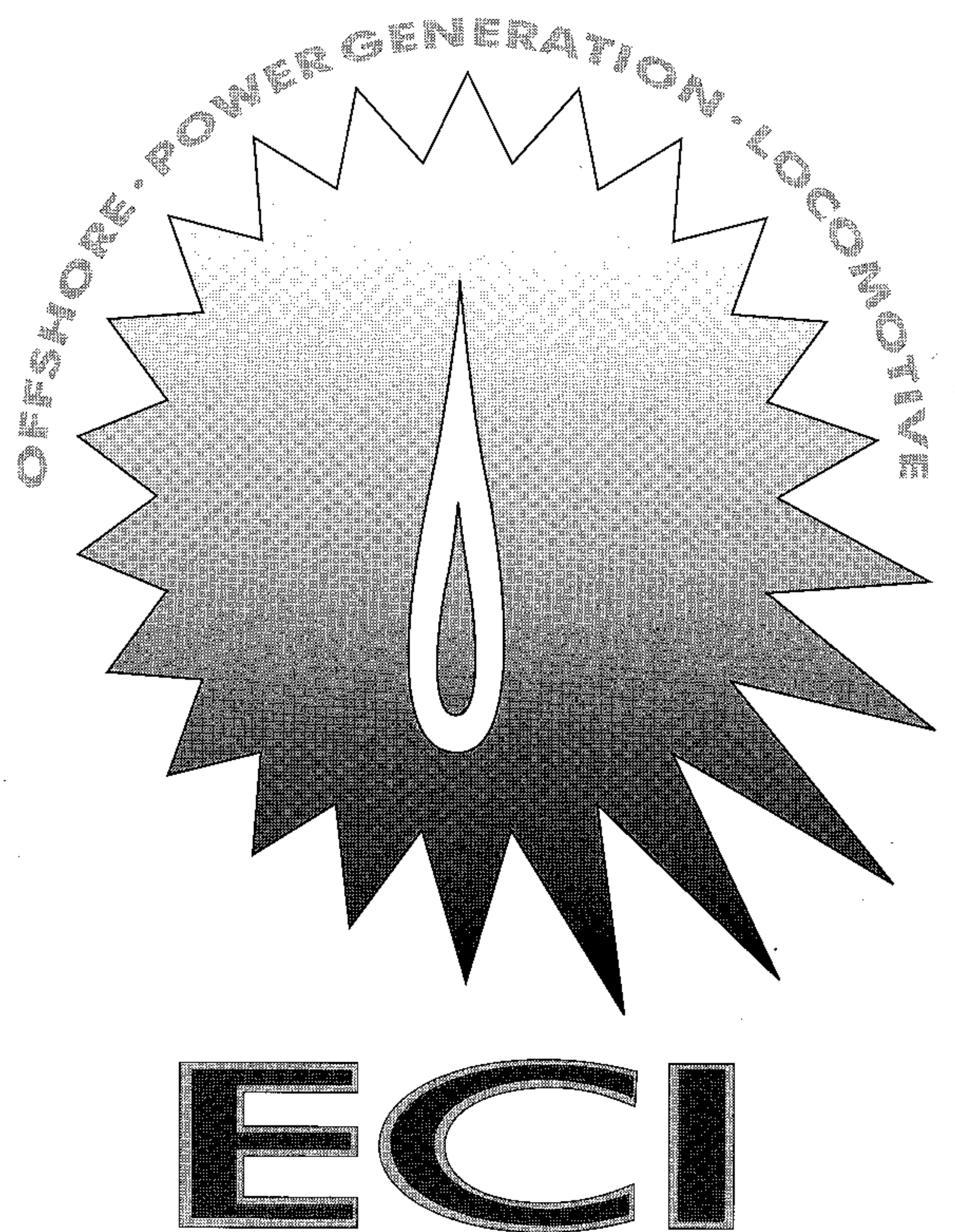


ENERGY CONVERSIONS INC.

Company Profile



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With gratitude— Energy Conversions, Inc.

Company Profile

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Through its ability to overcome technical limitations, Energy Conversions, Inc., has made its mark in the field of converting diesel engines to natural gas use. In addition to converting a pair of locomotives for Burlington Northern, the company has converted a variety of large, heavy-duty engines for both mobile and stationary applications.

Energy Conversions, Inc. (ECI), has managed the development of natural gas retrofit conversions for medium- and high-speed diesel engines since its formation in 1984.

ECI was founded by Industrial Trade Exchange, Inc. of Savage,

Minn., and Commercial Sales, Inc., of Tacoma, Wash., which has more than 30 years experience in marine and industrial diesel engine parts, service and rebuilding. ECI personnel consists of experts in many fields, including mechanical

engineering, computer science, mathematics, marketing, finance and graphic design.

The key to ECI's success has been its ability to overcome technical limitations that previously hampered the viability of converting

large engines to gas, including LNG. Prevailing engineering wisdom had been that no modified diesel engine would ever be able to produce full diesel horsepower on natural gas because modifications required to make a diesel suitable for natural gas operation decreased maximum output to the extent that a derated gas engine will generate only 50 to 75 percent of total diesel power. Gas therefore never gained much serious consideration as an alternative fuel for high-consumption transportation uses, either from big-engine manufacturers or from fuel customers.



Burlington Northern installed the ECI dual-fuel conversion in this SD-402-2 locomotive powered by a 16-cylinder EMD Model 645 E3B engine. The tender car behind it carries enough LNG to fuel a pair of these engines for a range of 1,600 miles.

ECI Conversion Kit Components

Pistons and Cylinder Heads	Ensure gas/air mixing, and along with the adjusted compression ratio ensure good combustion. Cylinder head is designed to accept the standard diesel injector, along with the ECI gas inlet valve.
Gas Inlet Valve	Provides a reliable method of metering and injecting gas into the cylinders. It is a pneumatic device, electrically actuated, whose timing can be precisely controlled by electronic means.
Electronic Control Unit	Controls critical engine functions such engine speed and, in locomotive applications, generator excitation, while monitoring engine temperatures and pressures for safety and data logging purposes. Incorporates constant electronic and mechanical equipment checking into a comprehensive safety system, designed to switch the engine immediately to full-diesel operation in the event of an irregularity, without service interruption.
Pilot Fuel Control	Employs an electronically controlled device that attaches to the governor/fuel rack linkage to enable engine to run equally well on full diesel or on natural gas at operator discretion.
Low Emission Idle	Improves pollutant emissions at low engine speeds while in full diesel operation. An electronic controller and mechanical linkage cause the engine to alternate left and right banks of cylinders. Even wear and load is maintained, but fuel consumption is reduced by 15%, reducing emissions during idle.

Source: Energy Conversions, Inc.

Convinced that full diesel power could be developed by a converted engine, the company set out alone to prove the point.

If accomplished, it would mean literally a brand new era in rail power, and high-consumption transportation in general, since natural gas would finally become an economically sound option for large-engine use.

ECI's technology, first introduced in 1988, enables the converted engine to operate at full original diesel horsepower; previous conversion systems sacrificed horsepower to use gas.

The ECI conversion system described in the table above converts the General Motors Electro-Motive-Division (EMD) model 645 medium-speed, high-horsepower engine. This two-cycle diesel is extremely versatile, providing power in applications as

varied as rail locomotives, stationary electrical generators, industrial installations such as ore crushing or irrigation, and marine propulsion.

Each of these uses involves slight differences in engine configuration, since each needs to optimize different performance characteristics of the basic engine.

The conversion kit has been engineered to accommodate the requirements of a wide variety of applications. Its flexible modular design enables ECI to tailor a conversion system to the needs of the end user.

The resulting gas admission system has a air-fuel ratio of 26:1. The gas admission system provides a homogenous fuel-air mixture, somewhat leaner than stoichiometric, resulting in full diesel horsepower from a lean-burn combustion system. ECI engineers

optimize the piston crown shape to provide better gas/air mixing than stock pistons provide.

ECI is perhaps best known for supplying the conversion technology for Burlington Northern's BN 7890 and BN 7149, the first full-horsepower natural gas locomotives in the world. Burlington Northern agreed in 1988 to purchase a conversion, with the stipulation that ECI meet the full-horsepower goal.

The \$15 million project involved eight years of work. Field trials of the BN 7890 and BNGT 100 began in February 1992. ECI engineers began work by developing a new type of gas injection valve and electronic valve sequencer. They then converted an eight-cylinder test engine, outfitting it with the latest in data acquisition and sensor technology.

A testing program unveiled a

need for new piston and cylinder head designs. ECI developed new designs that enabled the engine to operate with equal fuel efficiency in both diesel and gas modes.

Following an extensive 500-engine-hour durability test, field trials of the BN 7890 and BNGT 100 began in February 1992. Following the field trials, the completion of unit BN 7149 and tender BNGT 101 was undertaken.

Both BN 7890 and BN 7149 were subsequently fielded in BN's coal service between Decker, Mont., coal mines and Superior, Wis., ship-loading coal dock. Both locomotives and tender 101 continue to operate on Burlington Northern.

Railroad Conversions among Many ECI Projects

In Addition to the railroad work, ECI has performed natural gas conversions on large, low-speed Chicago pneumatic generator for the

Hawaiian research and development firm Unisyn. In this conversion, ECI attached Impco gas carburetors and designed and applied the conversion technique.

Another project involved maintenance and overhaul of ship engines for the National Oceanic and Atmospheric Administration (NOAA). The work included main engine and generator repair, and was performed in Dutch Harbor, Alaska and Lake Union in Seattle. Engine overhauls included EMD, Fairbanks/Morse, Caterpillar and Detroit Diesel Corp.

The U.S. Navy is also a client. The Naval Facilities Engineering Command Contracts Office awarded a contract to ECI to convert equipment and for technical services associated with converting diesel engines into dual-fuel engines. In addition, ECI performed dual-fuel conversion on a

high-speed 200 HP Caterpillar 3208 diesel truck engine, complete with micro processor controls.

ECI also rebuilt engines and pumps on the Bima gold dredge — the world's largest — in Tacoma, and maintained in Nome, Alaska, for West Gold, Inc.

Armed with patented designs for conversion system components — gas inlet valves, electronic control units, and pistons and cylinder heads — ECI pursues a future of new engine conversion challenges. ECI's advances in technology help to improve LNG's practicality as a heavy-duty motor fuel.

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