

RUSSIAN POWER, MOSCOW, 14-16 MARCH 2006

## **MOSCOW CITY, A STATE-OF-THE-ART COMBINED HEAT AND POWER PLANT**

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### **Siemens Power Generation Industrial Applications**

Cogeneration, or production of combined heat and power (CHP) is one of the most efficient and environmentally favorable methods of energy conversion in the power generation industry. This paper presents the technology of CHP plants and gives an example of an application in Russia, a project currently under execution.

"Moscow City" or the "Moscow International Business Center," is an \$8 billion project in Moscow, Russia,.. The preliminary work and the first stage of the construction to create an International Business Center has already been completed. It is planned to finish the entire construction by the year 2020. The vast project is subdivided into several separate smaller projects for the purposes of effective construction: an office complex on Taras Shevchenko embankment, Park-city, the Center, Aquapark, Power plant, Mini-metro, and Rapid transit railway system "Sheremetyevo - Moscow City".

To power this gigantic complex, Siemens Power Generation Industrial Applications will provide a 226 MW turnkey 'combi-cogen plant', a combined cycle power plant with cogeneration. The power plant is being built in the center of Moscow and will provide district heating and power to the new international business center, a mixed use complex covering 30 million sq. ft on a 100 hectare site.

The plant consists of two combined cycle blocks, type SCC-800 2 x 1. Each block is based on two 45 MW SGT-800 gas turbines and one 30 MW SST-700 steam turbine. It will be built in two phases. The work on the first phase has already started. The second phase is now under design and scheduled for connection to the electrical grid end of 2006 and will be in full commercial operation in 2007.

This paper will describe the advantages of the technology and the details of the specific application.

## Introduction

The technologies used in the generation of electric power, and thus the structure of the power plant market, are driven by the economic, political and social trends in the various individual countries, by regional economic alliances, and by the world as a whole. Population growth, economic development, trends in the cost of energy sources and consumer behavior all have an effect on power consumption. At the same time, high fuel prices and the rising social and financial pressure to avoid carbon dioxide emissions define the boundary conditions for future power plants.

The Moscow International Business Center (MIBC) is an ambitious engineering project being undertaken in the center of Moscow on an old urban area near the river embankment. In the long term, the MIBC “Moscow City” is planned to serve as the core, “the center of a center” in the context of the formation of the New Center of the capital. The goal of the project is to create a new business district within the city, with the creation of 2.5 million square meters of office, hotel, retail and leisure facilities, characterized by use of multistorey building and the concept of multifunctional space. A modern transport structure will be provided for metro stations, mini metro and highway construction, and state of the art telecommunication systems will be installed. The City will be powered by resource-saving technologies, using independent power and heat supply systems.

The whole complex is to be built on a 100 hectare site (divided into 30 plots) designated for new development on the Krasnopresnenskaya embankment. The management company for the project is CITY Joint Stock Company (CITY JSC), a company first set up in 1992 as a collaboration between the Russian government and private investors.

When CITY JSC and MOSENERGO JSC 1996-1999 investigated alternative solutions for energy supply to the MIBC development complex, the main considerations were minimal capital investment and high technical reliability. To meet these criteria, JSC “City Energo” together with the company that was to become part of Siemens Power Generation, was able to offer two combined heat and power plants (SCC-800 2x1), based on the SGT-800 gas turbine.



Fig. 1, City of Moscow Architectural Concept and Design

## Combined Heat and Power

The most efficient power plant type for gas and liquid fuels is a gas turbine combined cycle power plant. In combined cycle, electricity is produced by both a gas and steam turbine, where the steam production is about 30% of the electrical output. Combined cycle power plants reach electrical efficiencies of more than 50% and, if the low temperature heat is used for district heating or industrial processes, provide a fuel usage of up to 90 %.

Nowadays combined cycle and combined heat and power plants are used in a wide spectrum of power and heat generation applications in industries ranging from utilities to the food, pulp and paper, automotive and chemical industries.

CHP, the simultaneous production of electric power and heat, is a favorable solution in terms of economical and environmental efficiency. A CHP plant is an installation which generates usable heat and power in a single process. The basic elements of a CHP plant comprise one or more prime movers usually driving electrical generators, where the heat generated in the process is utilized via suitable heat recovery equipment for a variety of purposes including: industrial processes, community heating and space heating.

Siemens offers turnkey solutions for combined cycle power plants in all power ranges. If used as a CHP plant, combined cycle power plants can generate heat levels from 50 up to 500 deg C, with a high flexibility of power and heat generation.

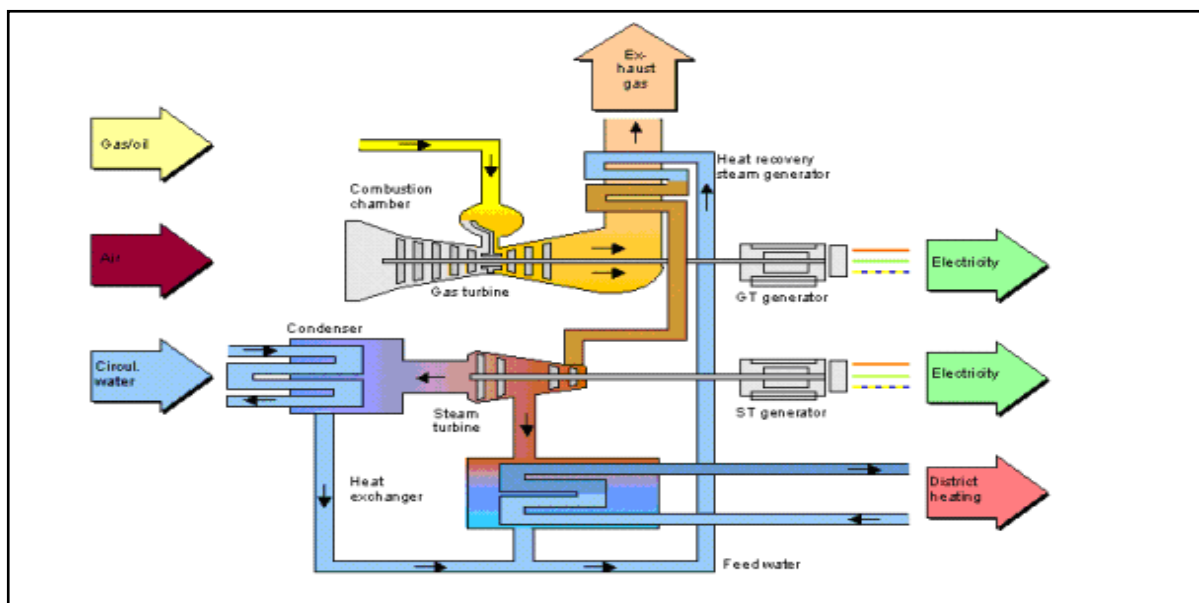


Fig 2, CHP Principle diagram

### Application Example “Moscow City”

Siemens has built more than 300 combined cycle power plants. One of the latest projects is the combined cycle power plant in Moscow, Russia.

Phase 1 is a 110 MW combined cycle power plant. It includes two 45 MW combustion gas turbines (SGT-800) fired with natural gas, two heat recovery steam generators (HRSG's), one district heating condensing 30 MW steam turbine (SST-700), one peak water heating boiler and auxiliary systems. The plant produces electrical power and hot water for the district heating network.. The main components and systems are designed, manufactured, delivered

and installed by Siemens Power Generation. The peak water heating boilers are designed and constructed by JSC “Drogobuzkottlomash” of Russia.

Electrical power is produced in three synchronous generators, two driven by the gas turbines and one by the steam turbine. The electrical power thus produced is fed to a 110kV and a 20 kV switchgear. The 110kV switchgear provides the plant with auxiliary power at start-up. The produced district heating water is fed to MIBC.

Hot exhaust gases from the gas turbines generate steam of two pressures in the HRSG. These high pressure and low-pressure steam flows are produced by the HRSG at superheated conditions and fed to the steam turbine, which is connected to a two-stage district heating condenser system. A summer cooler is installed to cater for operation cases when heating water requirements are low.

Phase 2 will be identical with Phase 1 and will double the power output of the plant. The 226 MW plant will start as a simple cycle to meet urgent power needs, and then switch to combined cycle and district heating in accordance with the long-term plans.



Fig. 3, Phase One is in an advanced stage of completion

### **Main components and technical details of the plant**

The SGT-800 gas turbine is an industrial gas turbine of modular design. It is of single shaft design, driving the electric generator through a parallel shaft reduction gear.

The gas turbine is mounted on a steel base frame with an integral oil tank and other auxiliaries. The package is based on a single-fuel gas turbine, fired by natural gas and including a dry low NO<sub>x</sub> combustion system.

A sound enclosure is located over the gas turbine and gearbox to ensure 85 dBA external noise limits at 1 metre. The enclosure is fitted with ventilation units, gas detection and fire suppression systems, and access ways for personnel during maintenance.

Combustion air is cleaned through a three-stage static type of intake filter. An anti-icing system and silencer are located at the air intake duct.

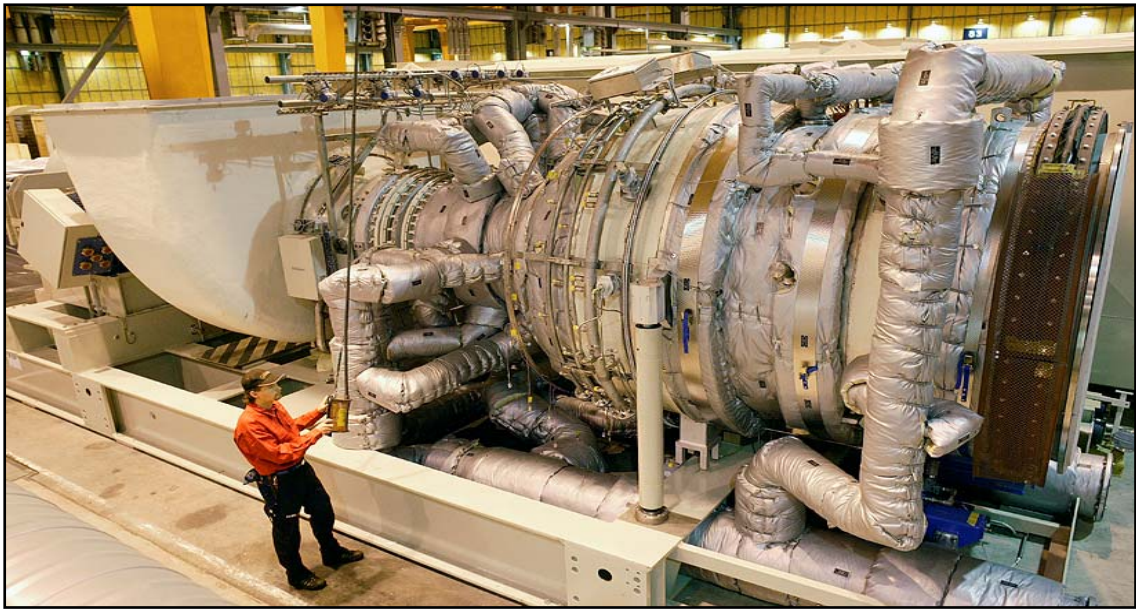


Fig. 4, The SGT-800 gas turbine

The steam turbine, SST-700, is a multi-stage district heating condensing turbine. The steam turbine and its electric generator are mounted directly on the turbine's concrete foundation. The steam turbine lube-oil reservoir is placed beside the steam turbine gearbox and the AC generator. An accessible sound enclosure is located over the gear to ensure required noise levels are adhered to.

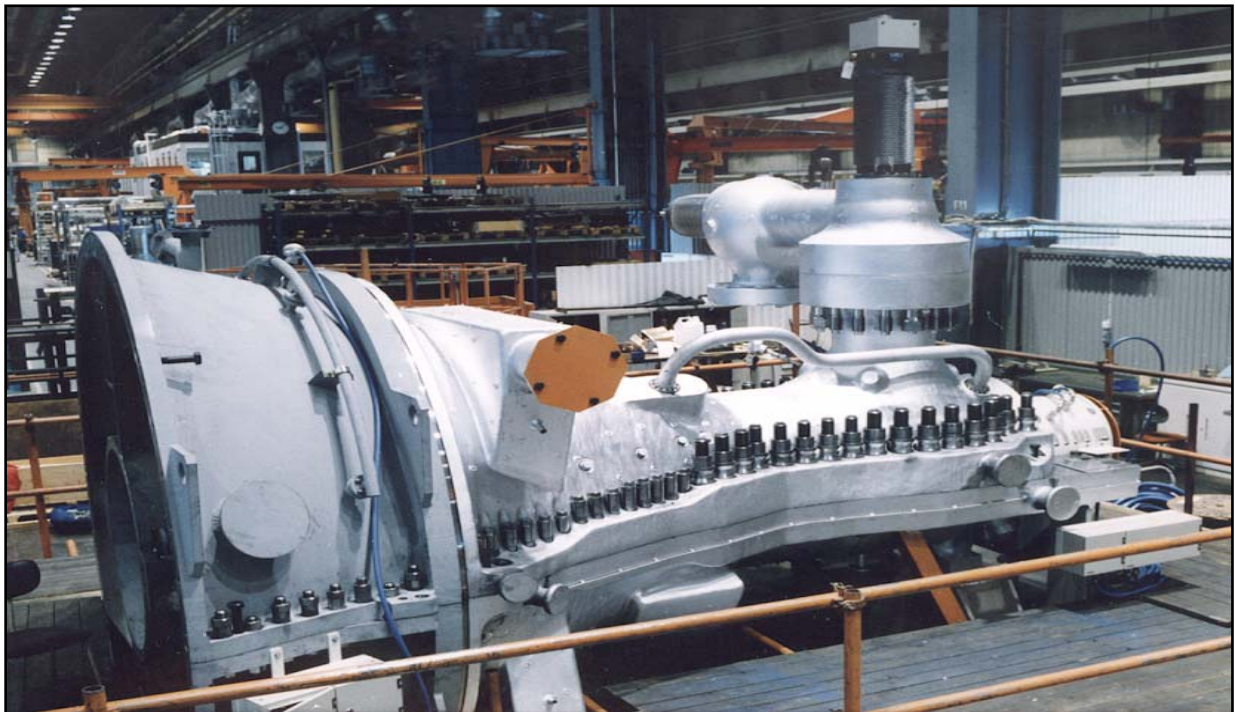


Fig. 5, The SST-700 steam turbine

The water/steam circuit consists of a heat recovery steam generator (HRSG) which generates steam by extracting heat from the exhaust gas flow of the gas turbine. The HRSG is designed as a dual-pressure, natural circulation boiler comprising:

- Stack with silencer
- Low Pressure (LP) Economizer
- LP Evaporator with steam drum
- LP Superheater
- High Pressure (HP) Economizer
- HP Evaporator with steam drum
- HP Superheater

The layout concept represents an optimal utilization for the site conditions. The advantages of this concept are:

- Short connections between all major plant components (piping and cables) resulting in reduced energy losses.
- Short distances providing for easy operation and maintenance.
- Adequate separation between the power train and the balance of plant components to facilitate maintenance.

The proposed layout offers good access to all components in the power station. Lifting beams are installed in the enclosures serving main equipment for easy maintenance and overhaul. A hoist is installed to transport components up and down between base level and the service levels of the HRSGs.

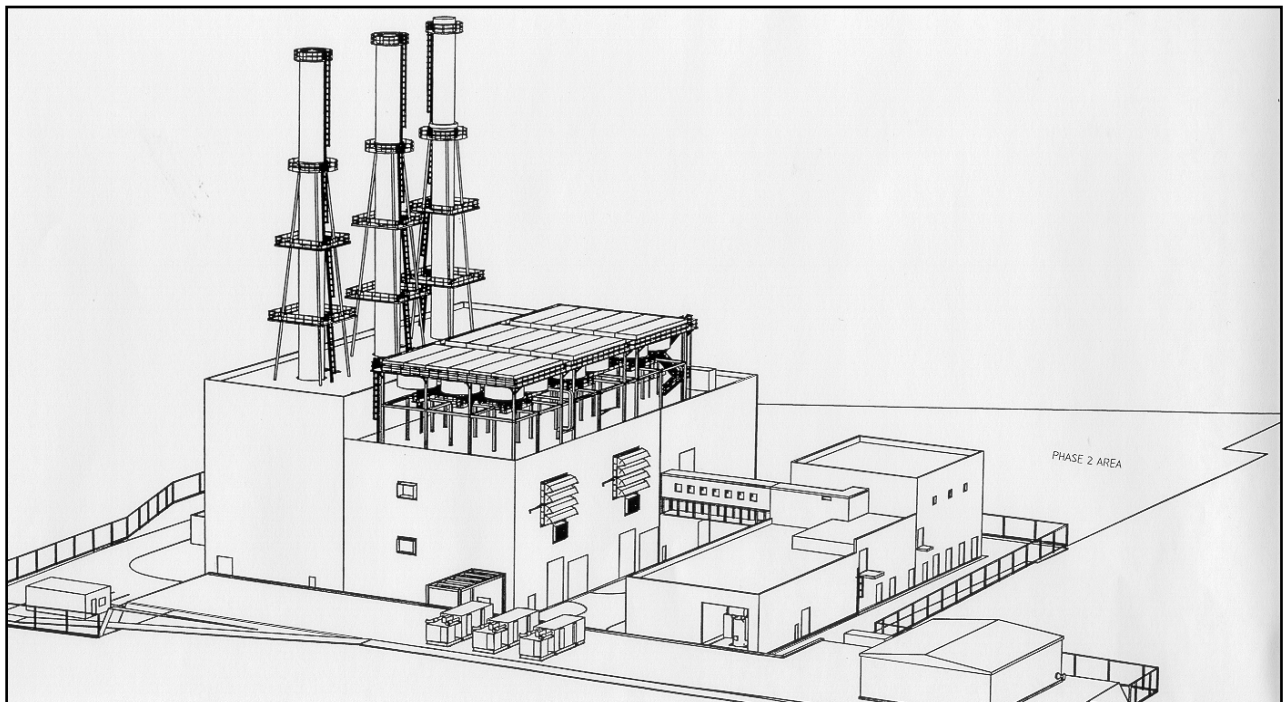


Fig. 6, The Plant Layout

## **Conclusion**

Traditional gas fired CHP systems are based on steam turbine cycles. Their total fuel usage is up to 80 %, with about 30% of the fuel energy converted into electrical power and up to 50% of the fuel energy into heat.

Due to increasing environmental awareness, resulting in the Kyoto Protocol and restrictive emission limits, today's power plant design has to provide simultaneously for high CHP efficiencies and low emission levels. The plant concept best suited to fulfil these requirements is a gas-fired combined cycle power plant.

State-of-the-art combined cycle power plants are the most efficient power plants today, with up to 50% of fuel energy converted into electric power and 30% into heat. Compared to other power plant systems a 226 MW combined cycle CHP plant saves more than 200.000 tonnes of CO<sub>2</sub> emissions per year.

Large, integrated industrial sites require a number of utilities like power, steam of different pressure levels, hot water, demineralised water and cooling. In many cases, the supply of all these utilities from one plant only is more efficient and thus more economical than separate production.

Further liberalization of the power markets will result in a high spread of base load and peak power prices. This will result in highly efficient plant with a built-in capability for cycling operation to be able to adapt the plant operation to the market power prices. Technically, this can be realized, for example with combined cycle power plants with fired heat recovery boilers.

By 2007 "Moscow City" will be powered and heated by such a hi-tech cogeneration combined cycle plant, providing the technical and delivery model for other Russian cities to follow.