SIEMENS energy

Asian Power Markets Demand

Efficient & Flexible Gas-Fired Generation

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Contents

The strong Asian economy continues to rely on inexpensive fossil fuels to energize its economies. However, many countries in the region have embraced natural gas and renewable resources for a more sustainable future.

This transition presents the classic energy trilemma:

01 How does a country balance security of supply (which includes the electricity supply chain—starting with indigenous fuel resources through the transmission and distribution of electricity)...

02 with the consumer electricity price sensitivity and...

03 environment protection and sustainable energy practices?

Each country in the region has approached balancing these often conflicting goals in unique ways.

Asian Power Market Trends

Electricity demand is expected to grow by two-thirds over the next two decades

In general, Asia's rapidly growing demand for electricity will continue to be satisfied mainly by fossil-fuel generation as the region's electricity demand is expected to grow by two-thirds over the next two decades, according to the International Energy Agency (IEA). Population growth, electrification, and increased demand for grid connection, and booming Asian economies are all spiking electricity demand. However, there is general agreement in the Asian community of nations that economic growth can no longer be served by merely constructing more and larger coal-fired power plants while ignoring the environmental consequences of those decisions.

The upward pressure on electricity demand is being eased by increased use of renewable energy and natural gas-fired plants, which have the added benefit of reducing the region's greenhouse gas emissions, a growing concern of many Asian nations. The growth of coal-fired plants has slowed significantly as liquified natural gas (LNG) has begun to play a significant role in Asia's energy transition. The continued growth of imported LNG, commonly used in Japan, Korea, and Taiwan, will sustain a large portion of Asia's electricity demand growth.

McKinsey & Company economists predict that China, South Asia, and Southeast Asia alone will add the equivalent of twice Japan's demand for LNG for power generation over the next decade due to depleting domestic natural gas reserves.[1] Asian countries now account for the largest share of global LNG imports (69%). The principal use of LNG in power generation applications is for new natural gas-fired capacity additions and to support renewable generation to reduce the amount of coal-fired generation, and bolster coal-to-gas switching policies to reduce air pollution.

Bloomberg's New Energy Finance (NEF) predicts that 58% of the Asian power mix will shift to renewables by 2050, which will significantly reduce the region's current 84% use of coal-fired generation.[2] The decline in coal-fired generation is expected to continue as renewables, hybrids and gas become more affordable. In this scenario, the primary role of gas-fired generation will not only be to provide bulk electricity production but also to supply critical back-up power for intermittent renewable generation and safeguarding grid stability, in most Asian markets.

The NEF predictions are certainly more predictive than reflective of the stated goals and recent actions of nations in Asia. Still, the general trend toward using more environmentally benign fuels is clear. The diversification of energy supply through investments in the use of LNG and renewable energy , coupled with improvements in energy efficiency and coal-to-gas projects, offer a practical and economical approach to expanding Asian electricity systems while simultaneously realizing its substantial socio-economic and environmental benefits. Also, the digital transformation of the energy business with AI, remote monitoring, and data analytics is particularly reflective of the changes now taking place in several Asian countries. Digitization of the power industry is an essential precursor to a robust and secure electricity supply system that can integrate the large amounts of flexible, natural gas-fired and renewable energy resources in the future, particularly in smart grid applications.

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58% of the Asian power mix will shift to renewables by 2050

Gas-Fired Generation Supports Asian Power Market Growth

The Asian Power Market continues to rapidly evolve, particularly concerning the adoption of advanced technologies in power generation, transmission, and distribution

Unlike Western nations, Asian power system planners must quickly balance increasing population growth, electrification of large populations thus far unserved, and an increase in industrial and individual consumer energy intensity. Together, these three realities will continue to apply upward pressure on electricity demand. Traditional electric utilities must develop new business models and power system planning processes to successfully adapt to these changes, particularly for the region's decarbonization and emission reduction efforts.

Natural gas has a significant role to play in the future growth of Asian electricity infrastructure. Generally speaking, renewable generation construction will continue to expand, and so will the need for rapid-response natural gas-fired combustion turbines (GTs) to backstop renewable projects when the wind doesn't blow, or the sun doesn't shine.

China's electricity production using coal will drop to about 54% this year (2020).

Flexible generation in Thailand will become increasingly important as regulators plan to increase renewables to 30% in 2036.

South Korea aims to boost renewable energy to 35% of total energy supplies by 2040

China, for example, has set minimum levels of renewable generation in each of its provinces that go into effect this year (2020). China's use of coal-fired electricity peaked in 2007 at 81% and has since steadily declined. China's electricity production using coal will drop to about 54% this year (2020) as renewable use and natural gas-fired generation from domestic production and imports continues to quickly displace coal. Thailand's electricity market is driven mainly by natural gas-fired generation, and demand is increasing due to increased air conditioning loads across the country and growth in the industrial sector. Flexible generation will become increasingly important as regulators plan to increase renewable energy resources to 30% by 2036.

Bangladesh's energy demand has been growing at an average rate of 10% over the past decade as the government pushes to electrify the country through new plant construction and by providing incentives for private sector investment. Natural gas currently powers about 60% of power generation in Bangladesh, although increasing demand will likely require additional imported LNG as domestic gas supplies are slowly being depleted. The industrialization of Vietnam has fueled a surge in demand for electricity that is expected to double over the next decade. In response to the increasing demand for electricity, Vietnam is planning to open a competitive retail electricity market in 2021. Over 40% of Vietnam's electricity production is by hydropower projects with natural gas used to produce about 31% of its electricity, with limited use of wind and solar power.

South Korea's electricity generation mainly comes from nuclear and fossil power which accounts for more than two-thirds of production. South Korea's most recent energy plan pushes for increased use of renewables and gas-fired power generation while scaling back coal and nuclear. South Korea aims to boost renewable energy to 35% of total energy supplies by 2040 and is currently the second-largest importer of LNG in the world.

The Role of Gas Turbines

The growth of natural gas-fired GTs specifically designed to operate efficiently and flexibly in tandem with intermittent renewable generation resources is a significant market opportunity in Asia. We now posit five design priorities for future GT designs for the Asia market:

01 Natural gas is an imported fuel, and therefore increased GT efficiency, particularly at part-load, is highly desirable. As a corollary condition, the startup and part-load operations must also produce low emissions.

02

GTs must reduce emissions as environmental regulations will continue to ratchet down allowable levels of NOx and CO2.

03

GTs must have a fast-start capability and be capable of dynamic load following when connected to a grid with large amounts of intermittent renewable resources.

04

GTs must show increased maintenance intervals and low maintenance costs.

05 As more large-scale renewable projects enter service, particularly wind and solar, system planners will need to proportionally add more gas-fired generation or uprate existing equipment to support an adequate spinning reserve margin.

Siemens' Gas Turbine Modernization and Upgrade Programs

Siemens has anticipated the need for more efficient and flexible GTs operating in conjunction with gas turbine upgrades to Siemens F- and E-Class gas turbines respond to these growing electricity markets.

Siemens F-Class Gas Turbines. The Advance Turbine Efficiency Package (ATEP) for SGT5-4000F GTs is one recent development project that fulfills each of the criteria noted above. The nominal performance of the SGT5-4000F is 329MW with a gross efficiency of 41% (50Hz), at standard operating conditions.[3]

The ATEP, when operating in a 1 x 1 combined cycle configuration, increases cycle power output by 39MW (26.4MW in simple cycle mode) and increases plant thermal efficiency by 1.5 % points. Depending on site conditions, the ATEP, when operated at constant load, also reduces CO2 emission by up to 18.60 tonnes/yr while burning 7.257 tonnes/year less fuel. These operating characteristics directly respond to the need for an upgrade package that increases thermal efficiency while reducing carbon emissions. Just as importantly, the GT after the ATEP upgrade package retains its pre-upgrade minimum load limit.

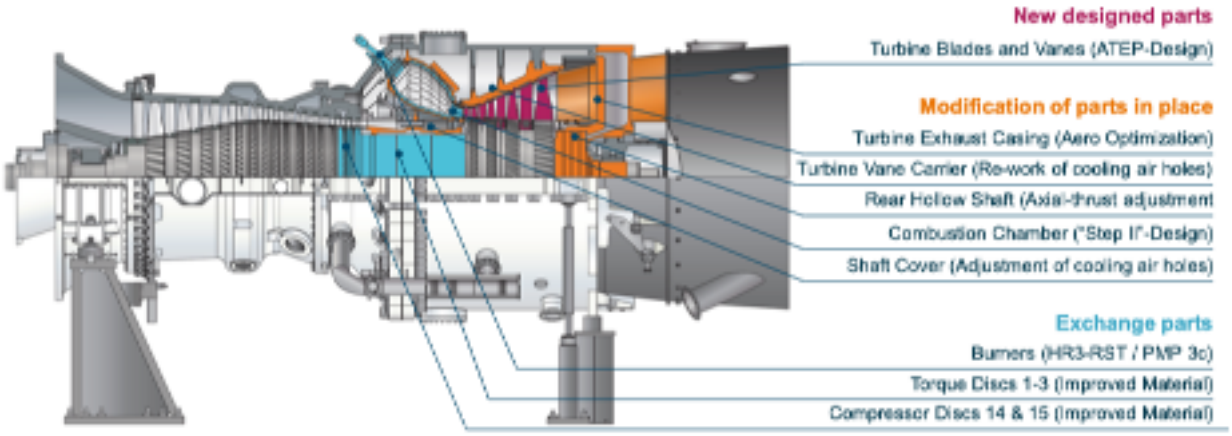

Figure 1. The Advance Turbine Efficiency Package (ATEP) modifications made to the SGT5-4000F for increased efficiency and reduced carbon emissions.

Two internal upgrades are necessary to achieve this level of performance improvement (**Figure 1**). First, the GT is upgraded with aerodynamically optimized hot gas path blades and airfoils based on the advanced computational methods used in the HL-class turbine. Also, the load distribution between the four turbines stages is balanced, and the blade tip design is improved to minimize secondary flow losses. Turbine cooling air requirements have also been reduced. Together, these upgrades produce a significant improvement in GT efficiency.

Also, with higher cycle temperatures, the thermodynamically optimum compressor pressure ratio increases, so compressor blades with improved geometry are required to handle the increased mass flow of air. Other casing and component upgrades are necessary, so the best time to complete these upgrades is during your next major outage. Depending on site-specific operating data, the typical payback for the ATEP upgrade is approximately three years.

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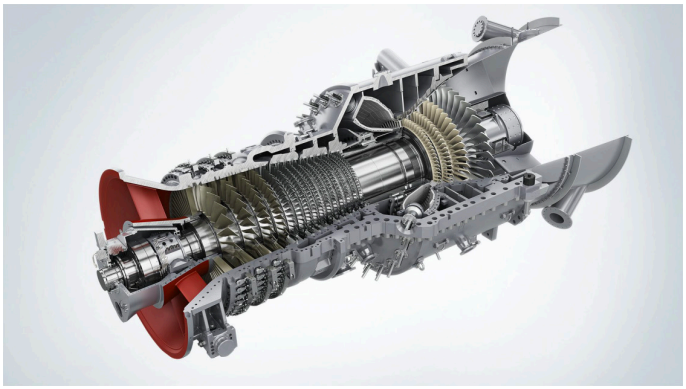
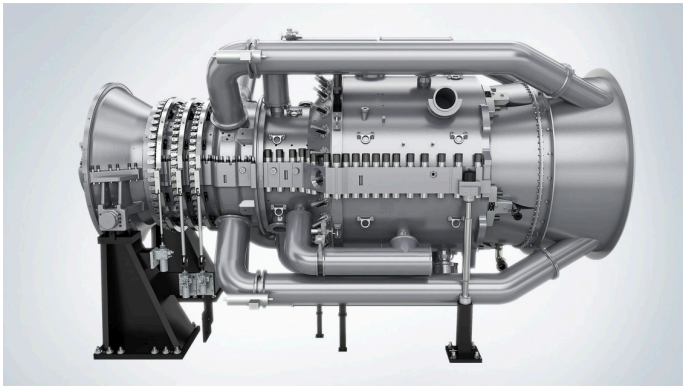


SGT5-4000F

Core Engine

Excellent simple cycle efficiency



Siemens has also released other performance upgrades for the SGT5-4000F, such as its Start Gradient Optimization package that is designed to increase the GT startup gradient up to 30MW/min, allowing the GT to ramp up from synchronization to baseload in less than 10 minutes. This high ramp rate also reduces the amount of natural gas consumed during startup, which is of particular interest to operators with unit startup emissions limits. The upgrade package requires tuning of the plant controls. Internal upgrades may be necessary, depending on the age and material condition of the candidate GT.

Other GT upgrades are available to current customers, such as the Turn Down upgrade that reduces the minimum part-load capability of the GT without increasing carbon emissions. This upgrade is particularly useful for combined cycle applications where part-load efficiency is desired. Also, the Turn Up upgrade will increase the GT output up to 6MW in simple cycle operation, and up to 9 MW in combined cycle applications above baseload, with higher efficiency. The upgrade also allows the GT to maintain the minimum primary and secondary frequency reserve when operating above baseload. This upgrade is particularly attractive to GTs when used in peaking service.

Siemens E-Class Combustion Turbines. The Siemens' SGT5-2000E, with over 300 GTs sold and another 200 GTs under license, has accumulated over 21 million operating hours with a best in class reliability exceeding 99.5%. The nominal performance of the SGT5-2000E is 187MW (50Hz), with a gross efficiency of 36.5%, at standard operating conditions. The SCC5-2000E 1x1 (one GT + one ST configuration) produces 275 MW at a gross efficiency of 53.3%. The SGT5-2000E is often found in both baseload and intermediate load, as well as grid support applications.[4]

Siemens recently upgraded the SGT5-2000E to increase its power output and is baseload efficiency. The Advanced Siemens Innovative 3D (Si3D+) program introduces a new aerodynamic airfoil design with improved coating technology. The upgrade package significantly increases the GT efficiency, up to 2.6% points in simple cycle operation, and 1.6% points in 1 x 1 combined cycle operation, over prior performance data. These improvements equate to an estimated 20MW increase in power in simple cycle and 38MW increase in combined cycle operation. The upgrade has other advantages to the plant owner, such as extended service intervals, which result in significantly reduced maintenance costs over the lifecycle of the GT and reduced NOx emissions.

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Much like the ATEP upgrades, the Si3D+ program requires internal component changes that are best completed during an upcoming major outage.

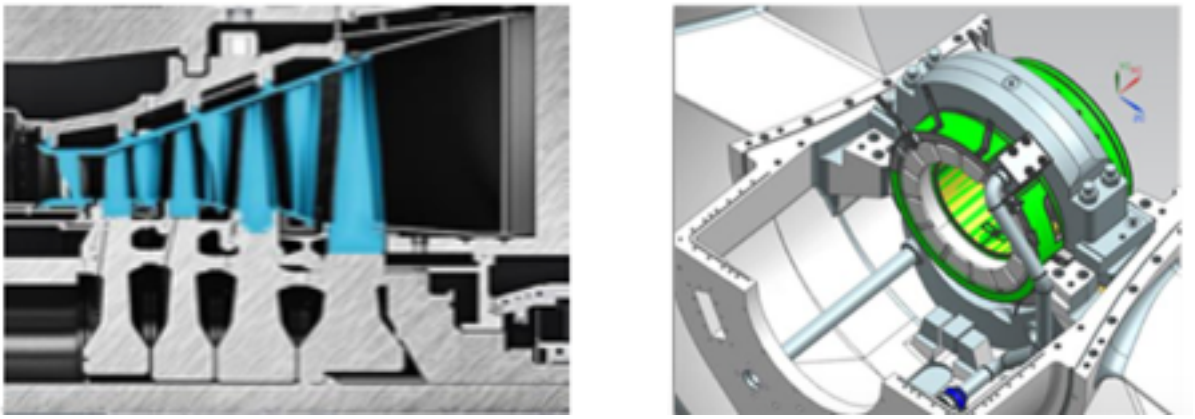

Figure 2. The Si3D+ upgrade program for the SGT5-2000E includes updated turbine blades and vanes (left) and an upgraded compressor bearing (right).

The scope of the Si3D+ includes replacement of the blades and vanes of the four-stage turbine (**Figure 2, left**), new seal rings in stages 2-4 that reduce the amount of cooling air required, and installation of an improved compressor bearing (**Figure 2, right**). These upgrades are compatible with the entire range of SGT5-2000E upgrade products.

Additional upgrades to the SGT5-2000E are also now available to customers, such as the Part Load Upgrade that optimizes and extends the part-load operation range of the GT without sacrificing emissions compliance. The Fast Load Gradient upgrade program is also available to customers who wish to improve the operating flexibility of their GTs to reduce start/stop cycling and to improve reaction time in response to grid changes.

There are also many steam turbine fast start upgrades are available to owners of combined cycle plants, such as prewarming, hot start on the fly, fast release to nominal speed, and fast steam turbine loading. Your Siemens representative can arrange for an onsite assessment of the potential flexibility improvements available for your plant.

Conclusions

The industrialization and electrification of many Asian regions are driving demand growth that far exceeds that of Western nations. The rising electricity demand is being met in unique ways in each country, although there are some conventional approaches currently being pursued. For example, new renewable energy sources play an essential role in energy planning as grids are extended through rural electrification.

However, baseload generation will remain the province of fossil fuels in most Asian countries in the coming years, although natural gas, where available domestically or imported as LNG, will play a key role in satisfying the growing demand for firm baseload electricity. In addition to baseload power supply, natural gas will also fuel new flexible GT plants that will backstop grids as more solar and wind resources come online. The Siemens SGT5-4000F and SGT5-2000E GTs are uniquely positioned to satisfy not only baseload power demand but are also highly flexible GTs that are capable of backstopping power grids when necessary.

[1]McKinsey & Company. Snapshot of LNG Market Dynamics: April 2020. https://www.mckinsey.com/industries/oil-and-gas/our-insights/petroleum-blog/snapshot-of-lng-market-dynamics-may-2020
[2]Bloomberg New Energy Finance. New Energy Outlook 2019. https://about.bnef.com/new-energy-outlook/
[3]For more information on the SGT5-4000F combustion turbine, please go to https://new.siemens.com/global/en/products/energy/power-generation/gas-turbines/sgt5-4000f.html
[4]For more information on the SGT5-2000E combustion turbine, please go to https://new.siemens.com/global/en/products/energy/power-generation/gas-turbines/sgt5-2000e.html

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