Power Generation Market of Today and Tomorrow

Green energy but mostly intermittent supply

- Wind energy
- Solar energy

Power Plants need to do more...

Siemens Flex-Plant™ combined cycles

Gas Fired Flex-Plants™ can Start Fast

Load Follow Up AND Down

High Efficiency Low Water Usage and Low Emissions

Low flexibility base load

- Coal fired plants
- Nuclear power plants
- Hydro power plants
Gas-Fired Power Plants Fill The Gap

Challenges:
1. Daily Starts and Stops
2. Fast ramps up and down
3. Large changes in power supplied

The non-renewable fleet requires daily start-stop operation, and higher load ramps...flexible gas-fired generation supports grid stability
### 60 Hz Combined Cycle Portfolio

Flexible solutions in every size

<table>
<thead>
<tr>
<th>60 Hz CCPP</th>
<th>Power Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCC6-2000E (1×1)</td>
<td>170 MW</td>
</tr>
<tr>
<td>SCC6-5000F (1×1)</td>
<td>350 MW</td>
</tr>
<tr>
<td>SCC6-8000H (1×1)</td>
<td>400 MW</td>
</tr>
<tr>
<td>SCC6-8000H (1S)</td>
<td>410 MW</td>
</tr>
<tr>
<td>SCC6-5000F (2×1)</td>
<td>700 MW</td>
</tr>
<tr>
<td>SCC6-8000H (2×1)</td>
<td>810 MW</td>
</tr>
<tr>
<td>SCC6-5000F (3×1)</td>
<td>1,040 MW</td>
</tr>
<tr>
<td>SCC6-8000H (3×1)</td>
<td>1,230 MW</td>
</tr>
</tbody>
</table>
Flex-Plant™ Features for Enhanced Performance

- High-Capacity Attemperators
- ST Piping Warm-up Systems
- Proven STG w/ST Stress Controller
- 100% By-pass
- Fast Acceleration to GT Sync Speed
- Advanced Drum or BENSON™ once through in HP section
- Rotor Air Cooler w/ Kettle Boiler
- Auxiliary Boiler
- Integrated T3000 Control system with Startup & Shutdown Automation & Stress Control Solutions

The efficiency and small environmental footprint of a combined cycle with the speed and flexibility of a simple cycle
DrumPlus Technology…An Enabling HRSG Technology for Maximum GT Flexibility

**DrumPlus Features:**
- Drum-type HRSG with OTSG Dynamics & Lifetime
- Unrestricted GT start-up (12min) over HRSG
- Designed for Cyclic Life Including Cold Starts
- Steam Separation External from Drum
- Smaller Diameter…Thin Walled Drum
- Conventional Water Requirements
- Drum = Water Inventory = Reliable/Robust
- Downcomer Design and Tube to Header Connections Designed for Cyclic Life
- Total Solution vs. Component Modifications
Unrestricted full ramp rate gas turbine start

*Fast MW on the grid*

*Low start up emissions (no low load hold)*

**Fast starting and fast cycling bottoming cycle**

*From start to steam turbine bypass in under an hour for a hot start*

*The entire plant can load follow with the GTs at max ramp rate*

**Low NOx and CO while ramping with Clean-Ramp™**

Integrated controls maintain NOx & CO during transients

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**Industry Leading Power Plant Technology for Clean, Flexible Generation**
Flex-Plant™ Technology

Traditional combined cycles were not designed to start up fast or ramp fast

Flex-Plants™ are the result of an evolutionary process to create fast, reliable, combined cycles that fully leverage the flexibility of the gas turbine - they start fast, change load fast, and shut down and restart reliably.

![Graph showing 2x1 Flex-Plant™ 30 ( < 16 hr shutdown)](image-url)
Transient Emissions
Improvements with Flex-Plant Designs

Flex-Plant fast gas turbine start capability results in significant reduction in start up and shut down emissions

- NOx
  - Warm Start: 393 (36% reduction)
  - Hot Start: 286 (37% reduction)
  - Shutdown: 51 (29% reduction)

- CO
  - Warm Start: 1,833 (81% reduction)
  - Hot Start: 1,194 (93% reduction)
  - Shutdown: 247 (78% reduction)

- VOC
  - Warm Start: 185 (33% reduction)
  - Hot Start: 136 (32% reduction)
  - Shutdown: 27 (22% reduction)

Information is for illustrative purposes only and is based on a 1x1 F class combined cycle starting to 100% GT load.
Siemens Improved Flexible Operation with Transient Emission Control – **Clean-Ramp™**

**Siemens Clean-Ramp™**

*Emissions control for ramping*

This system maintains emissions out of the stack while load following at full ramp rate

**Clean-Ramp** is available in a Siemens Flex-Plant™ Power Island powered by the SGT6-5000F or the SGT6-8000H
Siemens Flex-Plant™ combined cycles provide integrated, low cost, clean power generation that responds like a peaker.
Northern California Power Agency’s Lodi Energy Center
The Nation’s First Fast Start Combined Cycle

Siemens Flex-Plant™ 30
- Gas Turbine: SGT6-5000F
- Gas Turbine Generator: SGEN6-1000A
- Steam Turbine: SST-900
- Steam Turbine Generator: SGEN6-100A-2P
- Control System: SPPA-T3000

Installed Capacity 300 MW
Efficiency >57%
Fast start capability 200 MW in 30 Minutes
"The Siemens Flex 10 technology provides the California grid what is needed to meet aggressive environmental goals," said Steve Hoffmann, President of NRG’s West Region. "The fast-start features help firm intermittent renewable resources while the high efficiency meets new clean air standards."
Siemens Flex-Plant™ at El Segundo...Technology Validation Through Commercial Operation in the US Market
Optimize performance and Profitability

A leader in combined cycle power plant technology

The first combined cycle to achieve over 60% combined cycle efficiency in a power plant that provides up to 500 MW in half an hour

First operating fast start combined cycle in the US with the Flex-Plant 30 at Lodi Energy Center.

Success based on over 100 years of experience designing, implementing, operating, maintaining and upgrading
Advantages

Flexible
Fast
Dependable

The global experience of Siemens

Siemens Energy Power Plant Solutions

A power plant partner
For Full Turnkey Solutions

practical plant