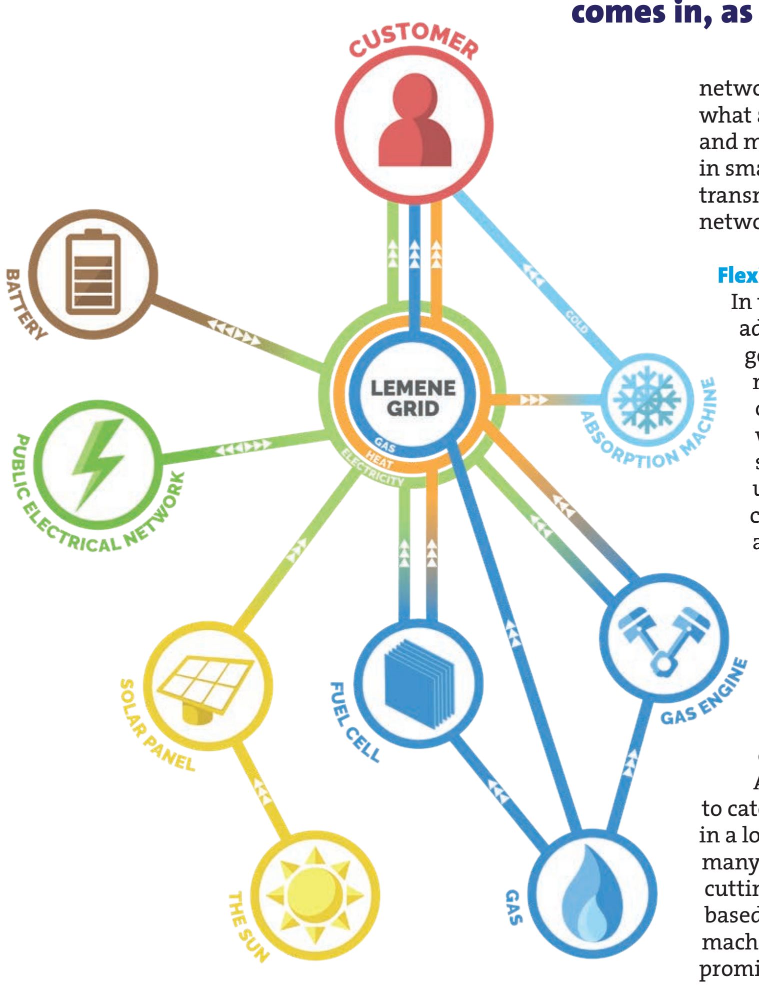
ARTIFICIAL INTELLIGENCE

AI in energy systems – local projects to transmission networks

Local energy systems can be fiendishly complex, incorporating multiple sources and vectors, and a variety of users. This is one area where artificial intelligence comes in, as *Andrew Williams* reports.



Schematic of the LEMENE grid project in Finland

Image: Lempäälän Energia Oy

Artificial intelligence (AI) is making its way into the very real world of local energy grids. A number of organisations are now actively developing smart energy grid systems – often based on, or supported by, machine learning technology. These smart local networks – generally devoted to electricity or heat, and occasionally commercial supply – are often operated in a very efficient manner, helping to minimise costs to consumers or reduce carbon emissions.

So, how do smart energy networks work in practice? And what are the key applications of AI and machine learning technology in smart energy generation, transmission and distribution networks?

Flexible network

In the past, the typical approach adopted by large power generators has been to sell as much electricity as possible, often with little regard to whether or not the energy supplied is wasted – or even used more efficiently – by customers. However, against a background of mounting cost and environmental pressures, a growing number of suppliers are investigating the possibility of deploying smaller, greener systems in an effort to promote better outcomes.

Although generally designed to cater to the specific conditions in a local area, a common theme of many such projects is the use of cutting-edge digital and data-based solutions, as well as AI and machine learning technology. One prominent example is the Finnish energy outfit Lempäälän Energia, which is currently working with Siemens on the LEMENE project – a self-contained smart energy system in the industrial district of Marjamäki, Finland.

A key feature of the novel network approach is that operators entering the industrial district are eligible to join the decentralised energy system and actively participate in the local electricity market. Notably, the 'intelligent' LEMENE system is flexible enough to participate in external markets or, if necessary, operate as an autonomous energy island.

According to Lempäälän Energia, the system also guarantees the sufficiency of electric power throughout the year by utilising, among other things, renewable energy sources such as solar power and biogas. In particular, there will be a 4 MW solar power plant, gas engine capacity of 8.1 MW and fuel cell solutions providing a total of 130 kW.

Jussi Maentynen, Head of Product and System Sales – Smart Infrastructure, Finland & Baltics at Siemens, explains that the company's role in the project is to deliver five smart distribution substations (dubbed 'e-houses') made up of medium voltage switchgear, distribution transformers and low voltage boards. The switchgears are equipped with Siemens Siprotec5 protection relays and SICAM substation automation units.

The network will be built in ring mode and feature advanced protection units, meaning that any kind of grid failures are solved in a short time, and power to customers is secured. The overall operation of the various energy systems is managed by a SICAM Microgrid controller, which Maentynen describes as a 'powerful brain' that is capable of running this complex microgrid made up of different energy production units, as well as different types of consumer, including cold storage, shopping malls and industries.

Test bed

As part of its overarching target of performing in an economically efficient manner, securing power supply 24/7 and keeping sustainability in focus, Maentynen also says that LEMENE will be connected to Fingrid's demand response markets with Siemens DEMS software. This technology utilises information from the microgrid controller, such as forecasts of power production, but also the expected flexibility available from generation and consumption, which can then be sold to yearly or hourly markets.

According to Maentynen, most of the systems involved in the project are already undergoing factory testing and all equipment is due to be installed throughout summer 2019. Full system commissioning is then slated for early autumn 2019 – with the full potential and capacity of the LEMENE network to be developed in the months and years to come. As part of this process, the network will also enable the implementation and testing of new technologies, including AI.

'As this is one of the first grid-scale microgrid projects in Finland, it has required a lot of collaboration between many parties. The LEMENE project is also planned to be a test bed for new solutions in the future, and AI technology could bring new aspects to the operation of the system,' Maentynen explains.

'Although the existing systems and processes are already very highly automated, AI could potentially help grids to become more resilient against potential failures and help microgrids to be more sustainable,' he adds.

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Energy Demonstrators

Elsewhere, the UK government has recently awarded funding to four local energy system demonstrators to focus efforts on how AI or machine learning technologies can best be employed to optimise local systems and develop novel ways of supplying heat, power and mobility. This, as well as to show how new ways of trading supply and demand at a micro-level might work to make better use of the system for everyone.

The initiatives, supported via the government's Industrial Strategy Challenge Fund, include the Local Energy Oxfordshire (LEO) project, which will showcase a local energy marketplace using new intelligence in the local networks and will be operated by a range of competing market players and suppliers.

As part of the scheme, low carbon energy projects in the surrounding area will be able to integrate operations with the local marketplace – in the process fostering the optimised use of local resources, balancing supply and demand across power, heat and transport and smoothing load on the network through peer-to-peer trading.

A second project, called Superhub Oxford, will demonstrate how stress can be taken away from local networks by enabling access to the national grid system as a means of providing electrical heating to local properties and fast charging for electric vehicle fleets. It will also employ AI-based grid response services through the use of a novel flow battery to create an income stream – in the process helping to facilitate an investable business model.

Meanwhile, in the far north of the UK, the ReFLEX Orkney scheme aims to demonstrate how a system generating excess renewable energy output can be optimised at a local level. In doing so, the project team will install an AI-based virtual energy system platform to optimise supply and demand across heat, power and mobility. This will be achieved, so the scheme's operators say, through micro-trading of the flexibility available in heat pumps, heat storage, batteries, electric vehicle charging and hydrogen production for ferries and buses across Orkney.

Artificial intelligence

For Professor Stephen McArthur, Head of the Institute for Energy and Environment at the University of Strathclyde, the key to understanding applications of AI in energy systems is to picture the technology as a collection of different algorithms and approaches that attempt to mimic human-like intelligence to solve a range of problems.

McArthur claims that machine learning – a branch of AI based around the idea that systems can learn from data and identify patterns – will be particularly valuable in the energy sector. The technology will likely be able to help network controllers to improve maintenance procedures and enable the timely replacement of critical and expensive equipment – by increasing the ability to predict failures, anticipate faults and accurately estimate remaining useful life.

Generally speaking, this can be achieved by using machine learning and statistical analysis of the increasing volume of monitoring data being gathered from plant items across the industry.

According to McArthur – who has been deploying AI solutions in the energy space for 25 years – machine learning can also be harnessed for transmission and distribution operation. This is chiefly because of the increasing volume of network monitoring, from power quality monitoring devices, active network management schemes and phasor measurement.

'We can learn examples of situations where either faults can occur, power quality can be reduced, or constraints on the network are breached. This would allow corrective control action to be taken under these circumstances,' he explains.

'This leads into the next area of AI that is important – distributed intelligence and autonomous control. Once we have data, and analytics that extract what we need from it, we can start to make improved control decisions,' McArthur adds.

Managing real-time complexity

Although the drive towards active network management has already started, McArthur predicts that the real-time complexity created as we add electric vehicles and home energy systems into the mix can also be tackled through AI decision making and optimisation algorithms.

In his view, this function will become increasingly important as distribution network operators become distribution system operators and, in the context of projects such as LEO, could then be extended to decision making across multiple energy vectors.

'We can take all of the layered data, machine learning and AI-based decision making outlined above and ultimately deploy analogous concepts inside the home, or a community or local energy system,' he says.

In the coming years, McArthur believes that one of the main challenges to implementing smart energy networks is that energy companies do not, traditionally, have the skills and experience to deploy the software and control advances coming from AI innovations. This is coupled with the fact that there is a significant journey between proving that AI works in principle and embedding a solution in a business-as-usual context.

'Also, it is an iterative journey of deployment, evaluation and improvement. This requires not just AI innovation, but data engineering, software engineering, commissioning and so on, McArthur says. 'The energy sector does not have large groups with these skills and abilities. Some are starting to build them, but it is an added cost on top of the key technical staff they need for their day to day operation.' ●

Andrew Williams is a freelance writer.