THE ENERGY INDUSTRY TIMES

October 2018 • Volume 11 • No 8 • Published monthly • ISSN 1757-7365 www.teitimes.com

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Transition will double electrification of energy demand, says new report

Electrification of sectors such as transport and industry will see the role of electricity in energy demand almost double by mid-century, according to a new report. **Junior Isles**

A new report says that continuing rapid electrification will see electricity's share of the total energy demand more than double to 45 per cent in 2050.

According to DNV GL's *'Energy Transition Outlook (ETO) 2018: Power Supply and Use'* report, this will be driven by substantial electrification in the transport, buildings, and manufacturing sectors. In the transport sector, the uptake of private electric vehicles (EVs) will continue to escalate rapidly, with 50 per cent of all new cars sold in 2027 in Europe expected to be EVs.

DNV GL's ETO 2018 report, which provides an outlook of the global energy landscape up to 2050, says the surge in global electricity production will be powered by renewable sources accounting for an estimated 80 per cent of global electricity production in 2050. As the costs for wind and solar continue to fall, those two energy sources are set to meet most of the electricity demand, with solar PV delivering 40 per cent of electricity generation and wind energy 29 per cent.

One of the report's major findings is that rapid electrification will lead to major expansion of electricity transmission and distribution systems both in the length and capacity of transmission lines. DNV GL predicts that the total installed power line length and capacity will more than triple by 2050.

While this will make the system operators' tasks substantially more complex, there may well be less energy flowing across the networks, resulting in fixed costs becoming a greater part of the bill, the report claims.

Despite major expansion of high-capital-cost renewables and electricity networks, energy will become more affordable. It is predicted that the total cost of energy expenditure, as a share of global GDP, will fall from 5.5 per cent to 3.1 per cent, a drop of 44 per cent. Absolute energy expenditure will still grow by 30 per cent over the forecast period, to $6 trillion/yr. DNV GL foresees a shift in costs, from operational expenditure, principally fuel, to capital expenditure. From 2030, more capital expenditures will go into electricity grids and wind and solar than into fossil-fuel projects.

Fossil fuels will, however, continue to play an important if reduced role in the energy future with its share set to drop from around 80 per cent today to 50 per cent by the middle of the century. The other half will be provided

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Power sector transformation crucial to EVs

Although electric vehicles can generate up to 67 per cent lower greenhouse gas (GHG) emissions than a gasoline internal combustion engine (ICE) car on a well-to-wheel basis, their competitive advantage depends on power sector transformation.

According to Wood Mackenzie's latest research on mobility transition, comparing GHG emissions from an EV and a petrol ICE car is not straightforward, noting that even though EVs have zero tailpipe emissions, they are not GHG emissions-free when evaluated on a well-to-wheel basis.

Notably, the research found that when there is a high share of coal or other fossil fuels in the power mix, typical in Asia Pacific countries, the competitiveness of EVs versus ICE cars decreases.

The company says its analysis is unique in that it focuses on well-to-wheel assessment. This involves a number of factors – how the fuel is produced in refineries, where the crude oil is sourced from, mileage of the car, how the electricity is produced, and the energy use associated with vehicle and battery manufacturing and charging. These factors differ from country to country.

Aman Verma, Wood Mackenzie Research Analyst, said: "When using our integrated model, based on the existing electricity generation mix in developing economies such as China and India, an EV can only displace up to half the GHG emissions of an ICE gasoline car."

Commenting on the findings of the report, Prakash Sharma, Wood Mackenzie Research Director, said: "The most crucial factor in sustaining the current advantage for EVs is decarbonisation of the power sector. As gasoline ICE vehicles become more fuel efficient, the power mix must comprise more renewables for EVs to remain GHG competitive. Currently, the power sectors in the UK and US are 30 per cent less emissions intensive than markets in Asia.

The organisation points out that the findings in the report reflect the current state, noting that "only time will tell" if power sector decarbonisation will go hand-in-hand with EV cost reduction and adoption.

Transport is largely viewed as the second major sector after power that needs to decarbonise. At the recent Global Power and Energy Exhibition (GPEX) 2018 in Barcelona, Spain, Oliver Weinmann Managing Director, Vattenfall Europe Innovation noted that "electricity has been quite a success story" but there was still a need to decarbonise transport – where emissions were still rising – and heat.

Chairing a discussion at the conference on decarbonising transport, Albert Cheung, Head of Global Analysis, Bloomberg New Energy Finance said there were now 4 million EVs globally and that figure was rising by 1 million every six months. In Europe, he said BNEF data showed that in Europe, EVs currently represent 2.5 per cent of vehicle sales but that figure would rise to 14 per cent by 2025.

THE ENERGY INDUSTRY TIMES is published by Man in Black Media • www.mibmedia.com • Editor-in-Chief: Junior Isles • For all enquiries email: enquiries@teitimes.com

Milking the ORC

A dairy factory in Italy is set to install a cogeneration plant that uses an Organic Rankine Cycle (ORC) that will operate at a higher temperature than existing systems. **Junior Isles** reports.

Owners of small Industrial facilities that require predominantly steam, as opposed to hot water and/or electricity, are often faced with a choice of either installing steam turbines, small or micro gas turbines or reciprocating engines – none of which are an ideal solution for processes with large steam requirements but little electricity.

A recent technology advance, however, now offers what appears to be the ideal solution for this market niche. Italian company, Turboden, has just announced that it is to deliver what it says will be the first high 'Steam & Power Organic Rankine Cycle (ORC)' plant to Centrale del Latte di Brescia for milk pasteurisation.

The new high temperature cogeneration solution is claimed to have an overall efficiency of more than 90 per cent with a high steam output – typically producing about 75 per cent steam, 15 per cent electricity and no hot water.

Commenting on the new technology, Paolo Bertuzzi, Turboden's Managing Director and CEO, said: "In terms of the market, we realised that we could address a niche – in terms of a different combination of steam, power and size – that is not covered by other existing cogeneration technologies."

Turboden's new technology will target projects between 500 kWe and 3 MWe, which corresponds to a steam output of 5-30 t/hr.

It is a market segment that is generally too small for a cogeneration system based on a single gas turbine. And although microturbines could be used, projects become complex if too many are required.

"Gas turbines are almost not present at this size," noted Bertuzzi. "Internal combustion engines are the leading technology at this size. However, although they give you about 40-45 per cent in terms of electrical efficiency, you only get about 18 per cent of steam. So, if you don't need hot water, you will lose 35-40 per cent of the energy input. If you do not need the power or hot water, this is not the most suitable technology."

With the new ORC technology, heat is received at a higher temperature than the 300°C used in its current ORC for CHP biomass applications. Normally this will deliver hot water at 80-90°C, which is suitable for low temperature cogeneration applications such as district heating or drying processes. The Steam & Power ORC increases the system inlet temperature to 400°C to deliver steam at different pressures, ranging from 6 bar up to around 18-20 bar.

Turboden first began developing the technology two years ago, analysing which applications required large amounts of steam, little electricity and little or no hot water. It found that industries such as dairies, food and beverage, paper, chemical, textile, and oil & gas could all benefit.

"We had all the components and were confident we could move our existing system technology to this new higher temperature," noted Bertuzzi.

Through a research and development project supported by the Italian Ministry of Economic Development's Fund for sustainable growth, Turboden designed a new ORC. The new system is based on a modified turbine, which uses a working fluid that is suited to the higher temperature. The company has a budget of about €5 million to develop the project.

The Rankine Cycle is a thermodynamic cycle that converts heat into work. Heat is supplied to a closed loop, which typically uses water as working fluid. The Organic Rankine Cycle's principle is based on a turbogenerator working as a conventional steam turbine to transform thermal energy into mechanical energy and finally into electrical energy through an electrical generator. Instead of generating steam from water, the ORC-system vaporizes an organic fluid, characterised by a molecular mass higher than that of water, which leads to a slower rotation of the turbine, lower pressures and no erosion of the metal parts and blades.

First developed in the 1950s, Turboden believes ORC technology has big potential, believing it can go from the current approximately just under 300 MW/year (of which 200 MW/year is in geothermal) to about 1 GW/year.

Speaking at a presentation earlier this year in Brescia, Italy, Bertuzzi said: "ORC for geothermal can go up to 400-500 MW/year, taking market share from steam turbines. Biomass could also be 100 MW/year, easily. And a market that has huge potential, is waste heat recovery for processes and oil & gas. This could be an additional 200-300 MW/year."

Development of the new ORC system will help realise this potential. According to the company, the components in the new system are the same as its existing cogeneration technology but new materials capable of withstanding the higher temperatures are used.

Pasteurisation in milk production will be a prime application for the new high temperature Organic Rankine Cycle technology

"We have validated all the components – we have selected and tested all the materials. Therefore we do not see any particular technological risk to this new development. We are used to designing units that run at different temperatures – very low in geothermal, medium in waste heat recovery, higher in biomass."

According to Bertuzzi, the new technology could make more small-scale industrial installations with high steam requirements become feasible. "To receive certain subsidies, such as White Certificates, you often need to comply with an overall efficiency that is sometimes very high. So if you don't need hot water, it is very difficult to meet these overall efficiencies."

With the possibility of receiving subsidies, which support project economics, payback times are impressive. Looking specifically at the dairy industry, where the first system will be installed, Bertuzzi notes that cogeneration systems are not so widespread.

"Most of them buy power from the grid and use gas fired boilers to produce steam. Investing in a cogeneration plant has a payback in the range of less than three years. It depends on the number of operating hours per year, the size of the project and other variables such as the price of the electricity – the higher the electricity price, the shorter the payback. The cost of the gas is almost neutral because you are already burning the gas to produce the steam."

The new unit at Centrale del Latte Brescia will be used to produce 700 kW of electric power and 5 ton/h of steam in the production processes for milk pasteurization.

Although the boiler can be designed to burn natural gas, biomass or recover waste heat, the Centrale del Latte Brescia installation will use a natural gas-fired thermal-oil boiler designed by industrial boiler manufacturer Bono Sistemi - Cannon group. The existing gas boiler at the dairy will be kept as a backup.

The new thermal-oil, gas boiler is not a conventional gas boiler that produces steam to drive a steam turbine. Instead it produces heat that is transferred to a thermal oil loop. The hot thermal oil evaporates the ORC working fluid and the organic vapour generated expands to the turbine, which drives an electric generator to produce electric power.

Downstream of the turbine, the organic vapour pre-heats the organic liquid in the regenerator and is then condensed at high temperature releasing its latent heat for steam generation, to feed the manufacturing process.

Delivery of the new ORC system is scheduled in 12 months. As a skid-mounted solution, erection and installation time is expected to be quite short. This will see startup of the unit at the end of 2019/start of 2020.

The owner of the unit is looking forward to the benefits it will bring to the operations. Dr Franco Dusina, President Centrale del Latte di Brescia, said: "Centrale del Latte is very sensitive to clean and environmentally friendly solutions; high efficiency cogeneration fits perfectly with our philosophy. For some years we have been looking for a suitable technology for our energy needs and for improving the energy efficiency of our production plant. We are sure that the synergy between Turboden and us, two important companies in the industrial context of Brescia, will lead to a successful project.

With this first project now firmly off the ground, Turboden is already targeting projects in other industrial sectors.

Bertuzzi said: "One will be in paper and the other is in chemical fibres. We are also aiming to have our first biomass project soon."

In terms of the technology, Centrale del Latte di Brescia is the first of what Turboden calls a "multiple size development" that will go up to 3 MWe and 25 t/h.

"We have a pre-design for four or five sizes but the detailed design of the larger sizes will be linked to the first project. Typically, each pre-design will validate the new size that will come to the market. We hope to conclude the development of the different sizes within two years from now," said Bertuzzi.

Commenting on geographic markets, he says the solution can be very attractive for all markets where cogeneration is either already best practice or in the development phase. "It depends on the price of electricity versus the price of natural gas and the presence of incentives to support high efficiency cogeneration. We are actively proposing this solution in Italy, UK and Ireland but will also be looking at other countries."

To support the roll-out of the technology, in addition to offering after-sales services such as remote monitoring and diagnostics, Turboden will also be looking at how it can support with financing installations.

Bertuzzi concluded: "In the cogeneration sector, most of the time customers are not eager to invest directly in a project but are used to having access to off-balance sheet solutions. With the support of financial partners and energy service companies, or even directly, we are available to study the best rental or energy service scheme or leasing facility, according to the customers' preference."

The gas-fired thermal oil boiler generates heat that is transferred to a thermal oil loop. The hot thermal oil evaporates the ORC working fluid and the organic vapour generated expands to the turbine to produce electricity. Downstream of the turbine, the organic vapour pre-heats the organic liquid in the regenerator and is then condensed at high temperature releasing its latent heat for steam generation