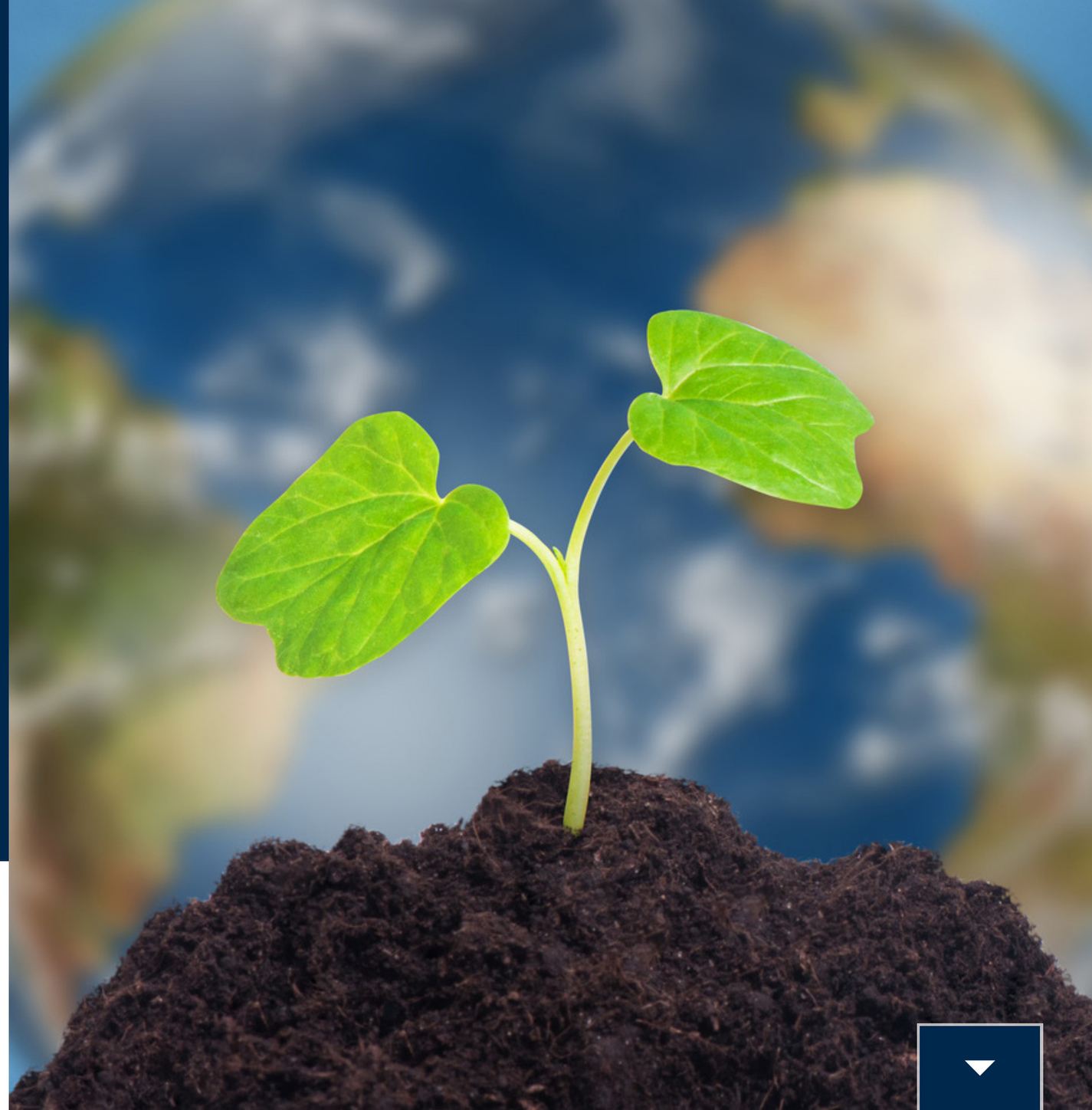
SUSTAINABLE POWER GENERATION: KOHLER'S PURSUIT OF CLEAN ENERGY SOLUTIONS

KOHLER®



INTRODUCTION TO THE SUSTAINABLE AGENDA

The climate crisis is the greatest single threat to global security.

According to the United Nations, resource extraction has more than tripled since 1970, including a 45 per cent increase in fossil fuel use. This unsustainable trend means global emissions are higher than ever, with the relentless rise in carbon dioxide in the atmosphere resulting in higher temperatures and more erratic weather patterns.

In short, the climate crisis is something that no one can ignore.

All companies, therefore, have a responsibility to future generations to act swiftly and decisively by significantly reducing their environmental impact. Kohler is acutely aware of this fact and is investing heavily to deliver advances in cleaner energy technology.

But what does this commitment mean for mission-critical equipment such as generators that serve a vital role in supporting a broad range of infrastructure? These reliable and dependable systems are deployed worldwide in places such as hospitals, data centers, airports, and water plants, supplying emergency power on demand during times of electricity failure. This performance provides crucial continuity of service and operations.

Most of these gas or diesel-powered generators - by the very nature of their application - are only used when called upon for short, infrequent periods. In normal circumstances they will have no environmental impact, as they will not be running. However, when in operation, they do emit pollution particles into the air. The drive is on, therefore, to improve the environmental performance of generators, through both evolutionary and revolutionary technologies.

This e-Book will provide an in-depth look at how we balance the need for emergency power with the climate emergency. It will outline how Kohler is responding to the sustainability agenda through the development of more optimized and efficient diesel and after-treatment systems, along with the use of pathway technologies such as biodiesel. It will also assess the opportunity to adopt radically new approaches, such as the application of battery or hydrogen fuel-cell powered generators for mission-critical applications.

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RESPONDING TO REGULATORY AND CUSTOMER REQUIREMENTS

The impetus behind the push for cleaner and more sustainable mission-critical power solutions comes from three primary sources: regulators, customers, and internal stakeholders.

Taking each in turn, governments and political and economic unions worldwide are committed to reducing the impact of air pollution through the adoption of more stringent laws and regulations. In Europe, for instance, this has resulted in the implementation of Stage V engine standards, which aim to reduce and control particulate number, particulate matter, and nitrogen oxide. Similar approaches have been taken in other parts of the world, including the United States. At the same time, local regions and municipalities have also banned the use of older engines in built-up areas to reduce local pollution levels.

Meanwhile, customers now have higher expectations of their system suppliers. For example, in the data center sector, diesel generators are widely used for the provision of backup power. However, hyperscale operators such as Google, Apple, Facebook, Amazon, and Microsoft (GAFAM) enjoy high public profiles and have a social responsibility to be green. As data centers become bigger and more power-hungry, these hyperscale organizations are looking to reduce their environmental footprints by assessing a broad range of technology options.

Also, the growing popularity of smaller edge data centers – often located in urban areas closer to the populations they serve – puts renewed emphasis on lower emissions.

And, finally, there is a drive and passion within Kohler to progress clean energy solutions. More than a decade ago, we committed to delivering NetZero GHG emissions across our operations and zero waste to landfill by 2035. As part of the company's Better Planet strategy, Kohler is also investing in renewable energy solutions and creating environmentally friendly products to help customers reduce their footprint. Part of our plan is to continue improving diesel efficiency, while investing in technologies such as hydrogen fuel cells and utility-scale batteries. Kohler recognizes that the sustainability agenda will transform power generation, and we intend to be at the forefront of delivering the required advances.

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DIESEL'S ONGOING ROLE IN MISSION-CRITICAL POWER

There is no doubt that diesel continues to provide the most robust solution for mission-critical power systems. It is a tried and trusted technology repeatedly shown to deliver the quickest and most dependable response to unexpected power outages.

KOHLER's diesel generators are built to power facilities of all sizes in every region of the world. In the data center sector, specifically, the latest models provide backup options up to 4MW, and can be configured to meet the requirement for the highest performance levels, such as Uptime Institute Tier IV. These generators are designed to be made customized and stackable for any site – from hyperscale, regional or edge.

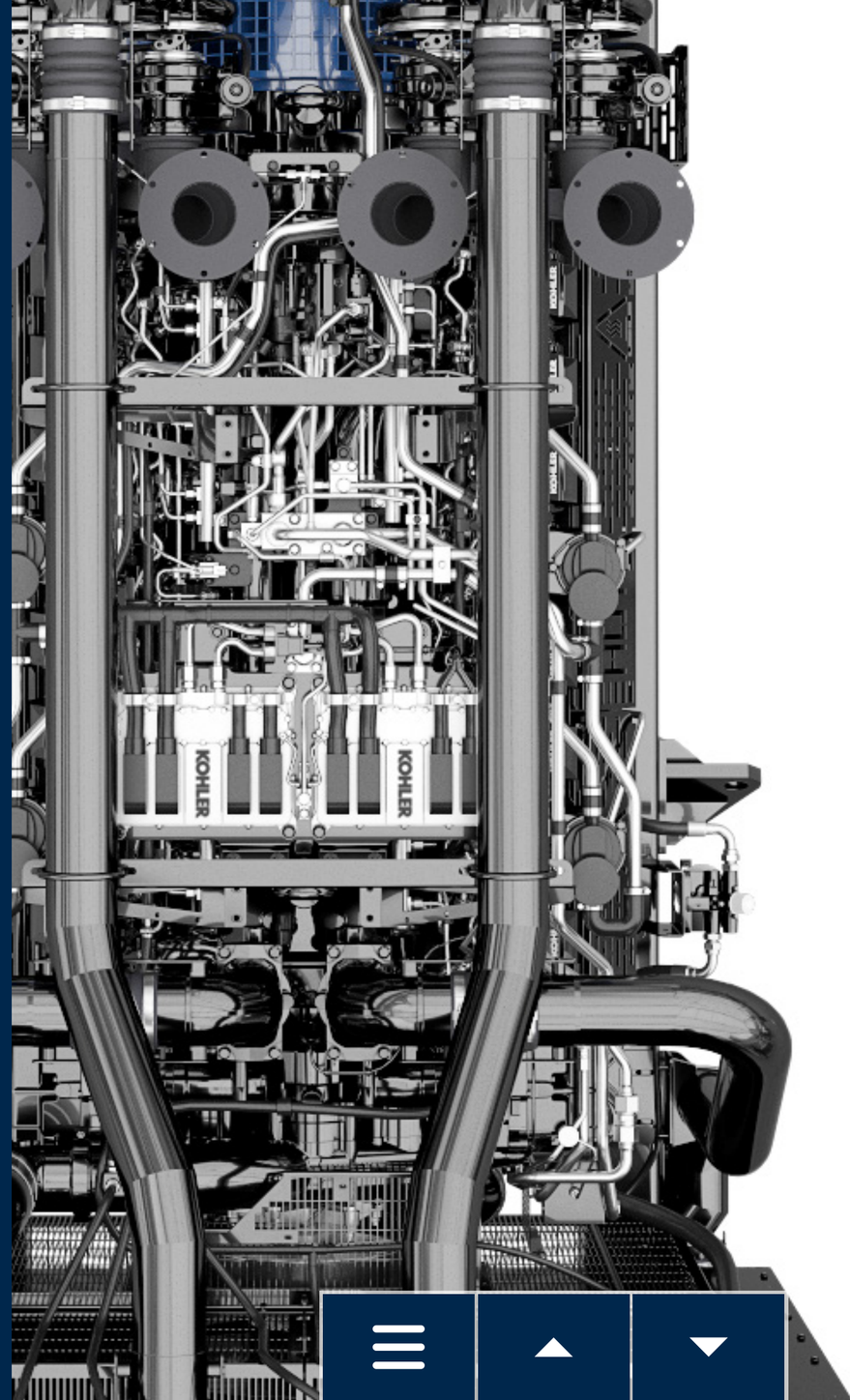
Indeed, diesel technology never stands still. Sustainability has been a primary guiding factor in recent years, with Kohler complying with all major global and local emissions standards such as EPA and the Medium Combustion Plant Directive in Europe. This compliance is made possible through highly optimized internal engine design and the adoption - where needed - of exhaust gas after-treatment including diesel oxidation catalysts, diesel particle filters and selective catalytic reduction. As a result, these advanced engines offer powerful performance, with the lowest emissions to date.

Other evolutionary 'pathway' technologies are being considered, too. These include the use of bio-sourced 'green' diesels which can help deliver a reduction in CO^2 emissions of up to 80 per cent over the entire life cycle. However, the specific composition of these fuels creates challenges around storage stability, corrosivity, and ageing due to micro-organisms. These issues are less of a concern with hydrotreated vegetable oil (HVOs) – a range of paraffinic bio-based liquid fuels produced from existing farm-based feedstocks such as rapeseed, sunflower, and soybean oil. HVOs are straight-chain hydrocarbons free of aromatics, oxygen, and sulfur, which can deliver high cetane numbers.

Crucially, HVOs can be produced without compromising fuel quality. They can be stored more easily than other biodiesels, and they offer a 'slot-in' solution that can be used in conventional diesel engines. Consequently, most of Kohler's diesel industrial and rental generating sets are already compatible with HVO paraffinic synthetic biofuels, while also being compatible with FAME (Fatty Acid Methyl Ester), a renewable fuel produced from vegetable oils, animal fats or waste cooking oils through a process of transesterification. Kohler is well on the way to ensuring that its mission-critical generators can make the most of these new types of cleaner fuels and the emissions-reducing benefits they bring.

> "Kohler is well on the way to delivering full compatibility of hydrotreated vegetable oil across its engine range, ensuring that mission-critical generators can make the most of these new types of fuel."

These are just some examples of Kohler's evolutionary approach to improving the environmental performance of diesel generators – and it is a journey that will continue for many years to come. For some parts of the developing world, where the infrastructure to support emerging technologies such as hydrogen fuel cells does not exist, diesel remains the only viable option for mission-critical applications. That is why Kohler will continue to pursue incremental advances to ensure diesel technology is cleaner than ever.



THE PROS AND CONS OF UTILITY-SCALE BATTERIES

So, what are the possible alternatives to diesel generators for back-up supply power, over the longer term? One area of interest is the use of utility-scale batteries, underpinned by advances in lithium-ion technology, and used in combination with renewable energy supply.

In the data center sector, in particular, GAFAM hyperscale operators are actively researching megawatt-scale battery systems, with ongoing trials currently being performed to assess technical characteristics such as energy density and space requirements. Interestingly, renewables-plus-storage techniques could potentially be used for grid service applications – with on-site batteries used to help utility companies manage imbalances on the grid.

The challenges around battery-based systems come with issues such as reliability, quality, and cost-effectiveness. While lithium-ion technology has matured rapidly in recent years, questions remain over its suitability for grid-scale deployment. There have been cases of data centers running on generators for several days at a time, and it is doubtful that a battery-powered back-up system could ever feasibly meet such demand. And if renewable technology such as solar power was to be used as an energy source, the footprint for the panels – certainly at hyperscale - would be enormous.

It would not be easy to manage this space requirement, particularly at data center sites in highly populated metropolitan areas.

Nevertheless, batteries and energy storage remain an attractive long-term option for providing mission-critical power. Realistically, though, such technology is only likely to be used in tandem with generators for the medium term, as reliability, scalability, and cost-efficiency issues are overcome.

Meanwhile, Kohler is working with industrial partners to develop battery-powered generators. It has joined forces with a leading power grid operator in Europe to produce a 400-600kWh lithium iron phosphate battery prototype. This is firm evidence of Kohler's ongoing commitment to cleaner energy solutions.

> " Renewables-plus-storage systems could be used for grid service applications – with on-site batteries used to help utility companies manage imbalances on the grid."

HYDROGEN FUEL CELLS ENTER THE MIX

Hydrogen fuel cells represent another area of interest in the race to develop a cost-effective means of supplying environmentally friendly back-up power. Once again, it is the data center sector that leads the way. Indeed, some hyperscale organizations are already running proof-of-concepts with proton exchange membrane fuel cells combining hydrogen and oxygen in a process that produces water vapor and electricity. For instance, a 250-kilowatt fuel cell system has been used to power a row of data center servers for 48 consecutive hours in one specific trial.

The chemistry is well-understood. Plus, hydrogen is one of the most abundant elements in the world. The challenge, as with battery power, lies with scalability and cost. At grid-scale, widespread infrastructure investment would be required to procure, store, and maintain a sufficient supply of hydrogen to power generators. It is estimated that to run 30MW of IT equipment for 48 hours would require 100 tons of hydrogen. A delivery truck can carry two tons of hydrogen – so around 50 shipments would be needed for a two-day outage. That requirement, in itself, would present significant logistical challenges at places like data centers for on-site storage, in addition to concerns over supply chain constraints.

Longer-term, there is interest is in how hydrogen fuel-cells deployed at grid-scale could lead to more dynamic energy infrastructure. For example, a data center supported by a system that combines fuel cells, hydrogen storage tanks and an electrolyzer that can be used to convert water molecules into hydrogen and oxygen, could theoretically be integrated with the electric power grid to provide load balancing services. In such an example, the electrolyzer might be switched on during periods of excess wind or solar energy production, with the renewable energy stored as hydrogen. Then, during periods of excessive demand, the data center operator could bring the hydrogen fuel cells online to generate electricity for the grid.

> “ In one specific trial, a 250-kilowatt fuel cell system has been used to power a row of data center servers for 48 consecutive hours.”

These are exciting possibilities, and Kohler recently announced that it is developing a prototype 60 kW hydrogen generator using PEM (Polymer Electrolyte Membrane) fuel cell technology. However, the widespread deployment of fuel cell technology is likely to be at least 10-15 years away. Under such a timeline, generators are likely to provide the baseline solution for back-up power, while engineers continue to assess alternative techniques. Kohler is committed to helping push forward the boundaries of technology on all fronts, seeking out relevant partnerships as part of a continued drive towards sustainability.

KOHLER'S ROADMAP TO A SUSTAINABLE FUTURE

It is clear to see, then, that there is much research and development going on around clean energy. Kohler, as a company, recognizes that we have a responsibility to future generations to leave the world in a better place than we found it. This duty means working towards having NetZero GHG emissions across operations and zero waste to landfill by 2035 – something we think is eminently achievable.

Our focus, therefore, is concentrated on developing sustainable power solutions – not just for mission-critical back-up systems, but across our diverse product range. Also, we must continue to reduce emissions and cut carbon footprint in our production facilities and across our broader operations. All this needs to be achieved while continuing to bring to market high-quality power solutions that are reliable, modular, scalable, and efficient.

So how do we plan to achieve our clean energy ambitions?

COMMITMENT #1: WORKING CLOSELY WITH OUR CUSTOMERS

Our talented teams of engineers and designers will continue to collaborate with our customers on clean energy technologies, bringing them new solutions that decrease their carbon footprints and solve their challenges.

COMMITMENT #2: DEPLOYING OUR ENGINEERING KNOWLEDGE

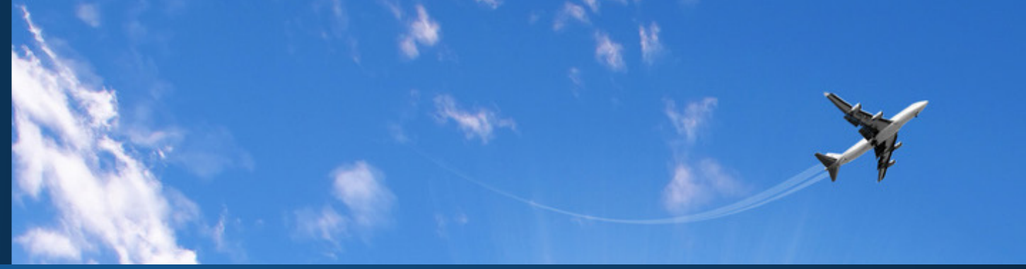
Advances in areas such as engine design changes are delivering higher efficiencies and optimized performance, while exhaust gas after-treatment can reduce emissions.

COMMITMENT #3: DELIVERY EVOLUTIONARY ADVANCES

Pathway technologies such as bio-sourced diesel offer valuable 'ride-through' sustainability options until revolutionary solutions are established.

COMMITMENT #4: ASSESSING RENEWABLE TECHNOLOGIES

Revolutionary technologies such as hydrogen fuel cells and utility-scale batteries could transform power generation and we are committed to continuously evaluating and progressing these exciting technologies.



We believe that by following this strategy, the journey to cleaner energy and sustainability can be successfully navigated – for the benefit of all. Our ethos can be summed up by the following quote from David Kohler, KOHLER's President and Chief Executive Officer.

> "Our sustainability strategy, properly conceived and executed, should not be about compromise or massive trade-offs. We believe it should be a win for the consumer, the associate, the environment and the company."

In short, Kohler has the power to bring your clean energy ambitions to life.

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