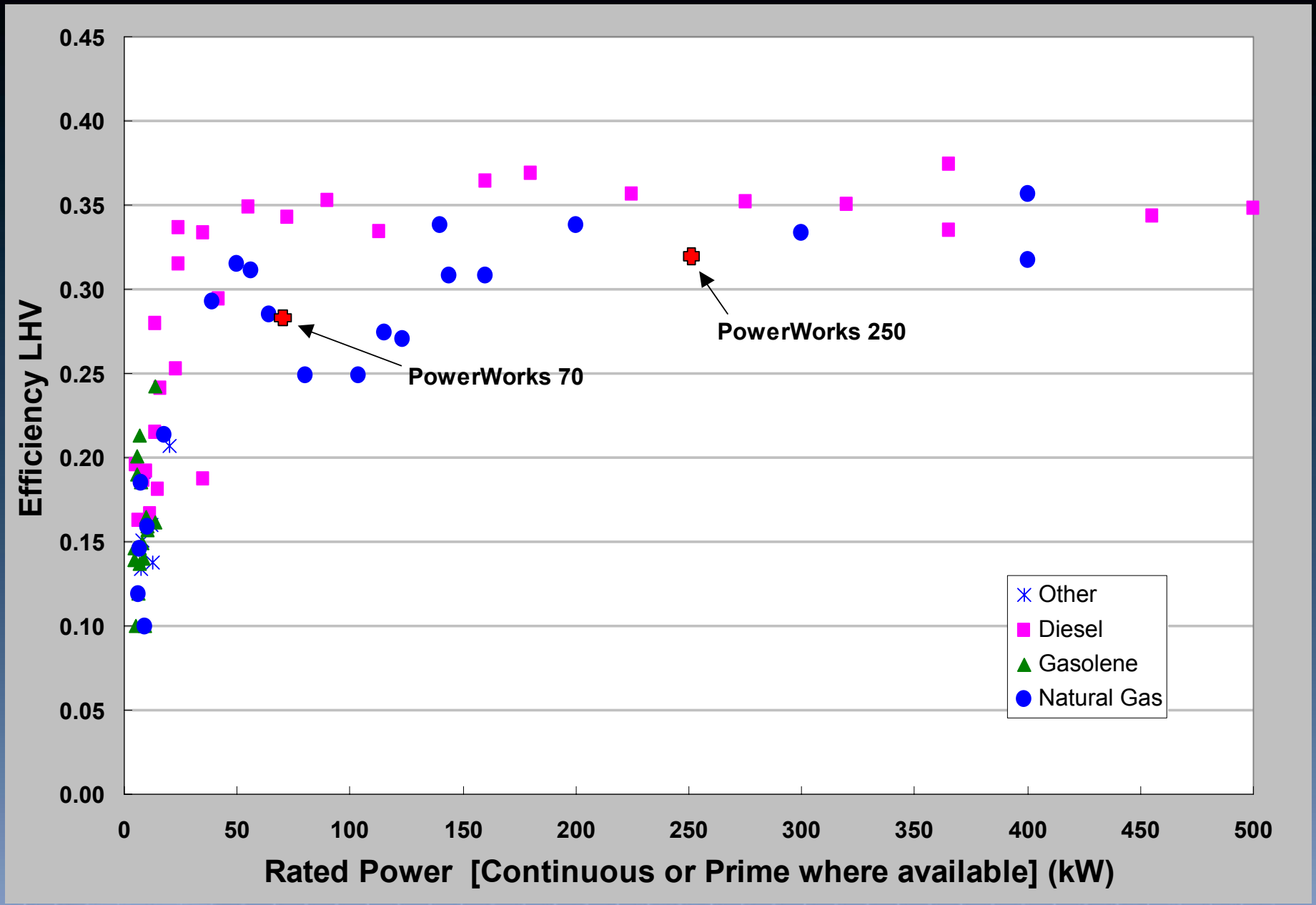
- Save money buying energy
  - Avoid penalty tariffs
  - Isolate loads to minimize demand charges
- Support energy conservation efforts
- Reduce environmental impact
  - Stop flare emissions
  - Safely destroy VOCs
- Avoid power outages
  - Eliminate production losses
  - Provide power during emergencies
  - Isolate priority loads in problem power areas
- Potentially helps solve facility power problems
  - Produce power where needed
  - Help correct power factor problems
  - Provide power to remote sites





Microturbine Advantages

- Clean electricity
- Very low emissions
- Quiet operation
- Low maintenance
- Long engine life
- High system efficiency
- Multi-fuel operation
- Cogeneration heat


0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Efficiency LHV
0
50
100
150
200
250
300
350
400
450
500
Rated Power [Continuous or Prime where available] (kW)
PowerWorks 70
PowerWorks 250
Other
Diesel
Gasolene
Natural Gas

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Applications

Customer Motivations	Cost Savings	Power Availability	Power Generation	Power Quality	Environ. Compliance
Typical Application Segments	Agriculture, Hotel, Chemical	Health Care, Universities, Food Distrib.	Landfill, Mining, Wastewater	Communication, IT, Hi-Value Mfg	Petroleum, Process, Materials

Type of Service

Cogeneration	✓	✓	✓		✓
Peak Shaving	✓	✓	✓		✓
Prime Power			✓	✓	✓
Running Backup	✓	✓		✓	
Remote Power			✓	✓	

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PowerWorks® 70kW Key Features

Patented Combustor

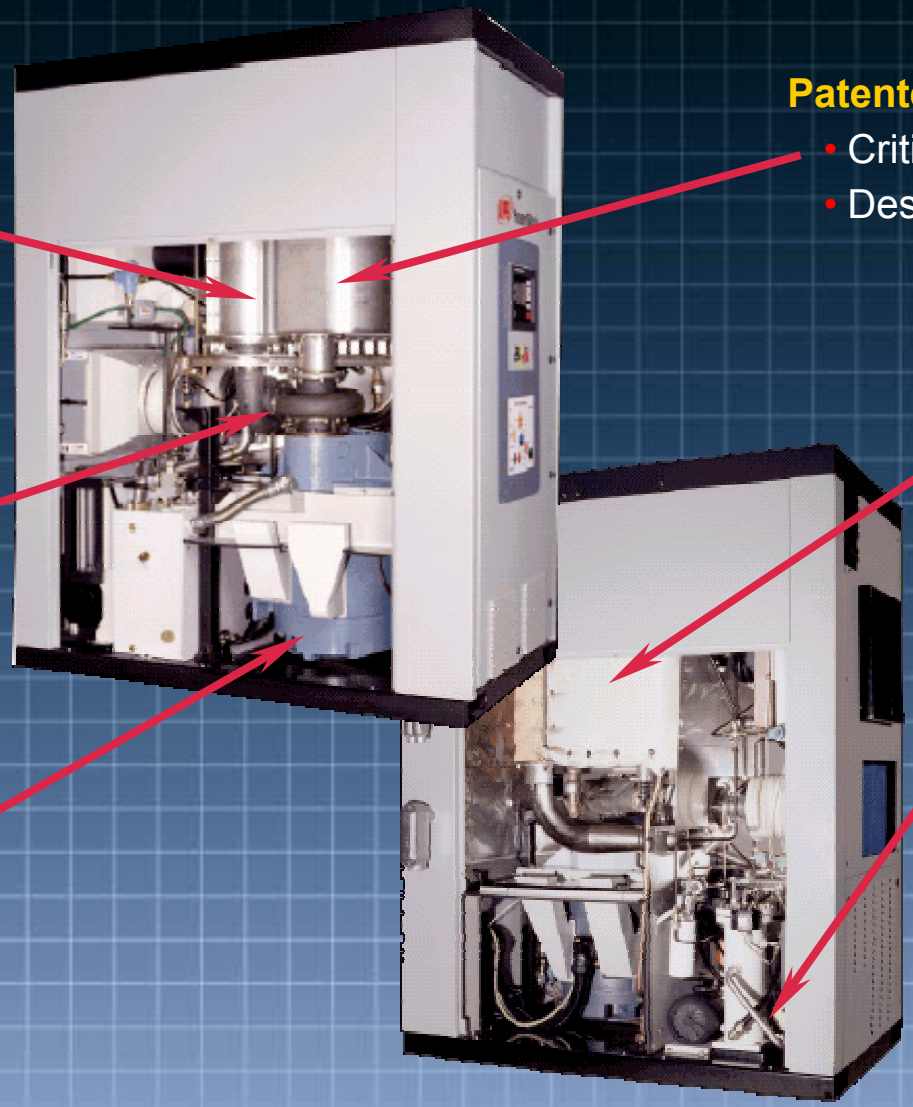
- Dry low NOx
- Easily meets stringent environmental regulations

Two-Shaft Engine

- Reduces stress for longer life

Proven Generator Technology

- Well understood by utilities
- Same technology used by utilities to power the grid



Patented Recuperator

- Critical to high efficiency
- Designed for 80,000 hour life

Integrated Heat Recovery

- Smaller footprint
- Controllable output level

Fuel Gas Booster

- Long-life design
- Fully integrated
- IR technology already used in thousands of critical industrial applications

IR PowerWorks.

PowerWorks 70kW Specifications

- 70kWe model
- Has 130% peaking power capacity on cold days (92 kWe)
- Efficiency
  - Induction system: 29% LHV electric (28% w/booster)
  - Synchronous system: 28% LHV electric (27% w/booster)
  - Up to 70% total with cogeneration
- Low emissions with natural gas
- 8,000 hour maintenance interval
- 80,000 hour engine life
- Grid-parallel or grid-isolated electrical generation
- Closed transitions to grid-isolated mode during grid outages
- Automatic block load handling up to 70kW

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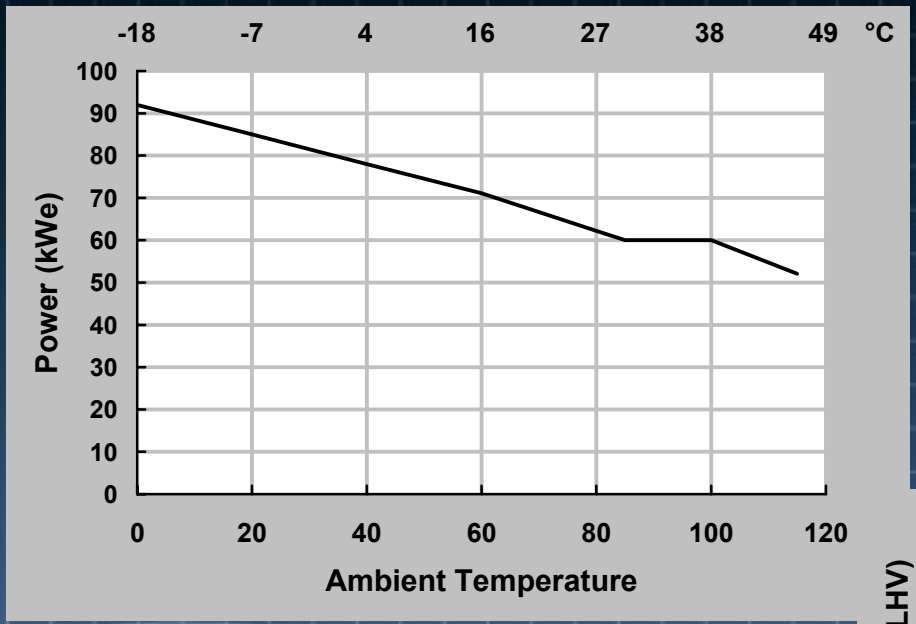
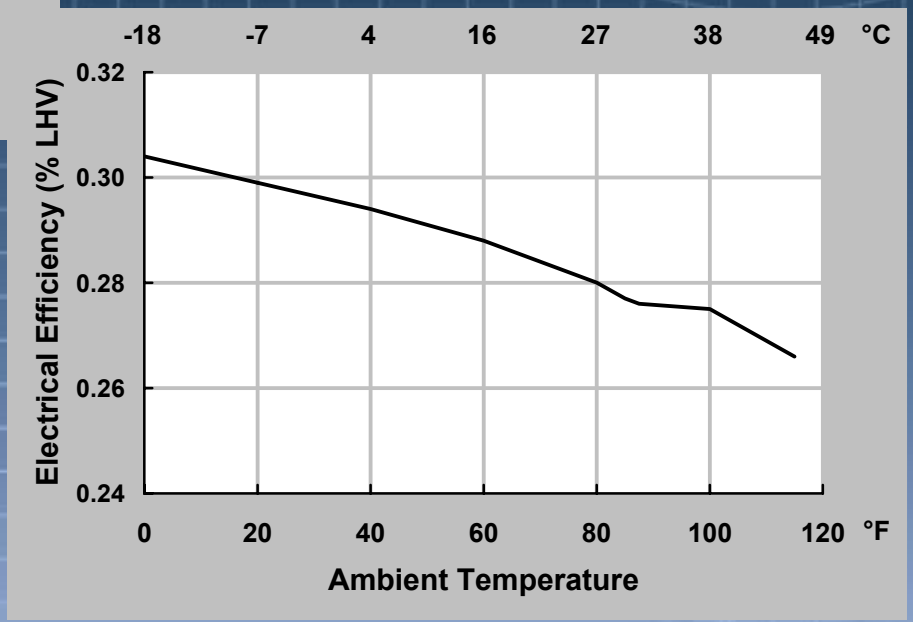
70kW PowerWorks Performance (Induction)



Note: KWe is electrical output at terminals corrected for parasitics, but not including gas booster power.



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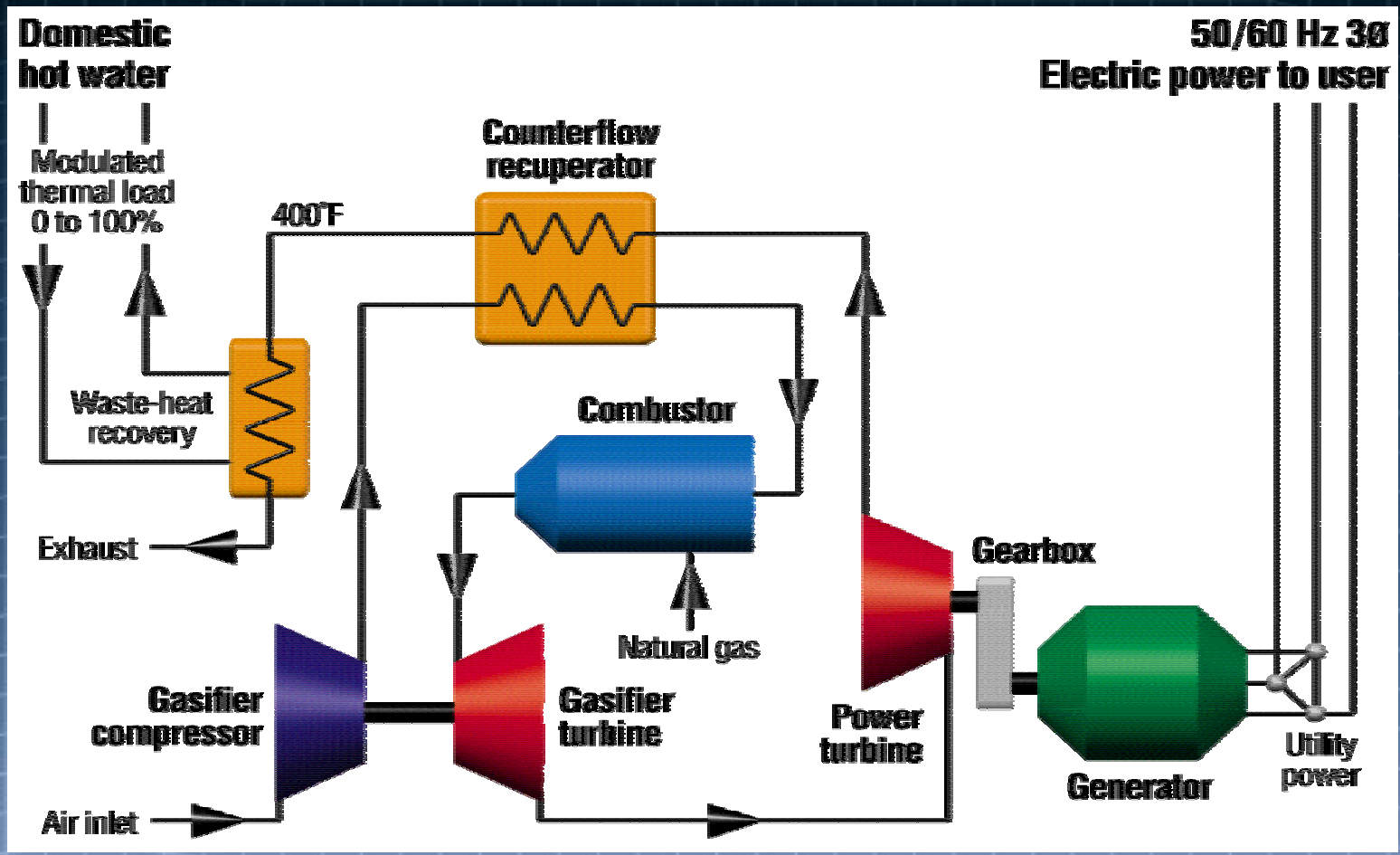
System Cycle Diagram



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250kW PowerWorks Specifications

- 250kWe model at ISO conditions
- Has 120% peaking power capacity on cold days (300 kWe specified)?
- Efficiency
  - 32% LHV electric w/booster
  - Up to 70% total with cogeneration
- Low emissions with natural gas
  - <9 ppmv NOx @ 15% excess O_2
- 8,000 hour maintenance interval
- 80,000 hour engine life
- 3x footprint of 70kW
- Grid-parallel or grid-isolated electrical generation (synchronous gen.)
- Closed transitions to grid-isolated mode during grid outages
- Engine principally handles block load changes alone

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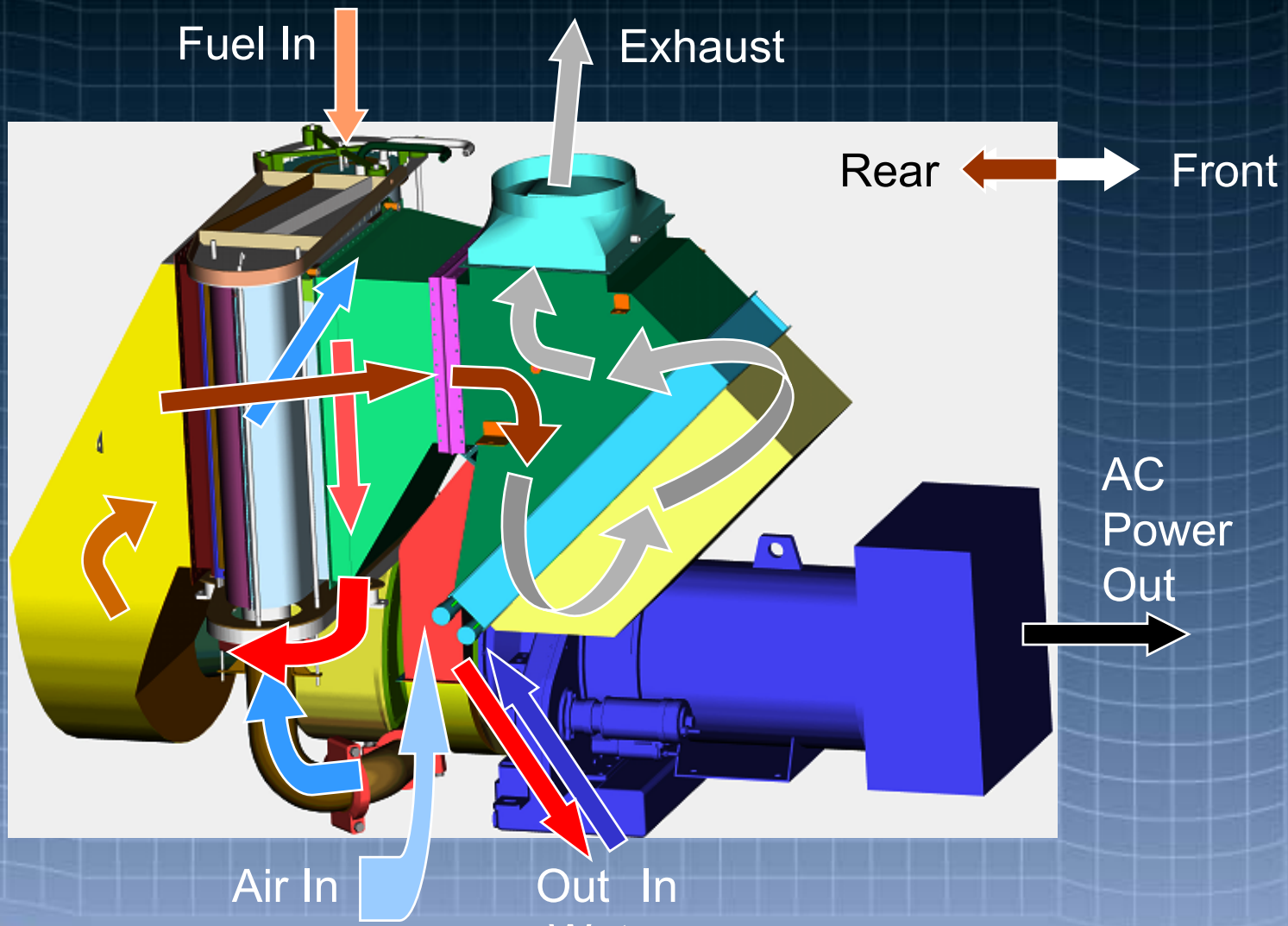
Prime Mover Configuration



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Davidson, NC Final Assembly

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IR's US Service Coverage

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Codes Used in Development

- UL 2200 — Stationary Engine Generator Assemblies
- NFPA 37 — Stationary Combustion Engines
- NFPA 54 — National Fuel Gas Code
- NFPA 70 — National Electric Code
- EGSA — Safety Codes Required by States & Major Cities
- ANSI / NSF 51 — Standard for Food Equipment
- ANSI C84.1 (60Hz) — Electric Power Systems & Equipment Voltage Ratings
- ANSI 133.8 — Gas Turbine Installation Sound Emissions
- ANSI 133.9 — Measurement of Exhaust Emissions From Stationary Gas Turbine Engines
- ANSI B133.10 — Gas Turbine Information to be Supplied by User and Manufacturer
- EPA Section 1417 — Safe Drinking and Water Act
- CSA C22.2 #100 — Motors and Generators, Industrial Products
- OSHA 1910.95 — Occupational Noise Exposure
  - .101 — Compressed Gases
  - .144 — Safety Color Codes for Physical Hazards
  - .145 — Signs and Tags
  - .146 — Permit Required Confined Spaces
  - .147 — Control of Hazardous Energy

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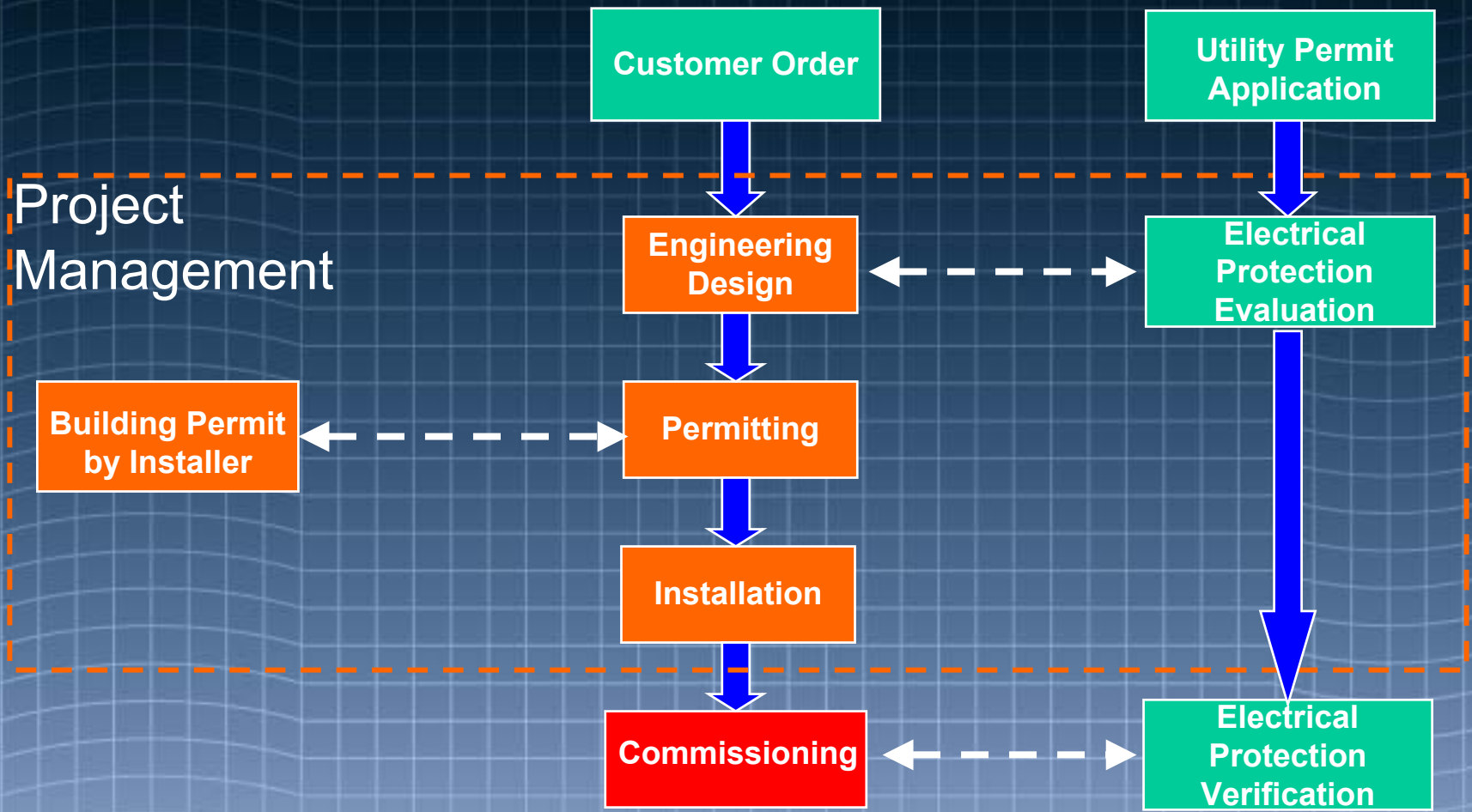
Other Codes That Can Apply

- UL1741 - Converters / Inverters / Charge Controllers For Independent Power Systems
- Existing Electrical Interconnect Standards
  - NY: PSC Standardized Interconnect Requirements …
  - CA: Rule 21
- Future:
  - IEEE SCC21 P1547 National Interconnect
  - FERC Small Generator Interconnect
  - MA: Collaborative Interconnection Standard
- Major building codes :
  - National Building Code
  - Uniform Building Code
  - Standard Building Code
- Geographic-specific codes:
  - New York State Uniform Fire Prevention and Building Code Title 9B NYCRR
- US EPA, State, and Local Emissions Requirements

The Installation Process



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Compact Footprint Enclosure

- Qualified for indoor use
- Low noise level: 78Dba @ 1 meter
- Built-in industrial controls
- Special foundation not required
- Independent inlet air ducting
  - 1100 to 1500 scfm typical
  - Cool, filtered air preferred
  - Consider using building exhaust

69L x 42W x 87H in (175L x 107W x 221H cm)
4100 or 4850 pounds (1860 or 2200 kg)

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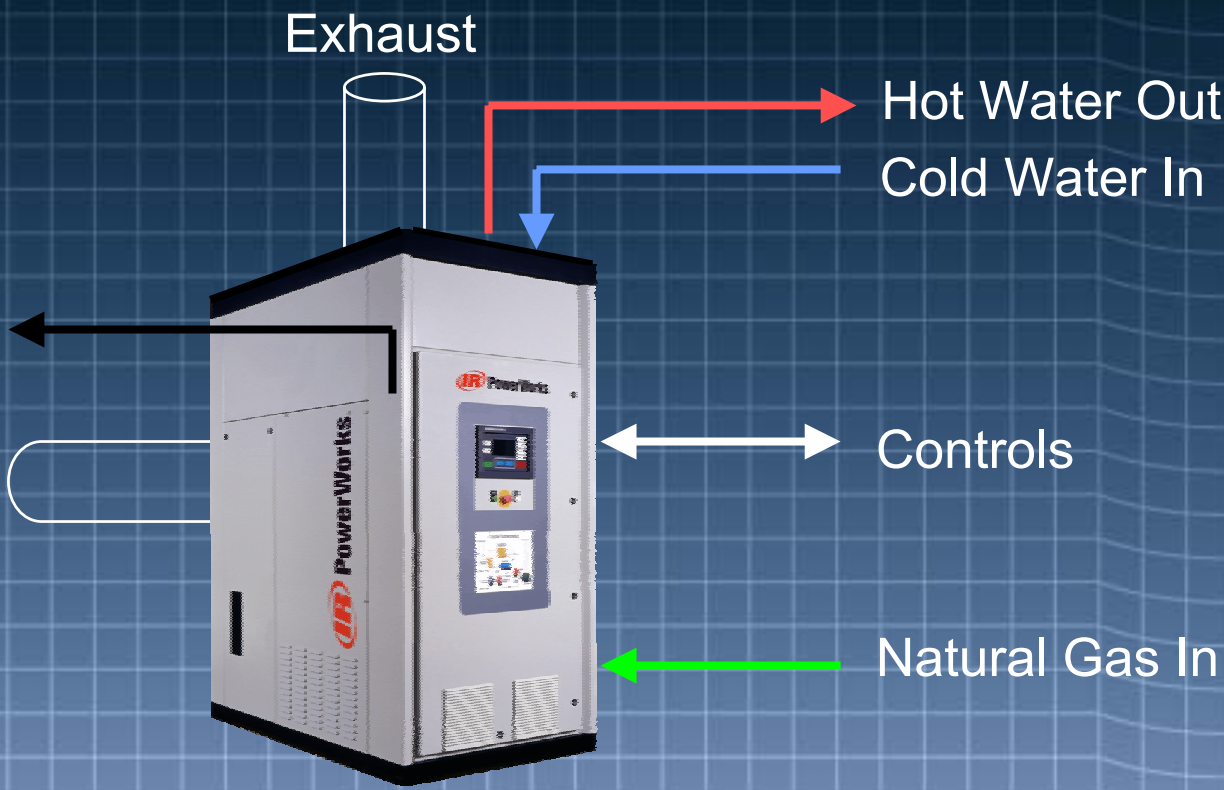
Facility-Microturbine Integration

Physical Layout



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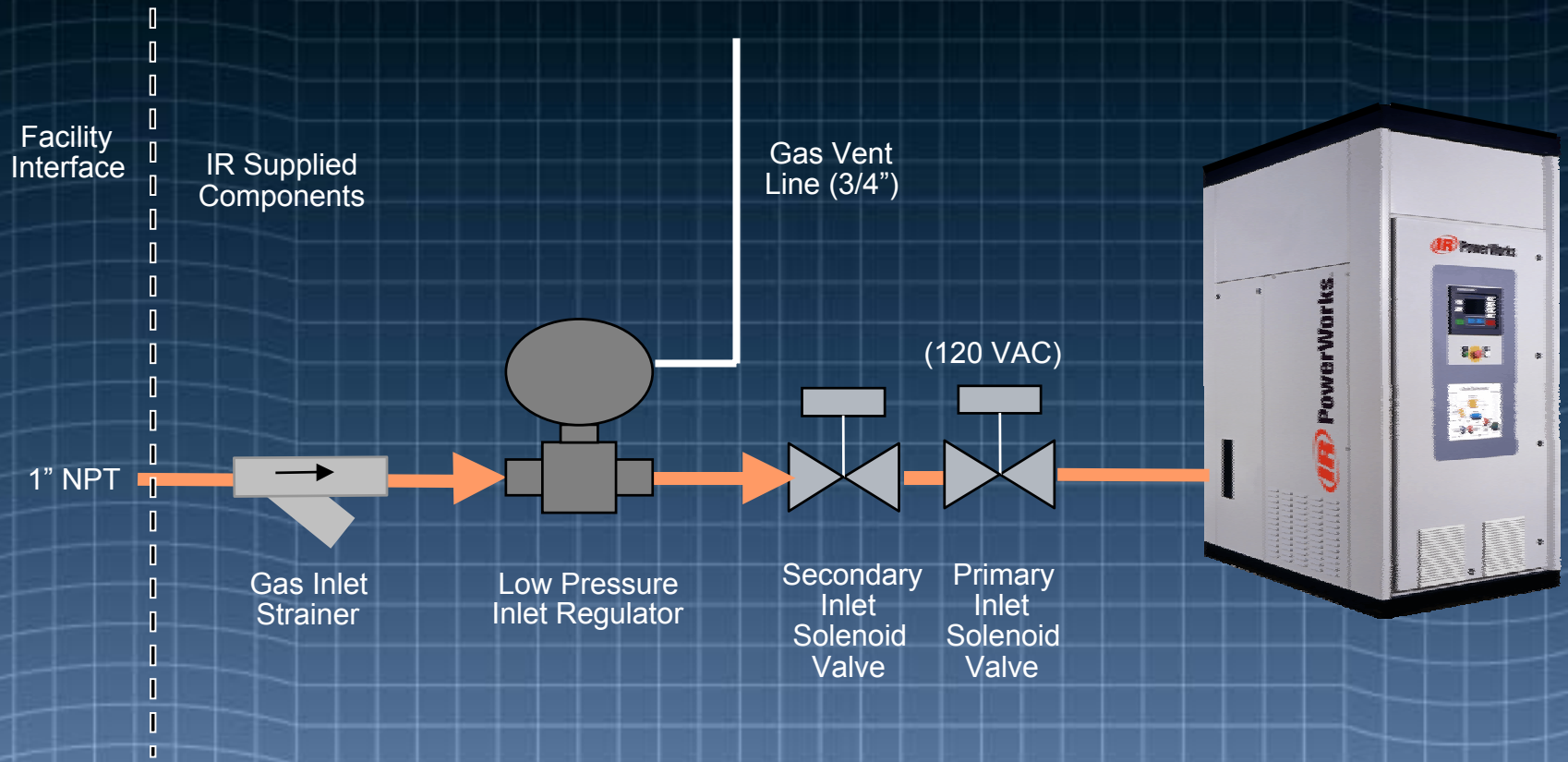
Typical Indoor Installation

Natural Gas Input



- **Sealed fuel handling system**
- **Minimum inlet pipe pressure = 0.29 PSIG**
- **Minimum flow = 52.9 lbm/hr**

Prime Mover Fuel Specifications

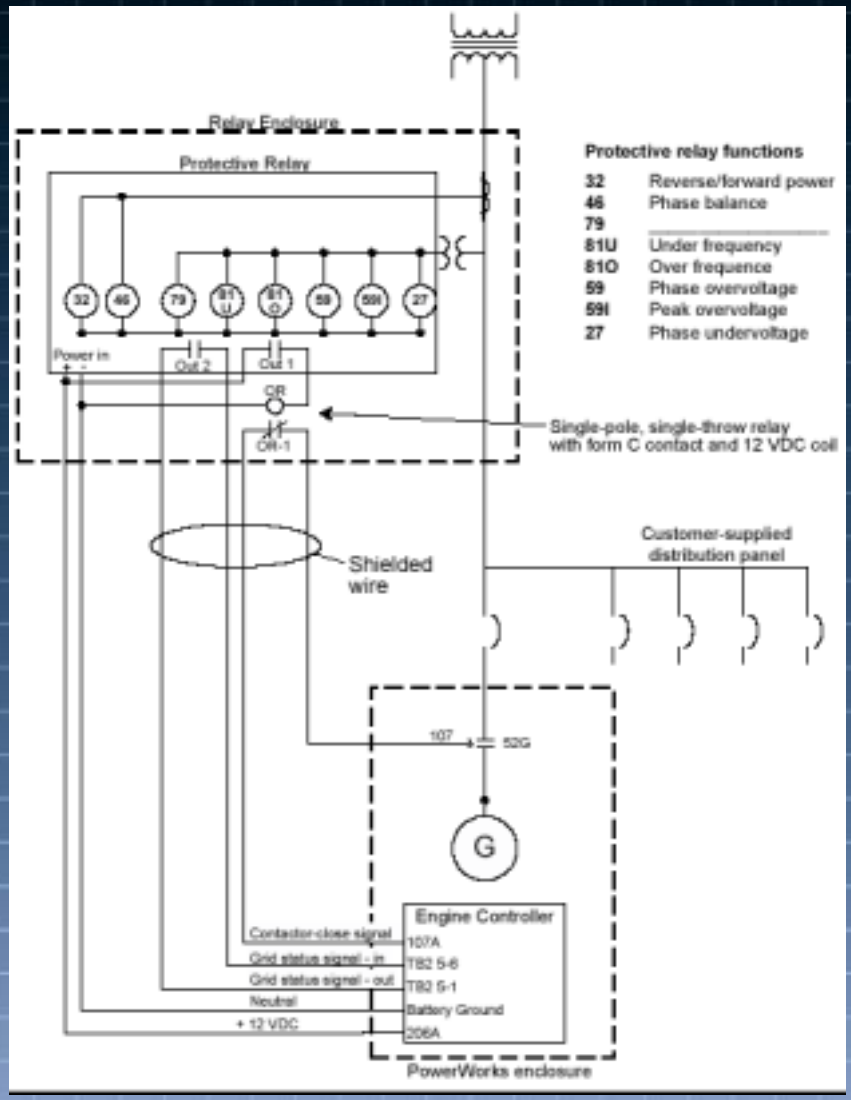
Table 4: Composition of the Gaseous Fuel

Composition	Limit	Comment
Oxygen	3% max	Do not exceed the flammability limits.
Hydrogen	5% max	Concern is that this increases flame speed which could lead to durability reduction of the fuel injection apparatus of the combustor
Fuel Bound Nitrogen	2 ppmv	Forms fuel bound NOx
Carbon Dioxide	45% max	Limit corrosive potential of gas in presence of moisture
Methane	38% min	Equals minimum required fuel energy content
Ethane	8% max	
Propane + Butane	2% max	
Moisture	150 ppmv max	Corrosion concerns

Table 5: Contaminate Limits of Gaseous Fuels

Contaminate	Limit	Comment
Hydrogen Sulfide (H2S)	25 ppmv max	Brief periods to 200 ppmv allowed
Siloxanes	5 ppm max	Concern of corrosion and fouling
Particulate	3 microns avg. size	Prevent rapid plugging of fuel filter
Halogenated Organic Compounds	200 ppmv max	
Non-methyl Organic Compounds	1500 ppmv max	
Alkali metal sulfates (Na, K, Li)	0.6 ppm mass max	Hot section corrosion

Simple Intertie Electrical Interconnect



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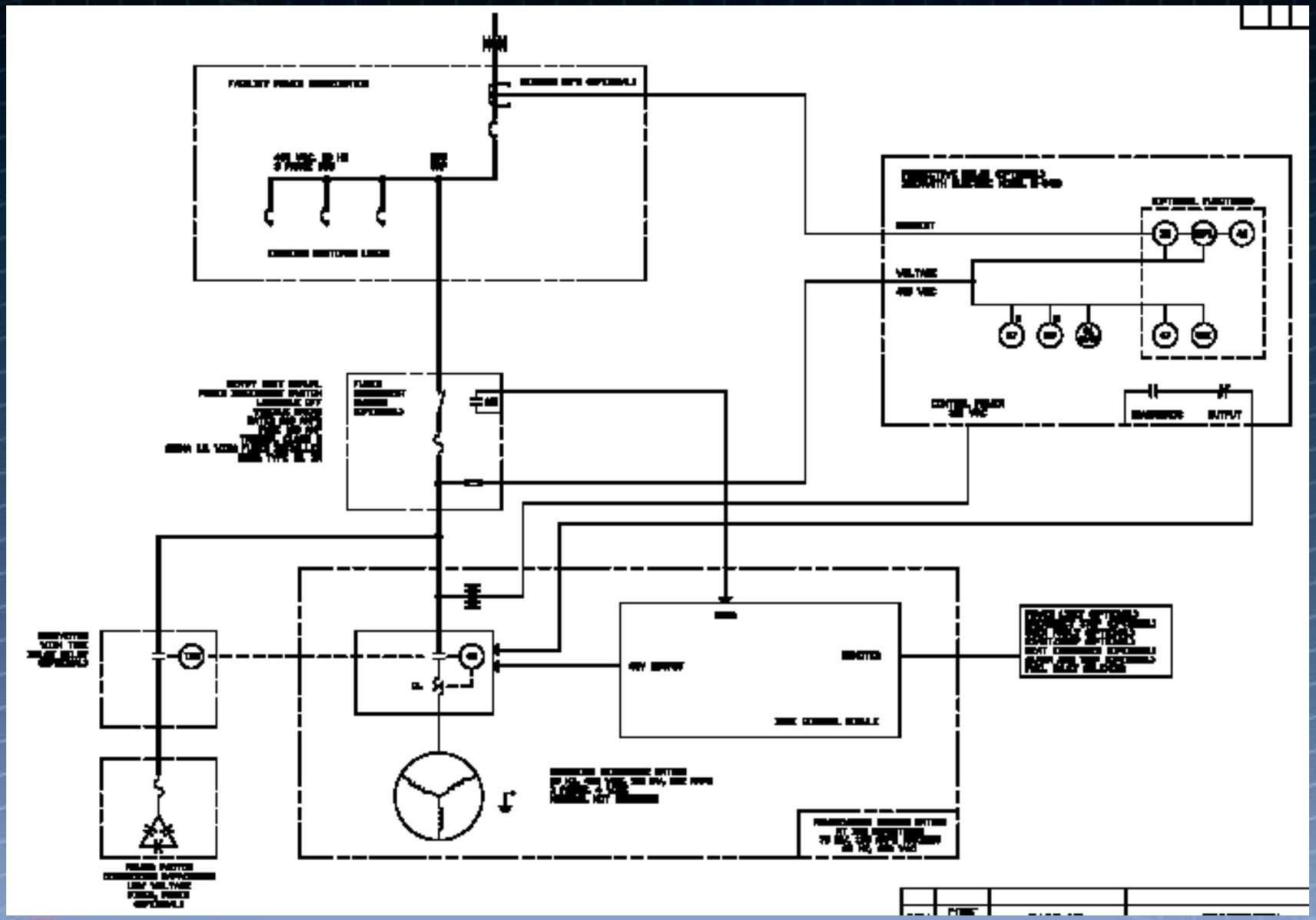
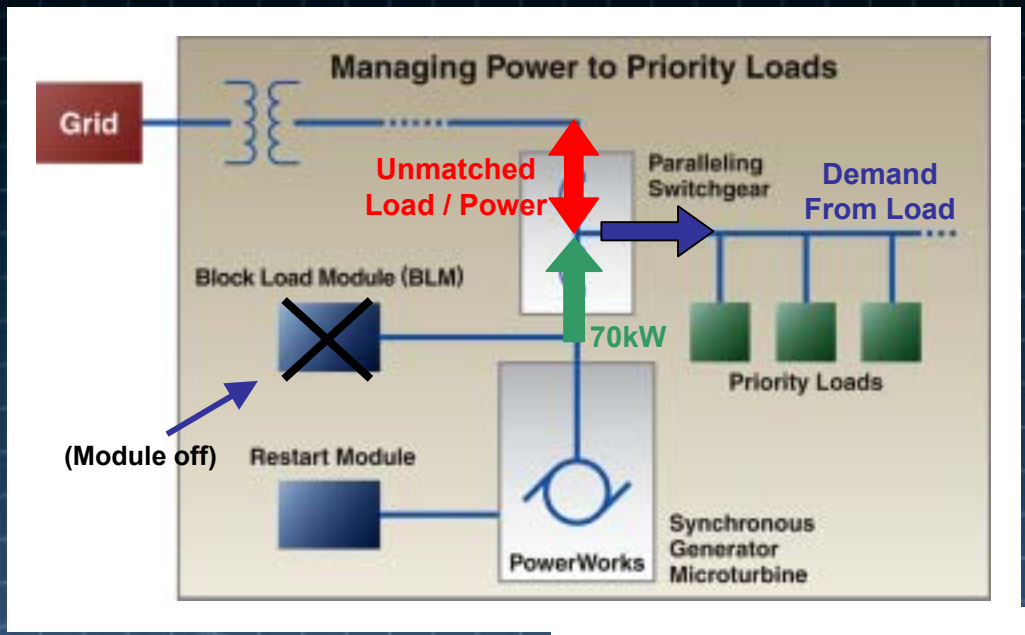
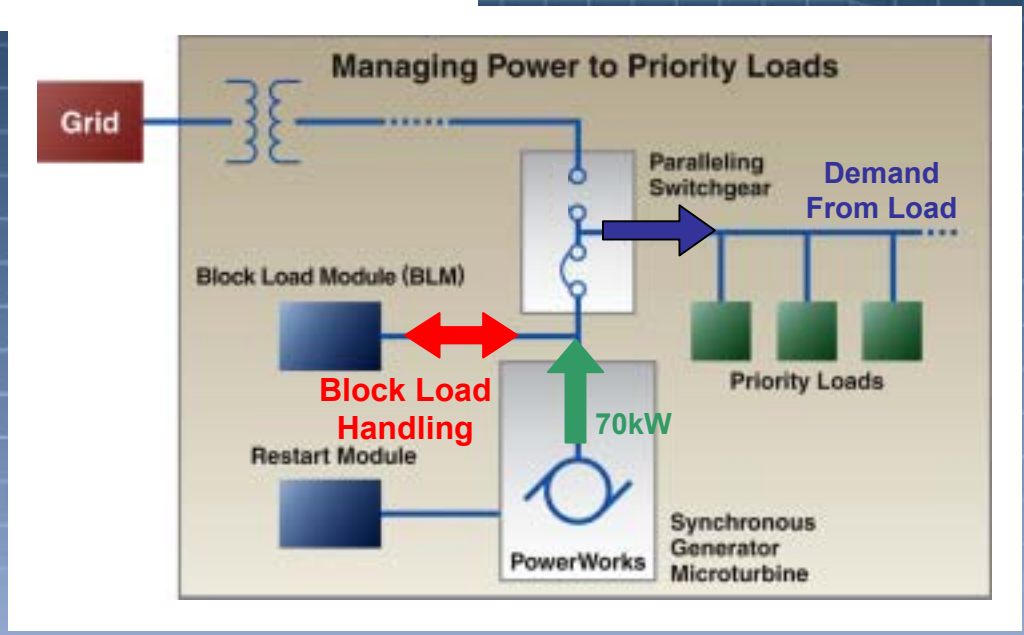
Typical Induction System One-Line



Synchronous System Capability





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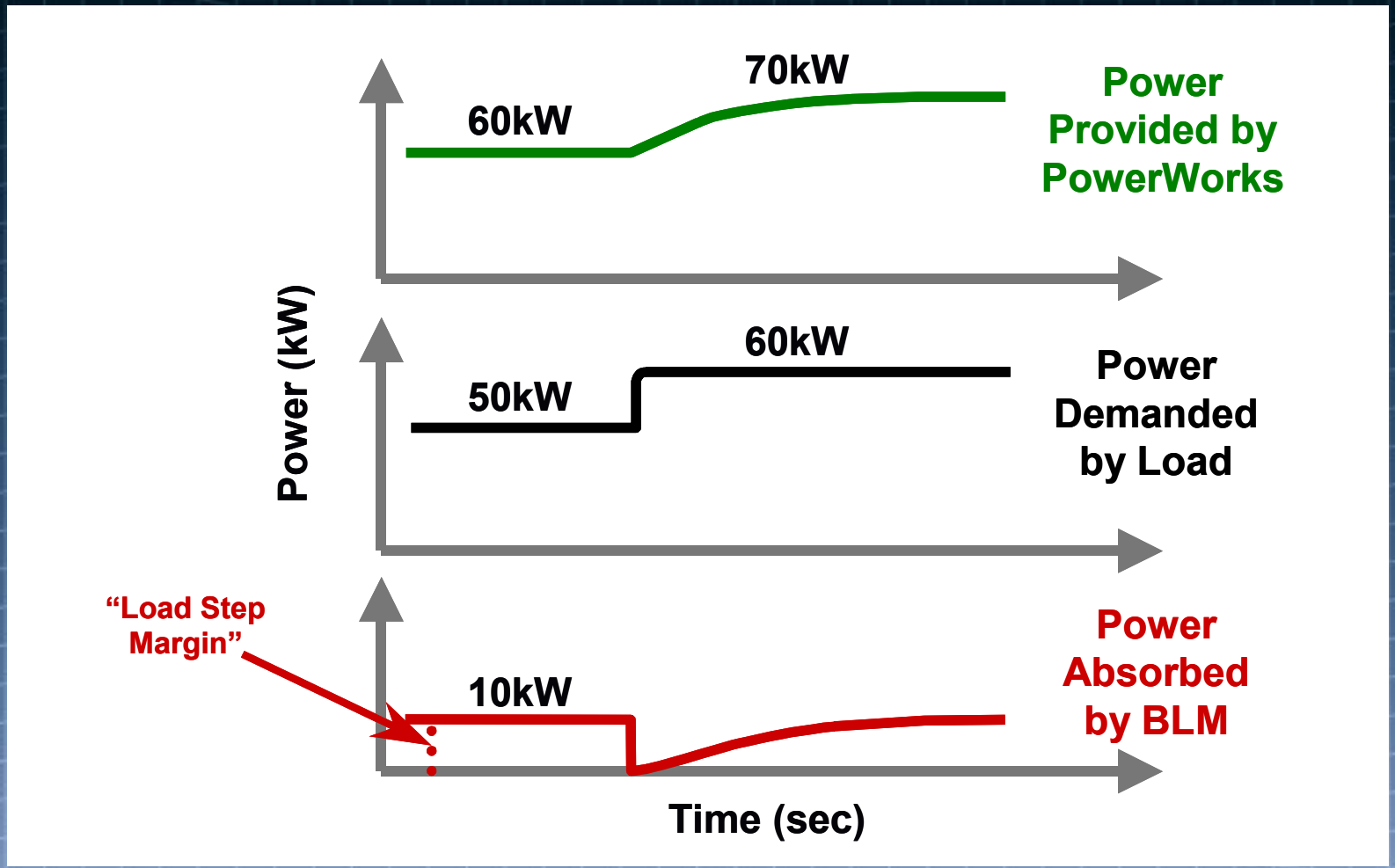
Block Load Margin Control



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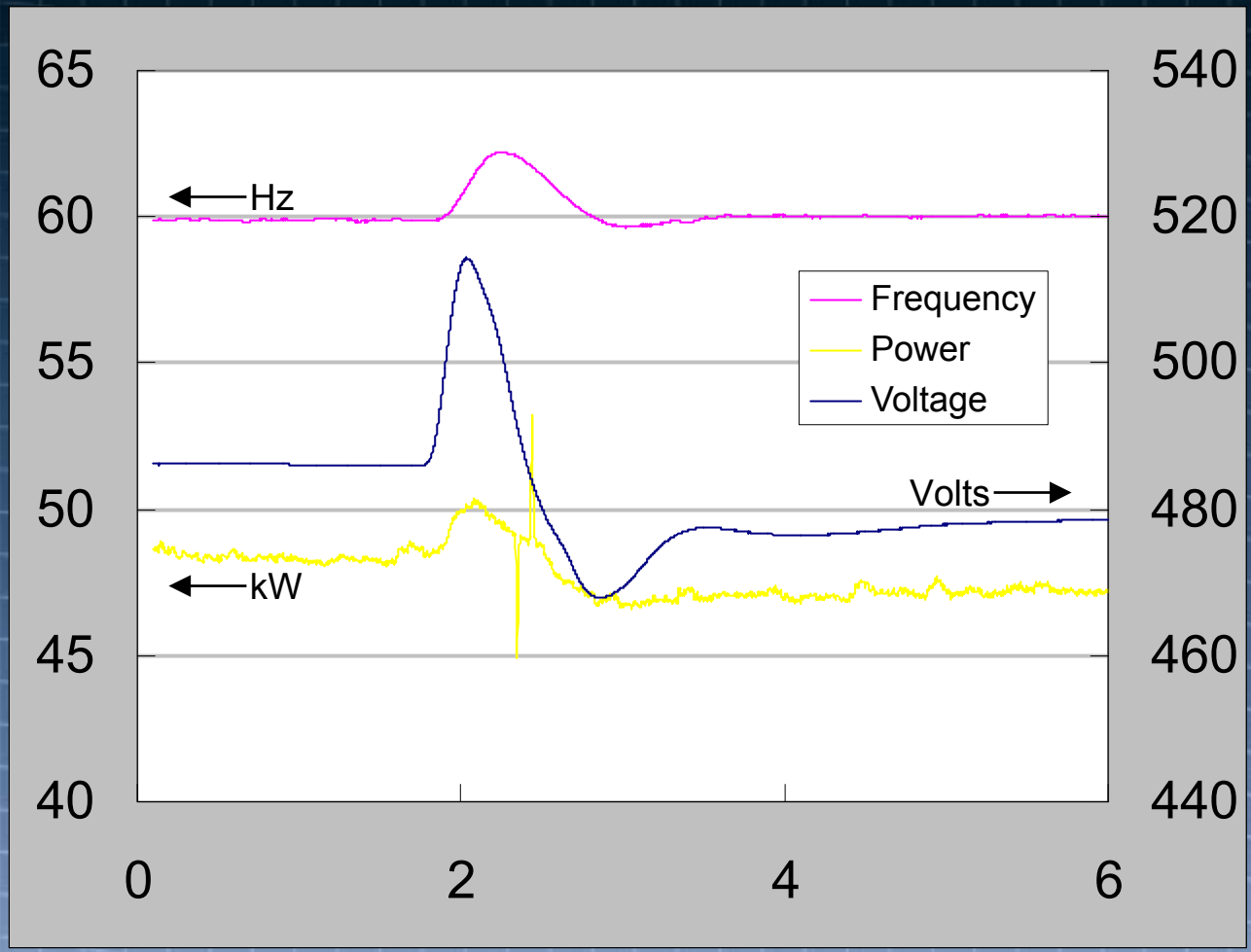
Grid-Parallel To Grid-Isolated Detail



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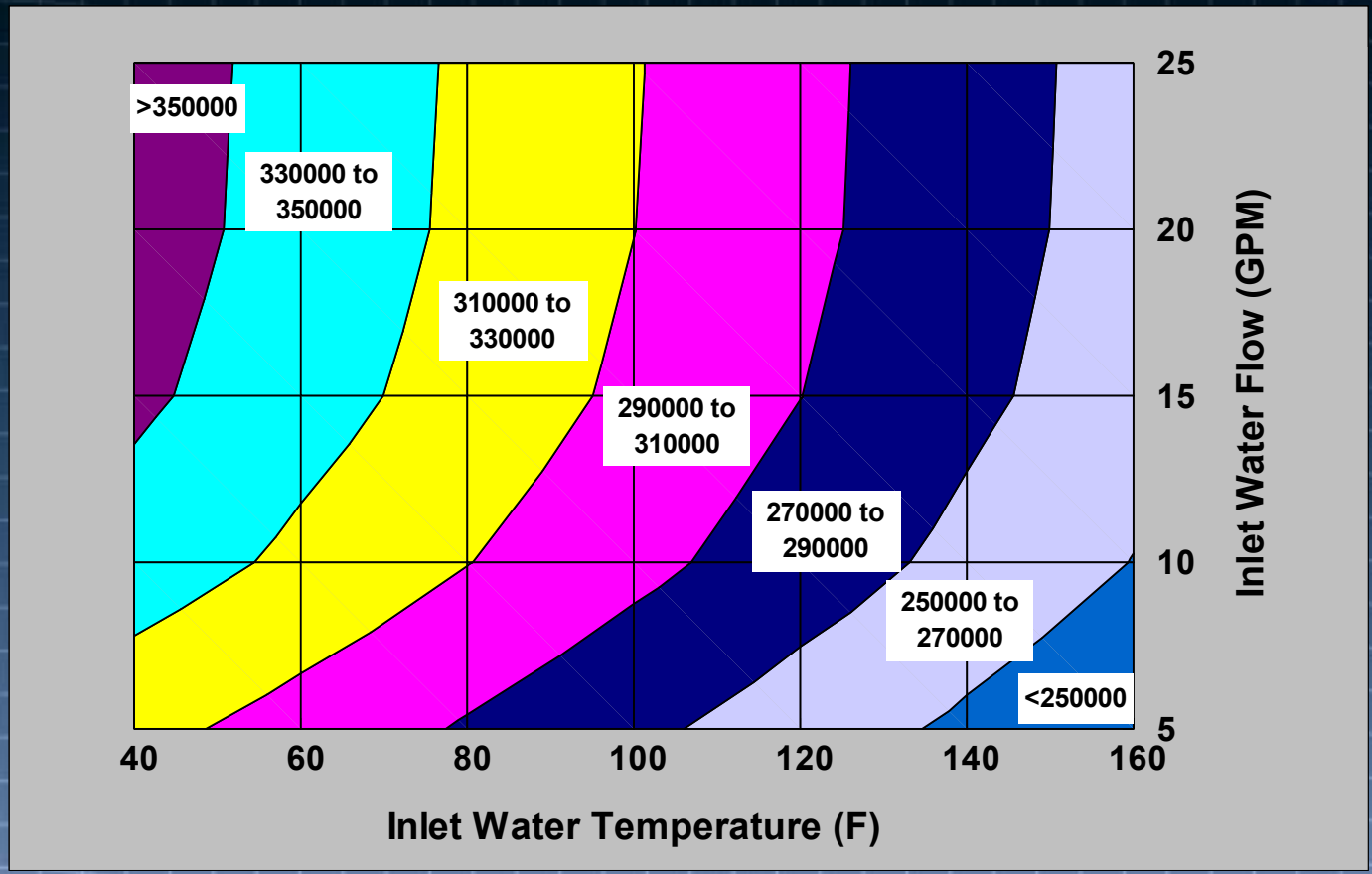
Fully Integrated Heat Recovery System

- Built into exhaust plenum immediately after recuperator
- Designed for heating water
  - 6 to 26 gpm
  - Up to 200°F water output
  - Suitable for potable water up to 125 psig
  - Example: 278,000 BTU/hr @ 20GPM with inlet water temperature of 140ºF
- Heat can also be recovered directly from exhaust
  - About 421°F after recuperator
  - Very clean, perhaps cleaner than input air!

Heat Recovery Output BTU/hr



- Recovered BTU/hr depends on inlet temperature and flow rate

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70kW Air / Exhaust Handling

- Independent inlet air ducting
  - 1100 scfm typical
  - Cool, filtered air preferred
  - Max duct pressure loss = 0.25” H2O
- Exhaust
  - Dry, low-NOx technology
  - NOx: <9 ppmv @15% O2
    <0.045 lbm/hr (<20 gm/hr)
  - CO: <9 ppmv @15% O2
    <0.045 lbm/hr (<20 gm/hr)
  - Max duct pressure loss = 0.75” H2O

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Low Emissions Combustion

- 70kW Specification at ISO Conditions:
  - NOx <0.41 lb/MWh (<9 ppmv @ 15% excess O2)
  - CO <0.25 lb/MWh (<9 ppmv @ 15% excess O2)
- 2003 California Air Resource Board Limits:
  - NOx <0.5 lb/MWh
  - CO <6.0 lb/MWh
  - VOC <1.0 lb/MWh
- Preliminary certification testing of 70LM:
  - NOx <0.15 lb/MWh
  - CO <0.25 lb/MWh
  - VOC <0.05 lb/MWh
- Testing by outside agencies confirms low levels

Hard-Wired Control Inputs and Outputs

- Remote Emergency Stop
- Remote Stop/Start
- Facility Fault Input
- Heat recovery On/Off
- Upstream Breaker Contact Position
- PowerWorks Alarm Indicator
- Fuel Inlet Solenoid Valve
- Protective Relay Contact

Remote Serial Monitoring / Control

Analog Values

- Remote kW Setpoint
- Electric power
- Fuel orifice differential pressure
- Fuel orifice temperature
- Fuel inlet temperature
- Water inlet temperature
- Water inlet temperature setpoint
- Water outlet temperature
- Gas generator compressor inlet temperature
- Turbine outlet temperature
- Compressor inlet temperature
- Intake air filter differential pressure
- Gas generator spindle rpm
- Electric generator rpm
- Running hours
- Number of starts
- Power-on hours

Digital Values

- Engine state flags
- Generator state flags
- Generating electricity
- First out alarm
- First out trip

Digital Commands

- Remote start
- Remote stop

Typical Power Needs For Facilities

• Convenience Stores	40 to 50 kW
• Fast Food	40 to 50 kW
• Restaurant Chain	50 to 70 kW
• Filling Stations	50 to 70 kW
• Box Stores	200 to 400 kW
• Older Supermarkets	150 to 300 kW
• Landfills	500kW (gas equiv)
• New Supermarkets	300 to 2,000 kW
• Hospitals	100 to 6,000 kW
• Hotels	200 to 2,500 kW
• Large Office Buildings	400 to 3,000 kW
• Universities	1,000 to 4,000 kW
• Factories	500 kW and up
• Waste Treatment	1.5 to 10MW

IR PowerWorks.

Applications - Community Center

- Skilled nursing facility located in NY
- 60,000 sqft facility
- PowerWorks generates hot water that provides most of the facility's Domestic Hot Water (DHW) needs
- Installed in new outside building
- Natural gas fuel
- 24/7 electricity (base load)

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Applications - Landfill

- Replaces Honeywell microturbines
- Installed in newly roofed area
- Low BTU fuel from degradation of biological waste (350 BTU / ft3 minimum?)
- 24/7 electricity (base load) exported to grid
- No heat recovery components (cogeneration)

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Applications - Greenhouse

- Claims highest yield of roses per sq-m in the world
- Winter: electricity defers sun lamps load
- Summer: electricity defers heat pumps load
- Recovered heat used to warm plant beds

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Applications - Industrial

- LCN - Division of IR Security & Safety in Illinois
- Offers heavy-duty fire/life/safety door closers
- Reservoir pumps city water to the microturbines which heat the water for use in a five-stage parts washing process
- Natural gas fuel input

Applications - Landfill

- OII (Operating Industries), Monterey Park, CA
- Inactive super-fund toxic waste landfill site
- Constant flaring at ~24% methane content
- Six PowerWorks units operating at 38-40%
- Exhaust gases are flared to ensure complete burning of gas
- Perimeter wells prevents landfill gases from affecting surrounding family dwellings

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