Flexibility Solutions
Solutions for your power plant optimization

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Optimize your plant with Siemens Flexibility Solutions

Siemens is the world’s leading supplier of flexible combined cycle power plants with more than 1,500 references. Our power plants are designed, supplied, and built with flexibility features and are better able to compete in rapidly changing markets around the world. We offer variety of options which can be selected and optimized according to.

Opportunities for additional revenue generation include optimized participation in reserve power markets, improved start-up and shut down costs, and more possibilities to participate in ancillary services markets.

Demands on fossil-fired power plants have been changing dramatically. With the growth of weather-dependent wind and solar generation around the world, the generation mix needs to include a reliable, dispatchable, and flexible generation partner. Siemens Flexibility Solutions are designed to meet these demands with the ability to start, ramp, unload and reload fast, frequently, and reliably.

Siemens combined cycle power plant capabilities go beyond meeting operational requirements - they enhance the economic benefits of the plant. When a plant starts fast, the fuel efficiency of the start up transient is higher, enabling a start cost reduction of up to 50%. Avoiding traditional low load hold points also improves the environmental footprint of the plant, reducing start-up emissions up to 95%. Fast load changes and fast duct firing enhances the ability to support ancillary service needs, potentially opening new revenue streams.

Our Flexibility Solutions support renewable resources, enabling high reliability, low electricity costs, and an overall cleaner generating grid.

Siemens combined cycle power plants offer all of these capabilities while maintaining the traditional benefits of gas-fired combined cycles - economic, low emission, reliable power generation. Having a plant that can do everything well, maximizes the potential for revenue generation over a long plant life cycle.

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Flexibility Solutions

Co-Start™
Fast and efficient plant hot start-up at reduced fuel costs and predictable load profile allowing higher plant flexibility and profitability.

Quick-Stop™
Rapid shutdown of the plant

Go-Ready™
Fast and efficient plant warm start-up

Steam-Assist™
Enables fast start without dependence on auxiliary boiler

Energy Control™
Enables fast start of air-cooled plants without increased ACC capacity

Dash™
Fast-moving supplemental firing

Challenge | Solution | Benefits
--- | --- | ---
Combined cycle power plants are operating mostly in intermediate and peak load | Co-Start™ | Fuel saving for one Co-Start approx.
Dispatch order is directly proportional to marginal cost and start-up cost | | Start-up time
Optimized start-stop operation required to be profitable | | 30 minutes

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Operational and economic benefits

Calculating economic benefit for base load alone is no longer an effective way to predict the value of a power plant. Dispatch efficiency calculates the total fuel usage for a dispatch of a given duration. Using dispatch efficiency instead of base load efficiency adds the cost of the transients in the plant evaluation, better reflecting future expectations.

Our Flexibility Solutions improve dispatch efficiency. Better dispatch efficiency increases profitability for shorter dispatch windows, opening up more opportunities for revenue generation with fluctuating demand.

Siemens Flexibility Solutions increase plant profitability. Fuel savings from higher efficiency and lower start charges lead to significant cost savings for plant owners and operators. Higher dispatch efficiency reduces greenhouse gas production which can also offer benefits like emission tax credits or certificates in countries where such mechanisms are in place.

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Case study

It’s not always possible to feed electricity into the grid profitably. This is what makes the flexibility of our plant so incredibly important.

With Quick-Stop and Go-Ready the gas turbine can be fired up and down very quickly.

Udo Brockmeier
CEO of Stadtwerke Düsseldorf, Germany

Location: Düsseldorf Lausward, Germany
Customer: Stadtwerke Düsseldorf AG
Plant type: SCCS-8000H 1S
Power output: 603.8 MW

Special features:
- Load changes of up to 55 MW per minute
- Hot start in 25 minutes to full load
- Heat extraction and record efficiency of 61.5%
- 300 MW in district heating output and 85% overall fuel efficiency
Our Flexibility Solutions consist of a wide range of single technical measures and improvements, each of which helps to increase the overall plant flexibility. Here are some of our project highlights!

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References
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Appendix

Overview pages for print

Every solution on one page
Co-Start

Fast and efficient plant hot start-up at reduced fuel costs and predictable load profile allowing higher plant flexibility and profitability.

Challenge

- Combined cycle power plants are operating mostly in intermediate and peak load
- Dispatch order is directly proportional to marginal cost and start-up cost
- Optimized start-stop operation required to be profitable

Solution

- Enable gas turbine to start similar as in simple cycle mode with continuous load ramp up to base load – no load hold after synchronization
- Start steam turbine as early as possible to take HRSG steam before gas turbine is at base load
- High pressure ramp rates due to low steam production with limited HP bypass flow
- Early closing of HP/IP-bypass valves

Benefits

- Shorter plant hot start-up time
- Fuel saving during start-up
- More profitable operating hours
- Reduced CO₂ emissions and cost
- Reduces global warming potential
- Higher plant efficiency during start-up
- Increased dispatch opportunities
- Increased operating flexibility

Plant start-up on short notice with Co-Start

- Conventional start-up
- Co-Start

Start-up time:
30 minutes

Fuel saving for one Co-Start approx.
850 GJ

Plant Load

Start-up Time

50 min

Co-Start

Conventional start-up

30 min

+ Electricity production

Fuel consumption

Plant Load
Flexibility Solutions

Quick-Stop

Fast and efficient plant shutdown at reduced fuel costs and predictable load profile for high plant flexibility.

Challenge

- Combined cycle power plants are operating mostly in intermediate and peak load
- Optimized start-stop operation required to be profitable
- High number of shutdown events at low lifetime expenditure required
- Low or no revenue for electricity during plant shutdown

Solution

- Simultaneous gas turbine & steam turbine shutdown (incl. ST load calculation for single-shaft)
- ST ramp rate is calculated with the same power output model as it is done during Co-Start
- No GT load hold
- HP steam bypass controls HP pressure to modified fixed pressure set point to keep more heat within the HRSG

Benefits

- Shorter plant shutdown time
- Fuel saving during shutdown
- More profitable operating hours
- Reduced CO₂ emissions
- Reduced global warming potential
- Higher plant efficiency during shutdown
- Increased operating flexibility

Quick-Stop reduces shutdown time

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Go-Ready

Fast and efficient plant warm start-up at reduced fuel cost and predictable load profile for high plant flexibility.

Challenge
- Combined cycle power plants are operating more and more in intermediate and peak load regime
- Impact of renewable power generation results in increased number of warm and cold starts
- Dispatch events are difficult to predict
- Optimized start-stop operation required to be profitable

Solution
- Plant warming system to keep HRSG, ST and BOP components warm during shutdown period
- Install electrical auxiliary steam generator (gas-fired optionally) to supply warming and ST seal steam to keep condenser vacuum
- Accelerated plant start-up based on Co-Start operating philosophy

Benefits
- Short plant start-up time even after few days shutdown time
- Lower fuel consumption during plant start-up
- Reduced CO₂ emissions
- Reduced global warming potential
- Higher plant efficiency during start-up
- Increased dispatch opportunities
- Increased operating flexibility

Start-up time
65 minutes

Typical fuel saving for one start
800 GJ

Go-Ready reduces start-up time
Steam-Assist

The Steam-Assist concept eliminates the auxiliary steam generator and instead uses the steam storage capacity of all HRSG stages to supply seal steam for a limited time during a plant shutdown and restart.

Challenge

- Reduce CAPEX and OPEX
- Achieve high operational flexibility with fast restart for shutdown durations < 16 hours
- Reduce emissions by eliminating or reducing run time of auxiliary boiler

Solution

- Eliminate the auxiliary steam generator
- Use the steam storage capacity of the HRSG during shutdown period and restart
- Modified start-up procedure taking full advantage of the steam supply from the HRSG

Benefits

- CAPEX savings from eliminating the auxiliary steam generator
- Decreased OPEX through lower fuel consumption during hot start-up
- Higher power output and efficiency by decreased auxiliary load
- Increased operating flexibility for hot and warm starts

Steam-Assist eliminates expensive auxiliary steam generator

Sealing ST glandes

Condenser still evacuated

HRSG

Steam Storage Capacity

Note: Incl. Aux. Boiler Energy Fuel during standstill app. 45 h. Actual benefit is dependent on plant configuration, operational profile and local market conditions.
**Energy Control**

Offers the ability for air-cooled power plants to start the gas turbines at full ramp rate without the need for an oversized air-cooled condenser (ACC).

**Challenge**

- Allow fast start of an air-cooled plant without increasing the size of the air cooled condenser
- Enables start of multiple GTs in multi-unit power train simultaneously for an air-cooled plant

**Solution**

- Energy Control is used to modify the flow of feedwater through the HRSG to create less steam during start-up without impacting the plant’s normal operation
- This is achieved by a combination of flow bypass and set point changes which reduce HRSG heat absorption until the system is ready to receive full steam flow

**Benefits**

- Quick start-up time
- Low start-up emissions
- Low water usage
- Fuel savings
- ACC cell reduction savings
- Lower auxiliary power cost of ACC
- Faster megawatts on the grid

Note: Actual benefit is dependent on plant configuration, operational profile and local market conditions.

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**Advantage of Energy Control**

![Diagram showing the advantage of Energy Control](image)

- **Conventional Plant Power**
- **Power Plant w/ Energy Control**

<table>
<thead>
<tr>
<th>Time</th>
<th>Plant Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100% GT</td>
</tr>
<tr>
<td></td>
<td>GT</td>
</tr>
<tr>
<td></td>
<td>GT + ST</td>
</tr>
<tr>
<td></td>
<td>GT + ST</td>
</tr>
</tbody>
</table>

- **Start-up emissions reduction of >85%**
- **$\text{\text{5}}$M**

Plant Capital Cost

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Benefits

• Rapid response to changing load demands through elimination of duct burner ramp limitation
• Ability to light off duct burners at lower gas turbine loads
• Ability to use the full power range of the power plant for fast response
• Eliminate the need to hold back gas fired MWs for ancillary service support

Note: Actual benefit is dependent on plant configuration, operational profile and local market conditions.

Dash™ vs. Conventional Plant Ramp

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Combined cycles operating with supplemental firing are limited by the slow reaction times of the duct burners</td>
<td>• Dash™ technology takes ramp rate limitations of the duct burners out of the equation</td>
</tr>
<tr>
<td>• Typical ramp rates for duct firing are in the range of 3 MW per minute</td>
<td>• The system dispatches the duct burners earlier, using the gas turbine and duct burners in concert to react to load demand changes quickly</td>
</tr>
<tr>
<td>• This slow moving behavior prevents the use of power produced by supplemental firing for fast response</td>
<td>• An advanced control algorithm and boiler design features keep temperatures and pressures within design limits during Dash™ operation, resulting in no impact to boiler</td>
</tr>
</tbody>
</table>

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Dash™

Achieve high flexibility for duct fired power plants over the entire plant load range including supplemental firing.

Increased profit
$25M NPV

Duct Fired MWs for ancillary services

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