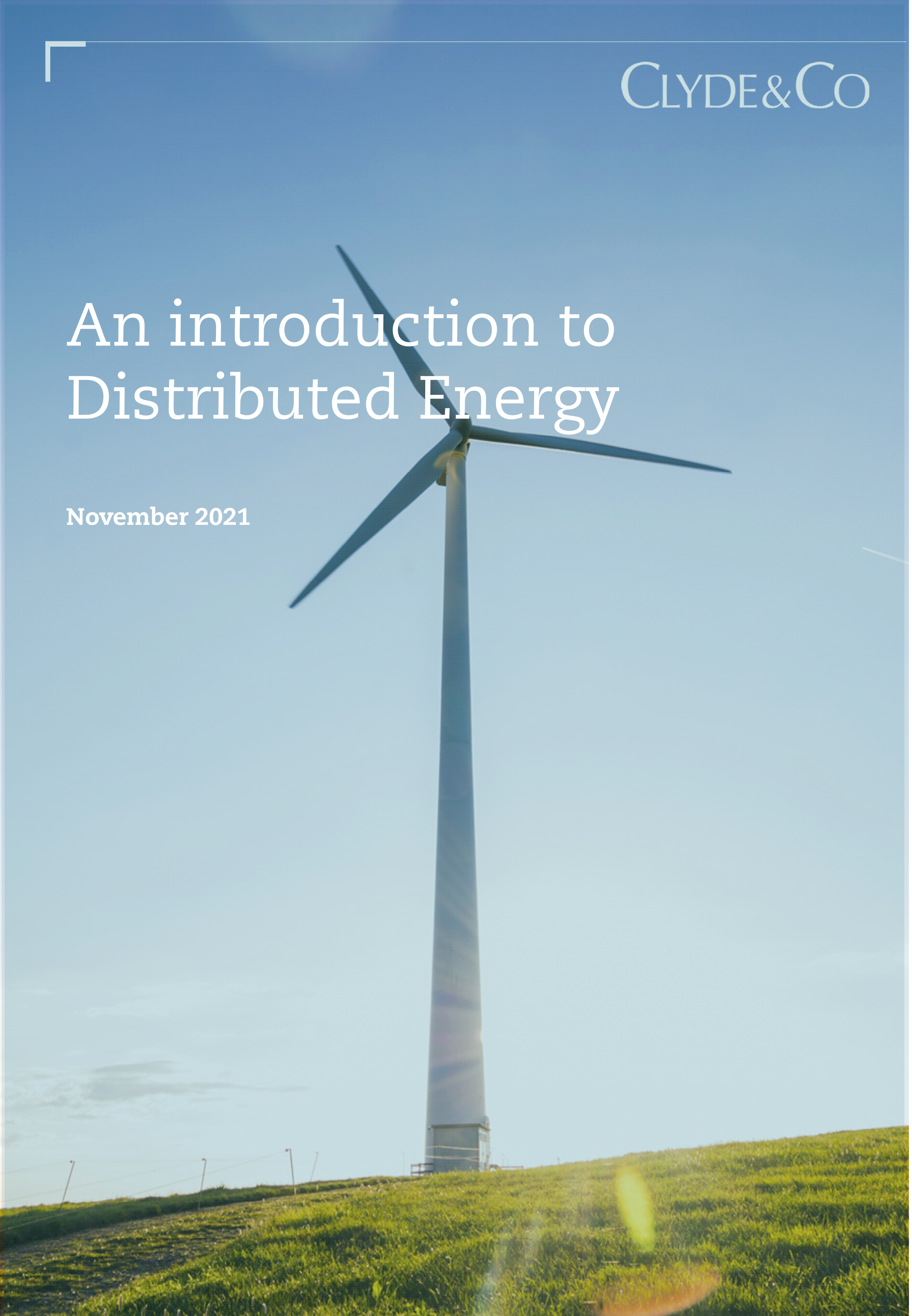


CLYDE&CO

An introduction to Distributed Energy

November 2021

Contents

Foreword

The global energy industry is moving through a highly undulating period, transitioning through decentralisation towards localised energy sources. With a perpetually growing focus on sustainable energy, novel technologies involving electric vehicles are placing heightened pressure on longstanding energy infrastructures the world over. As a consequence, businesses are searching for alternative sources of energy and, specifically, sources that are more economically attractive, flexible in their distribution and, of course, environmentally conscious.

The progressions and innovation in the energy sector, facilitated by industrial-scale digitisation and energy technology, have offered up a solution, distributed energy.

What is Distributed Energy?

Transition to Distributed Energy

Over the past century, the staunch growth in both population and economics have considerably hastened the global consumption of energy and electricity to an unprecedented volume, with nearly 30% of global energy consumption being used by buildings alone. The International Energy Agency (**IEA**) has predicted that, by 2035, the annual requisite investment for the supply of energy to meet global demands will rise to approximately $2 trillion per annum.[1]

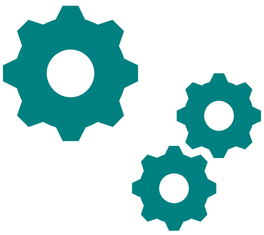
In order to handle these rapidly inflating costs, progressions in both smart meter technology and energy storage are bolstering opportunities towards a decentralised approach for energy management, namely, Distributed Energy (**DE**). The growing access to and obtainability of renewable energy sources, smart meter tech, and climate-induced regulation and policy facilitating net zero and a restriction on energy consumption, are all instigating the transition through a fluctuating energy landscape from a traditional centralised energy supply chain to dynamic energy supply chains involving multiple stakeholders and multi-layered energy sources through DE.

Distributed Energy

DE involves a small-scale unit of power generation operating locally whilst being connected to larger power grids at the distribution level, and the energy is utilised close to the source. Energies used involve any of the following: solar, small natural gas-fuelled generators, electric vehicles, such as HVAC systems and electric water heaters.

Although there has been considerable debate and discussion over the last decade in regard to the potential of energy efficiency and smart energy, there have been few breakthroughs in making a clear case for these solutions.[2]

In order to understand the sheer potential of DE systems, first one must understand what the term DE actually means. The World Alliance for Decentralised Energy has issued the definition of DE to be *"electricity production at or near the point of use, irrespective of size, technology or fuel used – both off-grid and on-grid"*.[3] Although, companies like Centrica have deemed this definition to be too narrow.



1 What is a distributed energy system? (inbuildingtech.com)
2 CBS_PoweringBritainReport_A4_24pp.indd (centricabusinesssolutions.com)
3 CBS_PoweringBritainReport_A4_24pp.indd (centricabusinesssolutions.com)

What is Distributed Energy? Contd.

Ultimately, DE also covers a diverse range of solutions, including energy efficiency, monitoring and on-site generation. All of these solutions help business and organisations that require a larger volume of electricity to take control of their energy and harness it for a commercial opportunity. Another key factor of DE is the flexibility of the resources and solutions it provides, offering consumers and users the ability to utilise a range of solutions best suited to them.

What does Distributed Energy involve?

DE involves small-scale units of power generation that distribute energy on a local level, but they are still connected to larger power grids at the network distribution level. Operating conversely to a traditional energy supply chain, DE creates a decentralised energy system, which comprises a substantial volume of electricity capacity being produced at small-scale. DE also involves a diverse array of energy generation, storage, monitoring and control solutions. For instance, DE may comprise the following fossil fuels: fuel cells, microturbines, internal combustion engines and Stirling engines; or conversely, the following renewable technologies: photovoltaics, wind turbines, solar, biomass generators, fuel cells, tri-generation units, battery storage and electric vehicles. DE could also be involved in new energy trading technologies which allow organisations to sell their excess energy, and also microgrids which offer considerable benefits to a DE system (discussed below).

As DE systems receive energy from a multitude of sources, they determine how to provide energy at the lowest cost possible to their owner. DE therefore creates the opportunity for building owners and consumers alike to considerably reduce their costs, whilst both refining reliability of their energy sources and locking in revenue by way of their on-site energy generation and load management.

Whilst traditional electricity generation systems and supply chains relied on the production from centralised plants, the renewable energy sources, in particular solar and wind power, are expanding power grid capability by creating two-way power flows. As a consequence, these DE systems provide the opportunity for a consumer to receive energy from the grid in addition to sending energy to the grid, monetising the process to their benefit.

What is Distributed Energy? Contd.

Amidst energy demand surges and peak consumption periods, centralised power grids often find it taxing to meet the growing energy demands, which consequently leads to inflated costs of supplying energy. Now, through DE, industrial-scale power plants and factories can secure additional sources of energy in tandem with reducing their overall cost of energy consumption. Both industrial-scale wind and solar farms are currently providing a rising percentage of power and electricity to large manufacturing plants that require massive amounts of operational energy, affording these manufacturers the ability to reduce their centralised energy consumption during periods of peak energy demand. With the rapidly rising demand for energy over the course of the coming decade, it is likely that this trend will emerge in large commercial and office buildings.

The potential of Distributed Energy

There is a rising demand for and interest in DE the world over. For instance, in Australia the Electricity Network Transformation Roadmap (**ENTR**) has stated that more than 40% of energy customers will use DE by 2027, with that figure reaching more than 60% by 2050.[4]

Additionally, Siemens produced a report examining the opportunity of applying DE to manufacturing facilities, commercial buildings, and both urban and rural residential communities worldwide. The report concluded that the deployment of DE had the potential to lower operational costs by as much as 25% to 40%, with a return on investment (**ROI**) of three to seven years.

The Siemens report discovered that DE systems are capable of creating substantial social-economic and environmental benefits, amounting to lower cost grid balancing, condensed greenhouse gas (**GHGs**) emissions and affordable extension of grids to unconnected, decentralised communities. What is key for business heads and building owners is that DE has the capability to considerably lower operational costs, whilst ensuring long-term energy security.

[4] What is a distributed energy system? (inbuildingtech.com)

What is Distributed Energy? Contd.

Microgrids[5 6 7]

As noted above, microgrids are a particularly important source of energy in DE systems, especially for remote communities or areas subject to catastrophic weather events. Micro-grids can vary in size from a full substation providing electricity to hundreds of units, or a single micro-grid providing electricity to a single unit.

Microgrids provide the ability to significantly increase electric reliability by placing generation near the consumer. The reason being is that, when within the locality of the consumer, the chances of disrupted energy flow or damage to a distribution wire are substantially reduced. Coupled with the increase in electricity reliability is the microgrid's ability to "island" during a centralised electricity power outage following a storm or other catastrophic weather event. When portions of any given grid are furnished with DE, they can continue to provide electricity whilst a larger distribution network is downed by storms, for example, meeting local needs with local generation via the microgrid (which is known as "islanding").

In this so-called "island" mode, a microgrid produces electricity entirely autonomously, relying on their own internal generators. This ability to "island" can also be a method for the host to reduce their costs by merely supplying electricity to meet certain critical needs within their premises, for instance, powering an emergency room in a hospital. The flexibility afforded by a microgrid is possible because such systems can work sequentially by providing power to the most essential parts of a premises, followed by the lower priority areas.

DE systems are able to make microgrids a more viable choice, due to the fact that the means of energy production are more readily obtained and distributed in communities of varying size. As a consequence, community-scale microgrids are very likely to be more resilient to disasters like hurricanes, storms and flooding in terms of the provision of energy.

5 MGK-Report-Evolution-of-Distributed-Energy-Resources_022119.pdf (microgridknowledge.com)
6 http://energy.gov/sites/prod/files/Microgrid%20Workshop%20Report%20August%202011.pdf
7 All You Need to Know About Microgrids - Concept Explained - Engineering Passion

What is Distributed Energy? Contd.

How do microgrids work?

The internal resources and mechanisms of a microgrid can vary greatly. Some microgrids are solely composed of renewable energy, others comprise traditional fuel generators, whilst many are actually a combination of the two. Both natural gas and diesel generators, solar panels, wind turbines, fuel cells and even electric vehicles are the common resources of energy generation within microgrids. In addition, microgrids are increasingly taking advantage of the technological advancements in energy storage.

Ultimately, the generation source behind a microgrids power is highly dependent on a variety of factors, such as the host's energy targets and demands, the operational parameters, the obtainability of the relevant fuel, and also whether thermal energy is in demand. Some of the older microgrids (in addition to some new versions), make use of combined heat and power (**CHP**) if they have a desire for both heating and cooling. CHP uses the heat by-product of energy generation in order to yield hot water, steam, or heating and cooling capabilities. CHP systems are extremely efficient, since they can produce two forms of energy, heat and electricity, from only one fuel source. In order to distribute the energy itself, a microgrid's infrastructure comprises wires, cables, switches, piping and transformers. In addition, a microgrid houses digital sensors and actuators that infuse the decentralised energy generation method with both data gathering and sharing capabilities, along with real-time response and management proficiencies.

Microgrid development is rising sharply, since their ability to sustain energy production and distribution is vital in a world pitched against Climate Change. With the cost of microgrid apparatuses falling, the attractive economics of microgrids is another factor that is shoring up their demand to an array of organisations. Ultimately, it is obvious why these organisations are keen to install microgrids when considering their reliability and the sophisticated energy management that they provide.

What are the benefits of and issues with using Distributed Energy as a fuel source?

A move towards microgrids has the potential for significant socio-economic and environmental benefits. Microgrids promote localised energy production and consumption, leading to significant distribution and transmission efficiencies which can in turn reduce consumer and producer costs. Equally, microgrids can be powered by renewable energy such as rooftop solar panels or small wind turbines, offering consumers autonomy over the energy they consume and assisting with the reduction of GHG emissions. Microgrids can also improve network resilience in the event of natural disasters through their ability to operate in isolation.

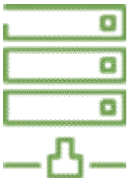
Background

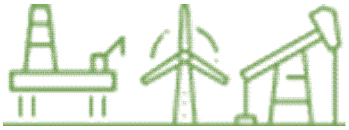
DE's localised system enables power to reach consumers and commercial outlets more quickly and efficiently. The benefits also extend to reduced life cycle emissions and reliability. However, like with most emerging technologies, they do have obstacles which hinder their progression.

Social Benefits

DE systems promote individual energy independence. Traditional systems of transmission & distribution grids provide sources of power to a large number of residents and businesses. This power is transported over vast distances, which often leads to inefficiencies and power being lost if there is congestion. A DE system can provide on-site power to remote regions, giving autonomy to the individuals or businesses that are not located close to larger transmission grids.

Research by the National Energy Renewable Laboratory has found that DE can grant flexibility in 'metering and billing arrangements'' using AI. This not only enables greater price transparency with customers and businesses but mitigates potential disputes around energy usage. However, this is not universal, and the financial benefits vary from country to country. Tanzania uses a signal tariff that does not differentiate between the national grid or mini grids.[8] The benefits may only therefore be in countries that have the technological capability to operate in a decentralised way.





[8] African Development Bank Group: https://energy4impact.org/file/1818/download?token=j67HKZEy

What are the benefits of and issues with using Distributed Energy as a fuel source? Contd.

Economic Benefits

There are significant global opportunities for commercial DE. The World Bank predicts the mini-grid market could supply half a billion people and that microgrid companies such as CleanSpark have to date, performed well. CleanSpark has attracted significant investor attention and enabled microgrids to be used in a variety of sectors including agriculture, commercial and military. To tackle the risks associated with an aging and unreliable global energy infrastructure, CleanSpark's software provides real-time data to maximise performance and resiliency operations.

However, a strong legal and regulatory framework must underpin these DE projects in order for their success to be realised. In Sub-Saharan Africa, around 573 million people still do not have access to adequate electricity. Kenya's approach has been to primarily focus on national grid extension which has excluded the proliferation of mini-grids. To date, there has also been restricted private sector development due to limited policy support. This is thought to change as Kenya successfully implemented 23 mini-grids and uniquely has specific mini-grid legislation aimed at increasing Foreign Direct Investment.

Similar approaches were adopted in Mali through a centralised approval board (**AMADER**), whilst in Tanzania some smaller energy distribution facilities are exempt from licensing.

Environmental Benefits

DE is versatile and includes renewables, diesel or hybrid technologies which could help create balanced and risk-adverse solutions for countries still dependent on traditional fossil fuel sources. A combination of microgrids and DE can increase resilience against electrical blackouts by helping to restart larger systems. This could have wider benefits in making businesses more competitive as outages are predicted to cost up to "31% in sales in Sub-Saharan Africa". Using local energy sources also helps eliminate "line loss" (wasted energy) which occurs during transmission and distribution in the electrical delivery system.

What are the benefits of and issues with using Distributed Energy as a fuel source? Contd.

Economic Issues

At an individual purchaser level, a key challenge is installation costs being transferred to the consumer. Within the US, *the National Renewable Energy Laboratory* described the distributed wind energy market as developing and difficult to access loans.

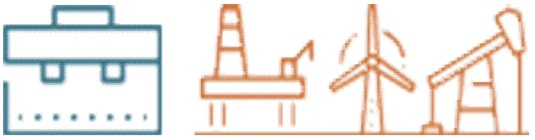
The CEO of ENEL (*the largest non-Chinese Renewable energy company*) argued that "for every dollar spent on renewables, you need to spend another dollar on grids". This represents DE as a mixed bag for utility companies especially. The main challenge is how these companies aim to integrate electricity from new sources onto the grid. Without the proper planning as to location and feasibility, DE can be an unreliable supply of electricity which requires significant upfront investment to accommodate in the grid system.

Environmental Issues

Microgrids are limited by their batteries' inability to store energy for months. Many African economies have faced this battery problem when implementing solar energy projects. For microgrid operators, lead acid batteries, as are commonly used in microgrids, were not invented and designed to provide electricity to households. Despite their relative low cost, lead acid batteries are not as efficient as storing power produced on a solar microgrid. This is due to a number of reasons including the toxicity of lead leading to shorter their lifetime. In contrast, crude oil is capable of being stored for up to six months.

China Ultra-high Voltage Electric Grids

To kick-start its manufacturing recovery and green energy initiatives, China has significantly invested in Ultra-High Voltage Electric Grids which transports energy produced by coal and renewables. This infrastructure is expected to boost the underperforming transport of wind, however, issues are still being faced as the Zhebei-Fuzhou line did not transport any wind energy in 2016 despite its promises. China is the major exporter of Photovoltaic technology but has opted for high voltage grids rather than using this domestically. Yet, the new 'distributed trading pilot scheme' suggests China is looking to use DE more. China is targeting areas with already efficient infrastructure to develop smaller, consumer-based power stations. This approach differs from Australia, for instance, who use DE to compensate for power issues associated with the main grid.



What are the benefits of and issues with using Distributed Energy as a fuel source? Contd.

Conclusion

DE could potentially bridge the global energy gap and help promote lower carbon infrastructure. To ensure there is the commercial incentive to develop these projects, two broad steps need to be taken. Firstly, legislation and permitting need to recognise DE rather than apply the same rules as grid networks. Secondly, to ensure resilience across the supply chain and price competition, there needs to be a more diversified supply of DE materials, which encourages competition at all levels.

What are some of the key organisations and projects driving the development of the Distributed Energy economy?

Key Organisations

Some of the prominent players in the DE generation market include established household names such as:

- Vestas Wind Systems A/S;
- Caterpillar;
- Doosan Heavy Industries & Construction;
- Rolls-Royce plc;
- General Electric;
- Siemens;
- Schneider Electric;
- ENERCON GmbH;
- Sharp Corp;
- Mitsubishi Electric Corp; and
- Toyota Turbine and Systems Inc.

However, governments, utilities and research bodies such as universities are also important players in this space. For example, the UK government has stimulated growth in district heating. District heating offers the promise of a neat solution for the supply of low-carbon heat to homes, businesses and public buildings. District heating takes energy released as heat from a varied range of energy sources and connects it to energy consumers through a system of highly insulated pipes.

There are already over 17,000 district heating networks in place in the UK, and nearly half a million connections to them, most of which are domestic customers. They are a particularly attractive option in dense urban areas, and have been cited as a way of tackling fuel poverty whilst also reducing housing management costs. The UK Government's Renewable Heat Incentive (RHI) has provided important fiscal impetus for the sector. In England and Wales, a £320 million investment programme has been launched by the UK Government, as part of ambitious plans to extend district heating capacity, driven by local authorities. The UK Government recently launched a consultation on district heating, the outcome of which is pending.

What are some of the key organisations and projects driving the development of the Distributed Energy economy? Contd.

Key Projects

There is now a vast array of operational DE projects across the globe. We cover a sample below which give a flavour of the type and variety of projects underway.

Onslow Australia

A remote area in Australia recently recorded an important power generation achievement, as the region received all its electricity from solar power and battery energy storage. Onslow, located in the state of Western Australia, was powered for about 80 minutes solely by solar-plus-storage. This feat was achieved via the installation of advanced microgrid technology that determined the best time and conditions to draw energy only from the town's solar resources supported by a battery energy storage system which was used to overcome intermittency issues. The set-up is part of a collaboration between PXiSE Energy Solutions, a grid management technology company and subsidiary of Sempra Energy, and Horizon Power, Western Australia's regional power provider.

Brooklyn Microgrid

The Brooklyn microgrid is a leading example of a blockchain based microgrid. Here, many residential and commercial premises have installed solar panels. Surplus energy is measured by specifically designed smart meters and turned into equivalent energy tokens that can be traded locally. The blockchain ledger records contract terms, transacting parties, volumes of energy injected and consumed and the chronological order of transactions. In addition, payments are automatically initiated by self-executed smart contracts. Every member of the community can have access to the ledger and verify transactions themselves. In such a system, blockchain establishes optimal automated bidding strategies between devices based on inputted user preferences, such as increasing energy self-sufficiency, reducing cost or bypassing main grid supply. This active consumer participation in the market is secured and recorded in a transparent way. The enabling of automated trading is also an efficient way of delivering price signals and information on energy cost to consumers, which further stimulates efficient consumption and serves to reduce overall costs.

What are some of the key organisations and projects driving the development of the Distributed Energy economy? Contd.

Annobon Island

Annobon island, off the coast of Equatorial Guinea, has a population of 5,000 residents who historically only had reliable electricity for up to five hours per day and spent an average of 15-20% of their income on supplemental power. The government of Equatorial Guinea contracted MAECI Solar and Princeton Power Systems to install a 5-MW solar microgrid system on Annobon Province. The solar microgrid, which supplies enough green electricity to meet 100% of the island's current energy demand, features 20,000 solar panels, system integration, an energy management system, remote control/update capabilities and battery storage.

Port of Rotterdam

At the Port of Rotterdam, a renewable energy trading platform has harnessed AI and Blockchain to enable commercial energy consumers at the Port to purchase and consume energy more efficiently. The trading platform provides each consumer with an AI enabled 'energy trading agent' software which learns their energy needs, preferences and consumption patterns. Consumers are provided with access to dynamic local energy prices which accurately reflect the balance between supply and demand on the Port microgrid. Use of the technology saw an 11% reduction in costs for consumers, a 14% increase in revenues for producers and led to 92% of the solar power generated on site to be consumed.

Wildpoldsried

Wildpoldsried is a small village in the district of Oberallgäu in Bavaria in southern Germany. The village has been recognised for its exceptional achievements in renewable energy production and in reducing its carbon footprint. It all began in 1997, when the community of Wildpoldsried began to construct a series of projects that produced renewable energy. The first efforts were wind turbines and biomass digesters for cogeneration of heat and power. In the time since, new work has included a number of energy conservation projects, more wind and biomass use, small hydro plants, solar panels on private houses, and district heating. Today, the impact of measures has resulted in the construction of nine new community buildings, including a school and a community hall, complete with solar panels. Wildpoldsried now produces 469% more energy than it needs and is generating €4 million in annual revenue. At the same time, there has been a 65% reduction in the town's carbon footprint.

What are some of the key organisations and projects driving the development of the Distributed Energy economy? Contd.

Berbera

Germany-based DHYBRID has installed a hybrid power system in the Somaliland port city of Berbera. The project features two solar PV plants with a total 8-MW of generation capacity, along with a 2-MWh containerised lithium-ion BESS and three diesel generators. The system is connected to local utility Berbera Electricity Co's grid. DHYBRID, a German company that specialises in hybrid power systems, supplied microgrid monitoring and controls technology, including its open-technology Universal Power Platform, and a supervisory control and data acquisition system.

Amazon Power Purchase Agreements (PPA)

As of 2020, Amazon has added 3.4 gigawatts of new renewable power to its portfolio, taking its total capacity to 6.5-GW. The company claims that it has now overtaken Google as the largest corporate user of renewables. Amazon's new wind and solar projects are distributed globally from Australia and South Africa to Sweden and the UK.

The retail giant is aiming to power all its operations, from its offices and fulfilment centres to the data centres of its Amazon Web Services business, with renewables by 2030. It claims to be on track to hit that milestone by 2025, and it wants to hit the target of being net-zero carbon by 2040. Amazon's renewable energy investments are a mixture of power-purchase agreements, new-build utility-scale projects and on-site installations. You can find a map of Amazon renewable projects here.

One of the new Amazon deals is a 10-year PPA with Ørsted for 250-MW of the planned 900-MW Borkum Riffgrund 3 offshore wind farm in Germany, the largest offshore wind corporate PPA in Europe. The project is expected to be operational by 2025.

What are the likely developments for Distributed Energy as a fuel source in the long and short term?

Short Term

Electrification

Electrification is an influential factor in the recent surge of distributed generation adoption. People, businesses and industries are now using far more electricity. For example, electric vehicles have become more widely adopted and cooling and heating appliances are a common sight in properties. These changing electricity demand patterns are favouring distributed generation, in that individuals / companies can purchase electricity generation which suit their demands, as opposed to relying on centralised infrastructure and decision-making. The falling prices of batteries, coupled with DE storage, offers consistent energy flow at lower prices, unfettered by the pushes and pulls of power demands.

Solar leads the way

Over the past decade, distributed solar has taken the lead over fossil-fuelled generators for behind-the-meter generation. Energy generation and storage are now much cheaper. Owing to the technological evolution, as at today a large portion of the world can reach grid parity for solar energy either subsidy free or approaching that status. Additionally, in the last decade, lithium-ion storage cost reduced by up to 80%. The result is that more people have access to renewable energy for self-consumption at an affordable cost.

Electric Vehicles Provide Storage Capacity

Electric vehicles will give rise to a mobile storage market. Falling battery prices should allow EVs to reach cost parity with internal combustion engine vehicles by 2025. Appropriate infrastructure will allow most EVs to be charged overnight, when electricity is plentiful, rather than during peak afternoons and early evenings, which should help mitigate their grid impacts. Public charging is harder to time-shift, but opportunities are opening for fleet vehicles like electric school buses.

What are the likely developments for Distributed Energy as a fuel source in the long and short term? Contd.

Shifting Regulation

We should expect to see increasing regulation designed to stimulate the uptake of DE systems. These might include fiscal tax incentives and credits for qualifying renewable energy products, grants and loan programmes, and additional national policies. These measures should be geared towards incentivising businesses and building owners to invest in renewable DE resources without the high costs of traditional installation and maintenance. In other words, such programmes will subsidise energy generation and distribution, further pushing it forward in the path towards a lower carbon footprint.

Digitalisation

The link between digitalisation and the development of solar and other DE resources is undisputable. Through digitalisation, producers can efficiently store and transfer excess electricity to the grid, thus maximising their return on investment (**ROI**). For local communities, blockchain and related tools are expected to support the peer-to-peer trade in power. Intelligent automation using the Internet of Things, Artificial Intelligence and Robotic Process Automation will increase the efficiencies for demand responsiveness and optimise costs, whilst analytical insight and mobile applications will be leveraged to improve customer service and relationships. Digitalisation will also allow electricity asset owners, prosumers and customers to price and trade energy in decentralised markets based on market value. Blockchain and smart contracts will bring in transparency and trust in the distribution process.

Long Term

Distributed Generation will Continue to Disrupt the Energy Mix

Renewable energy will continue to take centre stage and DE is a logic forum for installing renewable capacity. Companies such as Google, Amazon, Apple and Walmart have already begun by setting up their own solar and wind farms. The reasons to do so are many – going green, cost savings and greater control over energy requirements, to name a few. Such players will eventually emerge as alternative energy suppliers that will tap into the rapidly growing clean energy market. From large companies to start-ups, 'go green' businesses are set to disrupt the energy generation mix and ownership to reimagine the energy market.

What are the likely developments for Distributed Energy as a fuel source in the long and short term? Contd.

Further Increases in Resiliency are Required

DE systems will need to increase their resiliency. Fossil fuel generators can provide some services that solar PV alone can't, such as backup for days-long grid disruptions / in the event of increasingly common extreme weather events. Equally, an increase in battery storage capacity will play an important role in managing intermittency, as mentioned above, electric vehicles might be important in this regard also.

Some suggest hydrogen may also play a part in increasing resiliency. Hydrogen can be stored in containers, tanks or underground caverns and behaves in a similar way to a battery. However, whilst batteries lose their charge over time, when stored correctly, hydrogen should retain close to 100% of its energy. This makes hydrogen a potentially very useful tool in dealing with the intermittency issues posed by renewable energy generation. Excess variable power (which is energy produced by intermittent wind and solar projects) can now be directed to hydrogen production and stored or used in transport, industry, or gas grid injection. Used in this way, hydrogen becomes a source of storage for renewable electricity, keeping the power system flexible and helping to balance the grid. Equally, the residential sector will grow increasingly important in grid load management. There is a continued rise in adopting smart thermostats that can precool homes and fine-tune temperature settings, and smart water heaters can preheat and then shut down during winter heating peaks.

Factories, Workplaces and Homes can Become Powerplants of the Future

Factories, workplaces and homes will become powerplants of the future. With the advent of renewable energy technologies, instead of having to build a large fossil fuel generation plant it is feasible to install solar or wind generation locally at facilities / home. Add in some local energy storage technology and you have the capability of being able to store some of this locally generated energy to use it later. Some companies today already participate in demand / response programmes, reducing their energy consumption when supply does not meet demand or increasing their consumption where there is an abundance of supply. It's also becoming feasible in some locations to 'sell' surplus energy back to the grid when needed.

What are the likely developments for Distributed Energy as a fuel source in the long and short term? Contd.

Barriers to Adoption / Challenges

Decarbonisation and decentralisation (and, arguably, "democratisation") are targets for both EU and UK energy policy, amongst others. However, the current electricity market structure is impractical for achieving this vision quickly and there are significant barriers to adoption of an alternative. Despite the proven potential of DE and the rapid advancement in the technologies which can underpin them, DE systems have not yet been implemented widely.

A significant issue is the regulatory environment in which DE systems exist, or lack thereof. Traditional regulatory models are predicated on vertically integrated utilities being subject to heavy regulation in exchange for exclusive access to customers. In a complex distributed system, many questions will need to be answered, including: issues of ownership and access, the terms on which prosumers / consumers can trade energy, how the main grid interacts with the microgrid, how service issues will be managed and disputes settled. It will also be critical to establish a regulatory framework to deal with issues of data privacy.

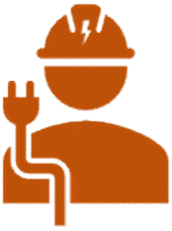
The relative scarcity of commercially functioning DE systems means that operational expertise is limited. This is in part due to the complexity of DE projects. The idea that either a utility or a neighbour will purchase the excess power of prosumers is straightforward in the context of small scale microgrids. However, due to intermittency issues, adding additional renewable capacity to a grid creates potential instability, inefficiency and outages. Therefore, the widespread installation of green microgrids will only occur in conjunction with the associated battery storage and smart infrastructure capabilities necessary to safely support the grid.

The above issues, amongst others, have so far stifled investment. Investors have until recently perceived DE systems as riskier than other green investments, in part because it is difficult to model the risks or accurately forecast returns. For example, microgrid production has not been standardised, meaning each grid is unique and must be assessed individually. This comes with issues of economies of scale for investors. Additionally, the lack of government subsidy models or financial support from utilities has served as another disincentive for private investment.

What are the likely developments for Distributed Energy as a fuel source in the long and short term? Contd.

The proliferation of decentralised and interconnected smart energy assets creates greater vulnerability to malevolent security breaches. Proactive risk assessments of cybersecurity programmes, and sharing of intelligence will intensify to prevent cyber and physical attacks on grids. This will include:

- recruiting hackers to proactively predict and manage cyberattacks;
- developing end-to-end enterprise-wide detection and response systems;
- creating effective data and access prioritisation; and
- increasing the use of blockchain technology.



Closing remarks

With both the arrival and growth of DE, a viable source of decentralised community-generated energy and its two-way flow of power, it is transforming the grid. Nations around the world are moving deeper into DE sources. For instance, Australia has already issued their Electricity Network Transformation Roadmap (**ENTR**), a joint publication by Energy Networks Australia and the CSIRO, which has projected that over 40% of energy customers will use DE by 2027.[9] Whilst the UK, according to Centrica *"is opening a new chapter in the way it uses energy. But unlike previous eras, the twenty-first century will be defined not by a single energy source, but by three distinct yet related trends: decentralisation, digitisation and customer control"*.

Now that consumers and corporates alike are pushing for a greener society, coupled with more affordable energy, it seems likely that alternative sources of decentralised DE are going to become increasingly popular in the coming years. As DE is a highly economic energy solution, and relatively easy to integrate, it offers businesses the opportunity to harness greater control and awareness of their power supply, whilst making greener energy solutions more accessible to businesses, prosumers and consumers. What this transition highlights is that companies are privy to the numerous benefits of converting from energy clients to energy creators by way of alternative energy solutions, such as DE.

Prior to the UN's COP26 in Glasgow, governments around the world promised a "green recovery" from Covid-19. Now that the historic COP26 has come and gone, with governments, policymakers and industry leaders alike pledging their climate commitments, only time will tell if DE will take a firm grasp of the opportunities laid forth by this energy and environmental transition to become a more centrally used source of energy generation, as Australia's ENTR predicts, or whether it will continue to act as an alternative, decentralised source of energy that is stifled by a lacking regulatory environment.

[9] AEMO | Energy explained: Distributed Energy Resources

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