Smart neighbourhood, smart micro-grid

Credit: DHYBRID

Micro-grids | Micro-grids can offer a resilient and secure alternative for both rural and city communities. Molly Lempriere looks at some of the micro-grids around the world that are transforming the way neighbourhoods produce and consume electricity

Around the world, communities and companies alike are increasingly looking to micro-grids, to help increase resiliency and energy security. In particular, as people turn to intermittent renewables such as solar PV to decarbonise electricity networks, micro-grids offer an exciting new alternative to conventional energy networks.

They have proved particularly successful in rural and remote communities, as an economic alternative to expanding national grids. But they are popping up in cities too, often to help secure generation against outages caused by extreme weather such as hurricanes, and to allow people to take greater advantage of self-generation.

In a Global Innovation Report report by Hitachi America, the biggest growing microgrid markets were examined, predicting that worldwide there is likely to be 7,500MW of capacity and a US$35,000 million market by 2024.

As senior vice president and general manager of the Energy Solutions Division of Hitachi America, Alireza Aram, explained in the report: "Against a background of successive natural disasters and terror threats around the world, a steady supply of electricity including measures against power outages is a common social issue for all countries, from the viewpoint of the safety and security of their residents.

"As the introduction of renewable energy proceeds as a measure against global warming, micro-grids are looked to as a promising solution to various issues."

How are micro-grids developing though, and how 'smart' can a neighbourhood become?

Micro-grids: not such a micro trend

As a concept micro-grids are not particularly new, they have functioned around the world using fossil-fuel generation for decades. But as renewable generation technologies have developed along with digitisation, the possibilities they offer have expanded.

In the US there were 2,250 micro-grids in 2018 according to Wood Mackenzie, with 545MW of capacity added that year alone. The majority of these micro-grids still use standalone fossil-fuel generation, but this is changing as communities and companies take advantage of technologies such as solar and blockchain.

Islands are one of the settings where micro-grid technologies could be most beneficial

For example, the Brooklyn Microgrid project that was established in 2016 takes advantage of blockchain to allow a collection of homes in the New York suburb to generate power using solar panels, and then use peer-to-peer trading. It was the first project of its kind in the US and has continued to expand and receive acclaim over the last few years.

Now there are over 50 homes and businesses within the grid, which is run by LO3 Energy. The desire for a micro-grid in the area came after Storm Sandy caused widespread blackout in New York in 2012, calling the security of the electricity supply into question for many.

Micro-grids like this are popping up in communities around the US and Europe, but they are also helping communities in energy-poor countries in Sub-Saharan African and Asia. A Navigant report produced in 2018 showed that the Middle East and Africa region was forecast to have

the world's fastest market for micro-grids. It suggested that there would be a compound annual growth rate of 27% in these regions, which could represent almost 1,145 by 2027.

In these communities the technology can offer electrification where there hasn't been any before, bringing a huge range of benefits. Not least among them, such grids can support lighting that allows people to move away from hazardous kerosene lamps, which pose a number of health risks from producing harmful gases to being a fire risk.

Alabama Power's micro-grid could be a prototype of the smart neighbourhood of the future

Credit: Alabama Power

The Alabama Smart Neighbourhood: the newest test ground

In Alabama, a micro-grid pilot project has been launched to test and trial the neighbourhood of the future. Completed in 2018, the project consists of 62 homes built with advanced energy efficiency measures, home automation and connected to its own micro-grid, all integrated together.

While the micro-grid can work together with the national grid, it can also be islanded, functioning completely separately, and relying purely on its own generation and storage technologies.

Todd Rath, marketing services director for Alabama Power, who is running the project, explains: "We wanted to create a neighbourhood that would be what we think a standard neighbourhood in the state of Alabama and the southeast would probably look like in the year 2040, and that would include building envelope requirements as well as technologies within the home with appliances and other connected technologies. And using an energy source that may be different than a traditional grid, such as a micro-grid with solar, battery storage and those kind of things."

The neighbourhood is the Southeast's first community-scale micro-grid, according to Alabama Power, and is designed to be a true testing ground, allowing the utility to understand the changing needs and opportunities of those living in Alabama and beyond. Alabama Power is a subsidiary of the Southern Company; a second subsidiary, Georgia Power, is now also running a micro-grid project to trial smart technologies.

The Alabama Smart Neighbourhood uses solar panels, battery storage and a backup natural gas generator to create a complete energy system.

The micro-grid has around 1MWp of electrical output, separated between three components; a 333kW fixed-tilt array, comprising 11 rows of solar modules with string inverters at the end of each row, a lithium-ion battery system provided by Samsung with a capacity of 333kW, and a 400kWp natural gas-fired turbine.

The neighbourhood was specifically modelled before it was built to use a third of a megawatt at peak power. As such, throughout the research project Alabama Power can vary the supply, testing the system both when islanded and utilising the wider grid, and how the different technologies perform.

Southern Company research and development engineer Jim Leverette adds that the generator was included predominantly as backup, as the battery system included in the project could not see the whole neighbourhood through 12 hours. As such, it was unlikely to last through a night, meaning that a backup source is needed for a few hours over night before the sun rises and solar power can once again take over.

Along with the technology making up the grid itself, the Alabama Smart Neighbourhood has tested how homes can interact and become more efficient within the micro-grid.

It uses a piece of software called Complete System-Level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC), developed by the US Department of Energy's Oak Ridge National Laboratory.

"The system basically sits out at the micro-grid, and it sees the generator, the battery and the solar," says Leverette. "It has a forecast of what the weather is going to be, a forecast of the predicted electric usage in the neighbourhood, and then it makes decisions about which assets to run. We can set different objectives, we can set it to just minimise costs, we can try to minimise carbon output, we can preconfigure it so it has additional savings and energy for backup power, a lot of different configurations.

"And that control system is also communicating to devices in the home, and it can actually adjust the set point on the thermostat and the set point on the water heater. So, it's able to look at those devices as possible control options as well as the battery, the solar and the generator.

"So really, it's looking at five or six different things and it can make decisions about what is the least impactful to the customer, what's the most cost-effective thing to do at any given moment in time."

Each home within the micro-grid can set parameters within which this software can make changes, such as maximum and minimum temperatures it will allow its heating, ventilation, and air conditioning (HVAC) to be adjusted to. This is particularly significant as HVAC is one of the most energy intense aspects of a home, and one that is set to continue to grow in coming years.

A report by the International Energy Agency in 2018, entitled *The Future of Cooling*, found that air conditioning and fans account for a fifth of the total electricity consumption in buildings globally, or about 10% of all electricity consumption now. As the world continues to get hotter due to global warming this is likely to increase, tripling by 2050.

If this rings true, new electricity capacity will be required that is the equivalent to the combined electricity capacity of the United States, the EU and Japan today, the

report concludes. As such, in a hot and humid state like Alabama, being able to effectively manage HVAC systems could greatly benefit both supplier and the grid.

As Leverette says, "there [are] millions of smart thermostats in the US and elsewhere. If there was a low-cost way to integrate them to the grid without impacting customers, you could potentially have a really big win-win for customers and utilities."

One of the biggest learnings that has come from the project is the impact a degree or two can make upon the grid and energy usage. This is particularly pertinent when looking at water heaters, as people rarely notice a degree's difference but collectively it can have an impact on grid capacity.

Following the construction of the micro-grid, the system was modelled post-installation using software developed by HOMER Energy.

Dr. Peter Lilienthal, founder at HOMER, says that micro-grid decision makers such as planners and engineers, can use modelling to understand precisely how new technologies can perform and interact. This also expands to further verifying that systems are operating as expected after their energisation.

"As the electric power industry starts implementing new technologies and combining them in new ways, such as these hybrid renewable micro-grids, the design simulation and optimisation capabilities of the HOMER software shows the economic impact of different configurations. We are glad to see this activity beginning to happen in every region of the country and the world."

This modelling, together with the constant monitoring of the micro-grid, is allowing Alabama Power to continue to learn from the micro-grid. The company is planning to continue to run the project, with the majority of those in the homes currently electing to continue to take part as it moves into another year.

DHYBRID: a global tech

Not all micro-grids are made the same, however, and German company DHYBRID offers a distinctly different approach. Specialising in rural and island communities, the company provides an energy management system that can run hybrid micro-grid systems, using its Universal Power Platform (UPP).

"Basically, we understand our UPP to be like the foundation when it comes to building smart grids and micro-grids for renewables," says DHYBRID CEO Benedikt Böhm.

"All the renewable assets, such as solar, batteries and also the existing generators in the micro-grid, are all built on top of that platform. And since our solution is manufacturer independent and technology neutral, the client or the operator does not have any issues when it comes to extendibility in the future, and scalability," he says.

DHYBRID's software now supports over 75 projects in 25 countries, as increasingly communities turn to micro-grids as a resilient alternative to national grids. One of the company's most recent projects was in Senegal, working together with the national utility company Senelec, which implemented seven hybrid projects scattered throughout the remote region of Ile du Saloum (pictured below). Its aim was to provide electricity to remote villages, with the option of eventually connecting them to the state grid should they require expansion.

"Three of these are so-called fuel-saving applications, meaning a direct combination of diesel generators and solar. And then four out of the seven are actually with storage. So, they are fully automated when it comes to the operation mode and switching between generators and battery operation," says Böhm.

Elsewhere the company has another project in the Maldives, where it is implementing its energy management system across 26 separate micro-grids, on 26 separate islands. These involve diesel generators, battery storage and solar.

According to Böhm, the interest in micro-grids is growing, fuelled by a number of different advances in the energy sector globally.

"I think the competitiveness of renewable energy is key, because a decade ago you had to pitch solar mostly about the environmental impact and the social impact that it would bring. But now renewable energy is much more competitive, solar is more competitive than most unsubsidised fuels," Böhm says, indicating that the scalability of micro-grids is being at least partly driven by how cost-competitive renewables are now with fossil fuels.

Technologies such as solar, that are often chosen for micro-grids have undoubtedly matured, bringing operational and cost benefits. The cost of solar power has fallen by 99% over the last four decades, according to MIT.

Hand in hand with this, Böhm says, is what he labels the "operation philosophy", with energy management maturing and leading to "a lot more reliability and professionalism when it comes to energy supply."

Moving forwards, it is clear that micro-grids offer an exciting opportunity to both small islanded communities and the smart communities of the future.

Böhm predicts that a key part of this will be continued growth in the size of a micro-grid, as well as continued integration of smart technologies. Instead of the current Master/Slave mode most micro-grids use, where different forms of distributed generation have different functions, with one the master source of generation and the others reacting to it, the micro-grids of the future will be hybrid systems, with generators and batteries seamlessly transitioning in what's accepted as "Master/Master" mode.

Such a system could offer an appealing alternative to today's national grids, providing a resilient and reliable solution to the integration of technologies such as solar, blockchain and management software, making microgrids a smart choice. ■

Credit: DHYBID

DHYBRID is testing its micro-grid technologies in a remote part of Senegal