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- **In July 2021 Kao Data became the first data centre operator in Europe to transition to 100% HVO fuel for backup power generation.**
- **By 2023 London could be a Gigawatt data centre hub. The vast majority of these data centres will be backed-up with fossil fuel, mineral diesel generators.**
- **HVO fuel reduces carbon emissions by 90% and testing by Kao Data showed reductions of 13% in particulate matter, and 6% in nitrogen oxide emissions.**

The Road to Net Zero Data Centres: Reducing Emissions by Transitioning to HVO Fuel

Introduction

Fuelled by the increasing power consumption of global data centres, and society's insatiable demand for the data-supported services they host, over the last five years there has been considerable demand for 'green' data centres.

Whether these are remote data centres directly connected to renewable sources such as hydro-electric, geothermal, solar or wind, or urbanised data centres using 100% certified green energy tariffs, tremendous efforts have been made by developers and operators to reduce data centres' carbon footprints by tackling the root source of their utility power.

However, while this progress cannot be understated, one aspect that has been neglected is data centres backup power generation. Potentially because backup power generation is infrequently used – such is the quality of traditional data centre power resiliency – it is not commonly scrutinised with the same rigour as the main utility power source.

This whitepaper will explore why that approach is a huge oversight and highlight how targeting traditional diesel fuelled backup power generation and transitioning to 100% sustainable hydrotreated vegetable oil (HVO) fuel has the potential to save considerable carbon emissions. Using the example of Kao Data – the first data centre developer/operator in Europe to transition to HVO fuel – the paper explains why HVO fuel was selected, how the transition was performed within an operational, mission critical environment, and the results from the post transition testing.

Backup Power Generation – Data Centres' Dirty Secret

Data centres require continuous power, and lots of it, to keep customers' information technology (IT) equipment energised, and online. A loss of power will result in computing processes being halted, causing a gap or delay in the computational service provided. This may be an insignificant issue for non-critical data centre workloads, and a slight annoyance for a film streaming service, or gaming platform, but the loss of air traffic control or the delay in sequencing genomes for life-saving vaccine research is far more critical.

No matter how resilient grid infrastructure is, utility power outages will occur for a variety of reasons including severe weather, technical malfunction and/or human error. Data centres, especially those operating to Uptime Institute Tier 3 equivalence and above, must plan and prepare against a loss of utility power and mitigate against this risk by installing on-site backup power generation. In the data centre industry, the traditional method of achieving this is to use industrial-grade generators fuelled with standard, mineral (EN590) diesel.

In the event of a grid outage, servers within the data centre are immediately powered for a short period by battery backup. These will cover the load until the generators have 'fired up' and are able to take over. This process happens very quickly, and normally, after 15-30 seconds from grid supply failure, a data centre's IT load is covered by a bank of generators which will run concurrently until utility power can be fully restored.

By adhering to industry standards and following resilient engineering protocols, diesel powered generator backup isn't often needed. However all data centre generators must still be routinely tested to ensure that in the event of a utility outage – however unlikely – they operate as required and are able to take the data centre's load quickly. The normal testing regime for a generator is approximately two hours per month, running at full output. This equates to approximately 24 hours of test runs per year for each generator.

"Sustainability is at the core of our data centre operations. From powering our campus with renewable energy to design techniques that enable our data centres to operate more energy efficiently, we examine every opportunity to make a more sustainable decision."

Richard Collar, Senior Design Development Manager, Kao Data

While this testing regime, which equates to just one full day out of a 365-day calendar year doesn't sound like it would have a significant environmental impact, the reality is different. As an industry we need to consider the diesel consumption, combustion and harmful emissions from a standard industrial grade generator, and the sheer number of them needed to backup the global data centre sectors utility power.

On consumption, an industrial grade MTU 1965KW output diesel generator (such as the ones used at Kao's Data's Harlow campus) will consume around 450-500 litres per hour when run at full load (1,965KW power output). For a normal two-hour monthly test run, 900-1,000 litres of mineral diesel can easily be consumed per generator.

Using the top-end estimate of burning 1,000 litres of mineral diesel, this produces on average 3.6 tonnes of carbon dioxide (CO_2). So as to provide some context to the volume

of carbon emitted, burning diesel fuel on this scale will deliver the equivalent carbon emissions as to that of a vehicle driving 25,400km (based on the latest 2018 data from the **UK Department of Transport**) – roughly a return trip from London to Cape Town!

The diesel consumption and combustion of one MTU 1965KW generator, operating a testing-only regime of two hours per month, therefore, produces the following approximate annual figures:

Single Generator (MTU 1965KW)
- Mineral diesel (EN590) consumed per year: 12,000 litres
- Carbon emissions per year: 43.2 metric tonnes of carbon dioxide (CO_2)

So, what would this represent across a larger data centre footprint such as in London – one of the global data centre industry's main hubs and a primary location for soaring data centre demand?

According to **CBRE Group Inc** London's data centre market had a total supply of 711MW during the second quarter of 2020 and started 2021 with a total of 778MW utilised. **Techarti** estimated a further 100MW of capacity was added across 2021, and by the end of 2022 **Computer Weekly** estimates London will be a 'Gigawatt' data centre hub (1,000MW).

The overwhelming majority of this 1,000MW will be Tier 3 equivalent data centre capacity, meaning it will need to be supported by backup power generators that, again, will require a two-hour per month testing regime.

Even with a basic, 'rule of thumb' estimation the figures scale quickly. To adequately cover 1,000MW of IT load, the industry will utilise between 450-500 generators of the same size and calibre (MTU 1965KW) and even at the lowest estimate (450) this provides the following annual figures:

London's Data Centre Generators (supporting 1,000MW)
- Mineral diesel (EN590) consumed per year: 5,400,000 litres
- Carbon emissions per year: 19,440 metric tonnes of carbon dioxide (CO_2)

In that scenario London's data centres generator testing regime alone will consume enough fossil fuel diesel to fill more than two Olympic sized swimming pools per annum, and emit almost 20,000 tonnes of carbon emissions every year. And, all of this just from an industry in one city, testing its backup diesel fuelled generators, for two hours per month.

Many data centre developers and operators will also, in the vast majority of cases, over-accommodate their backup power generation, building in an additional layer of resilience should one of a bank of generators fail to start when needed. This means 1,000MW of critical IT load will most likely be supported by far more than the 450 generators we have estimated and used as the benchmark in the above calculations.

In conclusion, this level of diesel usage and the resultant carbon emissions cannot go unnoticed or left un-tackled. For data centre developers and operators who are committed to reducing carbon emissions root-and-branch across their estates, backup power generation has to be considered with the same attention as both source utility power and energy efficiency measures within the data centre.

This is why, in July 2021, Kao Data became the **first data centre developer/operator in Europe** to transition all it's backup power generation from mineral diesel to HVO fuel.

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What is HVO Fuel?

HVO fuel (EN15940) is a second-generation, recycled and treated natural vegetable oil, synthetically made and refined to burn cleaner and more efficiently than fossil fuels.

HVO can be manufactured from waste food stocks, raw plant oils, used cooking oils or animal fats. Kao Data's supplier, Crown Oils, utilises used cooking oils to produce HVO, however, the use of the other two raw materials, though different in the manufacturing process, produces an equal product complying with EN15940. Plants are grown and oils are extracted and used for their main purpose (cooking), recollected and then converted into HVO.

The conversion is completed via a two-stage process known as hydrotreatment, where oils and fats are saturated with hydrogen at high temperatures (over 300°C), followed by a stage of isomerisation/cracking to give the end product with the desired fuel qualities. The rigorously controlled HVO production process ensures a consistent, resilient and high-quality product.

"Transitioning to HVO fuel is a fantastic step on the road to Net Zero operations and effectively eliminates fossil fuels from our data centre operations and campus."

Richard Collar, Senior Design Development Manager, Kao Data

Why HVO Fuel?

Cleaner
Compared to mineral (EN590) diesel, using HVO fuel eliminates up to 90% of net CO_2.

For every 1,000 litres of EN590 diesel burned, 3.6 tonnes of CO_2 is produced when you account for the whole life cycle emissions from mineral diesel. HVO fuel, in comparison, burns just 195kg CO_2 for every 1,000 litres of HVO burned.

HVO is free from aromatics, sulphur, and metals, making it an extremely clean-burning fuel, which also reduces nitrogen oxide emissions (NO_2 or NOx), particulate matter (PM) and carbon monoxide (CO) emissions. HVO fuel is also substantially more environmentally friendly than first generation bio-diesel fuel (EN14214) which can only achieve up to 60% CO_2 reduction. Further, because of its composition and structure, it can cause damage to older combustion engines, due to reactions with the internal components.

FAME Free
Crucially for fuel within mission critical infrastructure, HVO is also totally free from Fatty Acid Methyl Ester (FAME), making it not only environmentally friendly, but also a more reliable operating fuel. The lack of FAME within HVO fuel offers key advantages because it prevents microbiological or diesel bug attacks - a type of sludge commonly found in first generation bio-diesel fuel and ensures its performance isn't affected at both the point of

use or after prolonged storage – even without the fuel polishing regimes that bio-diesel or mineral-diesel might require.

Ease of Use
With a paraffinic petrochemical structure, HVO meets EN 15940:2016 and ASTM D975 specifications, which means it can be used as a drop-in alternative without needing to modify existing infrastructure. Paraffinic fuels can be blended with current stocks without having to empty tanks, saving the cost of an additional upfront investment to make the switch.

A wide range of OEM diesel manufacturers have already approved HVO fuel for use within their equipment. As a result, HVO can often be used without any engine or machinery modification.

HVO also has excellent low temperature performance, with a high cetane number of up to 90 and a low cloud point of -32°C. This provides improved cold start performance, clean combustion, and less chance of waxing in extreme temperatures.

Enhanced Lifespan
Finally, HVO fuel also has a longer lifespan and offers greater resiliency than traditional bio-diesel fuel. With zero bio, FAME or sulphur content, there's less chance of degradation, increasing its shelf life up to 10 years, compared to up to one year for mineral diesel. Further, its high purity and flashpoint provides improved safety, storage and handling, reducing the need for regular testing and expensive fuel replacements.

All of these benefits make HVO a very environmentally friendly and mechanically resilient alternative to mineral diesel, and for energy-intensive industries such as data centres, a game-changing solution in the zero-carbon transition.

"HVO fuel is dramatically better for the environment compared to traditional, fossil fuel diesels. It is 100% renewable, biodegradable, sustainable and non-toxic. It works in exactly the same way as traditional diesel fuel would do, yet with HVO, you have a 90% carbon reduction benefit."

Simon Lawford, Technical Sales Manager, Crown Oil

Kao Data Makes the Switch

Crown Oil has been a supplier to Kao Data since the data centre began operations in 2018 and in 2021 they approached the company about their alternative HVO fuel product.

Kao Data's technical and operations team investigated further by consulting with their generator manufacturer MTU, a Rolls Royce solution, to understand how the fuel would work with their equipment. MTU validated that HVO fuel was a suitable drop-in replacement with no modifications needed for their engines.

On the day of the changeover, Kao Data subtracted as much of the original mineral diesel as possible and refilled each generator's belly tank with 15,000 litres of HVO. In total, an initial 45,000 litres of diesel were removed and transitioned to HVO. Each changeover was completed independently to ensure that at all times adequate, live generator coverage was in place for the data centre.

After the transition, each generator was switched on and brought up to full operating load, ensuring they functioned normally and routinely.

Air Pollutant Emissions Testing

Following the transition to HVO fuel, Kao Data's technical team instigated a test procedure to evaluate the emissions output of HVO, compared to traditional mineral diesel. This was done to identify emissions savings of harmful air pollutants such as nitrogen oxide (NO_2 or NOx) and particulate matter.

To deliver these tests, Kao Data commissioned Crown Oil and Optimum Power Services. Using MCERT test protocol, they undertook emissions testing on one of the installed MTU 1965KW generator sets.

MCERT's test protocol is the Environmental Agency's Monitoring Certification Scheme for equipment, personal and organisations. Furthering this standard, Optimum Power Services have devised a staged load test. This ensures emissions are recorded over a typical duty cycle that is modified to be site-specific and ensures robust and repeatable results that can be replicated in the future when this test plan is followed.

"This pioneering approach to replace our generator's diesel provision with HVO fuel, is a key step in the company's efforts to become Net Zero, and a further demonstration of our leadership in the international data centre sustainability field."

Gerard Thibault, CTO, Kao Data

The equipment used for the testing was the Testo 350 MCERT's exhaust gas analyser and Dekati eDiluter pro--- ELPI +, which conformed to EN50379-2-10. These two items of equipment are extremely precise and enable best in operation comparison between EN590 and EN15940.

Crown Oils delivered HVO fuel and traditional mineral diesel in temporary tanks to ensure the results for EN15940 and EN590 were unbiased.

The generator that was tested was built with a low emissions engine; an MTU 16V4000 series G74F 1965kw which is an NEA Singapore rated lower emissions engine. This engine has a combustion recipe that optimises fuel consumption and emissions. Across the test, the generator was run at two staged loads: 75% and 100%.

The tests found that **a 13% reduction in particulate matter** was **achieved by the use of HVO fuel**, together with **a 6% reduction in nitrogen oxide** – both substantial reductions in two harmful gas emissions.

A further interesting point was also noted during the testing, which found that due to the higher 'cetane' rating of the HVO fuel, the generator was more fuel-efficient when operating on HVO compared with mineral diesel. This was shown by the reduction of engine measured fuel usage during the test:

Engine Load (Test Load)	Traditional Mineral Diesel (EN590)	HVO Fuel (EN15940)
75%	360 l/h	354.2 l/h
100%	458 l/h	457.6 l/h

Conclusion

Kao Data's pioneering approach of using HVO fuel in its backup generators demonstrates the potential for data centre developers and operators globally to further reduce their CO_2 emissions in the pursuit of Net Zero operations.

As demand for data centres and the cloud computing services they support increases, so does the pressure – environmental, financial and regulatory – to develop them in a sustainable way.

Transitioning to HVO fuel enables a greener and more sustainable use of existing data centre infrastructure, while avoiding high-cost modernisation programmes. It also empowers the industry to do the right thing and quickly; driving the sustainability agenda forward, whilst helping end-users reduce their Scope 3 emissions.

For an industry predicated on providing resilience and reliability to its customers, HVO fuel provides an increased level of protection, with reduced microbial growth and sludging within the fuel. Furthermore, HVO fuel provides a 90% reduction in CO_2 as well as substantial reductions in harmful air pollutants.

"We're proud to have worked with Kao Data to initiate a first-of-its kind project, which will be transformative for the data centre industry, and help point the way forward for significant reductions in industrial greenhouse gas emissions."

Simon Lawford, Technical Sales Manager, Crown Oil

The research and studies within this paper demonstrate that:

1. HVO is cleaner than EN590 diesel and easy to transition to.
2. HVO is highly adaptable and can be operated at a wide range of climates and temperatures.
3. HVO is more reliable and resilient in operation, easier to store, and has a lifespan of 10+ years.

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Cross-Industry and Global Potential

The data centre industry isn't the only industry that is heavily reliant on backup power generators. Hundreds of thousands of similar generators – big and small – are used within a wide range of commercial and business environments including construction, manufacturing, food processing, events, agriculture, oil and gas, mining and transport logistics.

In addition, they are the main source of backup power for mission critical sectors such as healthcare and defence and in many developing countries provide a first-line power source for remote, off-grid communities. In total, the **worldwide diesel generator market** is estimated to be worth almost $28 billion US dollars in 2022.

As HVO fuel can be successfully used as a drop-in replacement for traditional mineral diesel within a mission critical data centre environment, there is very little reason it can't be transitioned across the majority of generator sets within all of the above industries effectively – thereby replacing billions of litres of mineral diesel.

The global climate change debate is often hampered by continual talk about what could be done, and future targets that are set but not always adhered to. Confidence in tackling one of the world's most crucial issues is reduced when action doesn't happen.

Kao Data have proved that HVO fuel can be transitioned and used now. The process is easy, fast, no modifications are required and the impact is immediate.

The subsequent potential for colossal, global savings in greenhouse gas emissions and harmful air pollutants could be a game-changer in the fight against global warming and would benefit the health of millions of the world's inhabitants due to improved, cleaner air quality.