

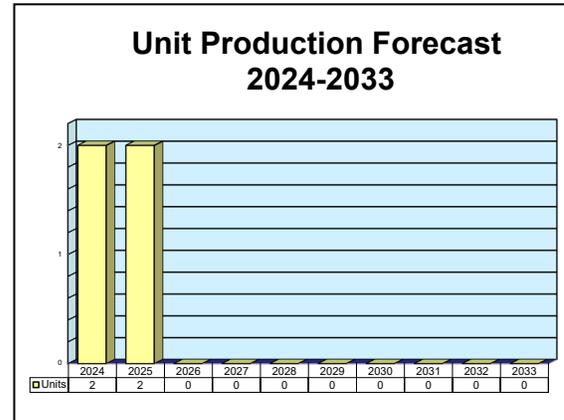
ARCHIVED REPORT

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Siemens Energy SGT-A65 TR

Outlook

- SGT-A45/65 no longer advertised by (now) Siemens Energy
- Sales likely limited moving forward
- The only aeroderivatives currently advertised by Siemens Energy are the SGT-A05 and SGT-A35



Orientation

Description. The SGT-A65 TR is a three-shaft, axial-flow, aeroderivative industrial 50/60-Hz gas turbine machine of 50-55 MW.

Sponsor. The SGT-A65 TR was privately developed by Rolls-Royce, and development was sponsored in part by the government of Canada and the province of Quebec. Further development is funded by Siemens.

Power Class. For electrical generation, the SGT-A65 TR develops 51-52 MW.

Status. Limited production likely

Total Produced. At least 124 SGT-A65 TR machines have been manufactured and installed. Of these, 115 have been sold to external clients. The balance are held by Siemens for research and development work or are available for lease by clients to cover emergency requirements.

Application. Utility and industrial power generation in 50/60-Hz markets, including combined-cycle and cogeneration installations.

SGT-A65 TR machines have officially been used in mechanical load drive duty (gas boost duty) since 2006, when machines were ordered by Qatar.

Price Range. Estimated in 2024 U.S. dollars as follows:

<u>Machine Model</u>	<u>Price (\$ millions)</u>
Electrical Generation	
SGT-A65 TR DLE	19.5
Mechanical Load Drive	
SGT-A65 TR	22.8

For electrical generation (simple-cycle), the genset price covers a single-fuel skid-mounted gas turbine, an electric generator, an air intake with basic filter and silencer, an exhaust stack, a basic starter and controls, and a conventional combustion system.

For mechanical drive, the price covers a natural gas-fired gas turbine (without driven equipment) with a gearbox, a skid, an enclosure, inlet and exhaust ducts, and an exhaust silencer; basic turbine controls; fire protection; starting systems; and a conventional combustion system.

Competition. In the electrical genset arena, the SGT-A65 TR faces competition from the LM6000 and LM9000. In the mechanical drive arena, the SGT-A65 TR competes with the GE LM6000PC Sprint.

Siemens Energy SGT-A65 TR**Contractors****Prime**

Siemens Energy	http://www.siemens-energy.com , Freyeslebenstrasse 1, Erlangen, Germany, Tel: + 49 1805247000, Fax: + 49 1805242471, Prime
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Subcontractor

Arconic Engines, Winsted Operations	http://www.arconic.com , 145 Price Rd, Winsted Industrial Park, Winsted, CT 06098 United States, Tel: + 1 (860) 379-3314, Fax: + 1 (860) 379-4239 (LPT Nozzle Guide Vane; Intercase; Seal Segment)
Cannon-Muskegon Corp	http://cannonmuskegon.com , 2875 Lincoln St, PO Box 506, Muskegon, MI 49441 United States, Tel: + 1 (231) 755-1681, Fax: + 1 (231) 755-4975 (Blade, CMSX-4, H/LPT)
Collins Aerospace Systems, Aerostructures	http://www.collinsaerospace.com , 850 Lagoon Dr, Chula Vista, CA 91910-2098 United States, Tel: + 1 (619) 691-4111, Fax: + 1 (619) 691-3030 (Inner & Outer Exhaust Nozzles)
Ionix	Festival Way, Stoke-on-Trent, Staffs, United Kingdom, Tel: + 44 1782274545, Fax: + 44 1782212992 (Wiring Loom Assembly)
Kawasaki Heavy Industries, (KHI), Gas Turbine Division, Akashi Works	http://global.kawasaki.com/en/ , 1-1 Kawasaki-cho, Akashi, Hyogo, Japan, Tel: + 81 78 921 1301, Fax: + 81 78 924 8654 (Discs; Turbine Case)
Ladish Co Inc	http://www.ladishvalves.com , 5481 S Packard Ave, Cudahy, WI 53110 United States, Tel: + 1 (414) 747-2618, Fax: + 1 (414) 747-3565, Email: wlarsen@ladishco.com (Compressor Disc Forgings; Compressor Shaft Forgings)
Precision Castparts Corp, (PCC)	http://www.precast.com , 5885 Meadows Rd, Ste 620, Lake Oswego, OR 97035 United States, Tel: + 1 (503) 417-4800, Fax: + 1 (503) 417-4817, Email: info@precastcorp.com (Exhaust Assembly Case; Tail Bearing Housing)
Safran Transmission Systems	http://www.safran-transmission-systems.com , 18, Blvd Louis-Seguín, Batiment K1, Colombes, France, Tel: + 33 1 41 30 50 10, Fax: + 33 1 41 30 54 12, Email: communication@hispano-suiza-sa.com (Accessory Drive Gearbox)
Saint Bernard Plastics	Saberhouse Lynchford Rd, Farnborough, United Kingdom, Tel: + 44 252 54 61 64 (Fan Case Liner; Noise Suppression & Abradable Tip Seal)
Woodward Inc	http://www.woodward.com , 5001 N Second St, PO Box 7001, Rockford, IL 61125-7001 United States, Tel: + 1 (815) 877-7441, Fax: + 1 (815) 639-6033 (Fuel Metering Unit; Fuel Control System)

Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 75 Glen Road, Suite 302, Sandy Hook, CT 06482, USA; rich.pettibone@forecast1.com

Technical Data**Dimensions**

	ELECTRICAL GENSET		MECHANICAL DRIVE SET	
	<u>Metric Units</u>	<u>Standard</u>	<u>Metric Units</u>	<u>Standard</u>
Length	28 m	92 ft	18 m	59 ft
Width	5 m	16 ft	5 m	16 ft
Height	12.5 m	41 ft	12.5 m	41 ft
Weight	172,000 kg	189.6 tons	66,000 kg	72.75 tons

Siemens Energy SGT-A65 TR

Performance

Mode	SIMPLE-CYCLE APPLICATION				
	Power Rating	Heat Rate (LHV)	Pressure Ratio	Exhaust Flow	Exhaust Temp.
Electrical Generation 50 Hz					
SGT-A65 TR DLE (a)	51,504 kW	9,021 kJ/kWh	33.0:1	151.7 kg/sec	444°C
SGT-A65 TR WLE (b)	58,000 kW	9,290 kJ/kWh	36.0:1	165.7 kg/sec	423°C
Electrical Generation 60 Hz					
SGT-A65 TR DLE	51,685 kW	9,059 kJ/kWh	34.0:1	154.6 kg/sec	440°C
SGT-A65 TR WLE	58,000 kW	9,279 kJ/kWh	36.0:1	162.6 kg/sec	429°C
Mechanical Load Drive	52,510 kW	6,033 Btu/shp-hr	34.0:1	337.9 lb/sec	824°F

(a) DLE = Dry Low Emissions.

(b) WLE = Wet Low Emissions.

	COMBINED-CYCLE GENSET				
	Net Plant Output	Heat Rate (LHV)	Net Plant Efficiency	GT Output	ST Output
50-Hz Operation					
SGT-A65 TR DLE (a)	64,046 kW	6,427 kJ/kWh	53.1%	49,951 kW	14,095 kW
SGT-A65 TR WLE (b)	72,061 kW	6,801 kJ/kWh	50.2%	58,000 kW	14,061 kW
60-Hz Operation					
SGT-A65 TR DLE	64,120 kW	6,464 kJ/kWh	52.8%	49,945 kW	14,175 kW
SGT-A65 TR WLE	72,477 kW	6,750 kJ/kWh	50.6%	58,000 kW	14,477 kW

(a) DLE = Dry Low Emissions.

(b) WLE = Wet Low Emissions.

Design Features. One of the industrial design objectives was to maintain the highest degree of commonality possible with the Trent 800, consistent with the achievement of exacting performance and integrity targets. There are only three major areas of change from the aero parent engine: the LP compressor, the combustion system, and the LP turbine. The aero LP spool was modified to suit the industrial mission of the new machine, with a direct drive to the generator. The spool operates at 3,600 rpm for 60-Hz and 3,000 rpm for 50-Hz operation, thereby eliminating the need for a main reduction gear. The changeover from 60 Hz to 50 Hz requires only a change in the LP compressor blades.

At baseload operation, in both simple-cycle and combined-cycle modes, the operating conditions of the SGT-A65 TR combustion turbine are similar to those of the aero Trent because the performance of the industrialized version's two-stage LP compressor is similar to that of the root of the aero-engine fan it replaces. As a result, the industrialized version has a thermodynamic cycle characterized by a high overall pressure ratio and high thermal efficiency at a power level higher than that of previous aero-based systems. In addition, the LP compressor boosts the airflow so that the power level is attained at a firing temperature sufficiently low to meet the most rigorous NOx

requirements and sufficiently high to give good cycle efficiency.

The power available varies with inlet conditions. At temperatures above 0°C, power is controlled to a firing temperature level. At colder temperatures, power is automatically maintained constant by the control system.

LP Compressor. The SGT-A65 TR has a two-stage low-pressure compressor with variable inlet guide vanes (VIGVs), smaller in diameter than those of the aero engine. There are two configurations with different rotor-blade stagger angles that allow almost identical performance in 50-Hz and 60-Hz applications when used with a direct-drive alternator.

IP/HP Compressors. The intermediate-pressure compressor has eight stages and three rows of variable stators. The high-pressure compressor has six stages, with no variable stators. Overall pressure ratio is 35:1 for the 50-MW Trent.

A modulated LP air bleed system accommodates flow discrepancies between the LP and IP compressors during start-up and low-power operations.

Combustor. The SGT-A65 TR features a dry low emissions (DLE) combustion system, a design that has also been used in the SGT-A35 RB gas turbine machine. The combustion system incorporates a series of staged

Siemens Energy SGT-A65 TR

premix, lean-burn combustion cans that enable the gas turbine to achieve low NO_x and CO simultaneously. Eight combustors are incorporated into a single module.

IP/HP Turbines. The SGT-A65 TR has a five-stage LP turbine, a single-stage IP turbine, and a single-stage HP turbine. The single-stage HP and single-stage IP aero turbines are retained from the aero engine, except for minor details in the film-cooling pattern of the HP-turbine nozzle guide vane. The compressor is driven by the five-stage, direct-drive LP turbine. The SGT-A65 TR LP Stages 4-5 have a larger gas path area and a lower exit Mach number than the Trent aero version.

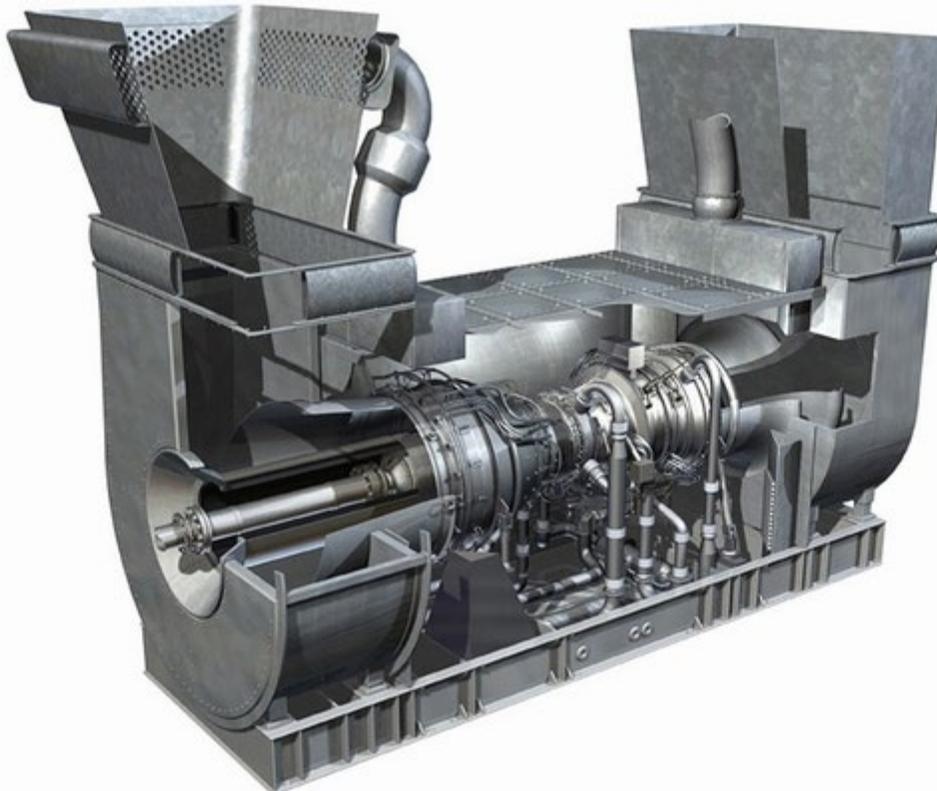
Control System. A Woodward control system provides for the integrated operation of multiple control functions while also offering significant externalizing for remote monitoring and operation. The system, designated the Engine Management System (EMS), is a Full Authority Digital Engine Control (FADEC) system. The system can also use an electrohydraulic precision fuel-metering system.

Operational Characteristics

The SGT-A65 TR features modular construction consisting of six prebalanced and interchangeable modules. This construction benefits the operator in that the machine is available more often, requiring a lower spares inventory. The modular design of the SGT-A65 TR engine can allow for rapid exchange of components while detailed work is carried out at a major overhaul facility, reducing the turnaround time for engine maintenance at overhaul. Siemens can also offer access to a lease engine to support customer operations during maintenance.

Each of the modules is fully assembled and tested before shipment. The gas turbine baseplate holds the required oil system to allow installation, testing and flushing in a shop environment, reducing site installation time.

The control system is designed to allow for easy site installation by using remote I/O technology to decrease the number of interconnect cables between the unit control panel and the equipment skids. All train control systems are then accessed by a human machine interface (HMI), which can be located in the main control room.



Rolls-Royce MT30

Source: Rolls-Royce

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Variants/Upgrades

Trent EconoPac. In November 1993, (then) Westinghouse and Rolls-Royce launched the Trent EconoPac, a complete 50-MW power generation package, in conjunction with the first announced order for the package.

The Trent EconoPac is a self-contained electric power plant used in either simple-cycle or heat recovery applications. The EconoPac includes the Industrial Trent and accessories, inlet system, exhaust system, generator and exciter with accessories, and control and electrical equipment. The Trent engine's standard accessories include an electrohydraulic starting system, a synthetic lube oil system, a compressor wash system, and instrumentation. The electrical generator choices are open air-cooled or totally enclosed water-to-air-cooled. The EconoPac control system is a fully

digital electronic system and includes an operator interface.

Dry Low Emissions System. The SGT-A65 TR has met or surpassed stringent NOx and CO targets set for its SGT-A30 RB DLE engine (see "Siemens Energy SGT-A30/35 RB" report in this service). The DLE system can be incorporated into the Industrial Trent.

Inlet Spray Intercooling. The SGT-A65 TR can be offered with an inlet spray intercooling (ISI) system to reduce the ambient inlet temperature and decrease the energy required for compression. This results in higher power and efficiency at ambient temperatures above 7°C.

MT30. Rolls-Royce produces a marine propulsion gas turbine designated the MT30. This variant is covered by a separate report in this service.

Program Review

Background. The SGT-A65 TR takes advantage of all the technological advances made with the aero Trent and other Rolls-Royce aviation and I&M engines. It shares significant commonality with its aero Trent 800 parent and draws on technology from the Industrial RB211 (now the SGT-A30 RB and SGT-A35 RB) gas turbine. The Industrial Trent was developed by Rolls-Royce Gas Turbines Canada Inc (Lachine, Quebec). Under the terms of the Canada-Quebec Auxiliary Agreement for Industrial Development, the governments of Canada and Quebec Province supplied about CAD17 million of the required CAD140 million for the Industrial Trent's R&D program in the form of a repayable, interest-free loan.

A new engine testbed was built at the Rolls-Royce Canada facility in Montreal to accommodate the Industrial Trent. The first test of an Industrial Trent took place in September 1994.

In 2004, Rolls-Royce introduced the wet low emissions (WLE) version of the Rolls-Royce Industrial Trent 60. With a rating of 58 MW, it was the most powerful of the aeroderivative industrial gas turbines then available. At 40.7 percent (60 Hz) efficiency, it is also among the most efficient machines in this size class, although not quite up to the level of the 52-MWe DLE version, the Trent 50. At 42 percent, the Trent 50 could claim to have the highest efficiency among industrial gas turbines of this size.

Rolls-Royce entered the Australian market in October 2007 when it won a contract from Alinta Ltd to

provide a Trent 60 WLE dual-fuel electrical generating set at its new Tamar Valley Power Station site on the Tamar River in Tasmania. The Trent 60 operates a simple-cycle plant providing 58 MW of electrical power as part of a 180-MW gas turbine installation, which provides backup electricity when required, as well as peaking capacity, to the National Electricity Market.

In December 2014, Rolls-Royce completed the deal to sell its Energy gas turbine and compressor business to Siemens for a GBP785 million cash consideration. Rolls-Royce later received a further GBP200 million for a 25-year licensing agreement, as previously announced, granting Siemens access to relevant Rolls-Royce aeroderivative technology for use in the 4- to 85-MW-power-output gas turbine range. Rolls-Royce returned the proceeds of the Energy sale to shareholders by way of a GBP1 billion share buyback.

In 2016, Vires Energy Corporation of the Philippines ordered a Siemens Industrial Trent 60 WLE ISI dual-fuel packaged gas turbine generator set operating in simple-cycle mode to be installed in Southern Luzon for supply of power into the Luzon grid.

Construction of the floating generation facility was expected to begin in the second quarter of 2016. The project would be supplied with natural gas from an offshore floating LNG storage and regasification import facility. When completed, it will reportedly be the world's largest single barge-mounted power plant.

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Renaming the Range

This turned out to be the last sale made under the Industrial Trent designation. Siemens decided to redesignate all the industrial gas turbines it had purchased from Rolls-Royce in order to eliminate the use of similar product names by two competing manufacturers. Under this reorganization, the Industrial Trent became the SGT-A65 TR, the Industrial RB211 became the SGT-A30 RB and the SGT-A35 RB, and the Industrial 501K became the SGT-05 AE.

In March 2017, Siemens secured orders to supply a total of 12 gas turbines to four turnkey industrial power plants in Argentina in a \$750 million order, including service and support. The orders included six SGT-A65 TR for two plants, one in Luján and the other in Matheu in Buenos Aires Province. Siemens has also been awarded a contract to supply six industrial SGT-800 gas turbines for two power plants in the cities of San Pedro and Zarate. All the sites have the option to be retrofitted as combined-cycle power plants in the near future.

New Variant

In November 2017, Siemens launched its first new product under the SGT-A family designation. The

SGT-A45 TR is a mobile 44-MW gas turbine oriented toward the fast power and distributed generation sectors. While based on the SGT-A65 TR, the A45 uses only two shafts as well as a free power turbine. The A45 sheds the A65 low-pressure booster to keep it compact. The SGT-A45 TR can use liquid or gas fuel and is able to switch as needed during operation, and it can go from 50 Hz to 60 Hz or vice versa with a simple field reconfiguration with no changes to hardware.

The first order for the SGT-A45 – a 41-MW (at 50 Hz) trailer-mounted mobile unit – was placed on March 25, 2019, by Bayat Power, a subsidiary of Bayat Energy, Afghanistan's largest energy exploration, development and production company. The project would be the country's first new gas-fired power plant project since the 1970s.

By 2020 it was apparent that the reorganization of Siemens – and its strategic reorientation away from its traditional areas of expertise and into new technologies – was more extensive than company statements had intimated. The company has spun off its power and energy operations into a separately quoted subsidiary (Siemens Energy), an independent entity in which the "new Siemens" has only a minority shareholding.

Funding

Commercial funding has been provided by the governments of Canada and Quebec Province. No military funding for the Siemens SGT-A65 TR has been identified.

Contracts/Orders & Options

<u>Contractor</u>	<u>Award (\$ millions)</u>	<u>Date/Description</u>
Rolls-Royce	N/A	Jul 2007 – Hidroeléctrica La Higuera SA ordered a Trent 60 WLE dual-fuel power generation package for its new power plant at Colmito, Chile.
Rolls-Royce	N/A	Jun 2008 – Energy companies in Hungary, the Czech Republic, the U.K., Russia, the U.S., and New Caledonia in the South Pacific Ocean confirmed reservations for 27 Trent 60 engines.
Rolls-Royce	N/A	May 2012 – Two Rolls-Royce Trent 60 gas turbines for Pristine Power York Energy Center acquired by Veresen Power.
Rolls-Royce	N/A	Mar 2013 – Rolls-Royce confirmed a contract to supply CYDSA, the Mexican textile and chemicals conglomerate, with a Trent 60 industrial gas turbine to power its processing plants at Coatzacoalcos and Veracruz in Mexico.
Rolls-Royce	N/A	Jun 2013 – NRG Energy order for Trent 60 gas turbines for the El Segundo Power Redevelopment project, units 5, 6, 7, and 8.
Siemens Energy	N/A	Oct 2015 – Provision of service and maintenance for nine aeroderivative gas turbines from former Rolls-Royce Energy and the related nine Dresser-Rand compressors, with a term of 18 years.

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Contractor	Award (\$ millions)	Date/Description
Siemens Energy	N/A	Mar 2016 – Order from Vires Energy of the Philippines for a Siemens Trent 60 to drive offshore power generation barge.
Siemens Energy	750	Mar 2017 – Argentine order for six SGT-A65 TR and six SGT-800 gas turbines for use at four power stations.
Siemens Energy	N/A	Mar 2019 – Afghan order for a single trailer-mounted SGT-A45 TR.
Siemens Energy	N/A	Sep 2019 – Astoria Energy order for eight barge-mounted SGT-A65 TR gas turbines to provide peaking and gap-filling generator capacity for New York.

N/A = Not Available

Worldwide Distribution/Inventories

Country	Year Installed	Total
Afghanistan	2019	1
Argentina	2016 (2), 2017 (6)	8
Australia	2009 (1), 2010 (3), 2011 (1), 2012 (2)	7
Bahrain	2011	2
Belgium	2008 (2), 2012 (2)	4
Bolivia	2011	1
Canada	1998 (1), 2000 (1), 2003 (1)	3
Chile	2008	1
Czech Republic	2012	1
Denmark	2002	2
Germany	2007 (2), 2012 (4)	6
Hungary	2011	2
Israel	2009	1
Madagascar	2018	1
New Caledonia	2012	2
Philippines	2016	1
Russia	2013	2
Slovakia	2011	1
UAE	2008 (2), 2016 (1), 2017 (2), 2018 (2)	7
U.K.	1997 (1), 1998 (3), 2002 (1), 2003 (3)	8
USA	2002 (1), 2005 (2), 2006 (1), 2008 (1), 2009 (2), 2012 (9), 2013 (7), 2014 (2), 2017 (17), 2018 (2), 2020 (8)	52
TOTAL		113
Note: Siemens holds 16 SGT-A65 TR gas turbines for lease and two for development purposes. Current status unknown.		

Forecast Rationale

Siemens has been undergoing some restructuring. The new Siemens Energy has seemingly dropped some of the turbines procured from the earlier Rolls-Royce acquisition. As it stands, the only aeroderivative turbines the company offers are the SGT-A05 and SGT-A35 (which are covered in separate reports in this service).

Although the SGT-A45/65 TR is no longer being offered, it might still be produced if a customer desires; therefore, it could see limited production.

Although production has dropped significantly, the forecast shows that a few turbines will be produced in the near- to mid-term future. This report will thus remain active.

Siemens Energy SGT-A65 TR

Ten-Year Outlook

ESTIMATED CALENDAR YEAR UNIT PRODUCTION												
Designation or Program		High Confidence				Good Confidence			Speculative			
	Thru 2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	Total
Siemens Energy Global GmbH & Co KG												
SGT-A45 <> a MW 20.0 to <50.0 <> Industrial Generation - Power												
	2	1	1	0	0	0	0	0	0	0	0	2
SGT-A65 TR <> a MW 50.0 to <100.0 <> Industrial Generation - Power												
	23	0	1	0	0	0	0	0	0	0	0	1
SGT-A65 TR <> a MW 50.0 to <100.0 <> Industrial Mechanical Drive												
	4	1	0	0	0	0	0	0	0	0	0	1
Subtotal	29	2	2	0	0	0	0	0	0	0	0	4
Total	29	2	2	0	0	0	0	0	0	0	0	4