

# Micro Turbines Installation & Operation

Distributed Energy Road Show

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Presented by:

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Engineering, Design, Installation, and Authorized  
Service Provider of Capstone MicroTurbines



# What is a Microturbine?

- A Microturbine is a turbine engine-generator, typically sized 250 kW or less
- A way to supply continuous energy to a facility at the point of use
- 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

# Microturbine Applications



Air Heating & Chilling: Indiana

## Combined Heat and Power (CHP)

- *Utilize both electricity and heat to increase efficiency to 70% - 90%*
- *Reduce greenhouse gases*
- *Provide air conditioning while reducing overall electrical load.*



Absorption Chilling:  
California

# Peak Shaving (no heat recovery)



# Digester Gas - Sun Prairie WWTP

## Baseload Electric and Heat



# Baseload Power, Standby Power and Heat City of Milwaukee's Lake Tower Office



# Benefits and Features

- Runs on Multiple Fuels
- Minimal Maintenance
- Very Low Emissions
  - < 9 ppm Nox
- Quiet Running
  - 65 db @ 30 ft
- No Vibration
- Built-in Electric System Protection



## Fuel

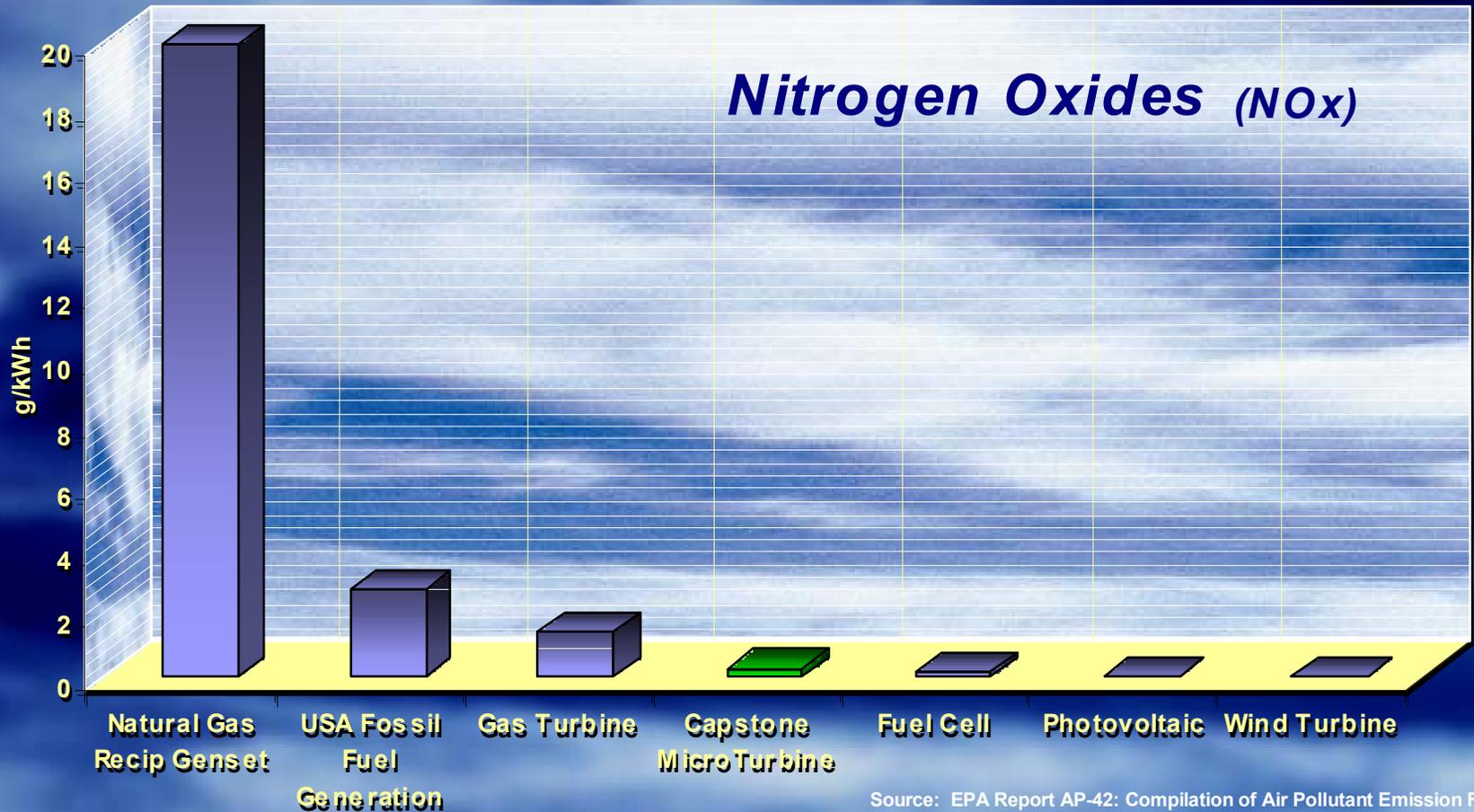
- **Natural Gas**
- **Up to 7% sour**
- **Propane**
- **Diesel**
- **Kerosene**
- **CNG/LNG**
- **Methane**
- **Low-grade landfill/digester gases**
  - **As low as 350 Btu**





# NO<sub>x</sub> Emissions

**World's cleanest fossil fuel combustion technology**



Source: EPA Report AP-42: Compilation of Air Pollutant Emission Factors

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# Design Concept

- ❑ Easy to Install
- ❑ One major moving part
- ❑ No gears or engine driven accessories
- ❑ No oil or cooling liquids
- ❑ Low emissions
- ❑ Low operating temperatures
- ❑ Indoor or Outdoor Installation
- ❑ Low operating cost, high life design

# Recommended Service Intervals

Item	Action	Interval
• Air Filter, Engine	Clean/Replace	8,000 Hrs
• Air Filter, Electronics	Clean	8,000 Hrs
• Fuel Filter, Internal	Inspect	8,000 Hrs
• Fuel Filter, External	Replace	8,000 Hrs
• Turbine Exit Thermocouple	Replace	16,000 Hrs
• Ignitor	Replace	16,000 Hrs
• Fuel Injectors	Replace	16,000 Hrs
• Engine/Turbine	Overhaul	40,000 Hrs

- Note: 8760 hours in a year

# Applications

## □ Grid Connect (Parallel Generation)

Peak Shaving

Baseload 24 x 7

Load Following

## □ Stand Alone

Emergency Backup

Dedicated Loads that need Clean Power

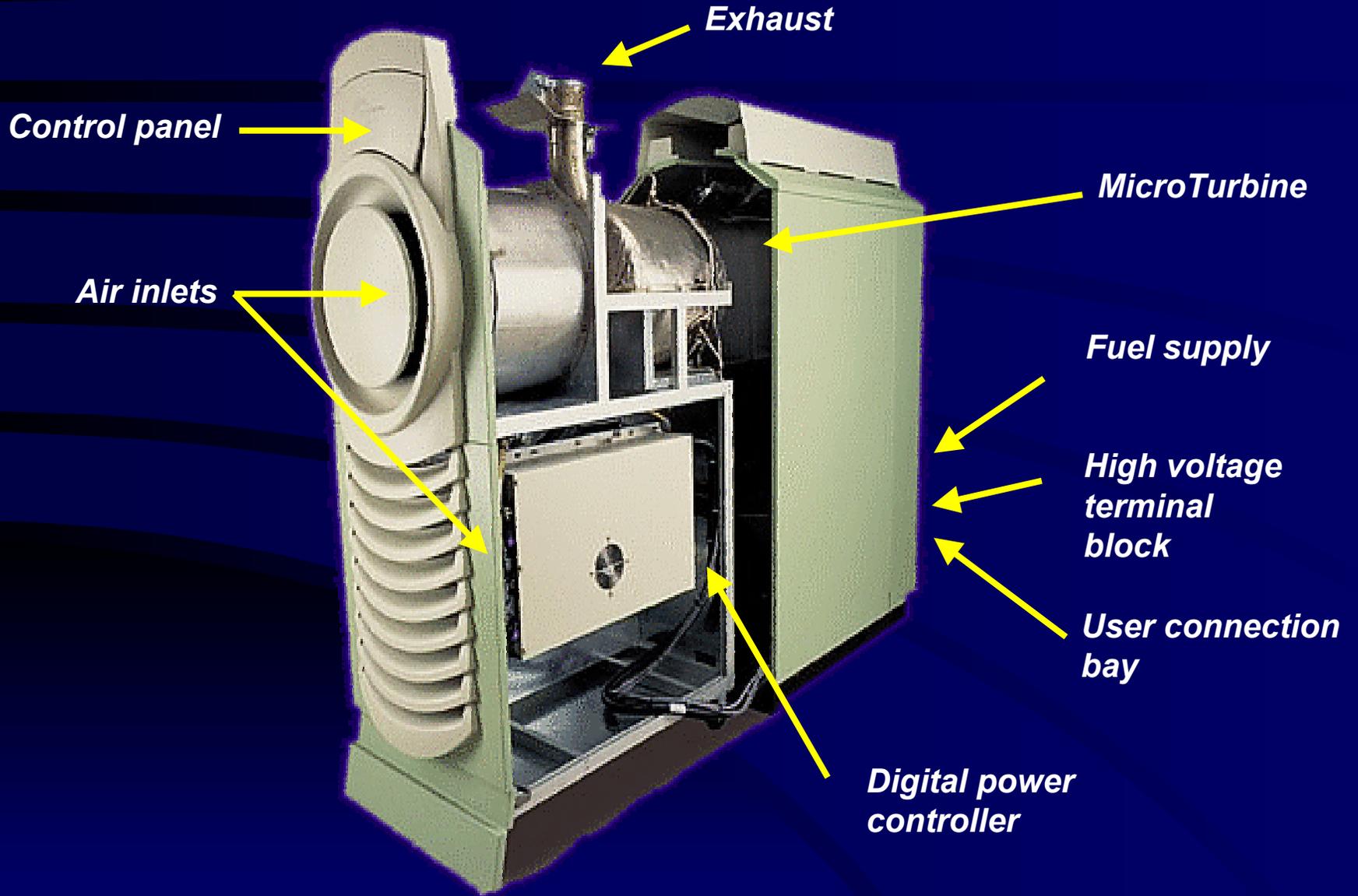
## □ Combined Heat and Power

Space Heating

Domestic Hot Water

Digesters (Agricultural and Waste Water)

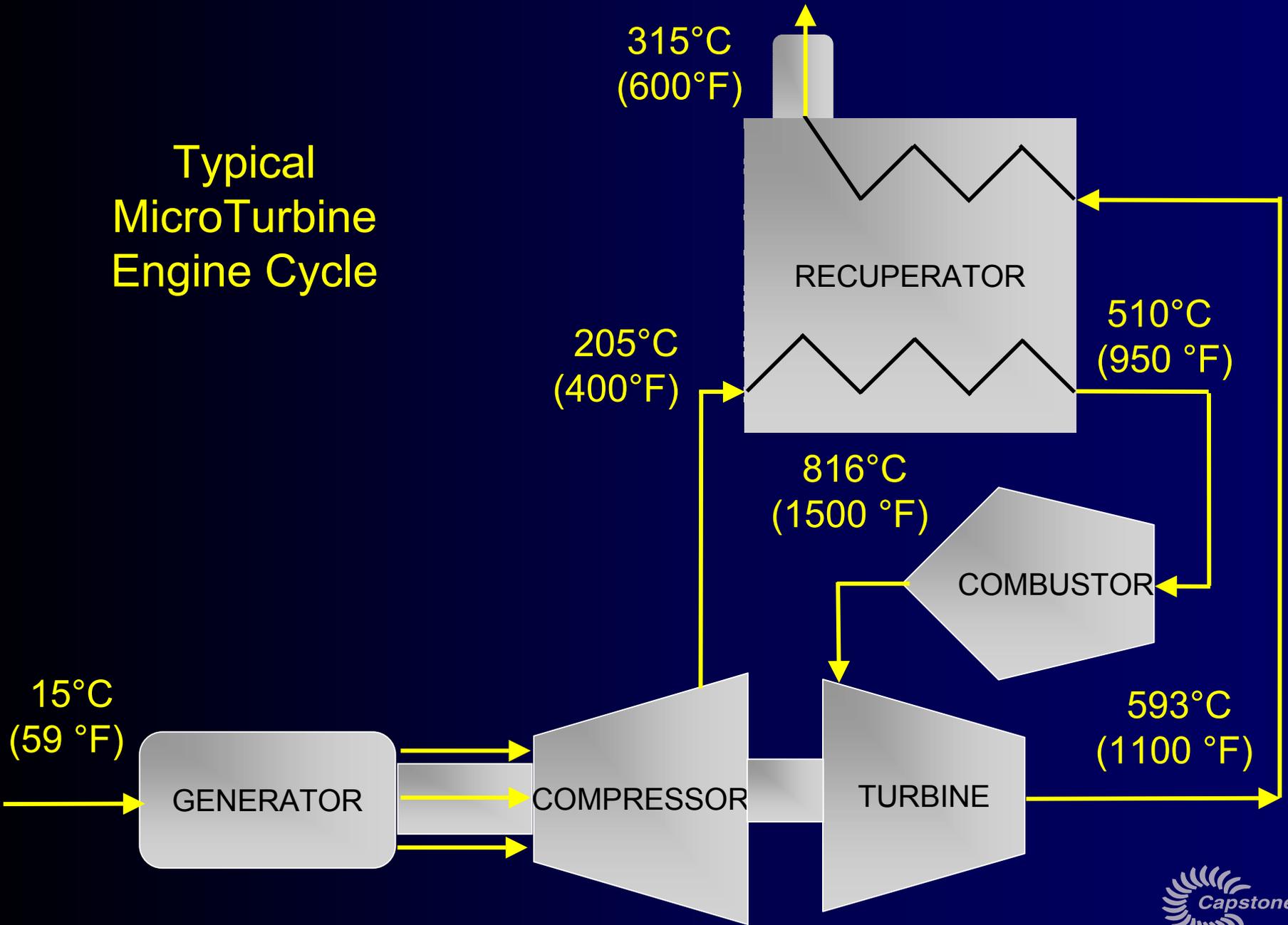
# Inside the Capstone MicroTurbine

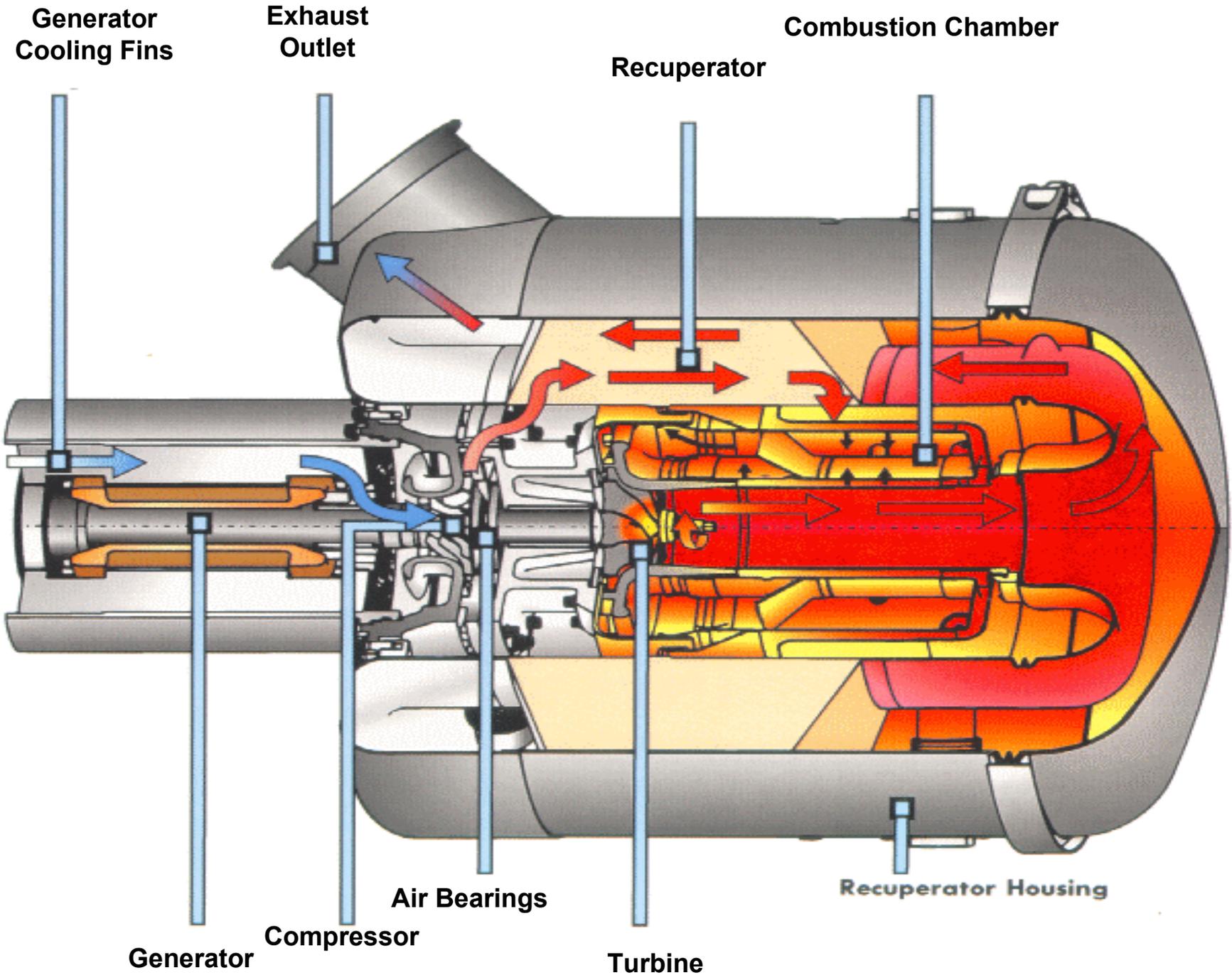


# Specifications for the 30kW Unit

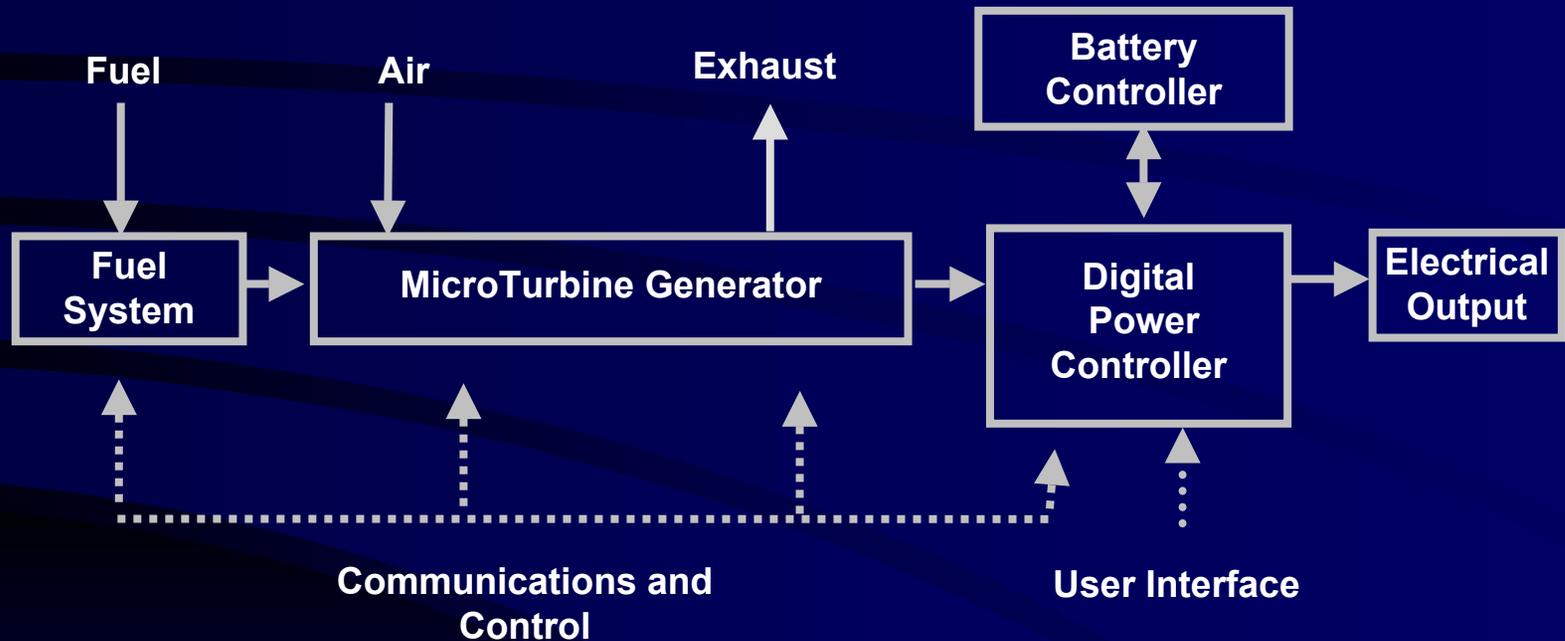
□ Turbine Inlet Air Flow	550 SCFM
□ Inlet Fuel	420,000 Btu/Hr
□ Heat Rate	13,200 Btu/kWHr
□ Minimum Inlet Fuel Pressure	60 psig for Biogas 0.5 psig for NG
□ Electric Output (Typical)	30 kW, 480v, 3 ph
□ Exhaust Gas Flow	575 SCFM
□ Exhaust Gas Temperature	560 °F
□ Exhaust Gas Energy	290,000 Btu/Hr

# Typical MicroTurbine Engine Cycle



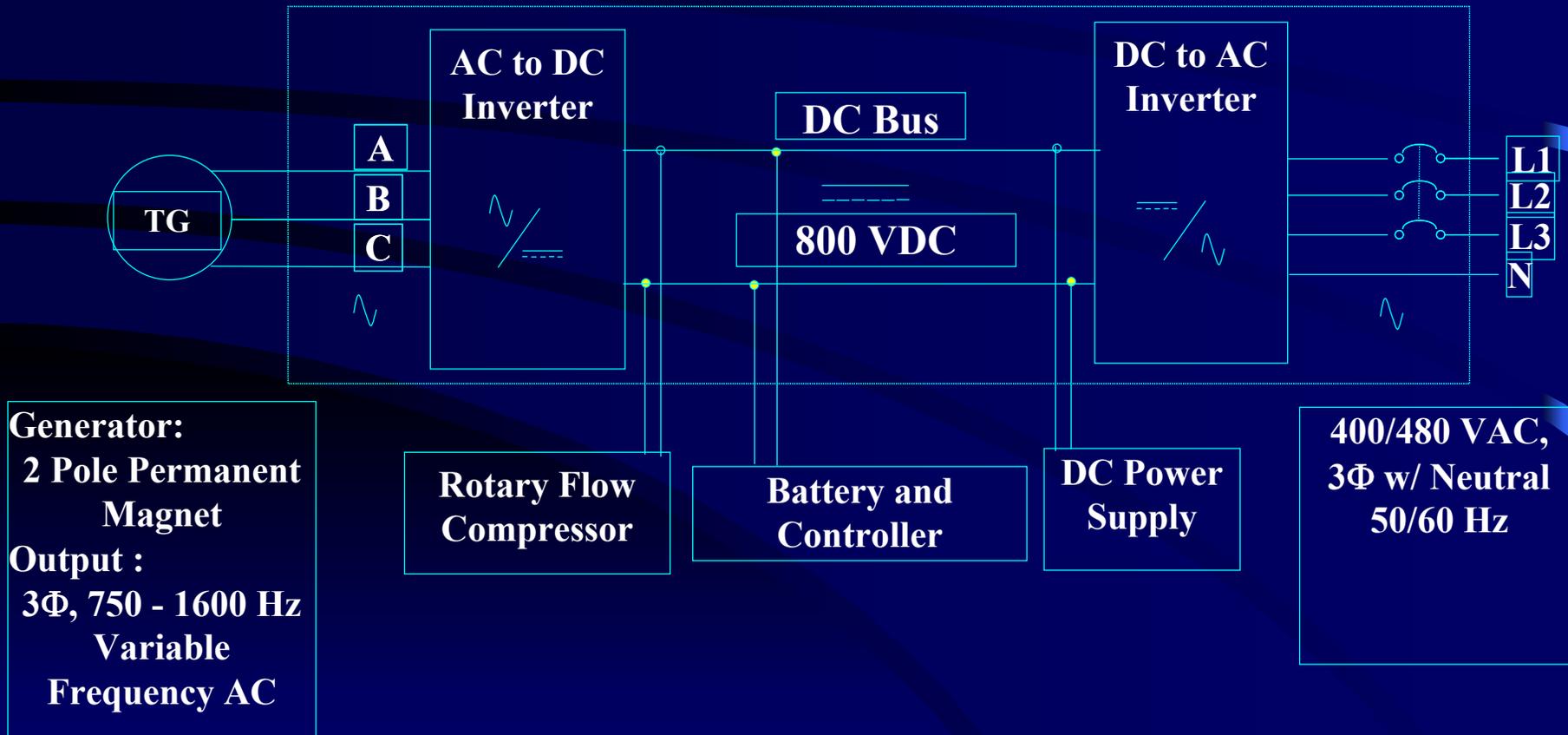


# System Block Diagram



# System Block Diagram - DPC Function

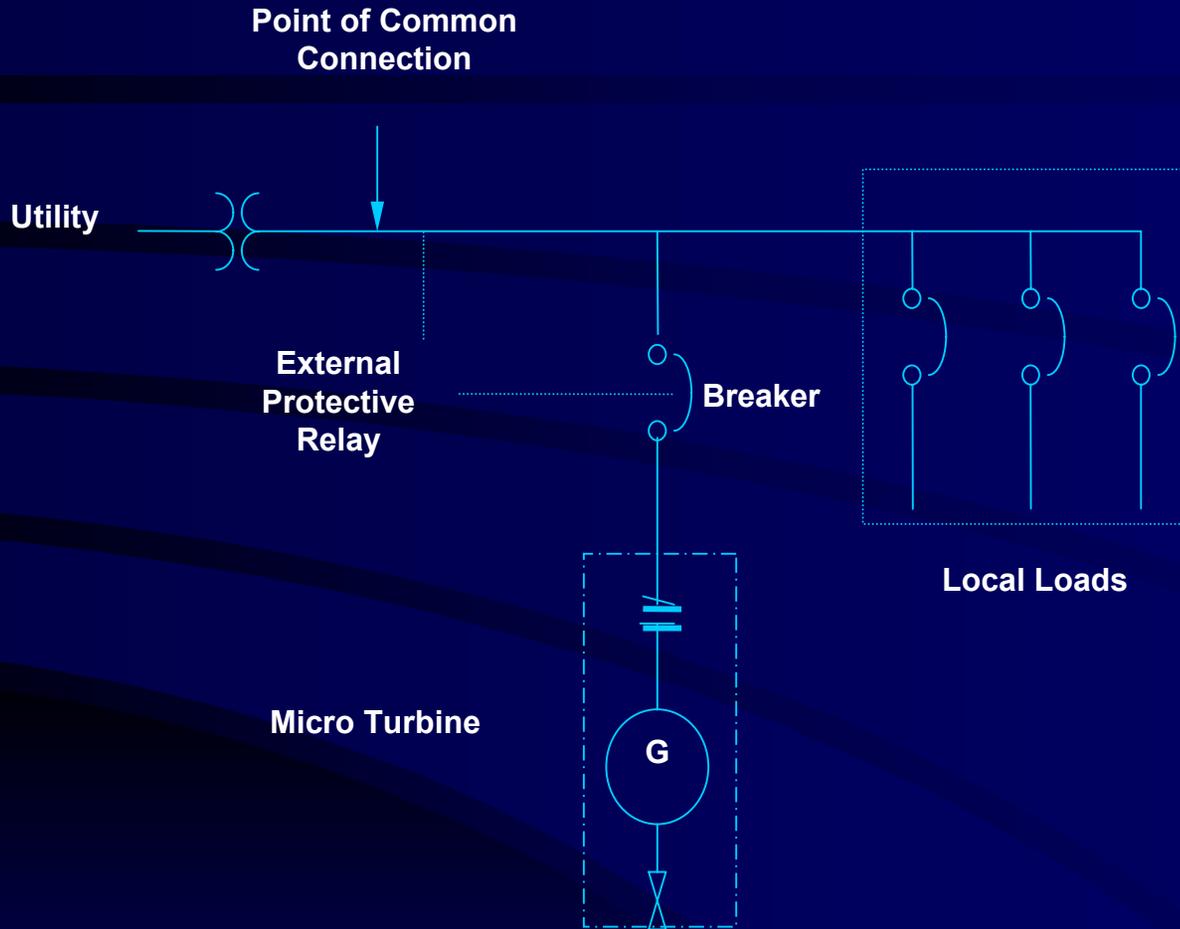
## Power Board



# Operating Modes

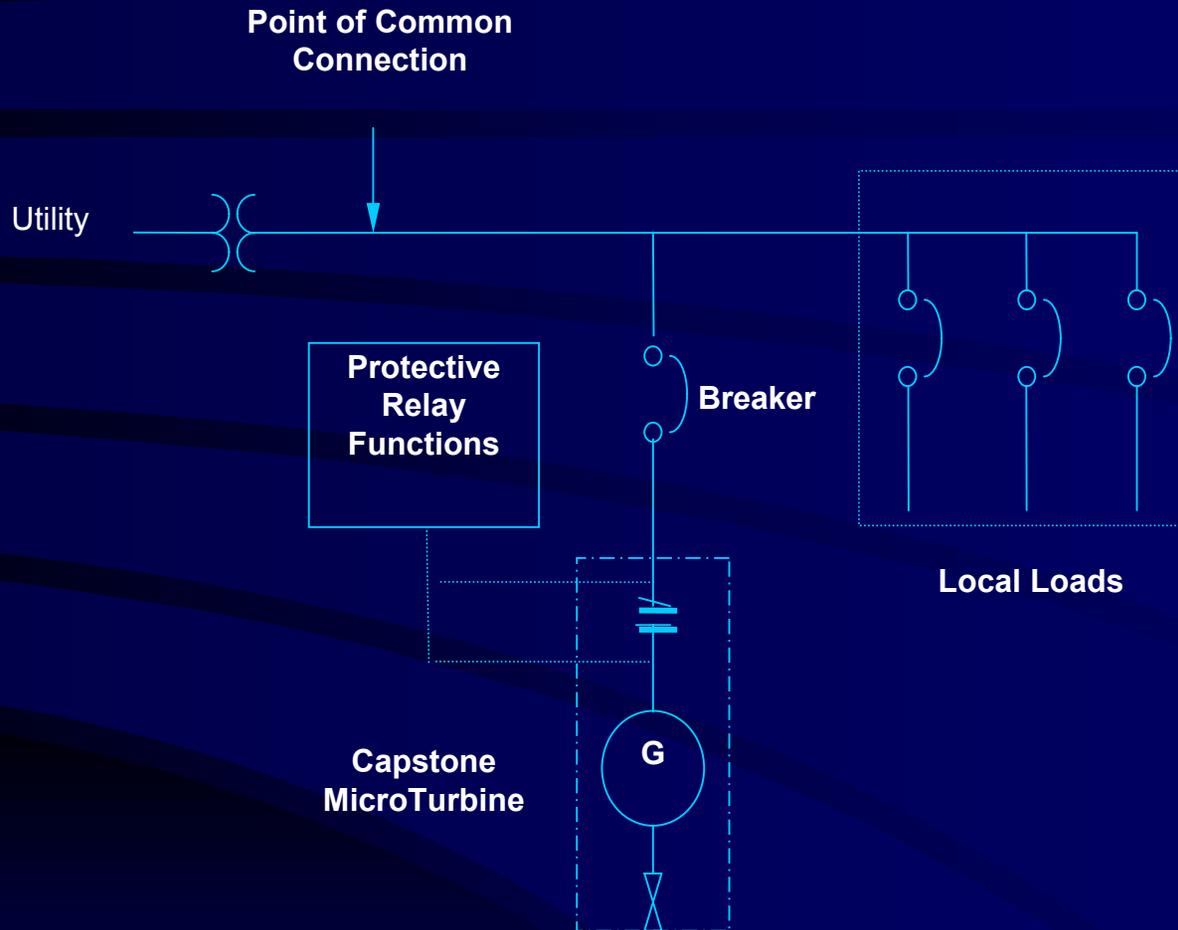
- Grid Connect
- StandAlone
- Dual Mode

# Installation Types – Single Unit w/ External Relay (Grid Connect)



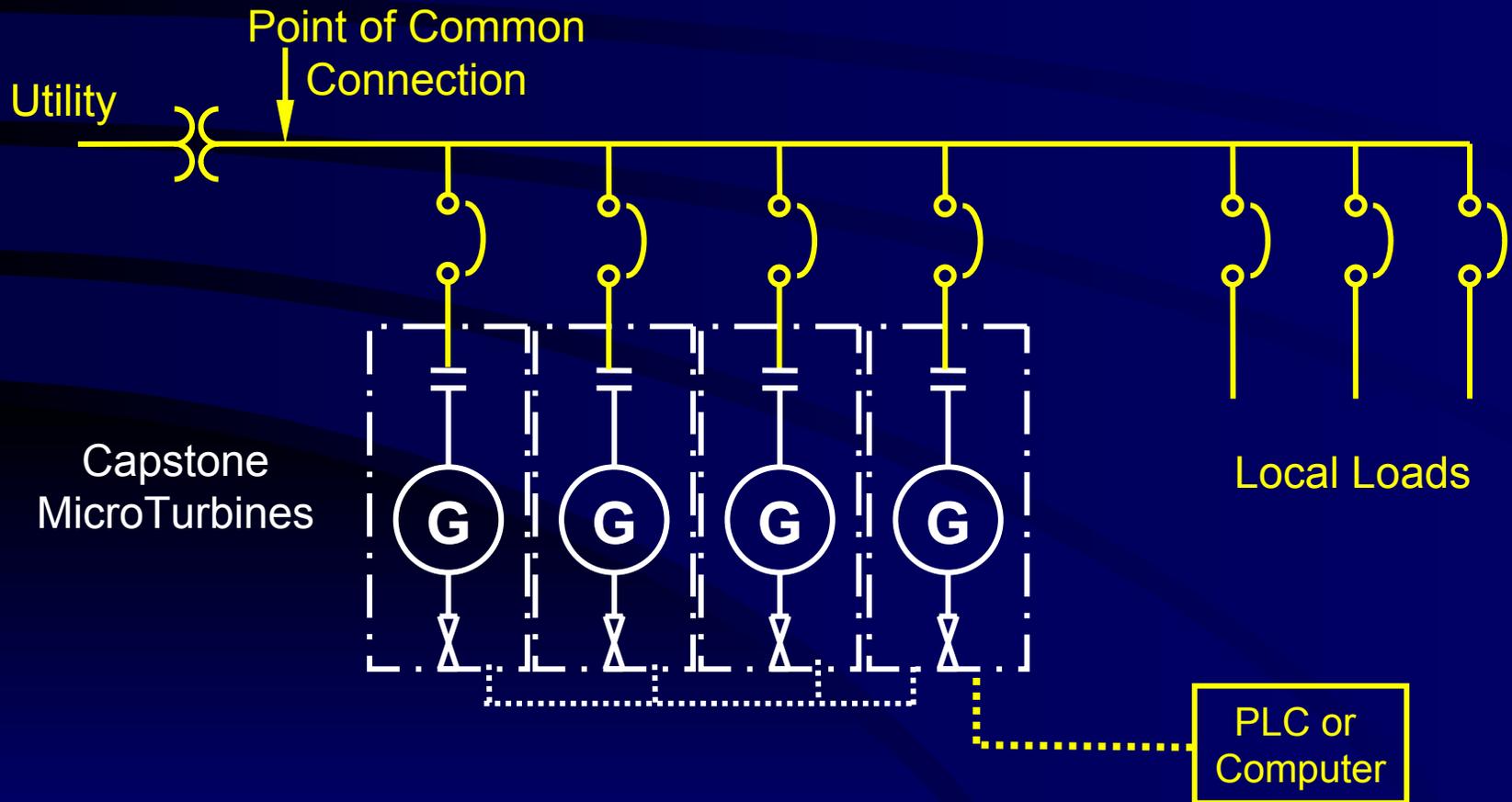
**Most microturbines (and internal combustion engines) require external protective relays**

# Installation Types – Single Unit using Internal Relays (Grid Connect)

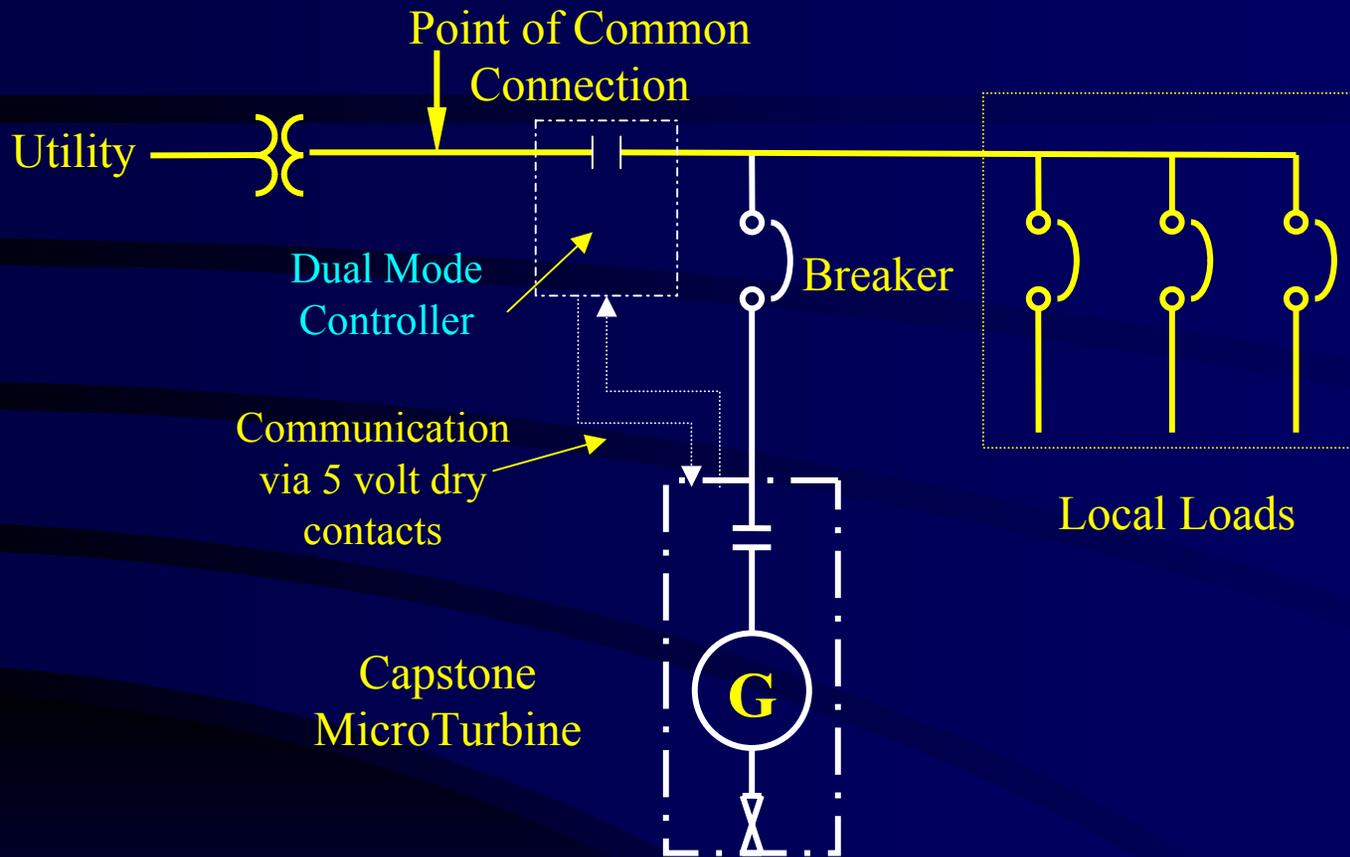


**Protective Relay Functions are built into the Capstone MicroTurbine and shut the Microturbine down if an island is detected or if the voltage or frequency fall outside of their programmable setpoints**

# MultiPac Installation Grid Connect



# Installation Types – Dual Mode



**An external controller automatically isolates the grid when the grid loses power, and commands the Microturbine to run in Stand Alone mode to supply power to protected loads. When the grid returns, the Microturbine shuts down and is commanded by the controller to run in Grid Connect mode again**



# Power Electronics & Interconnection



## Microturbine concerns

- Switching transients
- Harmonics
- Sags
- Surges
- Fault contributions
- Phase imbalance



## Grid concerns

- Harmonics
- Voltage regulation
- Fault current contributions
- Protective functionality
  - Over/under-voltage
  - Over/under-frequency
  - Over-current
- Anti-islanding
- Reverse power
- Overall safety

# Grid Interconnect Protection

- Protective Relay Functions are built in
- Inherently safe Grid Connect design prevents islanding
- Current-limited output – Basically no fault current
- Reverse Power Flow protection requires external power meter

# Over / Under Frequency

System will initiate a **shut-down** if frequency falls outside limits for 'Y' seconds

- Maximum 65 Hz  
user adjustable down to UF setting
- Minimum 45 Hz  
user adjustable up to OF setting
- Y is factory set to 10 seconds, adjustable down to 0.01

# Under / Over Voltage

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## Under Voltage

- System will initiate a **shut-down** if any phase sags below **X volts** for **Y seconds**
  - X is factory set to **360 VAC**. User adjustable up to OV setting
  - Y is factory set to **10 seconds**, adjustable down to 0.01

## Over Voltage

- System will initiate a **shut-down** if any phase swells above **X volts** for **Y seconds**
  - X is factory set to **528 VAC**. User adjustable down to UV setting
  - Y is factory set to **10 seconds**, adjustable down to 0.01



# Fast Under / Fast Over Voltage

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## Fast (Secondary) Under Voltage

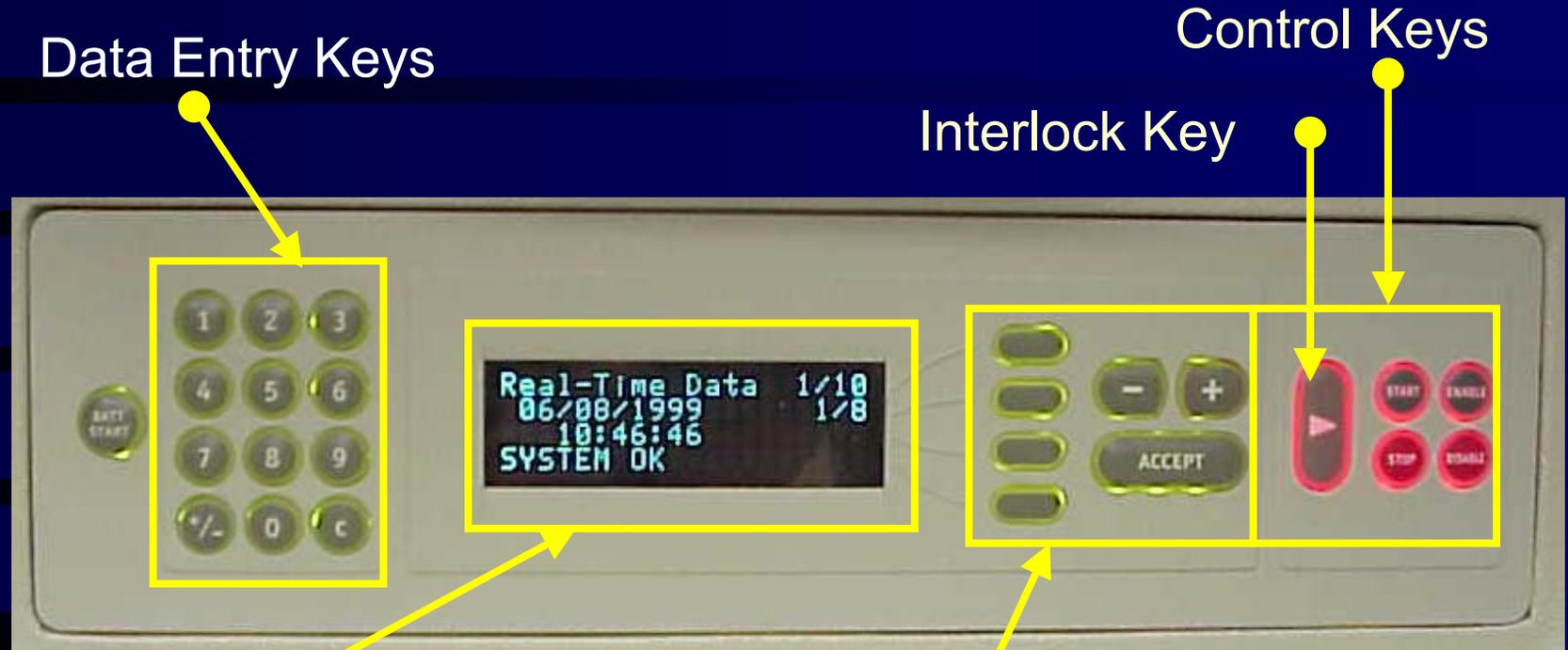
- System will initiate a **shut-down** if any phase sags below X volts for Y seconds
  - X is Primary UV minus 26 volts
  - Y is 50% of Primary UV time period

## Fast (Secondary) Over Voltage

- System will initiate a **shut-down** if any phase swells above X volts for Y seconds
  - X is Primary OV plus 26 volts
  - Y is 50% of Primary OV time period



# Data Entry Keys



Data Entry Keys

Control Keys

Interlock Key

Display Screen

Navigation Keys

4 lines, 20 characters  
Menu Feedback and Choices  
Display Data  
Make Selections and Enter Data

One Select Key for Each Display Line  
Forward and Back Keys Accept Key

# Capstone MicroTurbine Compliance List (Simplified)

- U.S. and Canada UL Safety Approval
- UL 1741 Certification (Inverters, Converters and Controllers)
- EPA Air Permit Exempt (Nat'l Gas)
  - Local permits may be req'd for Biogas
- Conforms to IEEE 519 (Harmonic Control)

# Installation Considerations

- **Mounting**
  - Is my mounting pad large enough and flat enough?
- **Public Access**
  - How do I limit public access?
- **Service Access**
  - Is there enough space to perform required maintenance and service tasks?
- **Fuel Supply**
  - Is my gas pressure high enough?
- **Power Wiring**
  - How long will my cable runs need to be?
- **Control Wiring**
  - How long does my communications cable need to be?
- **Intake & Exhaust Air**
  - Is my intake and exhaust air adequate?
- **Exhaust Heat**
  - Is there a concern about the high exhaust heat?
- **Regulatory Requirements**
  - Is UL approval required?
  - Which building and fire codes are applicable?

# Proper Installation Includes...

- Adequate workspace around equipment
- NEC req'd clearance at 480v Compartment
- Electric Disconnect per NEC requirements
- Turbine cabinet grounded
- Proper Gas Piping per NFPA (no plastic)

# Proper Installation Includes...

- Exhaust insulated with adequate clearances
- Heat Recovery equipment with proper safety features
  - pressure relief valve
  - “No Flow” alarm/shutdown
  - “High Temp” alarm/shutdown
- Fuel Shutoff Valves accessible
- Condensate being properly disposed of

# Applicable Standards and Codes

- UL 2200 Stationary Engine Generator Assemblies
- UL1741 Inverter, Converters, and Controllers for Use in Independent Power Systems
- UL508C Industrial Controllers
- NFPA 37 Stationary Combustion Engines
- NFPA 54 National Fuel Gas Code
- NFPA 70 National Electric Code
- ANSI C84.1 Electric Power Systems & Equipment Voltage Ratings (60Hz)
- ANSI 133.8 Gas Turbine Installation Sound Emissions
- CSA C22.2-100 Motors and Generators, Industrial Products
- Major building codes :
  - National Building Code
  - Uniform Building Code
  - Standard Building Code
- Existing Electrical Interconnect Standards
  - IEEE P1547 National Interconnect Standard