



## **1MW 4160Volt Diesel Generators**

### **Emergency Power Solutions**

**Turbine Marine Inc.  
1940 NW 32<sup>nd</sup> Street  
Pompano Beach, FL 33064  
Tel: 954-979-4409  
Fax: 954-984-8110  
[www.turbinemarine.com](http://www.turbinemarine.com)**

## **AIR-LIFT TRANSPORT SOLUTION**

**(May also be transported by pick-up truck, flatbed truck or air-freight)**

### **EQUIPMENT DESCRIPTION:**

Turbine Marine 1MW 4160Volts 60HZ 3 Phase Compact Series Turbine-Powered Generator

### **GENERAL DESCRIPTION:**

The Compact Series turbine-powered generator is so innovative and lightweight it can be easily towed with a standard size pick-up truck, or airlifted by helicopter as its weight is only approximately 9000 lbs and its overall dimensions are 144" L x 84" W x 86" H (12' L x 7' W x 7.16' H).

Its enclosure is sleek and aerodynamic to reduce drag while in tow or flight. The Military Lycoming T-53, engine powers the Compact series generator. It has the capability of using multiple fuels, including but not limited to: jet, diesel, gasoline and bio-fuels, without any changes to the unit by the user.

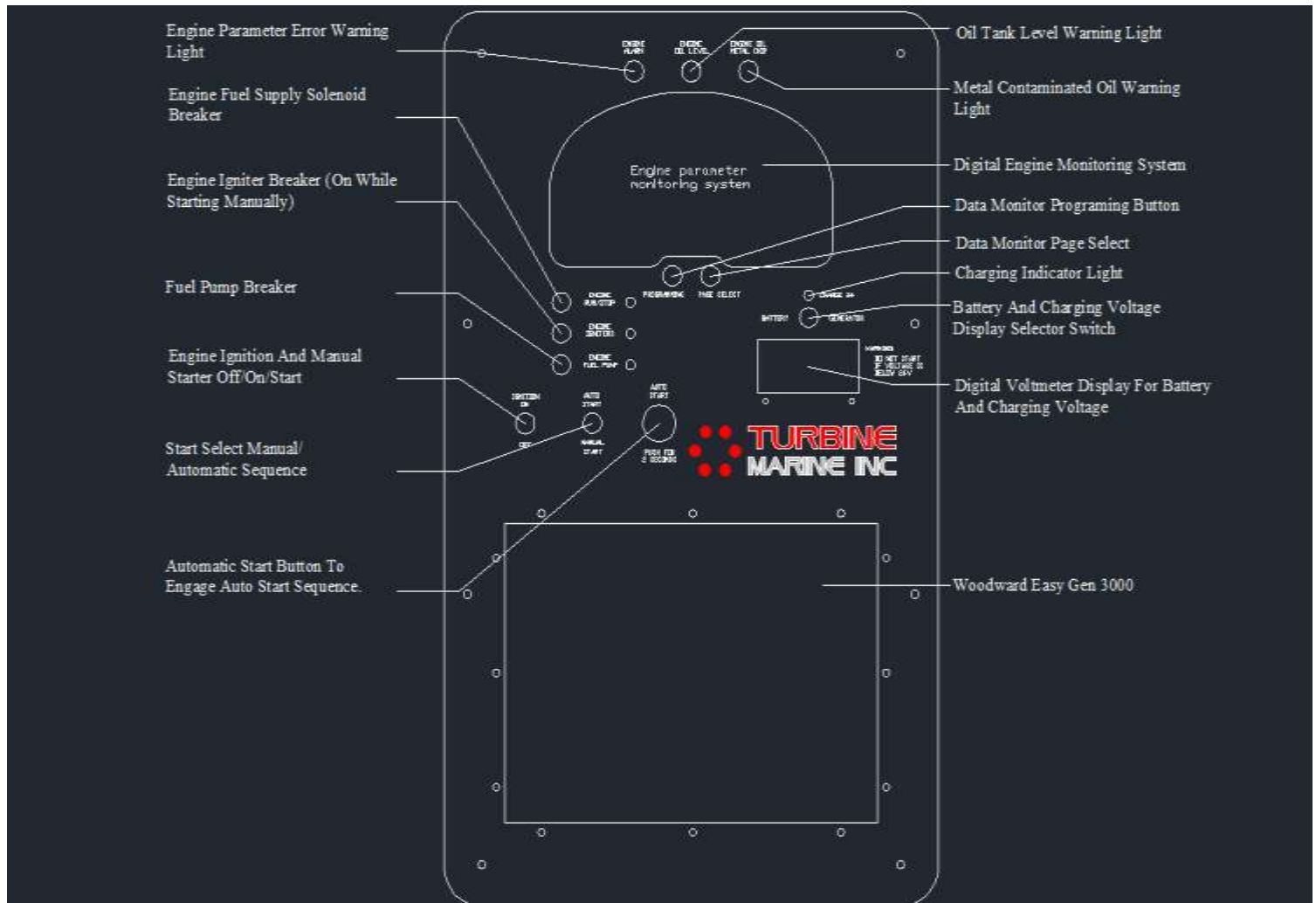
The Compact Series is manufactured with the highest industry standard components, such as Marathon Electric Generators (alternators) and Woodward Electrical controls for engine management and electrical current monitoring. The unit has a full digital control panel that is also capable of synchronizing multiple generator units. The 1MW generator assemblies can be ordered in any Hz and voltage configurations that the application may demand. The high-tech carbon fiber composite, fully weatherproofed enclosure houses a self-monitoring safety and shut down system. The enclosure also incorporates a dust/saltwater mist air filtration system for both the generator and alternator. This filtration system allows proper operation in any conditions land or sea. The generator assembly can be trailer-mounted for easy mobility. The trailer is a quick-mount system that can be removed in minutes and, by the use of the built-in air lift apparatus, the generator can be lifted by a medium size helicopter. All of our generators are easily serviced throughout the world.

## **ENGINE: RE-MANUFACTURED LYCOMING T-53 GAS TURBINE**

### **ENGINE TECHNICAL SPECIFICATION:**

<b>MAKER</b>	<b>TURBINE MARINE INC</b>
<b>ENGINE TYPE</b>	<b>LYCOMING T-53 GAS TURBINE</b>
<b>APPLICATION</b>	<b>POWER GENERATION</b>
<b>ENGINE POWER</b>	<b>Up to 1500 HORSEPOWER</b>
<b>TURBINE OUTPUT SHAFT RPM</b>	<b>1800 RPM</b>
<b>CYCLE</b>	<b>SINGLE</b>
<b>EXHAUST TEMPERATURE</b>	<b>600 C – 1112 F</b>
<b>EXHAUST FLOW RATE</b>	<b>13.1LBS/SEC</b>
<b>HEAT INPUT</b>	<b>13 MMBTU/HR</b>
<b>HUMIDITY</b>	<b>~ 20% BY VOL</b>
<b>FUEL</b>	<b>DIESEL #1, #2, LOW (&gt;15 PPM) AND ULTRA LOW SULFUR CONTENT DIESEL FUEL, GASOLINE, JET A, JP8, TS1, KEROSENE, BIO DIESEL,</b>
<b>FUEL PRESSURE</b>	<b>15 PSI</b>
<b>FUEL FLOW</b>	<b>110 GAL/HR (SAE) Standard Corrected Conditions</b>
<b>LUBE SYSTEM</b>	<b>SEPARATE INTEGRATED</b>
<b>STARTING SYSTEM</b>	<b>24 VOLT ELECTRICAL</b>
<b>START TIME</b>	<b>30 SECONDS</b>
<b>ASPIRATION</b>	<b>AIR COOLED</b>
<b>REDUCTION GEARBOX RPM</b>	<b>1800 RPM</b>

## CONTROLS AND GAUGES:



### ENGINE PARAMETER MONITORING SYSTEM

- (N1 Speed) Engine % Rpm
- (N2 Speed) Output Shaft % Rpm
- (EGT) Exhaust Gas Temperature
- Oil Pressure
- Oil Temperature
- Fuel Pressure
- Fuel Flow

### **ENGINE START UP:**

- 24 Volt Electric Starting
- 24 Volt Battery

### **LUBRICATING OIL SYSTEM:**

- Oil Tank
- Oil Filter
- Oil Coolers (Electrical Thermostat)
- 120 Volt Oil Heater

### **FUEL SYSTEM:**

- Fuel Priming Pump
- Fuel Filters
- Dry Break Fuel Connection

### **ENGINE COOLING SYSTEM:**

- Internally air-cooled

### **EXHAUST SYSTEM**

- Stainless steel welded with epoxy coated insulation

### **EXHAUST EMISSION DATA**

- NO EPA guidelines are required for this application and power plant.

## **FILTER SYSTEM**

- Dust /saltwater mist air filtration system for the engine

## **SAFETY FEATURES**

- Self-monitoring safety and shut-down system
- Emergency stop push button for engine shut- down
  - Disconnects generator output breaker
  - Terminates operation

## **EQUIPMENT SOUND LEVELS**

- 92 db's at 10 meters no load
- 95 db's at 10 meters full load

## **SPECIAL TOOLS, SPARE PARTS AND SHELF LIFE COMPONENTS:**

### **Spare parts:**

- Fuel filters (4 units) Cost of Each \$90 USD – In case fuel system is contaminated.
- Start fuel nozzles (4 units) Cost of Each \$750 USD - In case fuel system is contaminated.
- Engine air filter (1) Cost of Each \$275 USD

No special tools needed.

No parts/components needed that have limited shelf life subject to deterioration.

Recommended shelf life on filters is no more than 10 years

## **ALTERNATOR:**

### **TECHNICAL SPECIFICATIONS:**

#### **MARATHON ELECTRIC GENERATOR MODEL # 742FSM4364**

4160 Volts\*, 1200 kW, 1500 kVA, 0.8 P.F., 1800 RPM, 60 Hz, 3 Phase

Description	Value	Description	Value
Insulation Resistance	>10Meg	Overspeed	2250 RPM
High Potential Test		Phase Sequence CCW-ODE	ABC
Main Stator	9320 Volts	Voltage Balance, L-L or L-N	0.20%
Main Rotor	1500 Volts	L-L Harmonic Maximum - Total (Distortion Factor)	5.0%
Exciter Stator	1500 Volts	L-L Harmonic Maximum - Single	3.0%
Exciter Rotor	1500 Volts	Deviation Factor	5.0%
PMG Stator	1500 Volts	TIF (1960 Weightings)	<50
Stator Resistance, Line to Line		THF (IEC, BS &NEMA Weightings)	<2%
High Wye Connection	0.233 Ohms	Shaft Current	<0.1 ma
Rotor Resistance	0.768 Ohms	Main Stator Capacitance to ground	0.035 mfd
Exciter Stator	22 Ohms	Additional Prototype Mil-Std Methods are Available on Request	
Exciter Rotor	0.043 Ohms	Generator Frame	742
PMG Stator	2.1 Ohms	Type	MAGNAMAXDVR
No Load Exciter Field Amps at 4160 Volts Line to Line	.7 A DC	Insulation	Class H
Short Circuit Ratio	0.530	Coupling – Single Bearing	Flexible
Xd Synchronous	2.393 pu	Amortisseur	Full

<b>Reactance</b>	<b>27.633 Ohms</b>	<b>Windings</b>	
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<b>X2 Negative Sequence Reactance</b>	<b>0.242 pu 2.794 Ohms</b>	<b>Excitation</b>	<b>Ext. Voltage Regulated, Brushless</b>
<b>X0 Zero Sequence Reactance</b>	<b>0.03 pu 0.346 Ohms</b>	<b>Voltage Regulator</b>	<b>DVR2000E+</b>
<b>X'd Transient Reactance</b>	<b>0.189 pu 2.182 Ohms</b>	<b>Voltage Regulation</b>	<b>0.25%</b>
<b>X''d Subtransient Reactance</b>	<b>0.161 pu 1.859 Ohms</b>	<b>Cooling Air Volume</b>	<b>3870 CFM</b>
<b>T'd Transient Short Circuit Time Constant</b>	<b>0.166 sec.</b>	<b>Heat Rejection Rate</b>	<b>3759 Btu's/Min</b>
<b>T''d Subtransient Short Circuit Time Constant</b>	<b>0.013 sec</b>	<b>Full Load Current</b>	<b>208 amps</b>
<b>T'do Transient Open Circuit Time Constant</b>	<b>2.8 sec</b>	<b>Minimum Input hp required Efficiency at Rated load:</b>	<b>1697.2 94.8%</b>
<b>Ta Short Circuit Time Constant of Armature Winding</b>	<b>0.041 sec</b>	<b>Full Load Torque</b>	<b>4950 Lb-ft</b>



## **CONTROLS: WOODWARD 3000 EASYGEN PANEL**

### **TECHNICAL SPECIFICATIONS:**

<b>POWER SUPPLY</b>	<b>12/24VDC (8 TO 40 VDC)</b>
<b>CONSUMPTION</b>	<b>MAX. 17W</b>
<b>AMBIENT TEMPERATURE (STORAGE)</b>	<b>-30 TO 80 °C / -22 TO 176 °F</b>
<b>AMBIENT TEMPERATURE (OPERATION)</b>	<b>-20 TO 70 °C / -4 TO 158 °F</b>
<b>AMBIENT HUMIDITY</b>	<b>95 %, NON-CONDENSING</b>
<b>VOLTAGE AC INPUT</b>	<b>120VAC AND 480VAC TRUE RMS</b>
<b>ACCURACY</b>	<b>CLASS 1</b>
<b>CURRENT AC INPUT</b>	<b>1A OR 5A TRUE RMS, ISOLATED</b>
<b>ACCURACY IAC</b>	<b>CLASS 1</b>
<b>DISCRETE INPUTS (ISOLATED)</b>	<b>RANGE: 12/24VDC (8 TO 40VDC)</b>
<b>RELAY OUTPUTS</b>	<b>RELAYS, DRY CONTACTS</b>
<b>LOAD (RESISTIVE)</b>	<b>2A@24VDC AND 250VAC</b>
<b>ANALOG INPUTS</b>	<b>0 TO 500OHM, 0 TO 20MA</b>
<b>ANALOG OUTPUTS (ISOLATED)</b>	<b>± 10 V / ± 20 MA / PWM</b>
<b>FRONT PANEL MOUNTING (EASYGEN-3200)</b>	<b>PLASTIC HOUSING</b>
<b>DIMENSION (WXHxD)</b>	<b>282 × 217 × 99 MM</b>
<b>BACK PANEL MOUNTING (EASYGEN-3100)</b>	<b>SHEET METAL HOUSING</b>
<b>DIMENSION (WXHxD)</b>	<b>250 × 228 × 84 MM</b>
<b>SEALING (FRONT/BACK)</b>	<b>IP66/IP20</b>
<b>WEIGHT</b>	<b>APPROX. 1,850 G (PLASTIC HOUSING) APPROX. 2,150 G (SHEET METAL HOUSING)</b>

## **ENCOSURE:**

### **Carbon Fiber Composite Construction (light-weight for air-lift transport)**

- Lightweight and fully weather-proof
- Exterior Urethane paint finish with UV protection
- 316 Stainless hinges for all enclosure doors
- 304 Stainless locks with key entry for enclosure door
- Sound proofing on inner walls
- LED lighting
- Multiple doors for easy access

### **Trailer for Road Transport:**

- Twin axles, with 4 premium 235-85-16 tires
- Electric over Hydraulic brakes on all Axles
- Generator quick mount / removal system
- Brake and Turn signal lights

## **MAINTENANCE: ROUTINE SHORT AND LONG TERM MAINTENANCE GUIDELINES**

### **Short term:**

- Clean engine periodically with soap and water
- Replace fuel filters routinely
- Keep moving parts lubricated
- Keep batteries charged for full readiness (Built in battery charger)
- Maintain oil level in engine oil tank (No oil changes required before 2000 hrs)
- Keep exterior of unit clean by washing with soap and water (Not needed, however recommended)
- Check pressure in trailer tires when transporting over the road
- Check trailer break function when transporting over road

### **Long term:**

- Run engine quarterly if possible (No load needed)
- Check air lift harness for fraying and condition of straps
- Overhaul approximately two years of operation or 8,000 - 10,000 hours
  - These units are made for disaster emergencies; therefore, it is difficult to predict the operating conditions under which they may be exposed. An estimated time of a routine inspection and select component overhaul would be due after approximately two years of operation or 8,000 - 10,000 hours.

### **COMPLETE PARTS/MATERIAL LIST SUMMARY:**

- Lycoming T-53 Turbine Engine
- Engine Monitoring System
- Engine Governing System
- Emergency Kill Buttons on Exterior
- Marathon Electric Generator Model # 742FSM4364 or Equivalent
- Woodward 3000 EasyGen Panel Controls
- Carbon Fiber Enclosure with Stainless Steel Latches and Hardware
- Urethane Primer and Paint On Entire Unit (Skid And Enclosure)
- Turbine Marine Engine Intake Filter System
- Washable Engine Air Filters
- Stainless Steel Insulation Wrapped Exhaust System
- Oil Tank, Fittings and Lines
- Engine Oil Coolers, With Thermostats
- 24v Batteries (2 X 12v)
- 24v Engine Charging System
- Exterior Connection for 24v Battery Charger
- Fuel Pump, With Lines and Fittings
- Fuel Filters / Water Separators
- Internal Lighting
- Lift Rigging / Tie- Downs (Incorporated Into the Design For Air Transport)

- Easy Mount Lift off Release Trailer
- Trailer Hitch and Lights (For Towing By Truck)
- Trailer Tires (4)

#### **WARRANTY**

1 year from date of delivery.

#### **PRICING**

Upon request

#### **TERMS OF PAYMENT:**

Upon request

#### **Delivery Schedule:**

Subject to quantity

#### **SHIPPING:**

- Per unit shipping weight(s) in pounds: approximately 9000 lbs
- Unit dimensions in inches: 144" L x 84" W x 86" H (12' L x 7' W x 7.16' H).

#### **DESIGN DESCRIPTION**

##### **4160 VAC Trailer or Skid mounted generator**

Our generators are mounted on a quick-mount system trailer for over road transport. However, trailer is designed for an easy removal for air-lift transport. They are also equipped with hooks and hardware that allows them to be lifted by a medium size helicopter.

Our equipment has the potential to be utilized in various utilities across the United States. Using our own design, geared to emergency operations such as those that may be experienced by the Purchaser, our generators are specifically designed for the emergency, standby requirements of this bid.

## General

Our equipment is non-safety-related (commercial grade).

Our equipment is made with common materials and components.

Our equipment can be lifted by a forklift and is designed to be lifted by a medium sized helicopter and/or sent by air-freight. Our units have the following dimensions, 144" Length, 84" width, and 86" height.

Separation of support equipment is required, such as fuel tanks and circuit breaker assembly will be designed to have air-lift capabilities.

The units have preinstalled lifting points and connections to be transported by helicopter.

The T-53 turbine engines can operate on DIESEL #1, #2, Low (>15 ppm) and ultra low Sulfur content Diesel fuel.

Controls and gauges include Start/Run/Stop switch, Voltage Meter, Oil Pressure, Tachometer, Engine air temperature, Fuel gauge.

*Diesel fuel tanks can be provided separately. The unit was designed WITHOUT fuel tanks to meet weight requirements for air transport with medium duty helicopter.*

Turbine Marine Compact series generator units can be operated at any power level for any period of time. Power output from 50Kw at engine idle up to 1MW at full load. The turbine engine system is designed to throttle back to minimize fuel consumption at lower levels of load.

The generator will have a steady state output voltage rating of 480 VAC. It will meet the Voltage regulation no load to full load to plus or minus 0.5 percent voltage regulation.

The generator will be a three phase 60 Hz synchronous machine. Steady State frequency variation will be within plus or minus 0.25 percent.

The generator will have the capability to auto synchronize and operate in parallel with a similar rated machine for extended duration. The engine and generator set will have all necessary hardware to parallel multiple machines with any interface requirements supplied by Turbine Marine Inc.

The engine and the generator will be able to withstand full load rejection without tripping or over speeding.

The generator will have neutral ground and two safety ground capability. The Safety ground will be capable of connecting to station grounding grid for proper equipment operation and personal safety.

The engine and the generator will have its instrument rack and the control panel with all the controls including the emergency stop button and alarms.

The generator will trip and alarm on under-voltage, over-current, and reverse power conditions. The required power to operate the protective devices will be integrated into the generator assembly. No site power will be needed to operate the protective devices.

For an over-speed, short-circuit conditions, the generator will have an automatic shutdown and alarm.

Circuit breakers for conductor protection can be provided separately!

### **Environmental requirements**

The engine, generator and support equipment will be capable of continuous duty rated output at an ambient temperature between -40 F and 130 F.

The engine and generator will be capable of starting and developing required output characteristics without external support for starting in these environmental conditions, following a transportation period of up to 16 hours (i.e., no external power supplied to auxiliaries, such as heaters or battery chargers).

The engine, generator and support equipment will meet the description as described in NEI 12-06, "Portable towable equipment that is designed for over the road transport typically used in construction/remote sites are deemed sufficiently rugged to function following a BDB seismic event."

## **Principles and Methods of Operation:**

**Principle:** A Turbine Marine prepared turbo shaft turbine aviation engine is directly coupled to an industrial 1 MW alternator. A Woodward (off the shelf Diesel engine unit) electronic governing system is connected to the turbine engine's liquid fuel control system that maintains 60Hz as it adds or removes fuel from the engine. This is possible as the electronic governing system senses RPM from the on-board sensors.

## **Method of Operation for 1MW (Continuous Operation) Generator Air- Lift Transport:**

### **Airlift Transport:**

1. Lower generator unit on as flat as possible surface.
2. Lower fuel bladder as close to generator unit as possible.
3. Lower Generator's main breaker and cable assemblies as close to unit as possible.

### **Electrical Connections:**

4. Connect all cables from generator to generator main breaker. Breaker control cable / Line Phase 1 / Line phase 2 / line phase 3 / Neutral / Ground. (All Cables and connections will have standard color coding)
5. Connect load to generator main breaker (Confirm phase rotation to color codes on generator main breaker)

### **Fuel:**

6. Connect fuel source to generator unit and open fuel vent valve on tank. (Quick disconnect Dry break fuel coupling and hose supplied with fuel bladders assembly)

### **Generator Operation and Automatic Start Sequence:**

7. Secure or remove 4 point generator lifting harness used for air transport from generator unit. (Must not obstruct exhaust or air intake on generator unit).
8. Remove generator engine air intake cover
9. Turn main start battery switch on.
10. Turn on generator ignition switch and position start selector switch to Auto.
11. Turn on fuel priming pump.
12. Push start button for 2 seconds and release. (Auto start function has initiated)
13. Unit will spool up for 30 seconds and start. Generator unit is now stabilized at 60 Hz and is ready for operation.
14. After unit is in operation.
  - \* check oil level indicator sight Glass on oil tank. If oil level indicates low, top off oil level using on board oil supply tank.

(Open oil supply tank level valve until oil is at full mark on oil tank indicator, then close valve).

15. Any abnormal engine or alternator operating parameters will now be visible on the dash panel warning light system if triggered.

## **Generator Parallel Operation Procedure for Turbine Marine 1MW Compact Series Generators**

### **Airlift Transport:**

1. Lower main Circuit breaker with busbar on a flat as possible surface  
Electrical connections:
2. Connect emergency load to main circuit breaker. Breaker control cable / Line Phase 1 / Line phase 2 / Line phase 3 / Neutral / Ground. (All Cables and connections will have standard color coding)
3. Connect all generator main breakers that will be run in parallel to emergency load main breaker. Breaker control cable / Line Phase 1 / Line phase 2 / Line phase 3 / Neutral / Ground. (All Cables and connections will have standard color coding)
4. Connect circuit breaker control and load sensing cables to generator circuit breakers and main emergency load circuit breaker.
5. Connect CAN bus cable between generator control panels that will be run in parallel.
6. Start all generators that will be run in parallel per operating instructions (generator operation and automatic start sequence).
7. Generators will engage generator circuit breakers and synchronize before engaging main circuit breaker connecting to load.
8. Woodward Easy-gen system will sense load and shut down generator (s) not needed to carry load to save fuel. The delay time for adding another generator on line to maintain load is customer programmable.



The system is a NON- generator priority, system. Selection of units running to supply load demand is made by the Woodward Easy-gen 3000 in real time. Failure of one generator will not interrupt service of the other units. Adding an additional or replacing a failed generator can be performed while other units are in service.

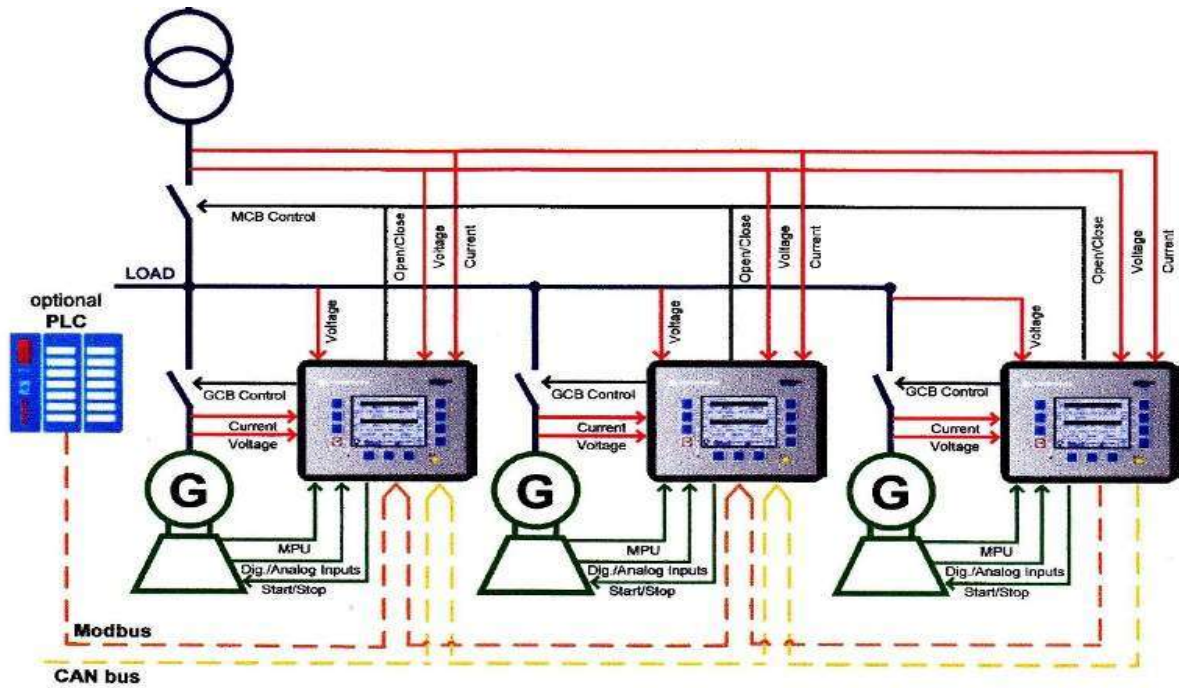


Figure 3-1: Multiple genset application mode

If the Woodward Easy-Gen 3000 automatic start sequence fails, the start procedure can be switched over to a manual start sequence bypassing the Easy-Gen 3000 with a switch. The manual start sequence requires the operator to hold the Start button depressed for 30 seconds as the unit spools up for start. The unit is now ready for its full load.

**John Arruda**

**President, Turbine Marine Inc.**