ABOUT US

CLEAN AIR POWER

NATURAL GAS TECHNOLOGY
Important Information

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# Contents

## Executive Summary

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

## Part 1: About Clean Air Power

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview</td>
<td>5</td>
</tr>
<tr>
<td>History</td>
<td>5</td>
</tr>
<tr>
<td>Current Product Portfolio</td>
<td>6</td>
</tr>
<tr>
<td>Second Generation <em>MicroPilot</em> technology</td>
<td>7</td>
</tr>
<tr>
<td>Key Markets</td>
<td>8</td>
</tr>
<tr>
<td>Group Structure</td>
<td>9</td>
</tr>
<tr>
<td>Facilities</td>
<td>10</td>
</tr>
<tr>
<td>Additional Information</td>
<td>10</td>
</tr>
</tbody>
</table>

## Part 2: Sources of Competitive Advantage

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Proposition</td>
<td>11</td>
</tr>
<tr>
<td>Intellectual Property</td>
<td>13</td>
</tr>
<tr>
<td>Partnerships</td>
<td>13</td>
</tr>
</tbody>
</table>

## Part 3: Market Opportunity

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>14</td>
</tr>
<tr>
<td>Russia</td>
<td>16</td>
</tr>
<tr>
<td>South East Asia</td>
<td>17</td>
</tr>
<tr>
<td>Europe, Australia and Other Markets</td>
<td>17</td>
</tr>
<tr>
<td>Impact of Oil Price Fluctuations</td>
<td>17</td>
</tr>
</tbody>
</table>

## Part 4: Vision and Strategy

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vision</td>
<td>18</td>
</tr>
<tr>
<td>Strategy</td>
<td>19</td>
</tr>
</tbody>
</table>
Executive Summary

Clean Air Power designs, develops and delivers Dual-Fuel™ and second-generation MicroPilot engine systems to enable heavy-duty, compression-ignited engines to run on natural gas mixed with small quantities of diesel to act as the “spark” that ignites the gas.

In the short-term, Clean Air Power is pursuing attractive opportunities for its existing Genesis-EDGE Dual-Fuel™ systems in the US, where its US2010 variant is in the final stages of development, and Russia where Clean Air Power is partnering with Volvo’s Russian business to supply its Euro V variant. The US and Russia are significant markets that are committed to natural gas as a road fuel.

Clean Air Power’s second-generation MicroPilot technology can offer heavy-duty truck operators fuel economy (natural gas substitution over 80% and fuel efficiency on par with diesel) whilst retaining diesel operational characteristics (450-500BHP and diesel fall-back) and relatively low costs of ownership (low running costs and residual protection through the ability to convert back to diesel). Research results also show that MicroPilot can reduce NOₓ by 60% compared to Dual-Fuel™, helping truck operators meet their public environmental commitments.

In partnership with Ricardo plc, Clean Air Power has secured a deal with one of the world’s largest truck manufacturers for the first phase to develop a MicroPilot engine for the South East Asian market which is planned to enter production in 2017.

With strong patents, highly sophisticated control systems and years of know-how developing natural gas systems and supporting them in the field, coupled with experience of working in partnership with major manufacturers and technology specialists, Clean Air Power is well placed to deliver its vision:

“To be the design, development and delivery partner of compression-ignited natural-gas engine systems for OEMs and Tier 1s”. 

Clear strategy

Focus on clean-technology software and systems development

Significant opportunity

Significant opportunities in the US, Russia and South East Asia

MicroPilot can deliver next-generation fuel and environmental performance

Competitive advantage

Fuel cost savings and lower emissions with diesel performance and reliability

Strong patents, highly sophisticated control systems and years of experience

Partnerships with major manufacturers and technology specialists
Part 1: About Clean Air Power

Overview

Clean Air Power is a group of companies (the “Group”) that designs, develops and delivers engine systems to enable heavy-duty, compression-ignited engines to run on natural gas mixed with small quantities of diesel (or any suitable combustion fuel) to act as the “spark” that ignites the gas.

By substituting natural gas for diesel, the Group’s Dual-Fuel™ and second-generation MicroPilot engine systems can reduce fuel costs and lower emissions of carbon, nitrous oxide and particulates, as well as having a distinct competitive advantage over other types of natural gas engine by retaining the base diesel engine’s power, efficiency and reliability characteristics.

The holding company of the Group is based in Bermuda with operational subsidiaries in the UK, the USA and Australia. The Group was admitted to the Alternative Investment Market (“AIM”) of the London Stock Exchange in 2006.

History

Clean Air Power has its roots in a consulting business, BKM, formed by Dr N. John Beck in 1975. Set up as Clean Air Partners Inc. in the USA in 1991 to commercialise BKM’s natural gas technology, the initial focus was on stationary power. Since then over $90m has been invested in developing the technology with the result that 62 patents are currently held or pending and the Group has over 200 man-years of experience developing compression-ignited natural gas technologies.

Some of the key events in Clean Air Power’s history are set out below:
Throughout its history, Clean Air Power has worked in partnership with some of the world’s largest OEMs and leading technology specialists:

### Current Product Portfolio

The Group currently assembles, distributes and installs two types of Dual-Fuel™ engine system and has a separate business that designs and manufactures innovative natural gas valves, filters and other specialist components for natural gas engines which are sold to truck manufacturers around the world and high-speed hydraulic valves.

#### NON-INTERFACED DUAL-FUEL™

*"Genesis-EDGE"

Developed in-house by Clean Air Power, drawing on 62 patents and over 200 man-years of experience

- Retro-fit by Clean Air Power (UK) or partners (overseas)
- Volvo 13L “Genesis-EDGE” (Euro V) and Mercedes/DAF (Euro III)

#### INTERFACED DUAL-FUEL™

Developed in partnership with OEMs as a fully integrated product designed to minimise development costs and optimise fuel economy

- Can be fitted on-line, as dealer after-fit or installer retro-fit
- Volvo “Methane-Diesel” and Caterpillar C10/C12/C15 engines

### SPECIALIST COMPONENTS

Based in Poway, California, customers include Volvo and Mercedes-Benz

Profitable and cash generative
Non-interfaced Dual-Fuel™

These are engine adaptation systems that have been developed in-house by Clean Air Power to be retro-fitted to specified makes and models of vehicle or diesel engine and substitute 50-60% of diesel with natural gas when averaged across the day-to-day duty cycles. Fitting can take place at the Group’s own facilities in Leyland, UK, or through installation partners based overseas.

The Group’s main product is designed to work on the Volvo 13L Euro V engine and is sold across Europe and in Russia under the brand “Genesis-EDGE”. A US version of the Genesis-EDGE Dual-Fuel™ has just launched in the US market. **It is the only Dual-Fuel™ product in the US that been certified by the US Environmental Protection Agency and is fully compliant with the US2010 emission regulations.**

Interfaced Dual-Fuel™

These work on the same principles as the non-interfaced systems, but are developed in partnership with manufacturers and are fully integrated with the manufacturer’s engine management systems. This allows a greater degree of control that optimises the level of diesel-natural gas substitution, delivering substitution levels of around 60-70%, again averaged across operational duty cycles.

The Group has developed systems with a number of leading manufacturers including Volvo and Caterpillar and continues to supply systems for the Caterpillar C10, C12 and C15 family of engines. These systems have been fitted as part of an on-line assembly process, through approved partners for after-market installation or direct to customers through the Group’s own installation facilities.

Second-Generation MicroPilot Technology

Recent advances in diesel engine technology, most notably common-rail diesel injection and exhaust gas recirculation (“EGR”), mean that the Group is now in a position to commercially develop its second-generation MicroPilot technology.

**MicroPilot** systems work in a similar way to Dual-Fuel™ but can exploit the higher levels of engine control that common-rail, EGR and other diesel engine advancements bring enabling the same performance with significantly smaller (i.e. “micro”) quantities of diesel spray (i.e. “pilot”). Averaged substitution of over 80% is achievable, and research performed in partnership with Brunel University, London, is demonstrating that MicroPilot technology consistently exceeds 90% substitution with a 60% reduction in NOx emissions compared to conventional Dual-Fuel™ technology.

The Group has secured a deal with one of the world’s largest truck manufacturers to develop a MicroPilot engine for the South East Asian market which is scheduled to enter production in 2017. This is a two-stage program supported by Ricardo plc (“Ricardo”) under a wider co-operation agreement between Clean Air Power and Ricardo, with a project gateway decision in April 2015.
Key Markets

Clean Air Power operates in the US, Europe, Russia and Australia directly or through distribution partners and has sold over 2,700 systems to date. The Group is currently focussed on on-highway applications, but has experience in power generation and other off-highway applications.

The Group’s short-term strategic focus is on the US market, where a US2010 Genesis-EDGE Dual-Fuel™ product is in the final stages of development, and the Russian market, where there are attractive opportunities for the Group’s Euro V Genesis-EDGE Dual-Fuel™ system.

The US and Russia are sizeable markets and have committed to natural gas as a road fuel. In the US, the need for energy independence coupled with the shale gas boom has positioned natural gas as viable road fuel and the number of natural gas filling stations has grown steadily. In Russia, a government-backed national conversion program is making it a requirement that 30% of heavy-duty trucks must run on natural gas by 2020, a move that has led Gazprom and Rosneft to commit significant investment to build a modern natural gas fuelling infrastructure.

In both the US and Russia, the Group’s products will be installed, maintained and supported through partnerships with Volvo subsidiaries or Volvo dealers.

Europe has been a key market for the Group through its relationship with Volvo. However, Europe moved to the Euro VI emissions standard in early 2014 and, despite strong support from its customer base, the Group has taken the strategic decision that the development of a MicroPilot system able to meet the challenging Euro VI emissions requirements would only be commercially viable if developed in partnership with a major manufacturer.
Group Structure

The Group operates through three main business units:

**Engineering Services**

Engineering Services undertakes design and development work for governments and manufacturers and is currently engaged on a program with a major truck manufacturer to develop a second-generation MicroPilot system for South East Asia. In the past, Engineering Services has “contracted” in-house to develop systems that are marketed and sold direct to customers as a retro-fit systems, such as the *Genesis-EDGE Dual-Fuel™* system.

**Natural Gas Systems**

Natural Gas Systems supplies complete or partial systems to truck manufacturers for on-line assembly, approved partners for after-market installation or fit systems directly customer vehicles at its facilities in Leyland, UK.

Natural Gas Systems also works with Engineering Services on major development programs to provide a full supply chain support service by helping manufacturers integrate Clean Air Power’s systems into existing supply chains and support dealers with advice and training.

The solutions designed by the Natural Gas Systems business will depend upon the needs of each manufacturer and can range from providing software and support to a full sub-assembly and supply service.
Specialist Components

As noted above, the Components Division designs and manufactures innovative natural gas valves, filters and other specialist components for natural gas engines which are sold to truck manufacturers around the world and high speed hydraulic valves.

Facilities

The Natural Gas Systems business operates out of facilities in the UK and US, where it shares the facility with the Specialist Components business.

Engineering Services work internationally out of both facilities and partner premises. Engineering Services also has its own powertrain development cell based in the US facility.

Additional Information

Additional information on Clean Air Power can be found on the website: www.cleanairpower.com
Part 2: Sources of Competitive Advantage

Commercial Proposition

The Group’s *MicroPilot* technology offers a source of competitive advantage over other natural gas technologies by being able to deliver fuel economy whilst retaining diesel engine performance. The chart below represents management’s view on how the different natural gas technologies compare:

<table>
<thead>
<tr>
<th>Natural Gas Engines</th>
<th>Compression-Ignited</th>
<th>Spark-Ignited</th>
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<tbody>
<tr>
<td><strong>Base Engine Retained</strong></td>
<td>FUEL ECONOMY</td>
<td>✓✓ ✓✓</td>
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<tr>
<td><strong>MicroPilot</strong></td>
<td>Substitution of 80%+</td>
<td>✓✓</td>
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<tr>
<td>Engine efficiency</td>
<td>✓✓</td>
<td></td>
</tr>
<tr>
<td>OPERATIONS</td>
<td>Power of 450-500 BHP</td>
<td>✓</td>
</tr>
<tr>
<td>Range</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Diesel fall-back</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>COSTS</td>
<td>Low purchase and running costs</td>
<td>✓</td>
</tr>
<tr>
<td>Maintain residuals</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Base Engine Modified</strong></td>
<td>FUEL ECONOMY</td>
<td>✓✓ ✓✓ ✓✓ ✓✓</td>
</tr>
<tr>
<td><strong>Spark-Ignited</strong></td>
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</tr>
</tbody>
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In simple terms, there are two types of natural gas engine: compression-ignited, where diesel is the main form of ignition fuel, although alternatives such as engine oil are feasible, and spark-ignited which uses spark plugs to ignite the gas in the same way as petrol/gasoline engines.

Compression-ignited natural gas systems can either retain the base diesel engine and all of the performance characteristics, or modify the base engine where some characteristics, such as diesel fall-back, may be sacrificed for other performance characteristics such as substitution.

**Dual-Fuel™**

*Dual-Fuel™* systems offer diesel power performance, range and the ability to fall-back to diesel, a major factor for truck operators who have a high opportunity cost to their business if the supply of natural gas is interrupted or trucks cannot refuel on long-haul routes. Furthermore, *Dual-Fuel™* systems are relatively inexpensive to maintain and, for systems that do not modify the base engine, residual values can be protected through the option to remove the system at the time of resale.

However, the limits of the technology mean that substitution is restrained to around 50-60%, with up to 70% possible on interfaced products, and there is some, usually small, efficiency loss.
**HPDI**

High-Pressure Direct-Injection (“HPDI”) engines also use diesel to ignite the natural gas and have high levels of substitution. However, HPDI requires the natural gas to be injected under very high pressure making the systems complex. It is difficult to assess the performance and cost characteristics of HPDI as the main developer, Westport Innovations Inc. (“Westport”), has withdrawn its HPDI engine from the US market and the planned launch of a Euro VI variant for the European market has been delayed with the current status unknown.

**Spark-Ignited**

Spark-ignited natural gas engines use 100% gas but cannot match the power output of heavy-duty diesel engines and have no diesel fall-back. This is a serious issue for long-haul truck operators where the natural gas fuel infrastructure is still being rolled out. Lower fuel efficiency also means that the benefits of 100% substitution are eroded by the consumption of higher quantities of fuel, potentially making spark-ignited engines less economical than conventional diesel. Spark-ignited natural gas engines are, however, well suited for urban and municipal vehicles with lighter loads and a return-to-base operating model. As such, spark-ignited engines are regarded as a complementary product.

This technology also carries a disadvantage for truck manufacturers as many use the Cummins-Westport spark-ignited natural gas engines in their vehicles which enables Cummins-Westport to capture the revenues from engine sales, parts and servicing.

**MicroPilot**

Clean Air Power’s second-generation MicroPilot technology can offer heavy-duty truck operators fuel economy (natural gas substitution over 80% and fuel efficiency on par with diesel) whilst retaining diesel operational characteristics (450-500BHP, range and diesel fall-back) and relatively low costs of ownership (low running costs and residual protection through the ability to convert back to diesel).

Furthermore, work at Brunel University, London is showing that MicroPilot can deliver a 60% reduction in NO\textsubscript{x} emissions over Dual-Fuel\textsuperscript{TM} which will contribute substantially to the environmental targets of heavy-duty truck operators.

Ricardo has also re-iterated its support for MicroPilot technology through its involvement in the South-East Asian program in an article on natural gas engines the Quarter 4 2014 issue of the Ricardo Quarterly magazine which can be accessed through the following web link: [http://www.ricardo.com/en-GB/News--Media/rg/](http://www.ricardo.com/en-GB/News--Media/rg/).
**Intellectual Property**

The Group has over 200 man-years of know-how in developing compression-ignited natural gas engines both for on and off-highway applications. The Group also has 62 patents, some of which have prevented major manufacturers from entering the US or European markets with similar products.

One significant source of competitive advantage arising out of the Group’s intellectual property is the sophistication of the Group’s control systems. The Group believes it is the only developer of dual-fuel systems that controls air, diesel and gas and, as such, the Group’s engine control systems can not only optimise performance, but more importantly protect the engine against damage from knock, over-fuelling, and other factors that affect reliability which are a risk with less sophisticated systems.

As well as technical expertise, the Group has substantial experience of managing supply chains and operating trucks in the field which has real value to manufacturers and dealers in the pre-production stage and in support of ongoing sales and service.

**Partnerships**

As noted above, Clean Air Power is a small business, it works in partnership with some the world’s leading truck manufacturers and technology leaders.

The Group has formed development partnerships with Caterpillar, Navistar, Volvo and, as noted above, is currently engaged with one of the world’s largest truck manufacturers on a *MicroPilot* engine program for the South-East Asian market.

In September 2013, the Group signed a global co-operation agreement with Ricardo to promote and develop the Group’s technology with leading manufacturers and the Group has also entered into technology research partnerships with Brunel University, London and Queens University, Belfast.

**Summary**

<table>
<thead>
<tr>
<th>Commercial Proposition</th>
<th>Intellectual Property</th>
<th>Partnerships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel cost savings and lower emissions with diesel performance and reliability</td>
<td>Strong patents, highly sophisticated control systems and years of experience</td>
<td>Partnerships with major manufacturers and technology specialists</td>
</tr>
</tbody>
</table>
Part 3: Market Opportunity

United States

The US is the world’s second largest truck market (China being the largest) and Volvo, for which the Group’s US2010 Genesis-EDGE Dual-Fuel™ is configured, has around a 20% market share.

The drive towards energy independence in the US and the growth in shale gas as a major source of new energy provides an opportunity for truck operators to generate savings as diesel prices continue a long-term upwards trend. The chart below shows that US compressed natural gas prices (“CNG”) have, on average been around $1.50 less than the equivalent gallon of diesel and the differential has been observed at over $2.00 in some Mid-West states.

![US Average Retail Fuel Prices](chart)

Despite this, natural gas trucks remain a very small proportion of overall heavy-duty truck sales. There are a number of reasons for this:

1. many truck manufacturers offer the Cummins-Westport spark-ignited engines as the only natural gas option, but these engines are less suited to the power requirements for heavy-duty trucks and have no diesel fall-back option which is a major concern to long-haul operators;

2. the market does not currently have a widely available dual-fuel alternative product that can deliver the overall performance that truck operators need;

3. the immaturity of the market leads to uncertainty over residual values; and

4. until recently, there was a lack of a national refuelling infrastructure.
Data provided by US Department of Energy’s Alternative Fuel Data Center, shows that the refuelling network has grown sufficiently and is approaching coast-to-coast coverage, for both CNG and liquefied natural gas (“LNG”):

CNG

807 Public Stations (shown)
1,515 Public and Private Stations

LNG

67 Public Stations (shown)
105 Public and Private Stations

Source: US Department of Energy Alternative Fuels Data Center (February 2015)

Longer-term, research from the US Department of Energy’s Energy Information Administration shows that the growth in natural gas as a fuel for heavy-duty trucks is expected to grow exponentially over the next twenty five years:

Figure 74. Natural Gas Consumption in the Transportation Sector 1995-2040 (Quadrillion BTU)

Source: US Department of Energy (Energy Information Administration)
In the short-term, Clean Air Power hopes to generate increased product awareness through sales of its US2010 *Genesis-EDGE Dual-Fuel™* system and, with an expanding network of fuelling stations and Clean Air Power’s *MicroPilot* technology offering a competitive advantage, the market drivers suggest that the timing is right for Clean Air Power to be able to secure a partnership with a major manufacturer for a new development program for the US market:

Russia

Whilst the Russian market is structured differently to the US, it is also being driven by the need for energy independence and, as noted above, a government-backed national conversion program is making it a requirement that 30% of heavy-duty trucks must run on natural gas by 2020, with Gazprom and Rosneft committing significant investment to build a modern natural gas fuelling infrastructure.

Clean Air Power is working in partnership with Volvo’s Russian business to offer a high quality, Volvo dual-fuel truck to Volvo’s exclusive customer base across Russia based on its existing Euro V *Genesis-EDGE Dual-Fuel™* platform.

A key attraction of the Russian market is that it has adopted the Euro V emissions standard and has no short-term plans to move to Euro VI, thus providing Clean Air Power with a longer product life for its Euro V *Genesis-EDGE Dual-Fuel™* system.
South East Asia

The Group sees attractive opportunities in South East Asia for its MicroPilot engine which is in development and due to enter production in 2017.

Europe, Australia and Other Markets

Europe has been a key market for the Group through its relationship with Volvo. However, Europe moved to the Euro VI emissions standard in early 2014 and, despite strong support from its customer base, the Group has taken the strategic decision that the development of a MicroPilot system able to meet the challenging Euro VI emissions requirements would only be commercially viable if developed in partnership with a major manufacturer. This is because of the complexity of Euro VI engine control systems, which use on-board diagnostics, and the technical limitations of current after-treatment systems which prevent dual-fuel engines meeting the tighter methane limits under the new standard. The Group continues to pursue opportunities for a Euro VI product and advancements made at Brunel University, London and Queens University, Belfast, offer ways to resolve the technical challenges.

The Australian market is small, but the Group continues to see opportunities. Other potential markets would include South America and countries that continue to use Euro V emissions standards where the Group may work in partnership with Volvo dealers if an opportunity presents itself.

Impact of Oil Price Fluctuations

The actual oil price has little bearing on the market opportunity, it is the differential between diesel and natural gas prices that is important and, as both prices tend to follow each other, the observed differentials in recent years have been relatively stable. Furthermore, the move to natural gas is driven by wider factors than just pure economics, particularly in the US and Russia where there is clear political drive towards energy independence, as well as the environmental benefits for whilst methane is still a greenhouse gas, it not poisonous and has no particulates.

Summary

<table>
<thead>
<tr>
<th>Significant Opportunities</th>
<th>Game-Changing Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MicroPilot</strong> can deliver next-generation fuel and environmental performance</td>
<td><strong>Significant opportunities in the US, Russia and South East Asia</strong></td>
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</tbody>
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Part 4: Vision and Strategy

Vision

Clean Air Power’s value lies in its intellectual property and, in particular, the sophistication of its control systems, its patents and the years of know-how that the Group has acquired both in system development, supply chain management and supporting compression-ignited natural gas vehicles operating in the field.

Up to this point, Clean Air Power has had to fund a large proportion of the costs of development programs and bear the risk of sales volumes in immature markets. This was necessary to prove the technology.

Going forward, this is not a sustainable business model and the Group has a clear vision to transition from being a largely self-funded developer to a design and development specialist for compression-ignited natural gas engines that can also bring substantial experience in supply chain and field operations to support manufacturers in the design, development and delivery of natural gas engines.

The Group’s vision can be summarises as follows:

“To be the design, development and delivery partner of compression-ignited natural-gas engine systems for OEMs and Tier 1s”.

This brings a number of clear benefits:

1. offering customers a leading-edge design and development solution combined with a full supply chain management and delivery service brings incremental returns and cash flow;

2. focussing on the competitive advantage of compression-ignited natural gas systems across a range of markets, both on-highway and off-highway where the potential fuel savings are significant, will grow stable revenues; and

3. securing funded-development programs with OEMs and Tier 1 manufacturers will reduce development costs and sales volume risks.
Strategy

In order to deliver this vision, the Group has a three-step strategy:

Step 1

Sell current Dual-Fuel\textsuperscript{TM} products in the US and Russia. This has two key objectives: (1) to promote product awareness and showcase the technology; and (2) to generate cash to fund investment in MicroPilot and third-generation technologies.

Step 2

With engines becoming more complicated and emissions standards becoming ever stricter, the only viable model for developing the technology is through partnerships with OEM and Tier 1 manufacturers. Step 2 of the strategy is, therefore, to reduce risk in the business and grow stable revenues by securing further OEM-funded or Tier 1-funded design, development and delivery programs; initially for on-highway programs and then diversifying into off-highway programs, where the potential fuel savings are significantly higher than in on-highway applications.

Step 3

Maintain technology leadership and competitive advantage by investing in “third generation” technology. The Group’s research programs at Brunel University, London and Queens University, Belfast are already producing results that demonstrate the future potential of the technology.
Summary

“To be the design, development and delivery partner of compression-ignited natural-gas engine systems for OEMs and Tier 1s”.

<table>
<thead>
<tr>
<th>Clear strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on clean-technology software and systems development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
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</tr>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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</tr>
</thead>
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Offices

UK
Aston Way
Leyland
Lancashire PR26 7UX
Tel: +44 (0) 1772 624499
Fax: + 44 (0) 1772 436495

USA
13615 Stowe Drive
Poway
California CA92064
Tel: +1 858 332 4800
Fax: +1 858 332 4893

Corporate Website: www.cleanairpower.com