

Energy Conversions, Inc.

Economizer Dual Fuel Conversion System



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(ECI) was formed in 1984 for the express purpose of development of natural gas retrofit conversions for medium and high speed diesel engines. It supplied the dual fuel conversion technology for the first full horsepower natural gas locomotives in the US, Burlington Northern's BN 7890 and BN 7149. Other projects include four EMD 645 12-cylinder generator sets converted to dual fuel on an offshore drilling rig in Trinidad, three EMD 645 20-cylinder generator sets converted for Springville Light & Power, in Utah. ECI also applied their technology to Caterpillar 399, 398 and 379 to run on dual fuel. Other dual fuel project ECI developed a spark-ignited system for the EMD 645, and currently in operation by NAPA Valley Railroad. A gas prechamber is used to spark-ignite a small amount of pilot gas in turn igniting the main chamber. This system will offer diesel engine users the conversion option of running completely diesel-free applications with their existing units.

ECI Introduces its latest dual fuel conversion system for the industrial four stroke diesel engine market. The Economizer is a cost effective and affordable means of converting diesel engines into diesel-natural gas engines. Allowing the use of cost effective natural gas without changing the entire engine. The Economizer dual fuel system is designed to be installed on new or existing diesel engines without modifying any internal engine components. Installation of the components are straightforward, with only reasonable mechanical expertise required. Final tuning and testing is typically performed by a trained service technician. Dual fuel units also allow the user the flexibility to run strait diesel or natural gas with diesel, an extremely important consideration for applications with potentially interrupted gas supply. Diesel operation remains unchanged. The

Economizer is engineered so if a function falls out of normal operational limits, full diesel operation is resumed instantly and seamlessly, with no interruption of service. The Economizer system is offered in three standard models with each model covering an approximate range of engine generator power.

- System 1: 150 to 300 KW Single Turbo**
- System 2: 300 to 1000 KW Dual Turbo**
- System 3: 1000 to 2000 KW Dual Turbo**

(Smaller and larger conversion systems are also available)

The Economizer utilizes electronic controls that monitor engine operation and automatically detect when gas operation is allowed, controlling the amount of gas the engine can operate with. The computer control utilizes closed loop tuning to maintain maximum fuel replacement while protecting critical engine parameters measured through industrial sensors. When all parameters are in proper levels, low pressure natural gas is delivered through a air/fuel diffuser to the intake air. Gas travels in the intake manifold to the combustion chambers, where it mixes with a small amount of diesel "pilot fuel" to facilitate combustion.

What It Takes:

Installation of the Economizer hardware usually takes two or three days. The site needs a gas supply line with at least 2 PSI of available gas to engine area. The gas supply needs to be routed within 8 to 10 feet of the engine. The system also requires voltage for powering the control systems typically 24 volts DC. All other necessary component to install conversion system is supplied in kit. Conversions system will

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include sensors to measure critical engine functions like engine speed, load, boost pressure, water temperature, governor position and gas pressure. Wire harnesses come with connector that is are pre-wired for Electronic Control Unit and finally the Gas Controller itself. The controller program is custom tailored to match the details of the engine/governor design. Fuel tables are developed for each engine family on site if necessary by performing a fairly simple load test. During the testing the fuel table numbers are generated and programmed into the control system. For engines already having been converted only testing and confirmation of proper operation is necessary. A standard laptop PC equipped with optional software may be connected to the ECU to conveniently view data at a remote location and download information for long term storage and further analysis.

SYSTEM HARDWARE LIST:

- Gas Supply,
 - Shut off valve
 - Gas Filter
 - Pressure regulator
 - Automated shut off valve
 - Gas flow control valve
 - Diffuser
 - Connecting fittings and hose
- Sensors,
 - Boost pressure
 - Gas pressure
 - Barometer
 - Speed
 - Kilowatts
 - Governor Position
 - Water temperature
 - Exhaust Gas temp. *
 - Knock / vibration *
 - Wires and connectors
- Electronic,
 - Control system,
 - Control computer
 - Analog module
 - System information screen *
 - Amplifier *
 - Knock detection filter *
 - Power module
 - Power relays
 - Driver module
 - Terminals, wire connections

* indicates optional equipment for smaller engine systems

Quality:

While reducing equipment cost is an important goal, no short cuts are taken with respect to quality. Only top quality products are utilized in the conversion system. From the touch screen information panel to the gold plated electrical connectors, there is quality around every corner.

Economics of Dual Fuel:

An ECI conversion is a sound investment for power users who are looking to upgrade their current system to alternative fuel technology, without revamping their entire system. As a retrofit technology, the ECI system provides an economically attractive alternative to buying costly new generators.

With the ability to operate both fuels, the engine will never be down due to a lack of adequate gas fuel supply. Another distinct advantage of dual fuel is the decreased engine wear that comes with the use of cleaner fuel. Due to a reduction of carbon soot buildup and cleaner lube oil, longer intervals between service maintenance can be expected, sometimes doubled. This means a longer economic life for the engine and a better overall return on your investment.

Cost Savings:

To determine approximate cost savings you will need to determine your present fuel cost, your fuel replacement percentage and replacement cost with natural gas. Be sure to apply any losses of efficiency and always estimate on the safe side. Ask a ECI representative to help you in determining your annual cost savings including fuel and maintenance.

When considering the cost of natural gas also consider your contract options with you gas supplier. Many suppliers are willing to give better rates if they are able to interrupt your fuel supply. An interruptible rate is exactly why the Dual Fuel system is a desirable option.

Fuel Curves

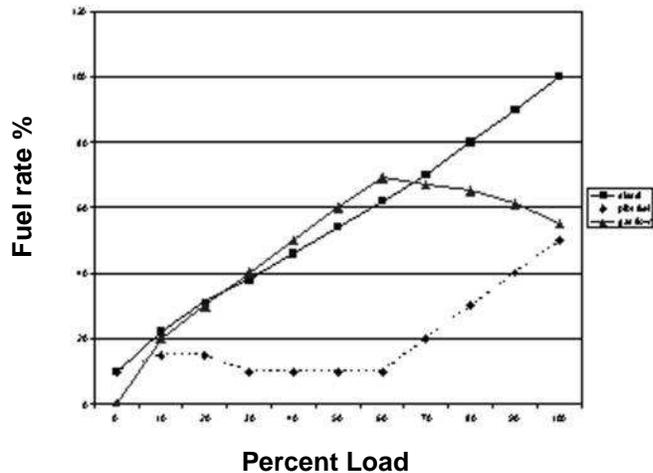


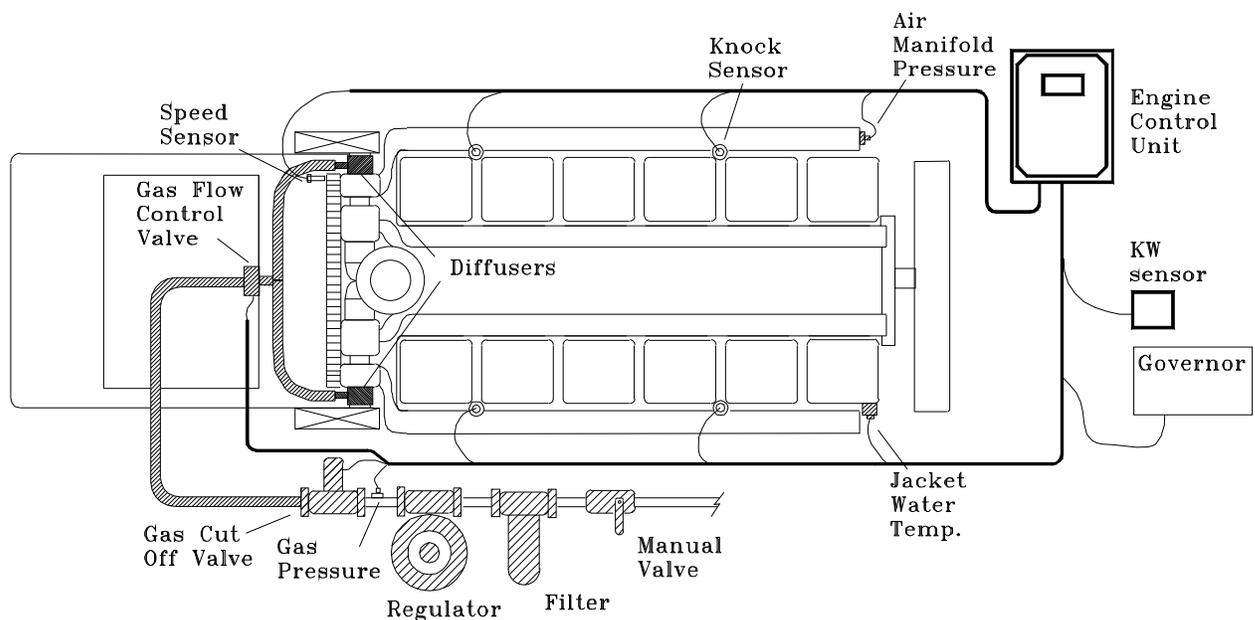
Chart of typical fuel replacement curves indicating the minimizing of pilot fuel at part loads while maintaining full power capacity with out combustion knock.

The Knock Discussion:

Combustion knock is where the already ignited, burning air fuel mix in the combustion chamber starts to auto-ignite from the increasing pressures and high temperatures. It causes high pressure spikes and can cause engine damage. Knock is the reason many engines can not run full power at a minimized pilot fuel setting. Each engine family has its own differences. Different fuel timing, compression ratio and Turbocharger configurations affecting air fuel ratio, boost pressures and temperatures. The ambient temperature affects the combustion and so does the content of the gas. All of these factors come into play and make it somewhat difficult to predict exactly what power limit will be reached with minimized pilot fuel and what amount of pilot fuel will be required at full power. The Economizer system is designed to replace as much diesel fuel as is possible without running into the combustion knock limit. To accomplish this the controller is programmed to meter gas fuel into the engine based on its fuel map. The map is a curve fit to the capacity of the engine. On larger engines knock detection is used to protect the engine in case the fuel gas content changes and replacement levels need adjusting.

System Overview and Description

The ECI Economizer dual fuel system is a retrofit technology that allows diesel engines to operate on a mixture of diesel fuel and natural gas. Conversion to ECI Economizer requires no major changes or modifications of the engine. After conversion to dual-fuel, the engine still operated on 100% diesel fuel without the loss of power or efficiency. The dual fuel system has been designed to allow for switching of fuel modes during full or part load conditions, without interruption in engine speed, power or stability. The system utilizes a fumigation gas delivery method whereby gas is delivered to the cylinders via the standard engine air-intake system and is then ignited by diesel pilot which acts as an ignition source for the air gas mixture.



Additional Conversions:

EMD conversion systems (Electro Motive Division) of General Motors is a two stroke cycle diesel that ECI has exclusively developed a conversion system for. Full power with high fuel replacements are its bench marks. This is a high end system initially designed for the locomotive industry.

**Springville Power 20 Cylinder Turbocharged
EMD 645 Dual-Fuel Conversions**



Caterpillar 3512



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