Grid Flexibility, Lower Emissions Among the Benefits of Cogeneration

Fears of Fukushima-repeats, the growing costs of fossil fuels, and increasingly stringent government regulations for greenhouse gas emissions are all pushing the utilities industry to look for cleaner-burning, higher efficiency methods of generating electricity. Thanks to advances in flying technology, a cogeneration – the production of both electricity and heat energy – is gaining new favour. Often referred to as either combined cycle power plants (CCPPs) or CCGTs, these power plants are starting to feature largely in many national grids, offering a smaller environmental footprint, potential cost savings, and greater grid flexibility.

Greater Fuel Conversion Efficiencies from CCPPs

Without a doubt, the greatest advantage to a combined cycle power plant over conventional power plants that use fossil fuels is the fact that it has a fuel conversion efficiency that can be as high as double. Where a conventional power plant can only provide a fuel conversion of approximately 33%, many of today's advanced combined cycle power plants have a fuel conversion efficiency of 50% or more – sometimes as high as 68%. Of course, that means a CCPP will burn about 50% less fuel compared to a conventional plant to generate the same levels of energy, which is good news in terms of cost savings and the environment.[i]

By comparison, a typical power plant will waste as much as 67% of the energy produced, mostly in the form of waste heat. By harnessing the heat from the burning of fuel through a heat recovery steam generator to produce additional electricity or for district heating, a CCPP can deliver extra electricity for the same fuel burned.

Though there are numerous models being tried and tested throughout the world, in a typical combined cycle power plant, 33% of the power generated is supplied by the steam turbine cycle, and 66% by the gas turbine cycle. The T-Point Combined Cycle demonstration plant by Mitsubishi, for example, includes a variety of features, such as, "Exhaust Gas Recirculation (EGR), higher cooling efficiency, lower thermal conductivity TBC, higher loading turbine aerodynamics, a higher pressure ratio compressor and advanced turbine materials." The TIT class gas turbine achieves a combined cycle efficiency of 63% to 65%, which is a 5% to 10% improvement over current available technologies. These technologies are being used to retrofit several existing gas turbine developments as well.[ii]

In another example, the General Electric 207FA combined cycle configuration achieves 100 MW greater output than a simple cycle system, and achieves an ISO efficiency of 58.5%.[iii]

The conversion efficiency of CCPPs is even capturing the attention of leaders in oil rich countries like Saudi Arabia. Given the country's rapidly growing population, the need for extremely efficient power generation will become increasingly important, even in a region rich in fossil fuels. That's why a massive new CCGT project being installed by Siemens (in a $1 billion contract) is so exciting. The plant, which will be commissioned in 2014, will provide 4 GW of energy and supply enough energy for 1/10th of the population.[iv]

The advantages of being able to burn less fuel to produce the same kWh of energy are self-evident. With higher fuel conversion efficiencies, a CCPP plant will produce significantly less air pollution and fewer greenhouse gas emissions unit of gas burned. A Spanish combined cycle power plant by Gas Natural Fenosa (GNF), for instance, will be making use of GE's dry low NOx 2.6+ combustion technology for gas turbines to reduce emissions and maintain high efficiency. Spain is currently experiencing a reduced electricity demand, and so GNF was looking for a way to maintain efficiency in compliance with environmental laws at lower loads. The new add-on from GE will improve dispatch response, lower fuel consumption, reduce NOx and carbon dioxide emissions, and allow GNF to deliver power during off-peak periods cost-effectively.[v]

In fact, CCPPs generate very low levels of emissions even when parked below 20% of the maximum load in many cases. The Siemens SGT6-8000H turbines have been sold to Florida Power & Light in part because of their ability to achieve lower emissions to meet increasingly strict emissions standards. These systems will be used to renovate power plants in Riviera Beach and Cape Canaveral using these gas turbines which achieve 60% efficiency and reduce carbon dioxide emissions by 50%.[vi]

This low emissions production makes CCPP systems attractive for many reasons, not least of which is the insulation it provides against regulation-imposed fees for air pollution. The lower levels of fuel burned make CCPP financially attractive as well.

Quick Ramp Up with CCPPs Offers Grid Flexibility and Better Integration with Renewables

For those national grids that are rapidly increasingly their renewable energy share, such as the UK and Germany, the need for power plants that can power up and down in a relatively short span of time without huge environmental or financial consequences is significant. This kind of grid flexibility is extremely important in light of the fluctuating nature of renewables like wind and solar.

Again, CCPPs are a fantastic solution for solving this problem. CCPPs offer a cost-effective, lower-carbon solution because of the relative ease of quickly ramping up a CCPP plant. CCPPs provide a guaranteed, secure power supply that can be turned on in just a few minutes to fill the gap when wind and sun power ebbs.[vii] This vastly simplifies the integration of renewable energy into the grid and helps to create a very stable system, regardless of the load offered by renewables at any given time. The mix of renewables with CCPP technologies allows utilities to guarantee their customers greater grid stability and increased competitiveness, while lowering their environmental impact at the same time.[viii]

Take the El Segundo Flex-Plant 10 550 MW system that provides two 1x1 cycles. It's the first CCPP that can boast the ability to get to 150 MW per block within 10 minutes of gas turbine ignition. This Flex-Plant 10 technology provides both fast start-up and extremely low emissions and high efficiency. [ix]

One of the reasons combined cycle power plants can offer such quick ramp-ups is because of their ability to operate in a stable fashion even at low loads. The Alstom KA24-2 CCPP, for instance, achieves 700 MW of output using a two to one configuration, operating at 60% efficiency. Using Alstom's Low Load Operation (LLO) technology, the CCPP system can be parked at 20% or lower with the steam turbine and both gas turbines still operating. [x]

Developing flexible gas generation that relies on within-day liquidity is based on supply-demand balance can optimize renewable energy deployed over a whole system to ensure consumer costs don't rise. This concept is being reiterated in many European studies, such as a recent Redpoint Energy and Imperial College London study commissioned by Wärtsilä in the Britain. The study concluded that flexible rather than conventional gas generation could reduce balancing costs in the national grid to save the country between £380 million to £550 million by 2020 and up to £1.54 billion by 2030.[xi]

Opening New Fuel Markets with Fuel Flexibility of Combined Cycle Systems

CCPPs offer significantly better fuel conversion efficiencies, especially when combined with high quality fuels such as natural gas or high grade oils like diesel fuel. The corrosive components of low grade fuels such as crude oil, some distillates and so forth require the addition of fuel treatment equipment, making them less attractive fuel options for such systems. This can be a limiting factor where these types of fossil fuels are not readily available or cost effective.

That said, there are many companies working with a wide range of configurations to offer a combined cycle add-on to existing and future power plants to boost efficiencies and reduce emissions using a variety of fuels. This makes combined cycle technologies very attractive for everything from solar to nuclear to biogas.

Small-scale combined cycle plants, for instance, can offer a practical electricity generating alternative to rural areas. That's because some technologies allow for the use of biogas derived from forestry waste, landfill waste, and agriculture waste, all of which are readily available in remote regions. This option is especially useful for areas that lack a cost-effective method of piping natural gas to the location.

Another extremely interesting option is the combination of a steam turbine with a utility-scale solar farm. These systems can generate significant heat which is harnessed in a combined cycle power station that operates virtually emissions-free. The waste heat generated by nuclear power plants is also seen as a great source of energy. Not only is this a very attractive option for rural areas, it’s useful for utilities looking for ways to reduce the carbon footprint of their power portfolio and squeeze even more energy out of their renewable and nuclear installations.

Embracing CCPPs as a Reliable, Low-Carbon Transition Solution

Given that most energy markets will rely on some portion of fossil fuels for the foreseeable future, combined cycle power plants are likely to play a larger role during the transition to an entirely carbon-free energy market. Given their lower carbon footprint, their ability to provide stability even at low operating loads, and the potential to use a variety of waste fuels including biogas and landfill methane, CCPPs are proving to be a more sustainable technology we can embrace as well move to a zero carbon economy.

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