COLUMN-To survive, coal power plants must become more flexible: Kemp

By John Kemp

LONDON, Nov 19 (Reuters) - Integrating an increasing supply of wind, solar and other variable sources of power onto the grid will require conventional plants to become more flexible. The question is whether coal-fired generators are up to the challenge.

On a grid with more renewables, conventional gas, coal and nuclear generators have to be able ramp their output up and down at short notice to offset short-term changes in wind speed and cloud cover.

Plants will need to be capable of "two-phase operation": generating power for a few hours to meet morning and evening peak demand and then going offline, with the cycle repeated once or even twice in 24 hours.

"Fossil power plants with a highly versatile operating response are the key to integrating renewables," power-engineering firm Siemens wrote in a technical paper issued in 2011.

For the industry and policymakers, the core issue is what sort of conventional generation provides the best combination of flexibility, cost and reliability to work alongside renewables on the emerging 21st century power grid.

FLEXIBLE GAS VERSUS COAL

The obvious choice is to rely on open-cycle gas turbines (OCGT) to back up

variable resources. Resembling the jet engines employed on aircraft, OCGTs are already used to provide fast-response emergency power supplies at times of peak demand.

Because these turbines do not have to heat large volumes of water to raise steam, they can ramp up quickly. OCGTs can ramp up to maximum output in just 10-15 minutes, compared with the four to eight hours that it takes a large coal power plant to reach full output even from a warm start.

But OCGTs are also inefficient and expensive. Peaking plants that use OCGT technology charge very high prices to supply extra power for 100 hours a year or less. They also generate lots of greenhouse emissions.

So the power industry is searching for ways to make the rest of the conventional generation portfolio more flexible too. Coal producers and generators are understandably keen to talk up the ability of coal-fired units to step into the gap.

Until recently, the debate largely ignored coal. Coal is neither as clean as nuclear nor as flexible as OCGT. The assumption was that nuclear would run as baseload and gas would provide flexible response. But the power industry has begun to take another look at how coal can be run more flexibly in future.

HIGHER OPERATING COSTS

The operational and financial challenges of operating conventional plants in a more flexible mode are enormous.

Large-scale power plants take hours to warm up to operating temperature and synchronise their turbines with the grid.

“(Grid operators) may have to cycle resources on and off more than once a day,” the North American Electric Reliability Corporation explained in a

recent report on integrated renewables in California.

“At times this may not be an option because the down time between shutdown and start-up of a resource may be too long, which would prevent the resource from being restarted in time for system peak,” NERC concluded.

While they are warming up, conventional plants waste huge amounts of fuel without producing useful output.

And repeatedly heating up and cooling down the boilers, economisers, pipework, turbines and other components shortens their life-span and requires more expensive maintenance.

On top of all this, cycling power plants must recover their more expensive operating costs as well as the expense of building them, while getting paid for fewer hours of generation each year.

INCREASED WEAR AND TEAR

“Increased rates of component life consumption due to thermal fatigue, mechanical fatigue and wear caused by differential thermal expansion comprise the bulking of cycling (costs),” according to the International Energy Agency’s Coal Industry Advisory Board.

“Every time a power plant is turned on and off, the boiler, steam lines, turbine and auxiliary components go through unavoidably large thermal and pressure stresses,” the National Renewable Energy Laboratory (NREL) wrote in a report on cycling costs published in April 2012.

“While cycling-related increases in failure rates may not be noted immediately, critical components will eventually start to fail,” NREL observed.

"Shorter component life expectancies will result in higher plant equivalent forced outage rates and/or higher capital and maintenance costs to replace components at or near the end of their service lives."

Increased wear and tear also heightens the risk generating plants will be unavailable when they are needed most, reducing grid reliability.

CAN COAL BE MADE FLEXIBLE?

The 2013 annual report of the IEA's Coal Industry Advisory Board includes a case study of how coal-fired power plants in Germany have responded to the cycling requirements imposed by the installation of large quantities of wind and solar on its electrical grid.

In Germany, combined load and generation adjustments have risen as high as 50 gigawatts in an eight-to-10-hour period - equivalent to more than 60 percent of the country's peak power consumption.

In response, production from coal plants has been successfully turned down to just 20-60 percent of normal output. The advisory board claims part-loaded coal-fired plants have been able to ramp down by as much as 3 percentage points per minute.

The board's optimism is spoiled, however, by the financial woes of Germany's big coal-fired generators. RWE this month announced yet more job cuts and said that 2014 would be a "valley of tears" for conventional power producers.

Rivals E.ON and GDF Suez have also warned of a prolonged crisis in the European power industry.

Enormous renewable generation, subsidised through feed-in tariffs, coupled with low wholesale power prices and the low number of hours in which coal and gas-fired power plants are able to operate mean that revenue is

inadequate for conventional generators.

REVENUE ADEQUACY AND DESIGN

In principle, coal-fired plants could still have a role in meeting residual demand if they can be made sufficiently flexible and appropriately compensated.

But they will need to achieve increased turndowns, faster and less damaging start-ups, faster load changes and reserve shutdowns at minimal cost, as the coal industry board acknowledges.

Much of the current flexibility has come from older, smaller and less-efficient subcritical plants.

More modern coal plants are designed to maximise efficiency by making them larger and employing supercritical and ultra-supercritical steam cycle systems. But that has also made them harder to run in a flexible mode.

The proposed new generation of super-efficient and greenhouse-friendly integrated gasification and combined cycle (IGCC) and oxy-combustion coal plants fitted with carbon capture and storage (CCS) are likely to be even less flexible, if they are ever built.

In IGCC and oxy-combustion plants, gasifiers, boilers, turbines, air separation units and the carbon capture system must all be made to work smoothly together. It may not be possible to turn down one sub-system without disrupting the efficient operation of the others.

New coal plants may need changes, starting early in the design phase, to enable them to operate in a more flexible mode.

The requirement for flexible operation currently conflicts with other trends

such as the need for increased efficiency and for carbon capture to reduce emissions.

Power plant designers and operators need to focus on flexibility for coal-fired generation to have a future in a power grid with a large share of renewables.