Lodi's 300MW Flex 30 plant ushers in a new era for the US

By Junior Isles

The Siemens Flex Plant 30 at Lodi designed to deliver 200MW of power to the grid within 30 minutes of startup is capable of daily cycling at over 57 percent combined cycle efficiency.

The Lodi Energy Center, owned and operated by the Northern California Power Agency, is the first operating Siemens Flex Plant 30 combined cycle gas turbine power plant in the US. Key operational features:

☐ **Output**. Lodi has nominally rated the plant at 300MW base load which is a bit lower than its design rating.

☐ **Duty cycle**. Designed for intermediate to continuous duty and capable of daily cycling.

☐ **Ramp rate**. Can ramp up or down at 13.4 MW/min and turndown in standard emissions compliance to less than 50 per cent load.

California has set very ambitious carbon reduction targets and renewable energy goals under the 2006 climate change act and 33 per cent renewable portfolio standard requirement of 2011 with its associated need for fast start backup power.

As intermittent sources such as wind and solar PV grow, so does the need for back-up power plants that are able to provide power quickly when the wind does not blow and the sun does not shine. Gas-fired plants are widely regarded as the best option for providing this back-up.

In August, the Northern California Power Agency inaugurated the Lodi Energy Center (LEC) – the first operating Siemens Flex-Plant 30 combined cycle gas turbine power plant in the USA is designed for intermediate to continuous duty and is capable of daily cycling.

Plant configuration

The LEC plant is designed around a 208MW natural gas-fired SGT6-5000F gas turbine with evaporative air inlet cooling and dry low NOx combustors to control air emissions, 3-pressure Nooter Eriksen heat recovery steam generator, selective catalytic reduction (SCR) and carbon monoxide (CO) catalyst to further reduce emissions, and a 100MW SST-900RH condensing steam turbine generator.

According to Siemens, overall plant start-up times are reduced by up to 50 per cent due to the integration of fast start-features, including the three-pressure HRSG with Benson once-through technology, high capacity steam attemperation (desuperheating), full capacity steam bypass systems, innovative piping warm-up

Lodi plant expected to have over 95 percent annual availability

Lodi Energy Center's design to combine operating flexibility with the ability to quickly start up and provide efficient part-load and base load power calls for a high degree of redundancy.

Lodi is expected to operate with an annual availability factor of more than 95 percent, calculated as the percentage of time that the plant is able to generate power – determined in large part by the reliability of critical operating equipment and maintenance shutdown requirements.

To ensure operational reliability and availability, Lodi has installed a number of back-up ancillary systems including:

- two 100 percent fuel gas compressors;
- two 100 percent capacity feed water pumps;
- two 100 percent capacity condensate pumps;
- two 100 percent capacity circulating water pumps;
- two 100 percent capacity air compressors; and
- extra capacity 7-cell evaporative cooling tower.

The plant also incorporates an evaporative cooling tower to cool the steam turbine's condenser. Recycled water for process and cooling water uses will be delivered from an adjacent City of Lodi's water pollution control facility and an onsite well will provide potable water.

strategies, and Siemens' steam turbine stress controller (STC).

The latest version of the SGT6-5000F gas turbine at the heart of the plant is capable of reaching full output in 30 minutes. It also can ramp up or down at a rate of 13.3 MW/min and remain compliant with emissions regulations below 50 percent part-load turndown conditions.

Fast-start design

According to Siemens, its fast start capability to deliver 200 MW in 30 minutes or less can result in a 30 per cent reduction in greenhouse gas emissions when compared to traditional F-class combined cycle plants i.e. more than 200 t/year of carbon monoxide.

Lodi Flex 30 combined cycle project

Lodi has nominally rated its Flex 30 plant at 300MW net output at an expected 57.8% net plant efficiency, including all BOP equipment.

SCC6-5000F 1x1 Plant	
Net plant output*	307,000 kW
Net heat rate LHV	5990 Btu/kWh
Net plant efficiency	57.0%
Lodi Flex 30 Plant	
Net plant output**	300,000 kW
Net heat rate (LHV)	≤6000 Btu/kWh
Expected efficiency	57.8%
Installed plant cost**	1300 $/kW
Operating cost (est)	$90 million/yr
Rated power capacity**	2,400,000 MWh/yr
Expected operation	1,600,000 MWh/yr

Sources: 2012 GTW Handbook* and Lodi Energy Center**

Lodi Flex 30 project. First operating Siemens Flex 30 combined cycle gas turbine power plant in the United States is nominally rated at 300MW net plant output and 57.8% net efficiency.

Since its first introduction in 1993, the engine has evolved over time with improvements made to increase efficiency and power output, extend maintenance intervals and enhance operating flexibility. According to Siemens, the engine is now designed for high reliability and frequent ramping and has no service penalty for fast starting or fast ramping.

It features a 13-stage compressor with four rows of variable compressor guide vanes enabling high efficiency at part load as well as at base load. The compressor is connected to the 4-stage turbine by a single tie-bolt.

No nickel-based alloys are used in the rotor construction. Instead the rotor uses upgraded steel discs in the turbine section with a rotor air cooler to allow for greater flexibility in turbine blade cooling air temperature.

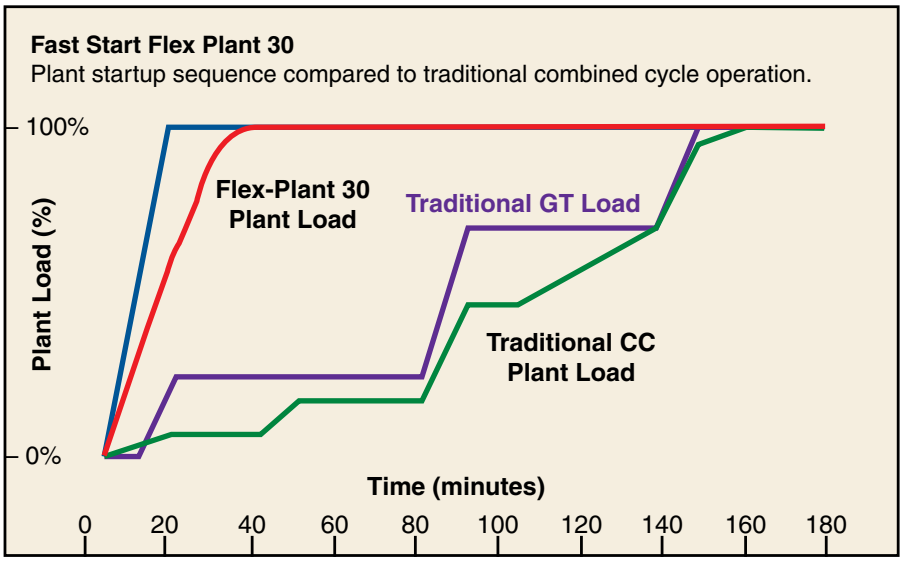
Ultra low NOx

The engine is offered with an option of two combustion systems. The latest version of the turbine uses an ultra low NOx (ULN) combustion system that employs 16 can-annular combustors to reduce NOx levels to less than 9 ppm.

The ULN system uses five fuel stages to mix the natural gas with combustion air. The pilot and the main pre-mixers on the combustor support housing employ swirler fuel injection, where the fuel is injected off the swirler vanes. This provides more injection points and better mixing than the previous dry low NOx combustor.

In addition to reducing NOx, the ULN combustion system controls CO, volatile organic compounds and particulate emissions. The reduction in low-load CO emissions is achieved by operational modifications and bypassing supplemental cooling air around the combustor.

The result of bypassing air around the combustor is increased combustor flame temperature, which leads to reduced CO production. In this version, CO emissions are kept below 10 ppm down to at least 40% load, without alteration to the internal architecture of the combustion system. This allows greater flexibility during cyclic operation.



Lodi opted for standard DLN

Lodi passed up the ULN option in favor of a standard 25 ppm DLN combustion system and rely on catalytic reduction to reduce plant emissions to less than 2 ppm NOx –in line with California environmental regulations.

Likewise, Lodi chose to equip its gas turbine with a standard motor and torque converter starter, with a turning gear speed of 3 rpm.

To achieve improved gas turbine start capability, the gas turbine could have been supplied with a static frequency converter (SFC) starter instead of a mechanical starter (with SFC design, the generator operates as a motor).

The SFC unit allows more efficient and faster rotor acceleration than an equivalent size mechanical starting motor. It can increase the turning gear speed from 3 rpm, for earlier models, to 120 rpm.

Higher turning gear speed enables the generator rotor wedges to lock up, prevents compressor blade locking mechanism wear, and locks turbine blades into running position.

The higher speed also helps the engine to cool down faster, because the turbine parts are cooled faster and blade tip clearances are similar to the cold tip clearance.

Combined cycle integration

Although flexible gas turbines can start fast, once deployed into combined cycle mode, steam cycle constraints need to be considered. The gas turbine is exhausting a high volume of high temperature air and the heat sink needs to be able to absorb and dissipate that energy without damaging any equipment.

In a traditional combined cycle power plant, the ramp rate of the gas turbine is constrained by limitations imposed by equipment in the bottoming cycle. To protect that equipment, the gas turbine is ramped to a low-load hold point – letting the rest of the cycle warm up and allowing time to achieve appropriate steam chemistry – then ramped a bit more.

At this hold point, the gas turbine produces much higher CO emissions than at base load, so the result is "low power" and "high emissions" during the hold. Typically the gas turbine in a three-pressure, reheat combined cycle arrangement experiences two such holds prior to allowing the steam turbine to go to a valves wide open condition.

Several changes were made to remove these constraints, the first of which was a change in boiler design.

Initial Siemens fast-plant operation, for example, was enabled by the use of a Benson once-through HRSG design.

This eliminated the thick walled drum and allows for unrestricted gas turbine ramping. It is still the benchmark of fast start HRSG technologies and is incorporated in Siemens Flex Plant designs, including the design used at Lodi.

HRSG designs improved

More recently, HRSGs with thinner walled drums have become available as an alternative choice for Siemens Flex Plants. They offer much faster ramp rates than a traditional cycle, but somewhat slower ramp rates than the Benson design.

In a traditional combined cycle, the bottoming cycle piping system is susceptible to stresses due to high thermal transients. In a Siemens fast start Flex Plant, the systems are fitted with high capacity attemperation to maintain temperature and avoid thermal shocks.

In addition, the steam turbines are supplied with stress controllers. And the cycle includes an auxiliary boiler to provide steam that keeps the steam turbine seal system warm and ready to start.

To benefit from all of these features, optimized control logic in a fully integrated control system is applied. This system monitors and adjusts to optimize combined cycle operation, protecting each part while enabling fast flexible gas turbine start.

Startup and ramping

The sequence of operation used to manage the Flex Plant 30 begins with accelerating the gas turbine to synchronization speed.

The exhaust gas is directed through the fast cycling Benson HRSG and the steam is initially dumped to the condenser, bypassing the steam tur-

Once-through HRSG. Nooter Eriksen three–pressure heat recovery steam generator with Benson once-through technogy equipped with SCR and CO catalyst to minimize emissions.

bine. The steam turbine and associated piping are warmed, and the steam turbine is then loaded to a valves wide-open condition.

This was never possible in a conventional bottoming cycle due to the high thermal transients that would result. This new start sequencing capability enables fast power to the grid from the early gas turbine ramp, and significantly lowers start-up emissions.

Starting the bottoming cycle quickly enables the entire plant to deliver power to the grid faster. According to Siemens, current versions of its Flex Plant enable 150MW in 10 minutes per gas turbine, and can move the bottoming cycle to valves wide open in well under 45 minutes for an overnight shut down.

Integrating renewables

The fast start and cycling characteristics of the technology was one of the key reasons for the use of Flex Plant 30 at Lodi.

Siemens also recently announced two new Flex-Plant projects in Temple and Sherman Texas along with the two California plants, one at LEC and the other at El Segundo.

Siemens reports that these four state-of-the-art plants will meet the US market's need for clean fossil power solutions with 'fast ramping' capability to balance intermittent renewables on the power grid.

According to the California Energy Commission, the operating flexibility of the new LEC will facilitate greater use of renewable sources such as wind and solar for electricity generation, which have been more difficult to integrate into the grid because of their intermittency.

"The Lodi Energy Center will provide grid reliability to the Central Valley, while integrating renewable resources," said Energy Commission Chair Robert. B. Weisenmiller. "This is the future for fast-start gas fired combined cycle power plants in the country." ■

Participants in the LEC project

The new Lodi plant will serve the needs of 13 different project participants actively involved in development of the Lodi Energy Center.

Agencies include the Modesto Irrigation District, Power and Water Resources Pooling Authority, Plumas-Sierra Rural Electric, State of California Dept. of Water Resources and the Bay Area Rapid Transit.

The project also involved the City of Ukiah; City of Lodi; City of Biggs; City of Azusa; City of Lompoc; City of Santa Clara; City of Healdsburg and the City of Gridley.

Total construction cost of the project is estimated at around $388 million which will be paid for through bond financing; the cost of operating the plant is estimated at $90 million per year.

Energy produced will be used in a variety of ways. The California Dept. of Water Resources, with rights to roughly one third of the plant's energy output, will use the electricity to move water down the state's aqueduct for millions of residents.

Importantly, for environmental goals, the new Lodi plant also will help the California Resource's Agency discontinue buying coal energy from outside the state. The last contract is due to expire next year.

Reclaimed water from the City of Lodi's White Slough wastewater treatment facility will be supplied to the power plant for cooling and steam generation.

The tertiary-treated water is further processed by LEC's advanced water quality facilities before use in the steam generation process and in the power plant cooling system.

The City of Lodi is expected to receive approximately $1 million for the sale of 1800 acre-feet of reclaimed water annually, turning a water disposal liability into a financial asset for the host city.

Cooling tower. The plant utilizes a seven-cell cooling tower provided by SPX Cooling Technologies.