Future-Proofing Diesel Power Generation

When Power Is Critical

IPU GROUP
Single Sourcing

WELCOME

On-site power generation is dominated by diesel engines. They power the bulk of the world's emergency generators, rental generators and energy market balancing reserves.

Their popularity is underpinned by unbeatable economy and reliability. If this popularity is to continue they need to address their greatest weakness: emissions.

Like any engine powered by a fossil fuel, diesel engines generate exhaust emissions that damage the environment. To safeguard their future these emissions need to be brought down to a level that is comparable to less harmful fossil fuels such as natural gas.

This handbook illustrates some of the technologies that can help diesel engines achieve this goal.

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REASONS TO REDUCE EMISSIONS

THE LEGISLATIVE LANDSCAPE

The primary motivation for organisations to reduce emissions from diesel engines is fundamental: they have to. Legislation and regulations mandate upper limits for emissions of gases, particulates and noise. Any organisation running a diesel engine has to comply with applicable law.

Responsible Bodies

UK businesses are subject to regulations from four main sources.

1. The UK Department for Energy and Climate Change (DECC).
2. The UK Department for the Environment, Food and Rural Affairs (DEFRA).
3. The European Union (EU).
4. Local authorities.

The UK's vote to leave the EU is unlikely to have much practical effect on the legislation that affects diesel engine emissions. Whether legislation originates from Brussels or London, emissions limits will be reduced regularly.

Although it's unusual, local authorities can impose their own emissions regulations. London, for example, responded to its

long-standing pollution challenges (see below) by introducing the Low Emissions Zone in 2008.

These regulations were tightened in 2012 and it can be expected that they will be regularly tightened in future.

REASONS TO REDUCE EMISSIONS

LEGISLATION, TIMESCALES & REFERENCE SOURCES

The Medium Combustion Plant (MCP) Directive

The MCP Directive is EU legislation that became UK law in December 2017.

The MCP Directive (Directive (EU) 2015/2193) covers diesel engines between 1 and 50 MWth capacity. These currently fall between two other directives that cover large combustion plants and small appliances. Large combustion plants over 50 MWth are covered by the Industrial Emissions Directive (IED). Boilers, heaters and smaller appliances under 1 MWth are covered by the Ecodesign Directive (CE labelling).

EU statistics estimate there are 143,000 medium-sized combustion plants in the EU. They represent an important source of emissions of sulphur dioxide (SO2), nitrogen oxides (NOx) and dust. The MCP Directive regulates emissions of all three and monitors emissions of carbon monoxide (CO). It is based on part of an earlier European Commission proposal, the 2013 Clean Air Policy Package.

Reasons to reduce emissions

The MCP Directive is the latest instrument to ensure the EU's implementation of its obligations arising from the Gothenburg Protocol under the UNECE Convention on Long-Range Transboundary Air Pollution.

The MCP Directive was enacted by the EU on 18 December 2015. Plants that come into operation after 20 December 2018 are classified as “new plant” in the MCP Directive; its emissions limit values (ELVs) apply as soon as the plants start operating. Older plants are classified as “existing plants” by the MCP Directive. They have to conform to the MCP Directive’s ELVs by 2025 or 2030, depending on their size.

In the UK, the emissions landscape is complicated by Capacity Market considerations. Plants that supply power to the UK grid under STOR, FFR or similar agreements have different compliance requirements and timescales. These vary according to how many hours the plant operates per annum, its output capacity, when it starts operating and its type of Capacity Market contract. Please contact IPU to establish how these complex regulations apply to you.

Download
The Medium Combustion Plant Directive can be downloaded from www.ipu.co.uk/medium-combustion-plant-mcp-directive.

REASONS TO REDUCE EMISSIONS

The Industrial Emissions Directive (IED)
Directive 2010/75/EU of the European Parliament and the Council on industrial emissions is the main EU instrument regulating pollutant emissions from industrial installations. The IED was enacted on 24 November 2010. It is based on a Commission proposal recasting 7 previously existing directives (including in particular the IPPC Directive) following an extensive review of the policy. The IED entered into force on 6 January 2011 and had to be transposed by Member States by 7 January 2013.

It applies to plants above 50 MWth so it is not applicable to this handbook.

Download
If more details are required the Industrial Emissions Directive can be downloaded from www.ipu.co.uk/industrial-emissions-directive-ied.

Large Combustion Plant Best Available Techniques Reference Document
The EU publishes a series of Best Available Techniques Reference Documents (BREFs) to guide organisations in different industries (http://eippcb.jrc.ec.europa.eu/reference).

This BREF deals with combustion installations with a rated thermal input exceeding 50 MW. Plants with a thermal input lower than 50 MW are also discussed where technically relevant because smaller units can potentially be added to a plant to build one larger installation exceeding 50 MW.

All kinds of conventional power plants (e.g. utility boiler plants, combined heat and power (CHP) plants, district heating plants) used for mechanical power and heat generation are covered in this work. Industrial combustion installations are covered if they use conventional fuel. The commercial availability of the fuel on the market has been used as an indicator to identify conventional fuels. The criterion for classifying a fuel as a 'conventional fuel' is a known composition which remains relatively constant, and indeed is usually standardised. Coal, lignite, biomass, peat, liquid and gaseous fuels (including hydrogen and biogas) are regarded as conventional fuels.

It applies to plants above 50 MWth so it is not applicable to this handbook.

Download
If more details are required the Large Combustion Plant Document can be downloaded from www.ipu.co.uk/best-available-techniques-reference-large-combustion-plants.

REASONS TO REDUCE EMISSIONS

The National Emissions Ceilings Directive (NECD)
Directive 2001/81/EC of the European Parliament and the Council on National Emission Ceilings for certain pollutants (NEC Directive) sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution. These are sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia. The NEC Directive largely leaves it to the Member States to decide which measures – on top of Community legislation for specific source categories - to take in order to comply.

The NEC Directive has been amended as part of the accession of new Member States. A consolidated NEC Directive for the EU 27 includes the entire Community including the 2009 amendment of committee decisions. The implementation of the Directive requires that Member States develop national programmes in 2002 and, where needed, revise those plans in 2006. Their aim should be meeting fixed ceilings of national emissions by 2010 and thereafter. Further Member States have to report their emission inventories to the EEA and the European Commission in order to monitor progress and verify compliance.

The National Emission Ceilings Directive 2001/81/EC (NECD) is currently being reviewed as part of The Clean Air Policy Package. The proposal repeals and replaces the current EU regime on the annual capping of national emissions of air pollutants, as defined in Directive 2001/81/EC. By doing so, it ensures that the national emission ceilings set in the current Directive 2001/81/EC for 2010 onwards for SO2, NOx, NMVOC and NH3 shall apply until 2020 and establishes new national emission reduction commitments ("reduction commitments") applicable from 2020 and 2030 for SO2, NOx, NMVOC, NH3, fine particulate matter (PM2,5) and methane (CH4).

Download
The National Emissions Ceilings Directive can be downloaded from www.ipu.co.uk/national-emissions-ceilings-directive-necd.

REASONS TO REDUCE EMISSIONS

UK Environmental Permitting (England and Wales) Regulations 2016

The Environmental Permitting (England and Wales) Regulations 2016 (EP regulations) provide industry, regulators and others with a single extended permitting and compliance system, called the Environmental Permitting System.

They have produced a single regulatory framework by streamlining and integrating:

- waste management licensing.
- pollution prevention and control.
- water discharge consenting.
- groundwater authorisations.
- radioactive substances regulation.

Although they have a broad scope that covers all sources of pollution, they have specific relevance to power generating sites producing emissions from diesel engines.

Download

The full 2016 regulations can be downloaded from www.ipu.co.uk/downloads/uk-environmental-permitting-regulations-2016/. Draft updates released in 2017 can be downloaded here: www.ipu.co.uk/draft-uk-environmental-permitting-regulations-2017/

THE INVESTMENT OUTLOOK

There has been a steady growth in ethical investments since the late 20th century. To qualify as an ethical investment, an opportunity has to consider social and environmental factors alongside the financial return that might be delivered.

To attract the attention of ethical investors a power-generation project has to demonstrate a clear intention to reduce the environmental impact of burning fossil fuels. This has normally meant ethical investors focus on renewable sources such as solar (PV), wind and hydro-electric projects.

However, no project is entirely free of environmental impact. Solar and hydro-electric projects, for example, have a substantial environmental impact during their manufacturing, commissioning and de-commissioning phases. It is a commonly -held (though not necessarily accurate) belief that renewable power projects can only be considered environmentally benign during their operational life.

Placing too much focus on emissions to the exclusion of other environmental impacts distorts the true environmental picture. Nuclear power, for example, generates no emissions. It can be a valuable part of any nation's programme to reduce greenhouse gases. But commissioning, decommissioning and disposing of

spent fuel means nuclear power struggles to match anybody's definition of an environmentally-benign power source.

To satisfy the ethical investor, diesel-based power generation projects need to demonstrate their ability to reduce emissions. The future-proofing technologies and options in this handbook showcase some key systems and techniques that achieve this goal.

In summary, it has to be remembered that ethical investors are, first and foremost, investors. They need to see a potential return from a project. This imperative favours future-proofed diesel-based power generation for many reasons:

- Diesel power is an established technology requiring relatively little research and development.
- Future-proofed diesel power is technologically safe, reducing the project risk.

The level of investment is relatively low, opening the opportunities to smaller investors who would not be able to consider direct involvement in larger capital projects.

Future-proofed diesel power works anywhere – onshore, offshore, town or country; it is not dependent on the availability of wind, tides or open spaces.

Future-proofed diesel power is consistent and reliable – switch it on and it works; it is not subject to the vagaries of the weather.

As long as they can show a desire to reduce emissions, future-proofed diesel-based power generation projects merit the attention of ethical investors.

REASONS TO REDUCE EMISSIONS

THE IMPACT OF CORPORATE SOCIAL RESPONSIBILITY

No shareholder report or investor relations statement is complete without a section on Corporate Social Responsibility (CSR). These detail corporate programmes that enrich the societies and environments in which a company operates. Programmes that reduce environmental impacts are a mainstay of such reports.

There are two ways a future-proofed diesel power generation facility can make a positive impact on a CSR report:

1. **Enhancements added to an existing plant** to reduce its emissions. As well as reducing the company's environmental impact, enhancements to existing plants are financially attractive. They extend the life of that plant and reduce the need for new capital expenditure (CAPEX).
2. **Deployment of a future-proofed plant** that generates lower emissions than earlier generations of diesel-based plants. A future-proofed diesel plant has the environmental advantages of reduced emissions plus the financial advantage of being more economical, efficient and reliable than renewable power sources.

CSR goes deeper than being able to provide statements and publish aspirations or commitments. Its success depends on actions that produce tangible improvements in a company's societies or environments.

Future-proofed diesel plants deliver measurable improvements over previous techniques for power-generation. The techniques and systems detailed in this handbook deliver reductions in emissions and fuel consumption that can be measured and declared.

REASONS TO REDUCE EMISSIONS

THE POLITICAL AND SOCIAL ENVIRONMENT

Dirty fuels

Coal has all but disappeared from the UK's industrial infrastructure despite low prices, abundant supplies and well-established technology. The only time coal reaches a news cycle is when a coal-fired power station closes or when the closure of similar stations threatens the reliability of the country's power supply.

The demise of coal is directly linked to its perception as "the dirty fuel". It is beyond the scope of this handbook to determine if there are effective ways to reduce emissions from coal-driven power stations. All that matters is that the coal industry did not move quickly enough to counteract the negative perception that eventually doomed it.

The world's desire for a sustainable future means that there will always be pressure to reduce the use of fuels with the highest environmental impact. Attention has now started to focus on diesel. The pressure that will start to build can be mitigated by delivering genuine improvements in the environmental performance of diesel. This will extend the practical relevance of diesel well into the second half of the 21st century.

It can be argued that public attitudes to diesel are almost schizophrenic. On the one hand, it is seen as a dirty fuel. Commercial disasters such as Volkswagen's attempts to hide diesel's environmental impact do nothing to help.

On the other hand, it is undeniable that diesel still has a lot of support – the abundance of diesel cars and total dominance of diesel in commercial transport shows that the public clearly understands it is a fuel with many advantages.

The world is pragmatic. In principle, both the general public and the petrochemical industry knows that diesel will not be the 22nd century's fuel of choice. But in reality, we all understand that diesel cannot be phased out too quickly. The 21st century world has to find a way to reduce diesel use fast enough to preserve the environment but slow enough to be practically and economically viable.

That is the role of future-proofing diesel engines.

REASONS TO REDUCE EMISSIONS

The focus on emissions

Diesel is criticised almost exclusively because of its emissions levels. But environmental impact is not just about emissions. Other power generation technologies have their own disadvantages:

- **Disposal**: spent fuel used to be a problem for the coal industry. Vast tracts of Britain's post-industrial landscape are built on the slag heaps of earlier generations. But the problem of spent fuel reached its peak with nuclear power. With extreme toxicity and a half-life measured in thousands of years, no other type of fuel presents the same level of long-term threat to the environment. The only factor in its favour is the relatively small quantities involved.

- **Geological**: the world's love affair with gas is not universal. There is a significant backlash in Europe against shale gas (or gas produced by fracking). Footage of flames spouting from kitchen taps are etched into the public consciousness. Although most of the negative imagery has been debunked, the perception lives on. Even if higher oil prices make fracking commercially viable, proposed sites would face massive opposition. America does not share Europe's concerns. It continues to produce vast quantities of shale gas.
- **Manufacturing**: for all their apparent elegance, solar (PV) installations hide a substantial environmental impact. Apart from the advanced materials used in the manufacture of panels, solar plants are often supplemented by large battery back-up installations that carry a heavy manufacturing impact of their own.
- **Aesthetic**: no application for a wind farm or tidal generator anywhere in the world survives a planning application unscathed. Neither installation can be hidden from view. Neither installation can be described as compact. Wind turbines are opposed because of the way they look, the supposed danger they pose to birds and the noise they make. Tidal generators are opposed

because of their appearance, their impact on marine businesses and their effect on fish migration.

- **Politics**: gas is the fuel of choice in the early part of the 21st century. The 'dash for gas' has spread across Europe and most parts of the world. But gas' environmental and financial attractiveness is counter-balanced by a darker political dimension. Eastern Europe is now heavily dependent on gas supplies from Russia. Many parts of Western Europe are following suit. The idea that Russia may stop being a willing and cooperative supplier is a favourite topic for thriller writers but recent history in the

Ukraine suggests that fiction and fact are not totally dissimilar.

- **Social**: the UK shares the Western world's concern for global standards in human rights. The same standards are not shared by many of the world's largest suppliers of oil and gas. We can be satisfied that oil and gas from Europe and North America is produced in ways that protect the rights, safety and dignity of workers. We cannot confidently say the same for oil and gas produced in some other parts of the world.

Financial implications

Nothing exists in isolation, not even a concern for the environment. The development of the next generation of power-generating technologies has to be affordable.

In the UK we have already seen opposition to the renewable power levy that increases everybody's energy bills to fund the deployment of green energy sites. That opposition has been muted because the amounts involved are small on a family-by-family basis but, nonetheless, it does exist.

The popularity of diesel cars is further proof of the power of money. Despite being dirtier, slower and noisier the British

pubic buy nearly as many diesel cars as petrol. Why? Because they're cheaper to run.

We all want to improve the environment but how much we want to improve it is heavily influenced by how much we want to spend. Human nature dictates that we're much happier if i) somebody else foots the bill (e.g. we don't mind other people paying a premium for hybrid and electric cars), or ii) the choice is taken out of our hands (e.g. the renewable power levy).

The gas benchmark

The UK's government's response to the Capacity Market (CM) consultation makes it clear that it supports the use of gas as the fuel of choice for power-generation. While it takes pains to stress its technical neutrality it goes on to say that it "plans to take swift and appropriate action to avoid any disproportionate impact on air quality from diesel engines".

Its acceptance of gas is repeated later: "we need to ensure the right incentives are in place to bring on new capacity as it is needed, largely expected to be gas, to guarantee our energy security in the 2020s".

This is in line with earlier statements from Amber Rudd, then Secretary of State for Energy and Climate Change, at the 2015 UN Climate Change Conference in Paris: "one of the greatest and most cost-effective contributions we can make to emission reductions in electricity is by replacing coal fired power stations with gas."

To ensure compliance with upcoming emissions regulations it is clear that diesel-based power generation sites should aim to match the emissions levels of gas-based sites.

ON-ENGINE SOLUTIONS

BIFUEL CONVERSION

If we accept gas-level emissions as our target, the most logical way to achieve this is to use gas as a fuel in a diesel genset. This is possible.

The solution is to use a ComAp Bifuel controller. These can be retrofitted to existing diesel gensets or fitted to new units, providing a controlled and manged way of using gas with diesel engines.

Bifuel solutions are usually promoted where natural gas is cheaper than diesel. In these environments the Bifuel option reduces costs. In the UK, natural gas may not deliver significant cost-savings because its pricing is similar to diesel. However, flare gas and other forms of waste gas may be available and financially attractive.

A Bifuel conversion's main advantage in the UK and Europe is its ability to reduce emissions. It has the added benefit of extending an engine's running time on a tank of diesel.

ComAp Bifuel controllers are available for diesel engines up to 20 cylinders. Although natural gas is most often used alongside diesel, the solution also works with well gas, landfill gas, coal gas, propane and biogas. The package comes with a controller and anti-knocking detection system, DETCON.

A Bifuel conversion requires virtually no engine modification. It works with high-speed diesel engines and provides the same performance as a normal diesel engine. The engine starts and stops on diesel and imposes no reduction in the engine's load acceptance.

It delivers the emissions goals required without a full replacement of existing plant, without research delays and without experimentation. With ComAp InteliBifuel conversion typical emission reductions are as follows:

	Improvement
CO2	5 to 20%
Particulate Matter (PM)	Up to 50%

	Improvement
NOx	5 to 40%

ON-ENGINE SOLUTIONS

NB: There is no reduction of CO unless a catalytic converter is fitted.

Typically, the highest substitution rate (i.e. substitution of gas for diesel) is at around 80% of the genset's nominal load. Higher load levels generally have lower substitution although this depends on the engine and gas type.

Further information
More details are available at www.ipu.co.uk/products/divisions/bi-fuel-controllers.

Summary: Bifuel conversion

- Uses existing diesel gensets.
- Simple installation.
- Suitable for existing and new gensets.
- Extensive engine monitoring provides class-leading protection.
- Available now.
- Engine starts and stops on diesel and can 'fall back' to diesel if no gas is present.
- Large contribution to goal of achieving gas-level emissions.

PARKER RACOR FUEL FILTERS

Fuel filtration's role in reducing emissions is easy to understand: if the fuel going into the combustion chamber is cleaner, the exhaust emissions coming out will be cleaner too.

Parker Racor's fuel filters have been at the forefront of filtration technology since 1969. In 1983 Racor introduced the first generation of its Aquabloc® filtration technology. The heart of the system is the three coalescing and filtration stages:

1. **Separation:** As fuel enters, it moves past the internal check valve, then through the turbine centrifuge where it flows in a spiralling direction, spinning off large particulates and water droplets. Being heavier than fuel, the large particulates and water droplets fall to the bottom of the bowl.

2. **Coalescing:** Smaller water droplets bead-up along and on the sides of the internal the conical baffle and on the surface of the Aquabloc® filter. When large enough, they too fall into the high capacity bowl to be drained as needed.
3. **Filtration:** Proprietary Aquabloc® cartridge elements repel water and remove solid contaminants from fuel at 98% efficiency of their micron rating. Water collecting on the surface of the element coalesces into larger drops that fall into the collection bowl.

Besides repelling water, asphaltenes, algae, rust, and tiny solids from fuel, Aquabloc® filters are waterproof, so they remain effective longer.

Racor's ultra-high-efficiency Aquabloc® media is an engineered blend of distinct media formulations – high-grade cellulose compounded with engineered fibres and chemical treatments proven to block water.

High contaminant capacity allows less frequent filter changes, boosting operating economy.

Aquabloc® media is both corrugated and pleated to keep pleats open and present a large effective filtration surface area to the diesel fuel flow.

The high dirt-holding capacity of Aquabloc® media dramatically extends the life of final-stage on-engine filters, and reduces the overall cost of filtration maintenance.

Aquabloc® cartridge filter elements are available in 2, 10, and 30 micron ratings so that protection can be tailored to the application, fuel quality, operating environments and service schedules.

Aquabloc® media helps OEMs diesel engines adhere to rigid government emission standards.

A fuel filter/water separator with replaceable cartridge element is the lowest-cost filtration solution.

Summary: Parker Racor fuel filters

- Technically simple.
- Suitable for existing and new gensets.
- Available now.
- Lower maintenance than low-quality fuel filters.
- Positive contribution to goal of achieving gas-level emissions.

Further information
More details are available at www.ipu.co.uk/products/racor-water-fuel-seperators.

ON-ENGINE SOLUTIONS

GAC ENGINE GOVERNORS

Standard electronic governors fitted to gensets will often over-fuel the engine to guarantee starting. This process of over-fuelling will commonly cause a large plume of black smoke. This black smoke is partially burnt fuel.

The bigger the engine, the more black smoke that is expelled. If you have multiple sets on site that start-up at the same time, the level of black smoke will be very high. This is not only detrimental to engine health but also to workers who are exposed.

As engines are now kept in a warm condition for emergency start requirements, the need to over-fuel such engines is no longer required.

Not only that, but legislation on emissions on existing gensets is constantly changing and gensets will need to be cleaner. Dramatically reducing the black smoke on start-up will help with compliance.

The GAC ESD5500 and EEG6500 engine governors, with engine starting fuel and speed ramping adjustment features offer a reliable and proven solution for virtually eliminating black smoke from standby gensets.

Electronic speed controllers from GAC with black smoke reduction will help to ensure your compliance with strict legislation and extend the life of your engine.

Summary: GAC engine governors

- Dramatically reduces black smoke on engine start-up.
- Prevents over-fuelling, reducing overall fuel consumption for engines.

Further information

More details are available at www.ipu.co.uk/products/gac-electronic-governing-system/electronic-governors/

FUEL SOLUTIONS

Alternative fuels represent the area in which most gains can be made. The biggest single factor that influences the exhaust that comes out of an engine is the fuel that goes into it.

GTL FUEL

GTL is the acronym for Gas-To-Liquid. It describes the synthetic diesel alternative being developed by Shell (and other oil and gas companies) to turn natural gas into a liquid fuel suitable for use in unmodified diesel engines.

GTL's similarity to diesel

GTL can be used in any diesel blend ratio from 0% to 100%. Although it has broadly similar physical characteristics to conventional diesel it is superior in several ways:

- it has a much higher cetane number.
- it has a higher mass calorific value.
- it has lower sulphur levels.
- it has lower levels of aromatics.
- It is almost free from other unsaturated molecules such as olefins (alkenes).

GTL also has a lower density which is advantageous is some ways (e.g. cold temperature performance) but presents issues with the EN590 standard for diesel fuels (see below).

These unique properties enable more efficient combustion at a lower temperature. This delivers lower engine emissions.

GTL can be packaged, transported and stored using the same equipment, materials, and procedures as conventional diesel. Diesel vehicles can also be run on GTL without engine or exhaust system modifications. GTL can be considered a drop-in replacement for conventional diesel allowing seamless introduction without investment in new engines or refuelling infrastructure.

FUEL SOLUTIONS

GTL, EN590 and EN15940

Engine manufacturers generally give a warranty on their engines if they are running fuel that conforms to the EN590 standard for diesel fuel. GTL is just below the standard's minimum density specification of 820kg/m3.

EN590 will be supplemented by a new standard, EN15940, for paraffinic fuels such as GTL and HVO (Hydro-treated Vegetable Oil). This standard was ratified in April 2016. Because EN15940 fuels are so similar to EN590 fuels it is also expected than engine manufacturers will readily extend their warranties to accept EN15940 fuels like GTL. Caterpillar, the largest engine manufacturer in the world, has already accepted GTL (see page 100 of the document).

The situation is slightly different in the USA and Japan. These countries never adopted the EN590 fuel standard. Their standards for 'diesel' fuel do not contain a minimum density value so GTL already meets them.

Test results

In a test on a London bus, hydrocarbon emissions were reduced by 28%, NOX by 2% and particulates by 16%. The test was conducted by King's College's London Environmental Research

Group (ERG) London Atmospheric Emissions Inventory (LAEI) section. It assessed the impact of switching most classes of diesel vehicles from standard diesel to GTL. The study suggests GTL can reduce the number of areas in London that break air quality limits by 19-39%.

GTL's other advantages

GTL has advantages that go beyond emissions.

- **Storage:** GTL can be stored for long periods with a much lower danger of contamination than today's biodiesel. GTL does not retain dissolved or emulsified water, a major cause of contamination. Reducing the water content limits the growth of microbial contamination (a.k.a. the diesel bug) and restricts the spread of rust in tanks and pipework. This is especially important for emergency generators that operate in standby mode, consuming little of their stored fuel.
- **Cold starts:** GTL's properties – including its lower density and low water content – make it better at cold starts. The fuel flows and ignites more easily. This reduces emissions at start-up (the time when diesel engines are at their most polluting), reduces the need for engine heating and improves starting reliability. This is critical for providers

to the Fast Frequency Response (FFR) and Short Term Operating Reserve (STOR) frameworks.

- **Noise:** GTL is not a mix of molecules like conventional diesel. It is a consistent and near pure fuel. This helps engines run more smoothly and quietly. This is an important factor in the siting and approval of urban power generation sites.
- **Non-toxic & biodegradable:** GTL is non-toxic and biodegradable. Whereas a diesel spill has environmental and health and safety implications, a GTL spill would not.
- **A technology for all applications:** other emissions techniques such as Selective Catalytic Reduction (SCR) work best in optimal conditions. For example, light loading often decimates the performance of exhaust treatments like SCR. GTL works all the time in all environments.

GTL's History

Although relatively unknown, GTL has been in development for nearly a century. The synthesis process at the heart of GTL fuels was discovered by Franz Fischer and Hans Tropsch in 1922. In 1945 Germany used the Fischer-Tropsch process to produce approximately 1,600 barrels per day of liquid transportation fuels from coal (CTL).

Shell began GTL tests in its Amsterdam Labs in 1973. A pilot plant was built there to test manufacturing processes in 1983. In 1993 it began production in what was then the largest GTL facility in the world in Bintulu, Malaysia. Its capacity was 14,700 barrels of fuel per day. This has since been eclipsed by Shell's Pearl plant in Qatar that produces 140,000 barrels per day.

Challenges for GTL

Although an attractive option, GTL faces three challenges if it is to become a viable alternative fuel for diesel-based power generation plants.

1. **It is not a heavily promoted product.** Despite being in development for 40 years, it has a low commercial profile. This will change in 2016 and 2017 when new distribution agreements come into effect in the UK.
2. **Secondly, its costs are unknown.** Like normal diesel its price will fluctuate with the cost of crude oil. Because the processing is different, estimates suggest it will be around 15% more expensive than diesel. These costs could be offset by lower running costs. Cleaner fuel means fuel filters will last longer, as will the SCR systems that will soon appear on diesel engines. Extended filter and scrubber life means fewer service calls and lower maintenance costs.
3. **GTL is not a solitary solution.** Future engines will incorporate exhaust treatments such as SCR as part of their standard specification. GTL will complement these treatments and help drive the emissions of diesel engines to gas levels.

Summary: GTL fuels

- Direct drop-in replacement for standard diesel.
- No equipment changes required.
- Suitable for existing and new gensets.
- Large contribution to the goal of achieving gas-level emissions.
- Not available until 2017.
- Not priced until 2017.
- Not included in engine manufacturers' warranties until 2017.

Further information
More details are available at www.shell.com/energy-and-innovation/natural-gas/gas-to-liquids.html.

FUEL SOLUTIONS

HVO FUEL

HVO is the acronym for Hydro-treated Vegetable Oil (HVO). HVO is a bio-based diesel than can be used as a blend or in its pure form.

Diesel engine manufacturers are testing their engines for use with HVO in place of diesel. MTU and Scania anticipate being able to deliver a 10% reduction in NOX emissions on their 2MW and 4,000KW engines during 2016. Tests suggest NOX emissions will drop from 6.4 to 5.8 g/KWh.

Summary: HVO fuels

- Replacement for standard diesel in some engines after manufacturers' approval.
- Moderate contribution to the goal of achieving gas-level emissions.
- Bio-fuels are subject to contamination.

Further information
More details are available at www.neste.com/en.

IPU ADV REGULATOR

ADV Regulator is a multi-functional diesel fuel stabiliser specially formulated to provide long-term benefits for stored diesel. It delivers environmental benefits by reducing contamination in the fuel fed to diesel engines and by improving the efficiency of the combustion process.

ADV Regulator is packed full of surfactant molecules. These molecules disperse within the fuel system. Some coat solid surfaces creating a mono-layer which increases lubricity and reduces friction and wear and tear. The molecules that remain in the fuel create a barrier against contact with oxygen or any water molecules suspended in the diesel, thereby reducing the possibility of fuel oxidation.

The surfactant molecules also help to lower the surface tension of the diesel fuel which allows for greater atomisation in the engine combustion chamber. This creates a more efficient burn and fuller conversion of energy, as a result fuel economy is improved and atmospheric emissions are reduced.

FUEL SOLUTIONS

ADV Regulator has shown excellent results during independent tests conducted with its manufacturer's business partners:

1. In 2004, tests with ProDrive showed an 11% reduction in fuel consumption at low revs on a vehicle engine. Reducing fuel consumption reduces emissions.

2. An Interfleet test (ITLR-T18176-001-Issue1-RevB) on a Cummins NTA855R3 railway locomotive engine showed a 4.3% reduction in hydrocarbon emissions, a 12.8% reduction in carbon monoxide and an 8.5% reduction in carbon dioxide (8.5%). Particulate matter and exhaust smoke both reduced significantly, by 95% and 24.6%, respectively.

3. A second Interfleet report (ITLR-T19162-001-Issue1-RevA) on a different railway engine with 35,000 miles operation in service showed a 6% reduction in fuel consumption. Particulate emissions were reduced by 12%.

4. A third Interfleet railway engine report (ITLR-T21092-001-Issue 1-RevB) showed a 7% reduction in CO emissions and 14.5% reduction in particulates.

Summary: ADV Regulator

- Uses existing diesel gensets.
- Technically simple but needs dosing unit.
- Suitable for existing and new gensets.
- Available now.
- Positive contribution to goal of achieving gas-level emissions.

Further information
More details are available at www.ipu.co.uk/products/diesel-adv-regulator.

EXHAUST GAS (EGT) SOLUTIONS

Exhaust Gas Treatment (EGT) describes a series of technologies that treat the emissions from engines before they are released to the atmosphere. There are three main technologies that relate to diesel gensets.

DIESEL OXIDATION CATALYST (DOC)

Diesel Oxidation Catalyst (DOC): a DOC is designed to oxidize carbon monoxide, gas-phase hydrocarbons, and the Soluble Organic Fraction (SOF) of diesel particulate matter to carbon dioxide and water. DOCs are a standard part of the catalytic converters found on road vehicles.

DIESEL PARTICULATE FILTER (DPF)

A DPF removes particulate emissions and soot from exhaust gases. Whilst there is nothing specific in the MCPD currently regarding levels of particulate matter, this is likely to change.

The construction of IPU's Diesel Particulate Filters offers much greater particulate trapping and storage capacity than other filters.

IPU's range of DPFs provide a 95% reduction in particulate matter.

SELECTIVE CATALYTIC REDUCTION (SCR)

SCRs are one of the most cost-effective and fuel-efficient technologies available to help reduce diesel emissions.

SCR reduces NOx emissions by combining exhaust gases with a reductant and passing it over a catalyst. Depending on the catalyst and reductant used, the result is usually less harmful forms of nitrogen, water and sometimes carbon dioxide. Common reductants include AdBlue.

The process has been under development for decades but is only recently reaching adoption for diesel gensets.

SCR systems will be particularly important to comply with the MCPD. The MCPD has a NOx limit of 190mg/Nm3@15%O_2 to all combustion plant/generators in the 1-50MWth range. SCR alone can achieve a 90% reduction of NOx.

IPU's SCR system is a turnkey solution that will ensure your engines comply to legislation.

Designed and developed in-house, IPU are able to provide you with a cost-effective system and less disruption to your plant's operation.

IPU's cleverly measured usage of AdBlue will also help to reduce the lifetime costs of your system. The closed loop system used

to inject the AdBlue reduces the volume required, meaning less deliveries and less storage space required on site.

Summary: Exhaust Gas Treatment

- Suitable for new and existing gensets.
- Hugely effective at reducing NOx and particulates
- Clever, compact designs. Ideal for sites with space considerations such as STOR sites.
- Reduces lifetime costs of engines; less AdBlue required over time due to controlled dosage
- IPU is a one stop shop for all these solutions; SCR, DPFs and AdBlue

Further information
More details are available at www.dieselforum.org/about-clean-diesel/what-is-scr.

OTHER OPTIONS

ENGINE HEATING FOR STOR AND FFR SITES

Engine heating reduces the emissions produced by gensets when they start up. This is especially important for gensets operating under STOR and FFR programmes. These gensets only operate at times of peak load. They start and stop more frequently than gensets that provide constant baseload power.

It is accepted that emissions levels are higher when engines first start. Combustion is less efficient in a cold engine. IPU's coolant and oil heating solutions keeps engines warm so they produce similar emissions to a warm engine even when they're first started.

Engine heaters are already a common part of many gensets. Most operators use them to guarantee a quick, reliable start-up and a rapid ramp-up to full power. Despite their importance, the emissions benefits have been ignored.

It is also fair to say that engine manufacturers usually fit the least expensive type of coolant heater: thermosiphon heaters. These rely on the heat of the warm coolant to circulate it through the engine. This is fairly effective but it does leave pockets of unheated coolant which reduces combustion efficiency. Pumped heaters avoid this problem.

Emissions are measured on engines that are running in their optimum condition. They're fully warmed-up and operating in a perfect ambient temperature. This is not a realistic scenario for sites providing power through STOR and FFR programmes. To reduce the real emissions produced by STOR and FFR gensets the engines need to be heated so that, even at start-up, they operate at close to their optimum performance levels.

Summary: Engine Heating

- Standard part of new gensets but better heaters are usually available.
- Positive contribution to goal of achieving gas-level emissions.

Further information

More details are available at www.ipu.co.uk/products/divisions/engine-heating.

OTHER OPTIONS

IPU DIESEL DEFENCE FUEL POLISHING SYSTEMS

IPU's Diesel Defence Fuel Polishing Systems maintain the cleanliness of stored fuel however long that fuel is stored. It is especially relevant to emergency generators which operate in standby mode and consume their stored fuel sparingly.

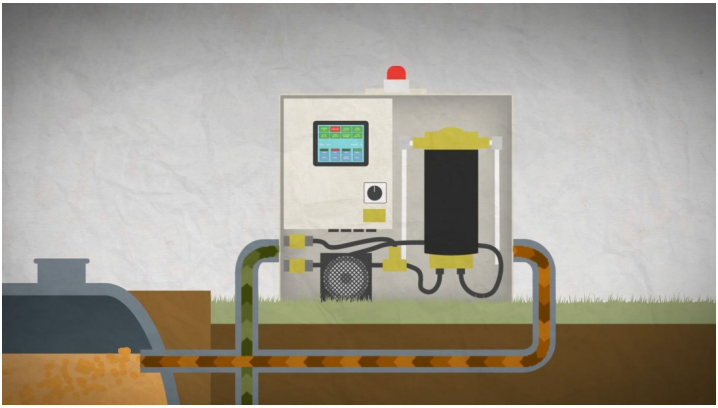
The main role of a fuel polishing system is to improve the reliability of emergency genset. They cannot run reliably on dirty fuel and reliability is the main requirement of an emergency genset.

Their relevance to reducing emissions is secondary but simple: cleaner fuel means cleaner emissions.

How fuel polishing works

Diesel Defence combines filtration and circulation to keep your fuel clean. The polishers circulate the diesel to prevent pockets of dirty fuel or water collecting in stagnant parts of your tank. Diesel Defence can circulate stored fuel indefinitely before it passes to the day tank or your generators.

Diesel Defence polishers are designed as a 'fit and forget' solution – simply set them up once and they will run unassisted, month after month.



Summary: Diesel Defence Fuel Polishing Systems

- Requires capital expenditure but benefits are shared between several gensets.
- Cleaner fuel reduces harmful emissions.
- Commissioning and installation considerations.
- Positive contribution to goal of achieving gas-level emissions.

Further information

More details are available at www.ipu.co.uk/products/fuel-polishing.

CONCLUSIONS

Diesel engines will continue to have a major role to play in the 21st century's power generation landscape. The base technology is so well-established and cost-effective it would be hard to replace.

Despite this, the Medium Combustion Plant Directive (MCPD) will change the face of diesel engines. In order to be compliant with the MCPD, there will need to be a dramatic reduction in emissions from engines, with a particular focus on NOx.

The main change to the industry will come at the input and output stages of every engine:

- Cleaner fuels that conform to the EN15940 standard will replace EN590 diesel in urban areas and other environments where low emissions are essential. The most promising EN15940 fuel is GTL. This will reduce emissions without imposing an unacceptable increase in running costs.
- Exhaust Gas Treatments will become a standard feature of future diesel engines. Selective Catalytic Reduction (SCR) systems and Diesel Particulate Filters (DPF) will be critical in reducing NOx and particulate contamination in order to comply to the MCPD.

- On-engine solutions such as bifuel conversions, Parker Racor filtration and GAC governors to reduce black smoke will also aid the reduction of harmful emissions.
- Finally, other solutions including on-tank fuel polishing units and engine heaters are other routes to consider to make your engines greener.

The combination of clean fuels and exhaust treatments will help diesel engines meet the emissions level of gas gensets. Although the changes will result in a rise in capital expenditure and a smaller increase in running costs, diesel engines will continue to be the mainstay of medium-scale power generation because of their flexibility compared to gas engines, especially in applications that require a fast response or variable load.

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Users should obtain starting information from their equipment manufacturer's user manual or service department for their specific application.

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