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CHP'S FUTURE IN A SUSTAINABLE ENERGY MARKET ■ GAS TURBINE-BASED CHP SYSTEMS MARKET OUTLOOK ■ EFFICIENCY BENEFITS OF EXHAUST GAS CONDENSATION ■ STRATEGIES FOR BOILER AND HEAT EXCHANGER MAINTENANCE

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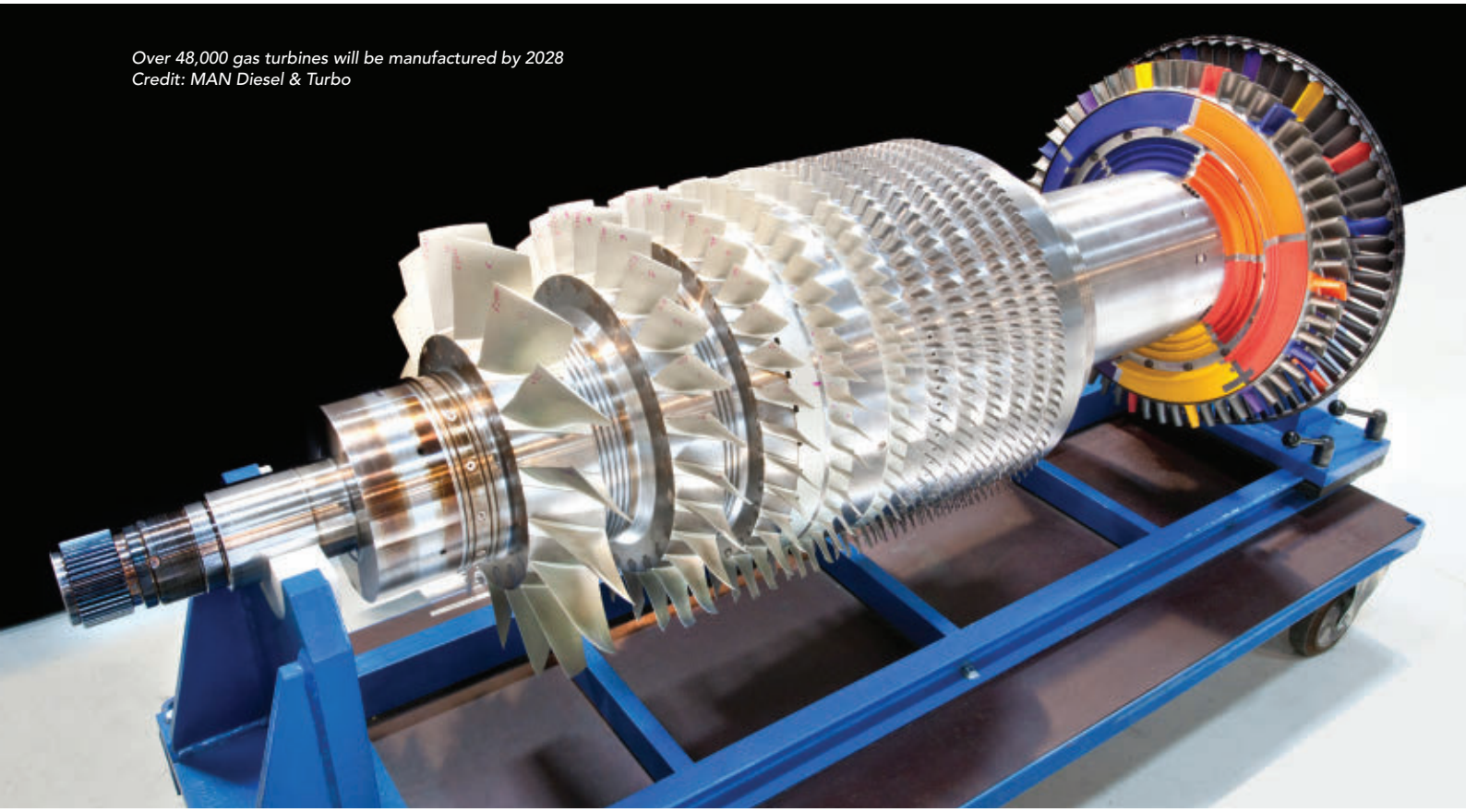
Business unusual

Even in today's changing energy landscape, it is tempting to believe that the future will be business as usual for manufacturers of gas turbines for CHP systems, given the substantial market growth predicted for the sector. However, there are still potential challenges on the horizon. Tildy Bayar investigates



Over 48,000 gas turbines will be manufactured by 2028
Credit: MAN Diesel & Turbo

Gas turbine-based systems lead the industrial CHP field, and it is predicted that over 48,000 industrial gas turbines, valued at almost $620 billion, will be manufactured by 2028. Substantial market growth is predicted as new environmental regulations, increased energy efficiency goals and changing national resources encourage the uptake of gas-based CHP systems.

Nevertheless, the coming years may not be an entirely smooth ride for gas turbine makers. We spoke with several to find out how they see the global market, and how they plan to deal with a changing energy economy and the potential for change in the CHP market.

A changing market brings changing risks

While the benefits of CHP are inarguable, it is still under-represented in most countries' energy profiles. One reason for this, policy risk, is a perpetual concern, subjecting many investors, project developers and turbine manufacturers to near-continual uncertainty. Martin Westerhoff, technical journalist with MAN Diesel & Turbo, notes: 'The market is, to a certain extent, driven by political visions. The political and economic framework must be right to trigger new investments in CHP, which have to compete with existing and depreciated capacities in the market.'

Jim Crouse, executive vice-president of sales and marketing at Capstone Turbine, adds: 'One challenge in the US is that we don't have a national energy policy that truly drives CHP. Really

it's the states that are left to implement – or not – policies that help either incentivise through rebates or cash incentives, or regulations that help end users make buying decisions around CHP.'

Regine Mowill, marketing director at OPRA Turbines, outlines some of the current market risks: 'There are obviously some geopolitical risks in certain areas,' she says – for example, gas supply from Russia and US sanctions there. 'In Europe we have uncertainty on where the legislation will go, while in other regions there are currency risks and fluctuations – in Southeast Asia recently, the Japanese currency has fallen, and so have the Indonesian and Malaysian currencies.'

Crouse adds: 'As a US manufacturer, the strengthening of the US dollar is challenging for us; we have to watch very closely and see how it will impact our business in the near-to-medium term.'

National markets

'The US is a bit fragmented and there are a lot of different utilities whose rates aren't the same, so it's been challenging,' says Crouse. However, in general his view of the US market is positive due to trends such as low gas prices, increasing utility rates, aging infrastructure and a national and local response to natural disasters. But Sasha Savic, CEO of Swiss firm SS&A Power Consultancy GmbH, injects a note of caution. 'The US is on the verge of a booming [gas-fired power] market, but how much of that is CHP is another story,' he says.

In Europe, 'the CHP market seems to stagnate with few new projects,' MAN's Westerhoff says. Savic agrees: 'In the last two to three years, there has been virtually no [gas-fired power] market in Europe – very, very little,' he says. 'There was clearly a peak before the financial crisis, but then, of course, there has been a significant drop in demand'.

However, Savic sees gas turbine-based CHP as a bright spot in Europe's gas power plant troubles. 'What helps', he explains, 'is those operators who have an additional source of revenue due to heat produced, for example district heating [DH] applications. We see that these operators can still operate to provide heat because they are getting revenues for that, even though possibly on the electricity side they are struggling.

'The heat market did have some problems on industrial generation because industrial demand has reduced,' he adds. 'However, those who have CHP duty do have an authentic source of revenue.

'China's market, by all accounts, is going strong, especially since the nation's gas deal with Russia last year. The deal will help the Chinese gas turbine market,' Savic says, 'and in the last two to three years we have already seen a significant rise in the number of new projects for gas-fired generation. I believe China in particular has a lot of industry cogeneration and also district heating requirements, so it should be a significant CHP market.'

'In the Middle East there is an abundance of gas at low prices and this will be the case for many years ahead,' he says. 'In the stable environment of the Gulf we see desalination and CHP for water production, and because of such cogeneration needs combined with low gas prices the Middle East market is perfect for CHP.'

'Russia is an interesting market,' he continues, adding that it is 'also ideal for CHP based on its boundary conditions, namely the availability of plentiful low-cost gas and a very high need for CHP for DH. When you put this all together you would expect Russia to be leading – but this has not happened so far.'

He cites a 'lack of interest', and the fact that '[Russians] have to pay for western equipment because they do not have advanced industrial gas turbine products of their own. This is a pity because today they are burning gas in atmospheric boilers with efficiencies of 10%–15% to provide district heating. Instead they could invest a little more money [in gas-fired CHP plants], use their gas in a more environmentally and economically efficient manner, use it in a much better arrangement and make additional profit. There is however currently a lack of incentives.'

Crouse adds that, 'being US-based, Capstone has the current [US] sanctions [on Russia] to deal with; most of the companies listed in the sanctions are our customers. Fortunately the sanctions were targeted enough for specific markets or technology applications that we haven't been impacted. But from a currency/financing perspective [Russia] was already a challenging and difficult place to get financing and do CHP projects, and now with the currency devaluation it's become even more challenging.'

Crouse also raises an interesting issue in relation to emerging markets. 'Where labour is relatively inexpensive, our microturbines give up some competitive advantage [over engines] from a lifecycle perspective,' he says. 'In the US or Europe where technicians and engineers are $100/hour, versus a market where it's dollars per hour, then the cost of changing the oil, spark plugs or filters is relatively low. The difference can range from several thousand dollars per year on a small cogen system to a thousand dollars per year.' This is an issue in markets such as India, China and Africa.

Gas turbine-based systems lead the industrial CHP field
Credit: MAN Diesel & Turbo

Technical challenges

There are still some technical challenges involved in developing gas turbine-based gensets for use in CHP systems. OPRA's Mowill says: 'In our power range, the important thing is to think about heat as well as power, so the heat-to-power ratio. This needs to fit the

client's needs; if it does, they get high overall efficiency and savings.' Oil and gas customers, she says, 'are not so concerned about overall efficiency; they're more concerned with reliability and having power on-site, such as sites where they need power for production and heat is less important.'

Savic believes that some technical problems remain for gas-based CHP. 'Every project will have its own challenges,' he says, but 'one or two situations need to be carefully examined.'

One such situation is the growing number of CHP desalination plants in the Middle East. 'I see a bit of a challenge in winter,' he says, 'because desalination plants have to provide a more or less constant amount of water. However, there is less of a requirement to generate electricity because nobody is using air conditioning. So now gas turbines have to produce enough exhaust energy to create enough steam for desalination plants and, on the other hand, they have to reduce their load. This can be quite a challenging situation and while there are solutions, they have to be carefully looked at to see that they are not too costly.'

Another challenge involves changing fuel requirements, making configurability a key concern. In response, Mowill says OPRA has developed a modular package that can be configured to the customer's requirements. 'It's the same core turbine,' she explains, 'with maybe different filters and different fuel systems, and it might use a different combustor if people use low calorific value fuels which need a larger combustor. If the customer needs low emissions we have a low-emission combustor.'

One example of a fuel-flexible system is a CHP plant in Turkey which runs on syngas. Another, a gypsum plasterboard manufacturer, currently has a CHP system running on natural gas, but Mowill says the customer's requirements included a potential upgrade to a dual-fuel system if and when an affordable, nearby syngas supply becomes available.

'Customers are always looking for flexibility,' says Crouse, adding that Capstone's microturbines are tolerant of different fuel types and can run on 'low-BTU fuel, from landfill up to propane or butane'. Examples are a Hawaiian resort and a Caribbean CHP plant, both of which run on propane, as well as 'quite a few' projects running on biogas, including a Russian chicken farm.

MAN is also looking into fuel flexibility for future developments. 'One market tendency is to investigate the possibility of using other gases than natural as gas turbine fuel,' says Westerhoff.

Among other challenges, Westerhoff notes that 'CHP's focus is not only on gas turbine efficiency like for mechanical drive applications. In general, electrical power has a higher importance for the development; nevertheless the exhaust heat, mainly the exhaust gas temperature, should be at a certain minimum level for an efficient heat process in the waste heat recovery system.'

Crouse says Capstone is currently working with the US Department of Energy to develop a more efficient, larger microturbine. The so-called 370 programme 'will end up with a 250 kW turbine as the first phase, which will produce 2%–3% more electrical efficiency than the current 200 kW product,' he explains. The second phase will aim to produce a 370 kW turbine with 'on the order of 40%–42% electrical efficiency'. Crouse is 'optimistic' that these products will be commercialised within the next four years.

Looking to the future, Savic expects 'a race' in terms of both efficiency and dollars-per-kW attractiveness. He believes that technology development in future will not focus on higher efficiency – which, he says, 'is not going to bring that much. Gas turbines will probably be developed more in terms of operational flexibility and better response to changing market conditions, and this is where developers should focus.'

'On the other hand,' he adds, 'the maintenance side of gas turbines will also experience some shifts and changes. From being undertaken largely by OEMs, maintenance has shifted to independent service providers, especially in the Middle East where these independent providers are dominating a little more and putting pressure on costs for users.'

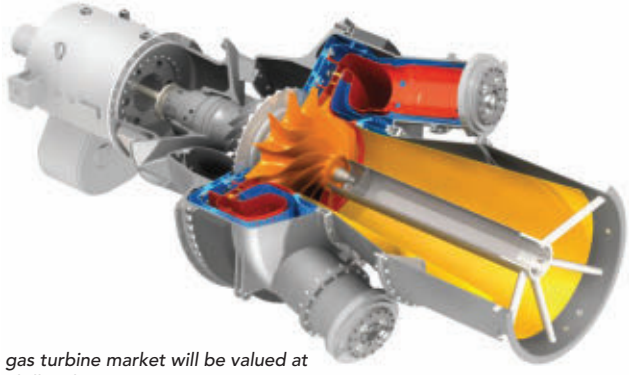
This shift in maintenance practice is happening 'right now', he says. 'Because European markets are under pressure to reduce generation costs, they're looking into all possible alternatives on the maintenance side. Gas turbines are probably the most expensive technology when it comes to maintenance, so any effort that can reduce those costs will be welcomed by the market.'

A coming challenge from gas engines?

The traditional distribution of gas turbines for larger cogeneration/CHP projects and gas engines for smaller projects may be about to change. The gas turbine versus gas engine question is 'a hot topic' at the moment, says Savic: 'What we have seen recently is some development in gas engine technology. Wärtsilä, and GE with their Jenbacher engines, have realised they can compete with turbine generation against the small to medium sized gas turbines.'

'The size of the project doesn't matter; it is just about the heat-to-power balance,' says OPRA's Mowill. She explains: 'Gas engines have higher electrical output but tend to have lower-grade heat, so if you want hot water and quite a lot of power engines are a better choice, but for higher-grade heat or steam production or direct drying in addition to power, gas turbines are better.'

She continues that 'the maintenance cost is higher for reciprocating engines. They have a bigger footprint, higher emissions, lower overall efficiency, higher losses,



The gas turbine market will be valued at $620 billion by 2028
Credit: OPRA Turbines

more vibrations, etc.' And she notes that time before overhaul must be considered: 'Gas engines involve a lot of constant maintenance, whereas our gas turbines have maintenance after 40,000 hours (approximately five years), and one annual inspection.'

Another advantage of gas turbines is fuel flexibility. Operators of waste-to-energy applications 'care about whether we can run on the fuel and whether they need fuel cleaning, because this can be very expensive,' she says. 'If they can put their fuel into our turbine without fuel cleaning, that's an advantage. Municipal waste sites gasify things and generate lots of contaminants which can be damaging for engines.'

MAN's Westerhoff adds that 'gas turbine-based systems provide more heat potential at a higher temperature level than engine-based systems and have their advantages for projects where this is important, e.g., steam production. An engine-based system, on the other hand, can reach a higher overall energy efficiency level of up to 90% and is less sensitive with regards to ambient temperatures.

'The operational mode is also essential to decide whether to choose an engine or a turbine,' he continues. 'In heat-driven systems, which tend to operate on constant loads, the turbine is likely to be more efficient. If high load-change velocities or even operation in start/stop mode are required, which is typical for electricity driven systems, engines are likely to be beneficial.

'Available fuel quality is of course important; gas turbines might, in principle, have some more flexibility. But most projects are still based on natural gas, with which both gas turbines and engines have no problem to operate. With engines the required gas admission pressure is lower, which reduces infrastructure costs for gas compression. So which technology to choose really needs to be decided on a detailed case analysis.'

However, Wärtsilä communications manager Jussi Laitinen says: 'Gas turbines are the business-as-usual option, but we're challenging the "big guys" in this game and capturing many projects as the size of engine power plants has grown very fast in the past few years. The only problem is that often tenders are tailored for turbines only' – something Wartsila is working to change. In fact, the firm recently filed an appeal over a tender for a new unit at Poland's Zeran CHP plant, with a capacity of 420–490 MWe and over 250 MWt.

In its appeal, the firm said the tender's provisions 'state that only companies offering turbine technology may participate in the proceedings. The provisions therefore exclude possibility for contribution from providers of alternative solutions, including engines offered by Wärtsilä.'

Risto Paldanius, vice-president Europe & Africa, Wärtsilä Power Plants, said: 'We firmly believe that there is no sufficient reason to discard the engine technology, especially since such solutions have already been proven in practical large scale projects which have been successfully operating for many years all over the world.'

Wärtsilä's internal modelling of CHP and district heating systems, Laitinen says, 'constantly get the result that engine power plants by us – smart power generation plants – are 30% cheaper than the turbine option, and operational costs are cheaper. Turbines tend to cost from €1100/kW, the engine option from €600–700/kW.'

SSA's Savic says attempts to open up the CHP market to gas engines are 'exactly what we are seeing. From an environmental regulations perspective, there isn't any difference between a gas reciprocating engine and a gas rotating turbine,' he says. 'Whichever is better for the client, if there's no negative environmental impact, should be considered.' But, he cautions, 'this is very difficult to generalise – it depends on the specific project requirements.'

And he adds that 'everywhere you have large industrial-frame combined-cycle projects, I simply cannot see gas engines taking that share of the market – it is economically and in CAPEX/OPEX terms not favourable. However, for peaking applications there is a good opportunity for gas engines to take market share.'

Another area where gas engines could have some success, he adds, is in projects that require black start capability/black grid restoration capability. 'For these projects gas turbines are normally not sufficient to perform the task; you would need a diesel generator to restore the island and then the grid. Gas engines are similar to diesel engines so they can start in that moment, with no additional cost. Just getting X number of gas engines would be sufficient for black start,' he concludes.

According to Capstone's Crouse, 'engines are going to be here for quite some time. They won't be replaced by microturbines; there are niches where we're better and niches where they're the better solution.' He also doesn't see other technologies such as fuel cells stepping up for CHP as there are 'still a lot of challenges with them'.

The importance of flexibility, Savic says, 'depends on trends in terms of distributed generation. How quickly are we going to get to point where we rely less and less on remote power generation facilities and focus on some combination of local utility and household generation?' But, he says, 'this will potentially be a good storyline for gas engines.'

Crouse believes that microturbines can be competitive with gas engines. 'For us to grow,' he says, 'we're looking to take market share away from Cummins, Caterpillar, GE, MAN, MTU – engine competitors.' In terms of gas turbines, 'as the market expands there's plenty of room for growth for everyone. In the multi-billion dollar market that is CHP, there's lots of room for us to grow without our competitors being too impacted,' he says.

Microturbines are predicted to gain a 24% market share by 2028
Credit: Capstone Turbine

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