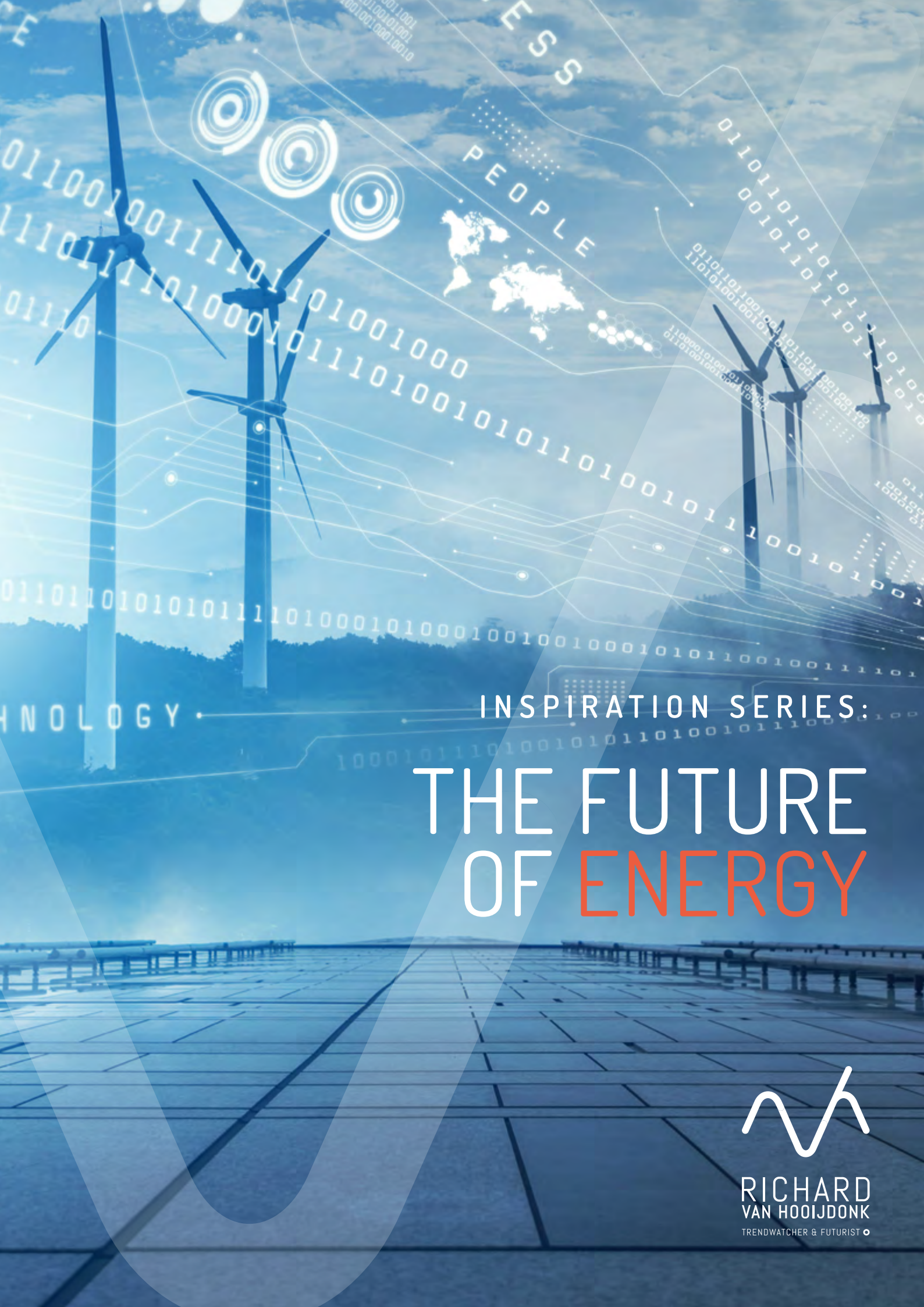


INSPIRATION SERIES:

THE FUTURE OF ENERGY

RICHARD
VAN HOOIJDONK
TRENDWATCHER & FUTURIST

CONTENTS

INTRODUCTION

As energy demands grow and traditional energy sources continue to threaten the environment, we're reconsidering the role of renewable energy.

Carbon Brief reports that for the first time in 100 years, coal provided zero power for the UK during several days in May 2016 and that from April to September, 5.4 per cent of UK's electricity demand was generated from solar energy, while coal provided only 4.7 per cent.

New solar and wind energy tech is set to transform the world of energy by leaving it fossil fuel-free. And while Blockchain ensures energy security, smart grid systems are automating efficiency. Thanks to big data's improvements to operation and reliability, the risk of power outages is minimised.

Researchers are also exploring the possibilities of the nuclear energy provided by fusion, which offers limitless clean power. Other scientists are experimenting with zero-emission hydrogen tech for cars.

There's never been a more exciting time to explore the future of energy.

1.0

WIND ENERGY

"We have a lot of confidence in the wind power market going forward, as the technology continues to improve, prices continue to go down and the call for clean, renewable power to reduce emissions, clean our air and create new jobs and new industries only gets stronger with each passing year."

- Steve Sawyer, the secretary general of the Global Wind Energy Council (GWEC)

Although we've been producing energy from renewable sources for quite some time, our production of clean power still lags behind dirty sources like fossil fuels. Indeed, we're contributing to global pollution by using these conventional energy sources, though increasing attention is being paid to the costs associated with these practices. The future demands change, and the transition to sustainable, green energy is inevitable.

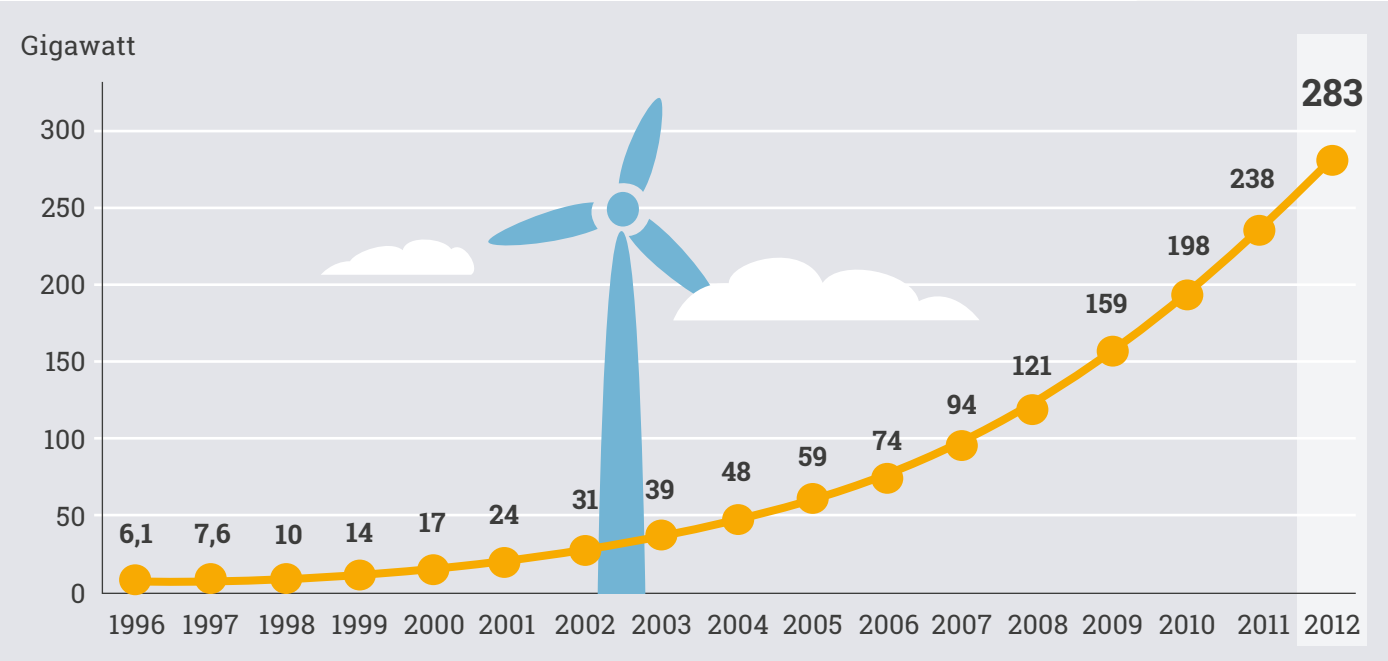
Wind was one of the first renewable resources people started to exploit; think of the era of sail and windmill. It stands to reason, then, that modern wind turbines were among the first, and greatest, renewable energy generators. China, the US, and Germany lead the way on this front, but their conventional wind turbines still need a few improvements.

This is where bladeless turbines step onto the scene. Spanish startup Vortex Bladeless is hoping to make wind turbines as popular as solar panels, allowing homeowners to install bladeless turbines on top of their houses, just as they would solar panels. These turbines produce energy through 'vorticity,' a process where wind is gathered in a cylindrical structure, vibrating with kinetic energy. A linear generator harnesses this power, and since bladeless turbines don't have regular blades, it's less expensive to build and maintain them. However, they're not as efficient as conventional turbines, converting wind energy into power with only 70 per cent efficiency compared to bladed turbines' 90 per cent.

Nevertheless, they have proven to be excellent energy generators. It's critical, of course, to position them correctly,

finding areas of nearly constant wind. The UK is already working on a giant wind farm off the north-west coast of England. The project is expected to be completed by 2021, when this offshore wind farm will be the biggest in the world. But there are some downsides, too. Beside their expense to build, these turbines can be a threat to animal life. For instance, the vibration of the turbine might disturb whales, while its blades can be deadly to birds. However, a study carried out by the Danish government and several energy companies reports that such threats are minimal. Referring to the two largest wind farms in the world, both located in Denmark, scientists came to the conclusion that an offshore wind farm is safe. Seabirds rarely crash into the blades, and although sea life might temporarily move away from the location where the wind farms are being built, the animals will come back after the construction is complete.

Wind power global capacity



Source: cleantechnica.com/2013/11/07/renewable-energy-charts-renewable-energy-facts/

Today, wind turbines come in different shapes and sizes, and designers are focusing on their visual appeal as well. Some are taking a step further, such as NewWind, a French company that developed Wind Tree, a structure resembling a tree and consisting of small turbines instead of leaves. With a height of 11 meters, the tree is capable of providing energy for 15 streetlights a year. Designed for private back-yards and public parks, these Wind Trees have already been installed in Paris.

Click for video

2.0

SOLAR ENERGY

"Renewable energy technology, especially solar and wind, has made exponential gains in efficiency in recent years, enough to achieve economic competitiveness and, in an increasing number of cases, grid parity."

- The World Economic Forum (WEF)

For many years, renewable energy has been a costly choice. But that's set to change as solar energy has become cheaper than coal in some parts of the world, promising further reductions in price over the next decade.

With technological advances, the field of solar energy is flourishing, and soon we might be living in cities completely powered by the Sun. At least that's what co-founder of Tesla, Elon Musk, has in mind. Musk transformed the isolated American Samoan island of Ta'u by equipping it with 5,300 solar panels and sixty Tesla batteries, freeing the island's community from the costly and hazardous diesel generators it had relied upon before. Even in inclement weather, these batteries provide three days of stored power, allowing continuous electricity for Ta'u's nearly 800 residents.

Governments worldwide are now looking to Ta'u for inspiration. For instance, in 2009, the UK issued an act to increase its use of renewable energy by 2020. Germany is doing the same by installing thousands of solar panels, hoping to transform its energy system and switch to exclusive renewable energy use by 2050. And not only developed countries are embracing solar energy. For example, Tanzania realised an initiative called 'one million solar homes', according to which one million homes got access to solar power at the end of 2017.

Indeed, the popularity of solar energy is spreading worldwide, but some are still sceptical about changing their traditional grid system because solar power isn't constant and requires high tech batteries to provide continuous power. Indeed, the former CEO of Microsoft, Bill Gates, thinks that the future of solar and wind energy is unviable. He says that the energy we use needs to be reliable and continuous, but when the Sun isn't shining, the entire process gets more complex because of the need for storage and later distribution. Such energy would be a great addition to other resources, but as a main power source, it's not ideal, Gates explains.

But a team of Chinese scientists is working on a solution. They've developed a prototype that enables solar panels to generate power, even when it's raining. Their innovation consists of a solar panel enriched with a graphene layer which generates energy from raindrops. This is achieved thanks to the ability of graphene's electrons to bind with the ions in water, releasing energy that's later converted into electricity.

Such advances take solar energy one step closer to becoming the most dominant source of power in the world.

3.0

BATTERIES

"Now, because we use fossil fuels, there's no need for energy storage in our grids. But when renewable energy is more widely used, we will need big, high capacity, long-lasting batteries that can, for example, store the solar power during daytime and release it at night, to be transmitted from the grid to other homes and industries."

- Zhi Wei Seh, a scientist at the Institute of Materials Research and Engineering (IMRE)

The effects of global warming are forcing more and more people to look to alternative energy sources, such as wind or sun, but even the strongest supporters of renewables know that without high tech batteries, we still depend on fossil fuels whenever the wind stops blowing or the Sun isn't shining. Only if renewable energy is stored correctly can it provide power during windless or gloomy days.

This is where batteries are essential to the future of energy.

A discovery made by scientists from Harvard, who created a battery that could last ten years, might be a game changer for storage. The team led by Ray Gordon and Michael Aziz developed a 'redox flow battery' that outclasses the lithium-ion based batteries in terms of cost and environmental safety. The flow battery consists of two tanks, each storing a supply of positive or negative liquid electrolytes. When these positive and negative electrolytes flow next to each other, they produce power.

Although lithium ion batteries are more expensive, Elon Musk thinks they're more efficient, and he's planning to reduce their cost by 35 per cent. His Tesla Gigafactory in Nevada is producing these batteries for Tesla vehicles and to store renewable energy from solar panels like the ones in Ta'u. According to Musk, the formula to make the entire world run on sustainable energy begins with 100 Gigafactories. He believes that by 2018, the number of batteries produced in Tesla Gigafactories alone will surpass the number of those produced worldwide in 2013.

Musk might have serious competition, as Zhi Wei Seh, a scientist from the Institute of Materials Research and Engineering (IMRE) in Singapore, is developing a new lithium-sulfur battery that is capable of storing five times more energy than lithium-ion batteries. Zhi Wei Seh says these batteries aren't only efficient for larger energy grids, they could also power devices like laptops and smartphones. Another advantage is their cost; lithium-sulfur batteries are much cheaper than current alternatives, though their life cycle is shorter. He estimates that the batteries will be ready for the market in just a few years.

4.0

THE SMART GRID

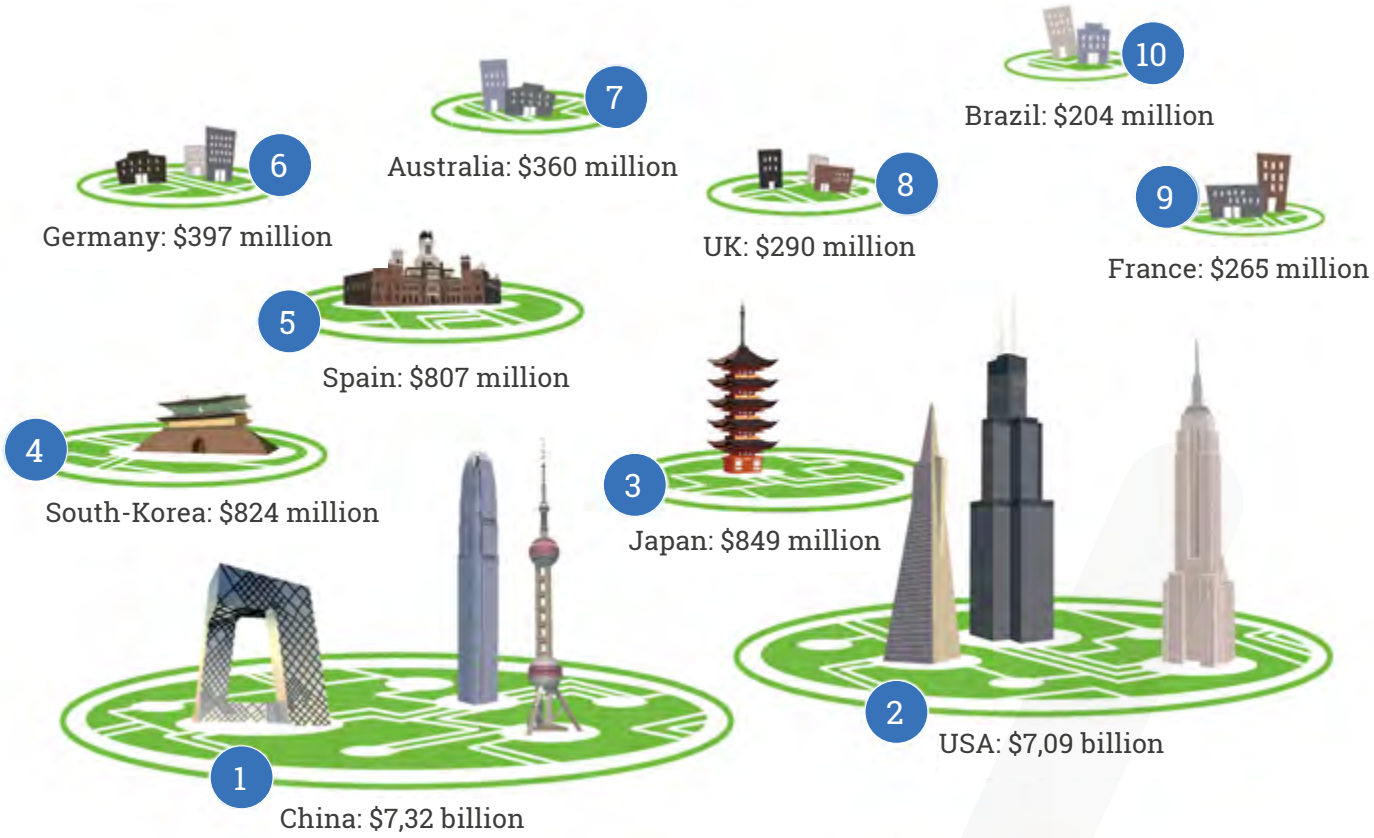
"Technology is not what is holding us back. Could I tomorrow install smart meters in every home and save energy? Absolutely. But until now, there has been absolutely no financial incentive to do this."

- Richard Kauffman, the chairman of Energy and Finance for New York

A smart grid combines multiple technologies and devices equipped with sensors into one effective system. Many countries are starting to see the real benefits of the smart grid transformation, and are restructuring their existing grid to gain these advantages. For instance, the UK is aware that its ageing infrastructure often fails to meet the demands of consumers, resulting in power outages. In collaboration with leading IT provider Cisco, the government is hoping to accelerate the desperate change its grid system needs, especially bearing in mind that no less than 50 billion connected devices are expected to come online by 2020. The UK's current grid couldn't satisfy this much demand. Moreover, Mike Norfield, the CEO of smartUC, points out that their grid system is outdated, making it vulnerable to cyber attacks.

The UK isn't alone in its concern about its electrical grid system. Many other governments worldwide see the need to switch to smart grid technology. Take cities such as San Diego and Jacksonville as examples. These two cities partnered with the Business Innovations Unit to develop a project to raise the public's awareness and emphasise the importance of green choices. Indeed, the future of energy is as much about conserving power as it is about generating and storing it. For instance, by installing 4,000 LED lights, each city managed to save $350,000 per year. And following in their footsteps, Texas has installed sensors and smart meters in some of its neighbourhoods to monitor and collect data about energy consumption. The gathered data will help Texas improve its grid functionality by knowing exactly which areas require improvements.

Top ten countries for federal smart grid investment



Source: Zpryme research & consulting

Implementing smart technology into the existing grid system, however, takes time and money. This is why the Department of Energy and the Pacific Northwest National Laboratory are funding a project which will - in a real-world environment - test how smart technologies work together with existing infrastructure. Alexis Abramson, the director of the Great Lakes Energy Institute at Case Western Reserve University, and one of the members involved in the experiment, says that they'll use different types of buildings to test the functionality of smart grid technology. The experiment will be conducted on two older buildings that will serve as real-world labs. Using Department of Energy/Pacific Northwest National Laboratory software, the researchers will track data such as "price points and stress levels on the grid to automate the energy usage of the buildings."

BIG DATA

"The goal is to turn data into information, and information into insight."

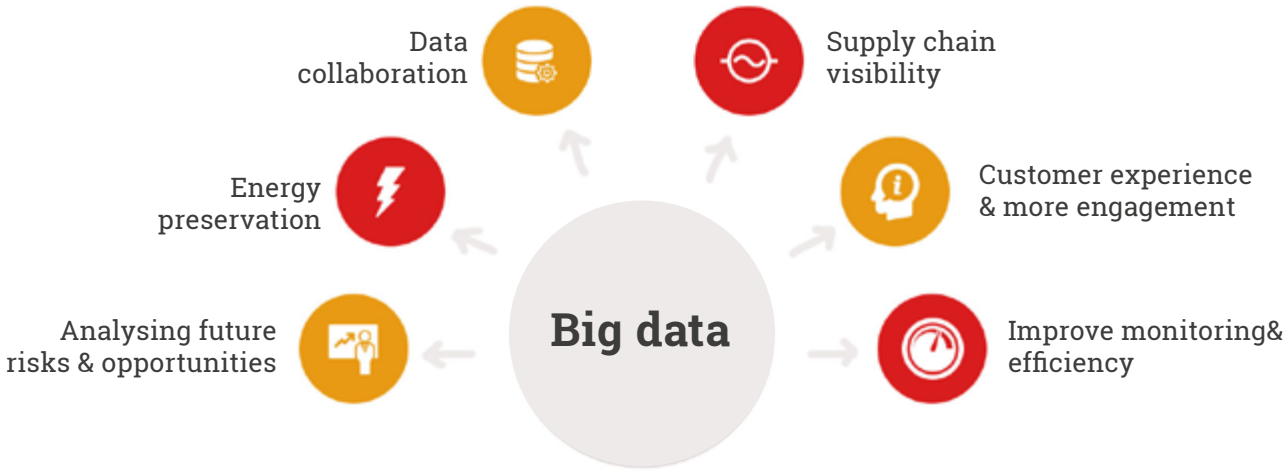
- Carly Fiorina, the former CEO of HP

The capacity of big data to redefine the future of energy is directly connected to our ability to collect, analyse, and use it. Too much unstructured data is simply too much, and given that the 'big' in big data can refer to the amount, variety, and/or speed of the data generated by our connected devices and sensors, we've had to wait on tech innovations to make use of data as an actionable resource.

Energy data isn't limited to usage measurements. Big data can tell us where to place wind farms or which areas possess the greatest solar potential. It can also guide our investments, help us plan smart grids, and enable smart metering of individual homes. Indeed, the most forward thinking energy companies have already moved far beyond the modest goal of measuring consumption. Instead, leaders like the Vermont Electric Power Company (VELCO) are providing imaginative energy solutions in which big data is merely a tool.

Our power grid was designed for permanent sources of energy like power plants, not the intermittent sources that are typically at the forefront of green energy. Although these are the future, they can be challenging to manage. Wind and solar, for instance, only generate power while the sun shines and the wind blows, demanding advanced batteries and smart grids to store and distribute power. And these green sources are also affected by changes in temperature and a host of other problems that demand information - and above all, insight.

There are many ways in which big data is adding a bigger advantage in the energy sector. Here are a few:



Source: www.apogaeis.com/blog/how-big-data-is-adding-a-bigger-advantage-in-the-energy-and-power-sector/

Only big data has the power to provide actionable insight from such diverse sources, on such complex issues, in real time. Jason Bordoff, writing for *The Wall Street Journal*, explained that "...nowhere in the energy sector is the impact of big data more revolutionary than in the operations of the electricity system, where it will play an increasingly pivotal role, integrating more and more renewables into the power mix." But this complicated dance of supply, demand, resource measuring, and optimisation requires new approaches to how we collect and analyse data.

For instance, if a region's power supply is primarily hydro-electric, a prolonged drought or heavy flood demands reaction. And in Vermont, where the state has witnessed no less than eight weather disasters in the last six years, weather forecasting is critical for energy companies. Recognising this, VELCO designed the Vermont Weather Analytics Centre (VWAC). In collaboration with IBM, the VWAC tracks and predicts adverse weather, matching this against supply and demand data to better manage finite supplies of energy.

And big data helps to ensure that our energy sources are properly managed. In everything from massive oil fields with hundreds of drilling rigs, to wind farms with dozens of turbines, to huge solar farms slowly turning to follow the sun, managers need to know in real time when something goes wrong. Only by collecting and analysing production data can we gain an accurate picture of present supply - and when something's not right, take immediate action. Moreover, under ideal conditions, managers need the capacity to adjust the performance of our green energy sources, boosting production.

For instance, Siemens' Winsight360 uses big data to adjust the control of its offshore turbines. Assessing the temperature of the air and the turbine, the wind speed and the current energy needs, Siemens' system adjusts the pitch of the blades to allow them to spin faster while controlling the load on the turbine to avoid damage. The result is 4 per cent more power per year, a huge gain for green energy.

6.0

BLOCKCHAIN

"Oh, this is shared economy. This is Airbnb, this is Uber, this is 21st century."

- Brooklyn resident Michael Guerra, describing the Brooklyn Microgrid, powered by Blockchain

You're probably familiar with Blockchain as the decentralised ledger system driving many of the world's cryptocurrencies, including Bitcoin. Blockchain works by recording transactions (or data) in a time series, embedding a record between links to form an inviolable chain. Hacking this chain is virtually impossible, and because the ledger is distributed, it's both transparent and permanent.

But Blockchain is proving to be much more than just a ledger.

Imagine a future of energy in which each home and building is equipped with the capacity to generate green power from solar or wind. If this sounds far-fetched, remember that Elon Musk has recently brought solar roofing tiles to market, and though they resemble ordinary materials like slate, they generate enough power to fuel an electric car every day. As these homes and buildings produce power, they'll offset their need for distributed energy, and in some cases, produce a surplus.

Smart metering can allow this excess power to be sold back to the grid, potentially enabling a truly smart system of energy production and distribution that trades power from one home to the next in a neighbourhood or city.

But at present, our system to manage such transfers and transactions has been described as cumbersome. Without smooth, easy, transparent, and secure transactions, this future simply can't happen.

But now there's Blockchain.

In Germany, the energy storage company, Sonnen, and the Tennet TSO, a German subsidiary of the Dutch power firm, are implementing a system that uses Blockchain to manage power transfers. In this 'Sonnen community', members will be able to share excess power with those in need, and by linking their battery systems to the grid, Sonnen promises to reward them with flat rating for electricity.

Germany isn't alone. LO3 Energy, a company devoted to alternatives to traditional power, has created a Brooklyn microgrid. Powered by Blockchain and smart meters, it's decentralising the energy market. Essentially, solar power produced in one home is sold to another that needs it, allowing energy and money to change hands automatically, in real time, and with an indelible, secure, transparent record. And because this system augments rather than replaces the traditional grid, it can supply power during outages, providing greater energy security. As lawrence Orsini, the founder of LO3 explains, "Blockchain is a really good communication protocol for what we want to do. People can now make choices and decisions about how they want to participate in the energy market: peer-to-peer markets, community markets, and other interesting and new business models."

A final innovation we'd like to share with you is SolarCoin. For homes or buildings equipped with solar panels, SolarCoin uses Blockchain to pay for each megawatt hour of solar energy produced. SolarCoins are mined, much like Bitcoins, but in this case, they're generated by solar energy. And while their value now is a paltry $.06 per megawatt, as more customers join, the value of SolarCoins is expected to surge. At some point in the near future, you might be able to earn consequential sums just by doing the right thing for the environment.

As Michael Guerra, a Brooklyn resident says, "Oh, this is shared economy. This is Airbnb, this is Uber, this is 21st century."

We think he's right.

7.0

THE INTERNET OF THINGS

"More and more devices, factories, lighting systems, buildings, transportation systems and smart cities and communities will be connected and controlled through the Internet. Brains in the Cloud will optimise energy use to a larger and larger extent. More IoT sensors and devices will enable more control, and greater savings over time."

- Gene Wang, the CEO and co-founder of People Power

The disruptive implications of the Internet of Things (IoT) involve billions of connected sensors and devices providing unimaginable amounts of data across networks. In the energy sector, harnessing such data from connected devices such as smart grids and smart meters represent a great way to operate the grid more efficiently, and help customers reduce both the cost and consumption of energy. For instance, Navigant Research reports that cumulative revenue associated with commercial and residential IoT products and services is expected to exceed $750bn by 2025. But to leverage on the new tech, aging electric infrastructure must undergo significant changes. Modernising the grid to make it more intelligent can greatly reduce the frequency and duration of power outages, reduce the impact of natural disasters, and restore and maintain energy supply systems faster when outages happen.

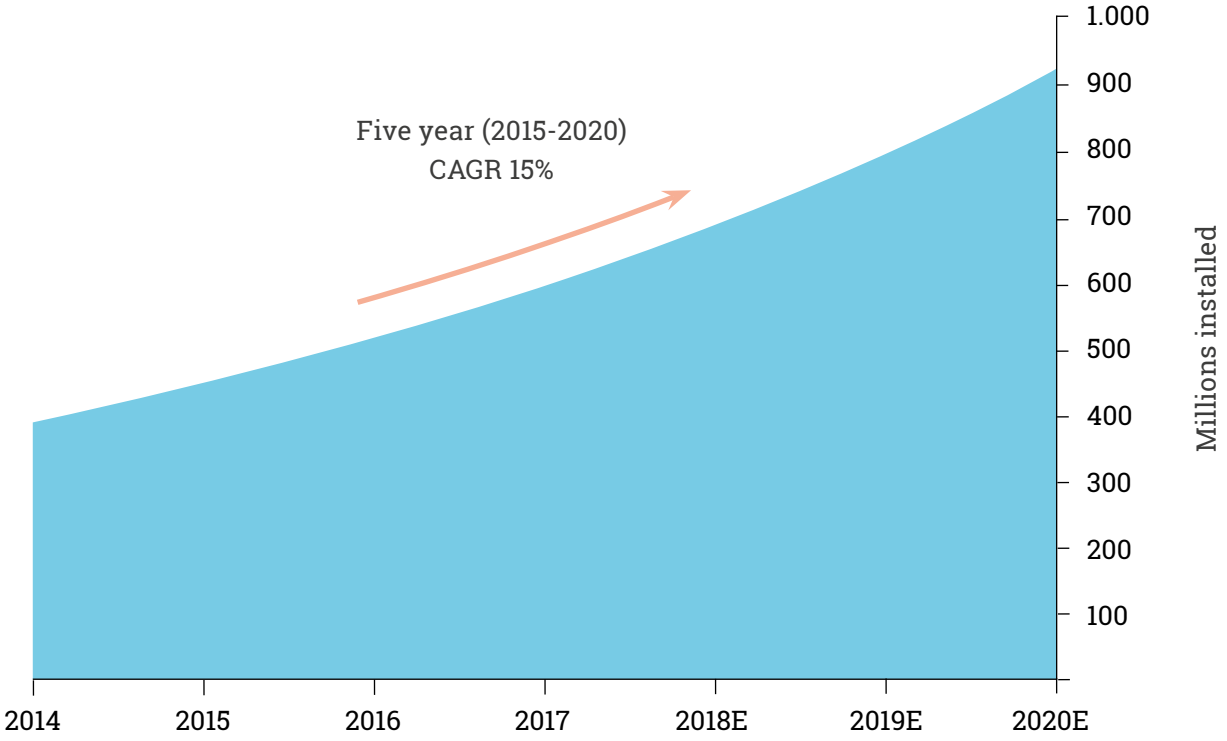
The smart grid encompasses energy generation, transmission, and distribution. The system is additionally enhanced by digital control and monitoring, providing real-time information about the grid. In essence, it tracks grid vitals such as voltage stability to prevent 'power grid arrest.'

The advanced technologies include Phasor Measurement Units (PMUs) or synchrophasors that help providers assess grid stability and automatically report outages, while smart meters give consumers better insight in their power consumption.

The University of Tennessee in Knoxville, in collaboration with Oak Ridge National Laboratory, deployed a system of GPS synchronised sensors to measure the voltage angle and frequency of the electric grid in real time. Synchrophasors provide a map that shows the frequency of the electric grid sensor network, enabling power system engineers to monitor the dynamic behaviour. The PMUs are useful as increasing numbers of customers are generating power from solar panels and wind, and feed power back into the grid. This can lead to voltage fluctuations that could damage the grid and cause outages. The PMUs network provides real-time snapshots that detect such fluctuations and can "re-route power around problems, and provides batteries that store excess energy and make it available later to the grid to meet customer demand."

Smart meters are devices installed in facilities and connected to a smart energy grid, which allow power suppliers to manage energy flow into buildings more effectively, while consumers - with access to their own data - can better manage their own energy consumption and costs. Also, smart meters enable consumers to cut their electric bills as they are informed about off-peak hours, during which they can use devices that consume more power.

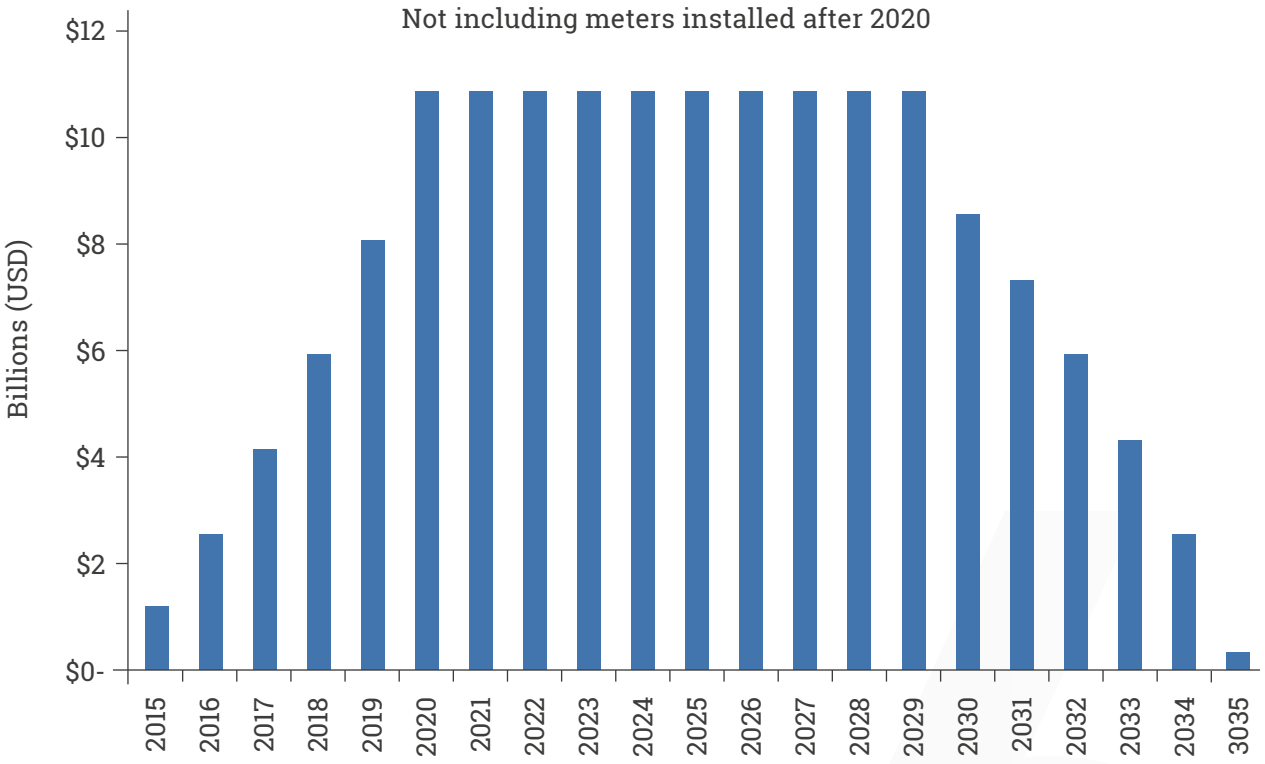
Estimated number of smart meters installed globally



Source: Pike research, IBIS World,USITC, European Commison, Northeast Group, Ernst & Young, NewsReleases 2010-2015, BI Intelligence estimates 2015

BI Intelligence estimates that the global installed base of smart meters will reach 930 million in 2020, while companies are expected to save an astonishing $157 billion by 2035 by using smart meters.

Estimated savings per year realised from smart meters installed between 2015-2020



Source: European Commision 2014, BI Intelligence Estimates 2015

Not only can we cut energy costs, we can even use energy for free.

Giving consumers the ability to store unused power and then sell it back to the grid is a starting point of the 'free energy for all' era. Unfortunately, not everybody agrees. Repeated blackouts in South Australia since September last year, *The Guardian* reports, caused a political rumpus over energy policy, as the federal government put all the blame on the use of renewable technologies. But as a response, Lyndon Rive, Tesla's vice-president for energy products, told the AFR that "the company could install the 100-300 megawatt hours of battery storage that would be required to prevent the power shortages that have been causing price spikes and blackouts in the state."

With new smart tech, the power sector will be able to improve power supply management and ensure our lights are always on.

HYDROGEN

"Energy is the most important issue of our time, and for energy, fuel cells are crucially important. And then for fuel cells, hydrogen is most important."

- Yu Lei, a Wet Process RnD Intern at Micron Technology and a doctoral candidate at Penn State

Most transportation, manufacturing, heating, and cooling systems run on fossil fuels. But with the latest scientific breakthroughs, hydrogen could be the clean energy of tomorrow. A team of scientists from Penn State and Florida State University have developed a catalyst to produce hydrogen through an ingenious low-energy water-splitting process. And according to Yu Lei, a doctoral candidate at Penn State, the process is completely eco-friendly. "People have been searching for a good catalyst that can efficiently split water into hydrogen and oxygen. During this process, there will be no side products that are not environmentally friendly."

Even though the idea of water-splitting may not be new, standard industrial water-splitting methods use platinum as the catalyst to drive the process. Although almost perfect as a catalyst, platinum is incredibly expensive. A much cheaper catalyst could make hydrogen a feasible alternative to fossil fuels. Mauricio Terrones, a professor of physics, materials science, engineering, and chemistry at Penn State University, emphasised that they have finally found an alternative: molybdenum disulfide (MoS2).

However, MoS2 acts like a semiconductor in its stable phase, which limits its capacity to conduct electrons. This in turn impairs its ability to catalyse the water-splitting process. But the team managed to solve this problem through a tungsten-molybdenum alloy. They joined MoS2 with tungsten to create a thin film with alternating graphene and tungsten-molybdenum disulfide layers. "What happens in these alloys is an exquisite overlap of orbitals which makes the reaction more efficient. This is not observed in the pure components. It is an example where the hybrid is better than the pure components," explained Jose L. Mendoza-Cortes, a professor of engineering and scientific computing at Florida State University.

The water splitting process uses a very small amount of power, applied to an electrode immersed in water. The protons in the solution are absorbed onto the surface of the catalyst. Then, two protons migrate together to create a hydrogen bubble that rises to the surface, eventually releasing the hydrogen. The hydrogen can then be gathered to create clean energy.

Companies like BMW, Anglo American, Shell, Toyota, and Hyundai see tremendous potential in hydrogen fuel cells, especially as they are far less polluting than their petrol or battery equivalents.

9.0

ARTIFICIAL INTELLIGENCE

"Many aspects of the utility enterprise will benefit, but in particular, AI has great potential to coordinate and optimise the use of distributed energy resources, electric vehicles, and the IoT."

- Shawn Chandler, an IEEE Senior Member

Smart grids, smart meters, and a host of connected appliances that feed the central system with data about energy usage, may be susceptible to malicious attacks and possible information tampering.

Emerging AI technologies provide an answer to this challenge. For instance, by reviewing data from smart meters and sensors, sophisticated machine-learning techniques can model the behaviour of individual devices and battery storage units. Also, having metering devices on the grid - rather than on the central server - can take pressure off the central server as it only requires metering at the site level, not for every device.

Moreover, the Institute of Electrical and Electronics Engineers (IEEE) Senior Member, Shawn Chandler, thinks that AI has the ability to optimise the consumer's use of energy generation and storage. "For example, automated management using AI – such as moving or scheduling a particular use of energy into a specific demand period – can result in a decrease to the cost of service for a consumer. AI may also alert or inform a consumer based on real-time sensing. For example, informing on an emergency issue, such as a failing appliance in the home, or a downed power line in an expected path of travel, or for recommending choices and services, such as energy-related equipment settings, replacements or upgrades."

Chandler points out that "the use of AI can be considered critical to the management of the Energy Cloud," (a decentralised grid system) "given the number of points of control in the grid increasing from many tens of thousands to hundreds of millions, or even billions." As the trend toward renewable energy continues, we'll have more fluctuations and irregular peak loads in the power grid as these are typically intermittent sources. As a result, power distribution grid operators are facing obstacles they think can only be overcome with AI.

In 2016, Adaptricity, AEK, Alpiq, and Landis+Gyr, together with the Canton of Solothurn in Switzerland, started investigating how artificial intelligence can optimise, monitor, and control the power grid in a pilot project called 'SoloGrid.' The project is being conducted in the town of Riedholz, a municipality in the canton of Solothurn. The test phase will last 18 months, and the GridSense technology is being used in approximately forty single-family homes in Riedholz.

Click for video

The GridSense technology has been developed by energy services provider Alpiq, together with the Scuola universitaria professionale della Svizzera italiana (SUPSI). The core of the GridSense technology consists of several algorithms which intermittently measure grid load, electricity consumption & generation, and electricity price. They learn the behaviour of electricity consumers, which helps GridSense optimise power consumption. This is achieved by reducing peak loads in the power grid and balancing distribution.

The companies are also using DPG.sim software to simulate decentralised dynamics in the grid. The software was developed by Adaptricity, a Swiss Federal Institute of Technology (ETH Zurich) spin-off. With its ability to simulate a number of grid scenarios for analysis, these smart algorithms are learning from the pilot grid in Riedholz.

The test is expected to show how the new tech, based on machine learning algorithms, controls heat pumps, household batteries, and even charging stations for electric vehicles, and how it integrates the measurement data from photovoltaic systems to optimise performance and price. ■

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10.0

FUSION

"We need to be doing more on advanced biofuels. We need to be doing more on carbon capture and sequestration. We need to be doing more on advanced nuclear technologies. We need to be doing more on fusion, for heaven's sake."

- John Holdren, the Teresa and John Heinz Professor of Environmental Policy at the Kennedy School of Government

Fusion has been unsuccessfully pursued for more than forty years, beginning with the development of the Tokamak reactor. A team of Soviet scientists led by Igor Tamm and Andrei Sakharov designed a device that used a magnetic field to maintain hot plasma to enable a fusion reaction. Today, fusion researchers at the Princeton Plasma Physics Lab firmly believe that fusion's feasibility should be demonstrated soon, "so that fusion power can be incorporated into planning for our energy future."

And there's a good reason to chase fusion power, as it is clean, zero carbon, and low waste.

In fusion, two nuclei of the hydrogen atom isotopes - deuterium and tritium - fuse together, producing incredible energy. However, the process is not as simple as it sounds. As both nuclei are positively charged, they repel each other. But if they are moving extremely fast when they collide, they'll fuse, releasing vast amounts of energy. This occurs naturally in the Sun. But here on Earth, researchers must use powerful magnets to contain an extremely hot gas of electrically charged deuterium and tritium nuclei and electrons called plasma. The process requires a large amount of energy to heat up plasma to sun-like temps, reaching more than 100 million degrees Celsius. To achieve such

high temperatures, scientists have been using two methods: magnetic confinement and inertial confinement. The first approach uses magnetic fields to heat and control plasma, while the second uses powerful lasers to produce enough energy to enable fusion. Using one of these two methods to produce the incredible temperatures necessary, the positively charged nuclei are then forced to move fast enough to overcome their electrical repulsion and fuse. Once it gets going, fusion has the potential to generate enough energy to maintain its own heat, allowing us to draw off excess heat to power steam turbines.

While deuterium is plentiful in water, and the reactor itself can make tritium from lithium, we still need reactors capable of reaching these extremely high temperatures.

David Kingham, the chief executive of Tokamak Energy, is pretty enthusiastic about his new reactor's abilities to produce plasma temperatures over 15 million degrees Celsius, and soon, he hopes to reach the 100 million degree mark. "The ST40 is designed to achieve 100 million degrees C and get within a factor of ten of energy break-even conditions. To get even closer to the break-even point - where the plasma produces as much energy as is needed to catalyse fusion - the plasma density, temperature and confinement time then need to be fine-tuned," he claims. And Tokamak Energy's goal is clear - to produce electricity for the first time by 2025, allowing fusion power to take its place in the smart grid by 2030.

CONCLUSION

As energy demands grow, fossil fuel depletion and the constant harm they cause to the environment are pushing us toward renewables as a welcome solution. With smarter infrastructure, including smart grids, sensors, and smart meters, we can build an intelligent system that will ensure an intermittent power supply that provides stable electricity. AI and Blockchain will ensure that smart grids stay secure, and our progress toward workable fusion energy and hydrogen catalysts promises clean, abundant sources of future energy to compliment the wind and sun. Our path towards cleaner energy won't be easy, but tech innovations such as these make this road a little less bumpy.

Inspiration sessions from trendwatcher & futurist

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