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Fuel Efficient Internal Combustion Engine (ICE) Technologies Worldwide

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Abstracts

Internal combustion engines (ICEs) power our cars, trucks, big rigs, trains, generator sets, ships, and a host of other applications worldwide. Unfortunately, conventional ICEs boast low efficiency – most convert only 30% of fuel into usable work, and that is under optimal conditions. When accounting for idling and sub-optimal speeds, efficiency drops to 15 to 20%. That means, for every gallon of fuel placed into the engine, only 15 to 20% of the energy in that fuel is ever transferred into usable mechanical energy under typical conditions. The remaining 80 to 85% of energy contained in the fuel is wasted – wasted on friction, losses to heat, incomplete burning, and other inefficiencies characteristic of conventional ICEs.

Spurred by the current global focus on reducing carbon emissions, promoting sustainability, and enhancing energy use efficiency, global governments and industry leaders are driving strong interest, research, and investment in improving ICE efficiency. Companies as diverse as automaking giants Ford Motor Company and Toyota, to engine manufacturers in the U.S. and Europe, to a handful of tiny Silicon Valley and MIT associated startups, are pushing the efficiency envelope of ICEs.

Generally speaking, ICE efficiency measures come in two forms: (1) specialized components, add-ons, and auxiliary systems that are worked into the basic framework design of a conventional reciprocating internal combustion engine; and (2) highly modified or novel engine designs, which seek to re-engineer the internal combustion engine from the ground up, using alternative and novel designs and processes. Measures in the former group are being more widely pursued by the existing automotive and ICE production industries, where manufacturers are focusing on incremental design updates to conventional engines. These technologies include engine deactivation, cylinder deactivation, variable valve timing and lift, turbochargers and superchargers,

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direct fuel injection, smaller displacement motors, hybrid and partial hybrid systems, and homogeneous charge compression ignition. These measures apply to conventional designs with relatively little modification.

The second category of ICE energy efficiency measures provides a more radical break from convention, and is being forwarded primarily by various small and mid-sized start-ups and venture capital firms, alongside breakthrough-oriented government grants and other funding mechanisms. These endeavors significantly redesign internal combustion engines, and include redesigned combustion chambers, opposing piston designs, split cycle engine designs, opposed piston/opposed cyclinder engines, and updated rotary engine designs. Proponents and investors in these technologies are focusing on the larger industry's current lack of interest in breakthrough-oriented ICE technologies, and generating a race toward commercialization for potential new technologies.

Now is therefore an exciting time in the ICE engineering and technology industry. Mainstream industry investment in design upgrades will drive typical operating engine efficiency up from 15-20% to upwards of 30%. Some of the potential breakthrough/redesigned systems claim efficiencies upwards of 40 and 50%, although commercialization of these technologies has not yet been achieved. Accordingly, many industry insiders and durable goods manufacturers are banking on sharp increases in demand for energy efficient ICEs in the transportation and distributed generation industries worldwide. Expectations are driven by a lack of foreseeable near term technological maturity and competition from fuel cells, electric motors and batteries for transportation, and other envisioned high efficiency transport and distributed generation solutions. Thus, while the gap between demand for higher efficiency engines and available high efficiency technologies continues to widen, the ICE industry is betting on itself to fill that gap more quickly than fuel cells or other technologically immature solutions.

Demand for energy efficient ICEs has strengthened notably with the ongoing economic recovery. Following stagnation during the 2008 and 2009, efficient ICE demand rebounded strongly in 2010 and 2011, increasing from a total global value of $80 billion in 2009 to $121 billion in 2011. From 2006 through 2011, the market showed an overall increase of $70 billion, equivalent to a compound annual growth rate (CAGR) of nearly 19%. Through 2021, the efficient ICE market is expected to expand significantly, in spite of near term softening in emerging markets. Specifically, the global market is expected to reach $401 billion by 2021, equivalent to a 10-year CAGR of nearly 13%.

The market expansion projected for efficient ICEs maintains strong roots in the

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automotive and light truck industries. Other key markets include ground transport, distributed power generation, marine transport, and industrial/mechanical uses, including mineral extraction, petroleum extraction, wastewater treatment, and many other industries where mechanical energy is not typically provided by electric motors. A significant advantage of these multiple drivers is that demand for efficient ICE technologies is resilient in comparison to goods that serve more limited markets. While the automotive and transport markets are highly competitive, other non-transport markets provide diverse niche opportunities that may be available to well-positioned start-ups.

Fuel Efficient Internal Combustion Engine Global Markets contains comprehensive data on the worldwide market for efficient ICE technologies (engine deactivation, cylinder deactivation, variable valve timing and lift, turbochargers and superchargers, direct fuel injection, homogeneous charge compression ignition, reduced displacement engines, hybrids and partial hybrids, split cycle engines, and opposed piston/opposed cylinder engine designs. Market data are provided for historic (2006 to 2011 Q3) and forecast (2011 Q4 to 2021) market size data in terms of the dollar value of product shipments. The report identifies key trends affecting the marketplace, along with trends driving growth, and central challenges to further market development. The report also profiles leading startups and established manufacturers of fuel efficient ICEs that are most relevant to the fuel efficient ICE industry.

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