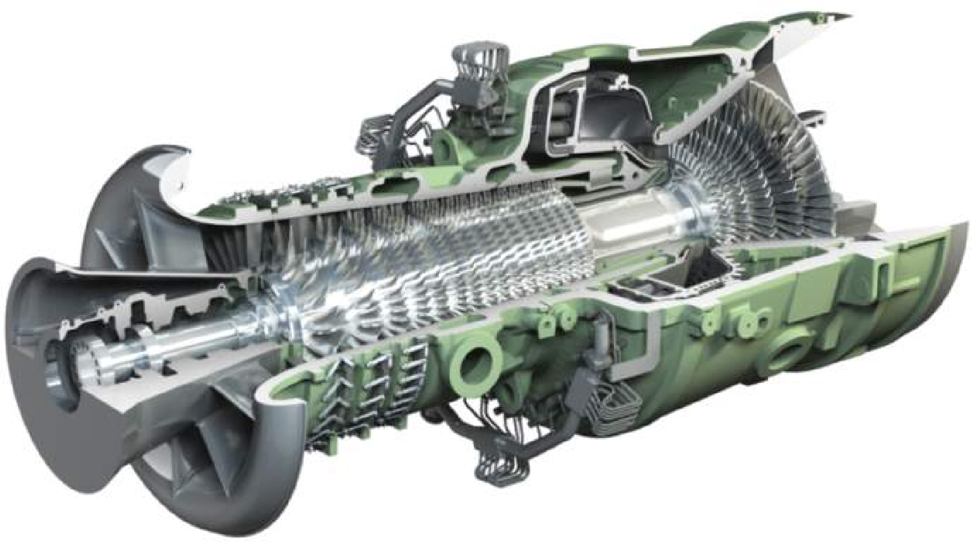
Increasing Power Generation Efficiency in Russia and CIS Countries through Further Development of the Alstom GT13E2 Gas Turbine

Conference Paper



POWER

Paper presented at Russia Power in Moscow, Russia, 05-07 March 2012

Increasing Power Generation Efficiency in Russia and CIS Countries through Further Development of the Alstom GT13E2 Gas Turbine

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1 Introduction

Changing market requirements

Today's power market generally requires solutions delivering the most economic electric power while minimizing the impact on the environment. This trend is likely to go on, putting increasing pressure on the development of new power generation products.

The market requirements may vary strongly depending on the regions, driven by local power generation market structures and grid operation characteristics and, therefore, the priorities and the relative importance of these requirements may changes across the regions. However, the general trends show that large power generation plants need to be designed for the highest efficiency and operational flexibility to save fuel cost over a broad range of operating conditions, and matching a strongly changing power demand. This market segment is generally covered by combined cycle power plants based on large gas turbine units of the advanced technology offering the utmost performance levels.

But in addition to this high-end market, another market segment exists requiring solutions based on smaller gas turbine units, sometimes in multi-unit configurations. For these projects, the main requirements for the gas turbine is the capability to meet the specific project requirements, to adapt plant configuration to the various applications to be served, and to offer the best customized solution with highest reliability, however without compromise on performance and environmental issues.

For this segment, versatility is the key word. The GT13E2 gas turbine has already demonstrated to be a most versatile engine, being used in connection with many different applications, and meeting a very broad range of environment and operation conditions. The GT13E2 upgrade described in this paper further improves these capabilities.

Russian gas power market development

In the last two years the Russian power industry has gone through fundamental changes in regards to its power project developments. One goal of the Russian privatisation program was and still is to boost the installation of new and highly efficient power generation facilities, so that more gas could be sold on the international market.

The recent trend has been to move away from highly standardised power generation towards optimised and tailored Combined Cycle Power Plants (CCPP). Together with the international procurement of main CCPP components such as the gas turbine(s), the heat recovery steam generator(s) (HRSG), the turbogenerator(s) and the steam turbine(s), this trend is just at its start and will steadily increase, so that the current project development process in general may have to be adjusted accordingly. Certified design institutes, for example, will depend during the pre-feasibility stage more on the support and quality of input provided by equipment suppliers.

Foreign Original Equipment Manufacturers (OEM's) and EPC contractors have encountered difficulties when dealing with Russian codes and standards, as well as Russian work processes. In the course of these experiences many foreign OEM's / EPC contractors are reluctant to offer turnkey CCPP's. Hence, local Russian companies have to-date tended to build the combined cycle and/or cogeneration power plants and are still doing so.

Depending on their experience, however, difficulties have occurred when the Russian EPC contractors have tried to integrate the main equipment components purchased abroad into a functional combined cycle power plant. The Russian EPC contractors have experienced challenges such as omitted/missing scope and final commissioning co-ordination issues, which in some cases, has made it extremely difficult to meet performance guarantees, project schedules and pricing budgets. This meanwhile has reached even federal authorities attention. One of the already initiated counter-measures for example is that the federal office GLAVGOSEXPERTIZA is putting increased attention to compliance of the complete development process (e.g. мдс -80-8.2000 "Guidelines"), in accordance with the Urban Planning Code, for the development of technical scope of tender documentation"), before a new CCPP permit is granted.

With the different technical needs, EPC contractors are also faced with new commercial challenges. For example, balancing the risk profile in view of own capabilities versus scope of supply to be purchased and therefore level of risk outsourced becomes the important question for a competitive CCPP offer.

For EPC contractors, with a strong in-house engineering division, it may look commercially more attractive to purchase individual equipment only and therefore take on more risk regarding possible omitted scope, overall performance guarantees, project time schedule etc. While for other EPC contractors it may be commercially more attractive to look for a greater risk-share with the main component supplier, e.g. in terms of Power Island (PI) overall performance guarantees, or commissioning schedule of the main PI components.

With its unique power generation portfolio, Alstom has developed standard solutions ranging from the supply of main components to fully integrated power island solutions specifically engineered for the needs of the Russian market conditions. For all such solutions a scope description and clear division of work (DOW) will serve as a starting point with developers/owners and/or EPC contractors to tailor the project specific scope and DOW including the project risk sharing.

With flexible product offerings, Alstom can tailor and customize its approach so that developers/owners and EPC contractors have more flexibility to optimise their in-house resources versus the technical and commercial requirements and finally the overall project risk profile.

To-date, Alstom has supplied either directly or in consortium more than 170 turnkey Combined Cycle Power Plants worldwide, and continues to be one of the leading turnkey suppliers of CCPP solutions.

Russian market requirements

The Russian & CIS power market has grown rapidly over the last decade. Russia is the fourth largest electricity producer in the world, behind only the US, China and Japan, and electricity consumption in the near- to mid-term is expected to grow at about 2% per year. Demand for new capacity is driven both by economic growth and by the need to retire old plants. Nearly half of the installed capacity in Russia is over 30 years old, and a majority of these units are inefficient gas-fired steam plants. Based on new plant orders over the last five years, gas plants top nuclear, conventional steam, and hydro as Russia's top choice for new capacity. This trend is expected to continue, with 60% of new capacity in the next ten years coming from gas turbine based power plants.

A common market requirement is that the plant must be able to meet the steam needs of existing Combined Heat and Power (CHP) systems, which are prevalent throughout Russia. Repowering is another important market segment, where existing conventional steam plants are transformed into the steam cycle for a combined cycle plant. The choice of gas turbines is sometimes simply based on which provides the best fit with the existing power plant. The most challenging requirement for gas plants in the Russian market, however, is the need to deal with extremely wide ranges of ambient temperatures. Operating temperatures typically are specified as a range from −40°C to +40°C.

To cope with all the diverse conditions and requirements, a highly versatile type of engine is required. The Alstom GT13E2 gas turbine is well adapted to the specific conditions of the Russian & CIS market and offers the highest performance in its class to produce economic and clean power. The GT13E2 operation and experience records show that the GT13E2 has proved to be the perfect fit for power generation projects, also including special applications like cogeneration projects for district heating, desalination or other industrial applications, or repowering opportunities.

Only last year Alstom has been awarded 8 GT13E2 units for projects in the region. Most of them will be used in combined cycle CHP projects for district heating application.

2 The GT13E2 Development History

In 2013, we will celebrate the 20th birthday of the GT13E2 gas turbine. Since its first operation in 1993, the GT13E2 gas turbines have demonstrated significant user's advantages of this technology platform. Unprecedented operational flexibility, robust design, high gas turbine efficiency, low emissions over a wide load range with world-class levels of reliability and availability are characteristics of these gas turbines.

The GT13E2 is a medium sized gas turbine of the 200 MW class. It has a 21-stage compressor with a variable inlet guide vane, an annular combustion system with closed loop combustor cooling and a 5-stage turbine.

Figure 2.1: GT13E2 gas turbine thermal block

The annular combustion system includes 72 EV (EnVironmental) burners. The EV burner is a dry low NOx burner with a long operating history and is used in the entire Alstom gas turbine portfolio, which allows a concentrated development and cross feed of improvements between the different gas turbine platforms. To cover the different power output requirements different numbers of burners are used in the different platforms.

In 1993 the first GT13E2 started operation. Major scope of the 2002 upgrade was a new turbine that pushed performance from 166 MW at 35.7% initially to 172 MW at 36.4% gas turbine efficiency. This upgrade also included TBC coating on the downstream part of the combustor, the so-called combustor zone 2, as well as the option to operate the engine at two different operation modes. These two different operation modes are using two different firing temperature levels such that for the lower temperature firing level the lifetime consumption is lower and hence operation intervals between inspections are longer. In parallel fuel switch over from natural gas to fuel oil and vice versa was optimized such that fuel switch over can reliably be done also at full load.

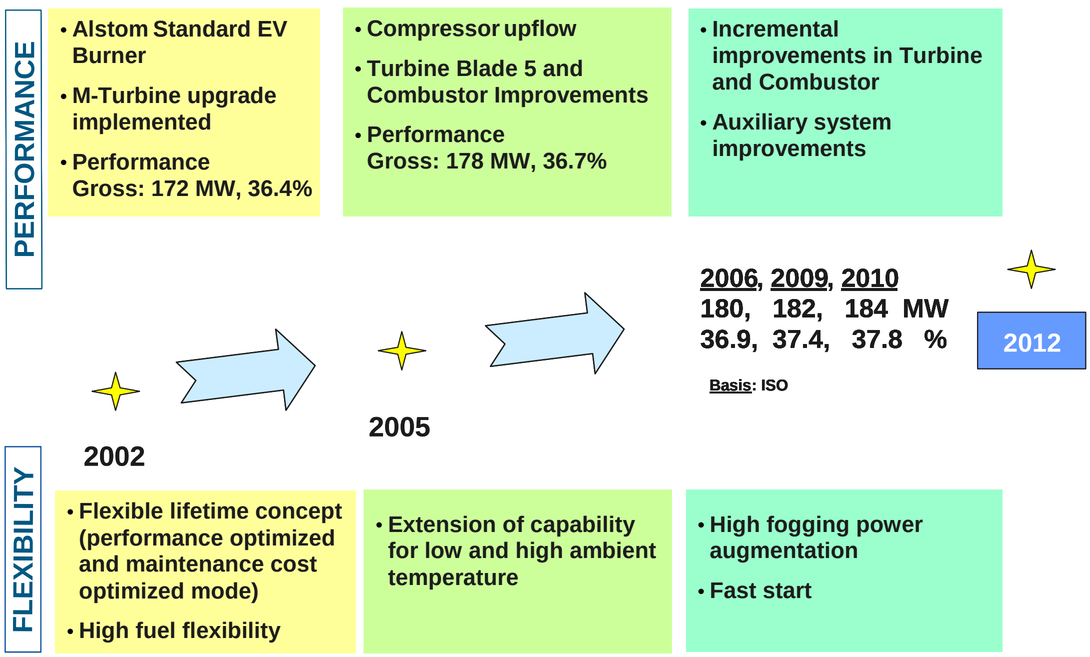

Figure 2.2: GT13E2 performance and flexibility evolution

In the 2005 upgrade the compressor stages 1-5 have been re-staggered to increase the mass flow by approximately 4%. The profile of the last turbine blade was optimized to match the increased mass flow. In the front part of the combustor, the so-called combustor zone 1 liner segments, thermal barrier coating (TBC) was applied and the film-cooling pattern was adapted. As a result improved flame stability and lower NOx emissions over a wider ambient temperature range were achieved.

Continuous improvements and product care especially through the use of optimized coatings, through leakage reductions and reduction of auxiliary power consumption as result of feedback obtained from of over hundred operating GT13E2 engines in 2005 allowed stepwise performance increase to 184 MW and 37.8% gross efficiency. Upgrades of the control software and hardware resulted in faster start and higher load gradients. Implementation of power augmentation options like air inlet cooling, high fogging and water injection resulted in the possibility to keep the power output almost constant from 15°c ambient temperature up to 45°c.

Today, the GT13E2 has been sold more than 150 times worldwide and the fleet has accumulated more than 7.5 million operating hours and over 54’000 starts. 21 engines have accumulated more than 100’000 fired hours with the fleet leader having achieved over 128’000 hours. 10 engines had more than 1’000 start/stop cycles.

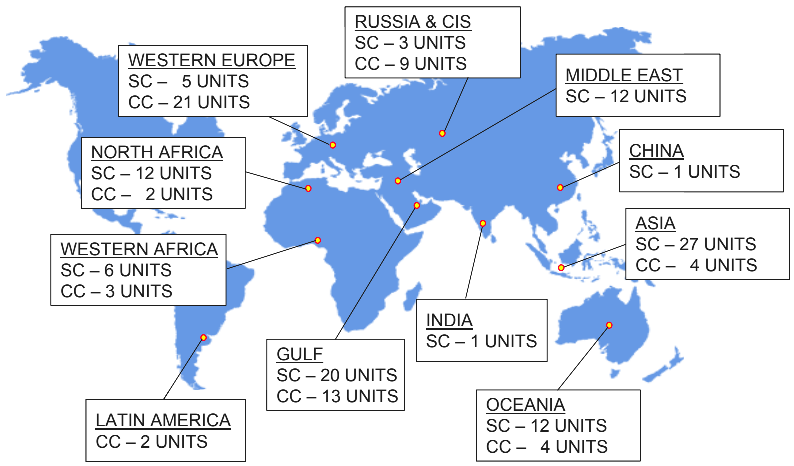

Figure 2.3: GT13E2 global references

The GT13E2 has demonstrated superior reliability. Figure 2.3 shows the latest reliability figures over the period from 3rd quarter 2010 to 3rd quarter 2011 from the ORAP report of the independent SPS/ORAP report. The reliability figures of the GT13E2 are clearly and consistently above that of the average of the industry.

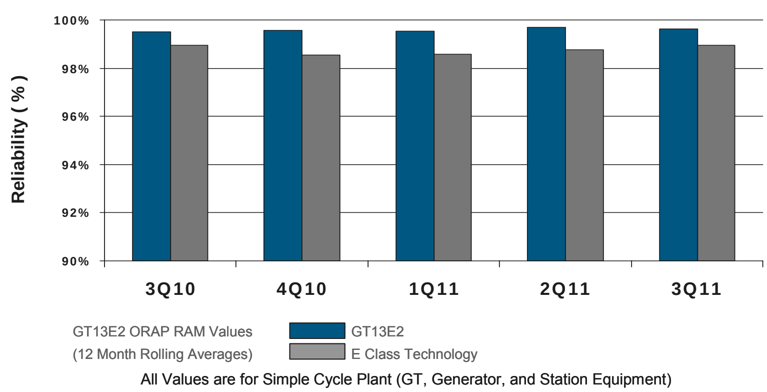

Figure 2.3: GT13E2 reliability

3 GT13E2 – A most Versatile Engine

Over the years, the GT13E2 has proved its unsurpassed versatility in countless projects around the world, being used with benefits in all kinds of applications or plant configurations, and under a wide range of operational conditions.

- Used under very different ambient conditions, from cold to hot places, from dry sandy sites to wet seashores or polluted industrial areas
- Used extensively for both simple cycle as well as combined cycle plants
- Used in connection with very demanding industrial application, like aluminium smelters etc., often powering small island electrical grids, without connection or support from large utility networks
- One third of the installed fleet used for simple cycle or combined cycle cogeneration applications (CHP plants), with heat supplied to district heating systems, desalination plants or industrial processes
- Several projects were started as simple cycle then converted into full combined cycle plants through steam tail add-on, while some GT13E2 units have been used in repowering applications, for the conversion of existing steam power plants into combined cycle plants
- Many combined cycle plants have been fitted with bypass stack, some of them for phased installation and operation first of the gas and later of the steam turbine(s) – i.e. steam tail add-on as above mentioned
- Many of them, especially in very hot climatic regions, have been fitted with air inlet cooling systems
- Running on very different types of fuel, with a broad range of gas or liquid fuel compositions, and also varying compositions during operation, etc., in gas only, dual fuel, or oil only configurations

Figure 3.1 shows the example of Alba combined cycle plant, in Bahrain, based on three blocks KA13D-3 (3-on-1 configuration) and two blocks KA13E2-2 (2-on-1 configuration) for a total of 1530 MW, mostly operated in island configuration

Figure 3.1: Alba – One of the largest aluminium smelter plants in the world

4 GT13E2 Upgrade

Development focus

In the recent years even more challenging requirements for flexibility and environmental friendliness have emerged. New governmental regulations on emission reduction over a broad load range and for largely varying natural gas composition have or will be put in force. Varying energy demand during day/night and summer/ winter as well as the increasing number of wind and solar power generation units further make operational flexibility a key requirement. Already today Alstom gas turbines meet most of these future conditions and requirements.

In order to further enhance performance and operational flexibility of the GT13E2 an upgrade has been defined, based on

- integration of a proven compressor with higher mass flow and better turndown capability
- upgraded combustion system

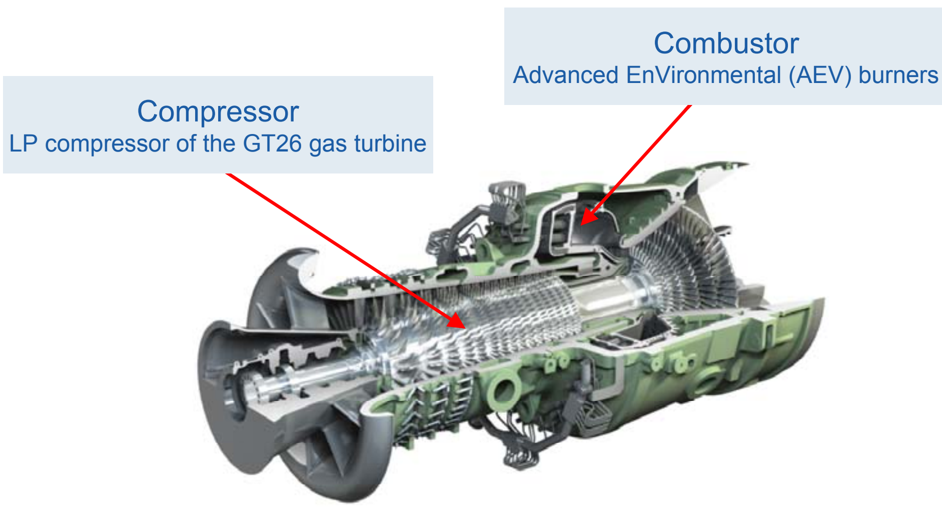

Figure 4.1: GT13E2 development focus

Compressor

To increase the power output and the turndown capability of the GT13E2 the first 16 stages of the proven compressor used in the GT26 have been integrated into the GT13E2 engine. Three variable guide vanes allow a wider range of turn down at higher compressor efficiency as compared to the previous compressor with single variable guide vane row. The mass flow of the engine is increased by approximately 10%. The compressor blades and vanes as well as the compressor housing and the compressor section of the rotor have been taken over from the GT26 with minor adaptations to the GT13E2. The air intake system and the rotor bearing on the compressor side are also adapted from the GT26 design so that the previously used intermediate shaft to the generator is no longer required resulting in a shorter arrangement. Compressor bleeds have been found to match well the turbine cooling system requirements. Blow off during start-up of the engine is injected into the exhaust system eliminating the previously used blow off silencers.

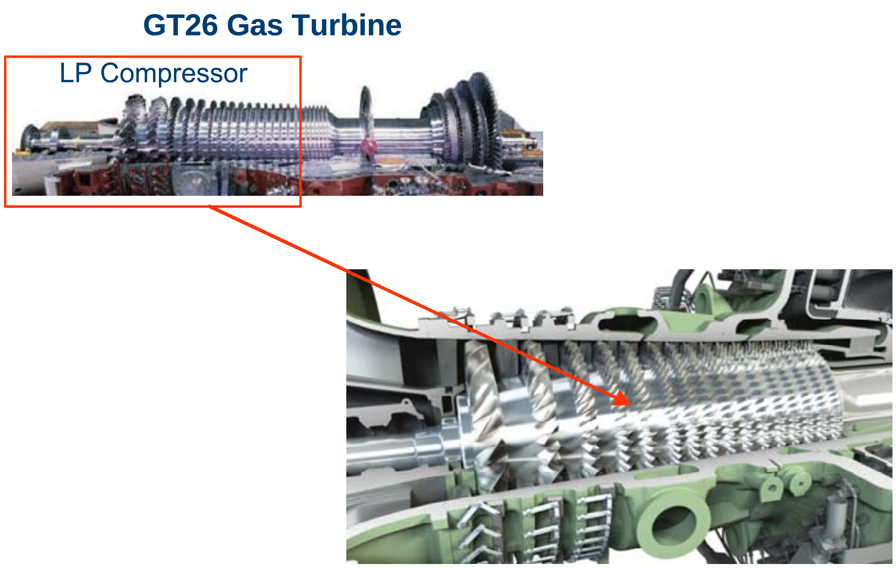

Figure 4.2– GT13E2 Gas Turbine compressor based on the GT26 compressor

The compressor design builds on a fleet experience of more than sixty GT26 engines. It includes the air inlet cooling and power augmentation systems successfully in operation on many GT26 turbines.

Combustor

The combustion system has been upgraded to further enhance the emission behaviour and the operational flexibility of the GT13E2 by implementing the Advanced EnVironmental (AEV) burner. The AEV burner is based on the well proven standard Alstom gas turbine EV burner technology as an evolutionary approach for both gas and fuel oil operation.

The design features of the AEV burner are shown in figure 4.3. Main difference between the AEV and the EV burner is the dedicated mixing section in the burner body downstream of the swirler. The design of the four-slot swirler is aerodynamically optimized with a higher throughput of combustion air as compared to the existing GT13E2 EV design. As a result the number of burners is reduced, from 72 EV burners to 48 AEV burners.

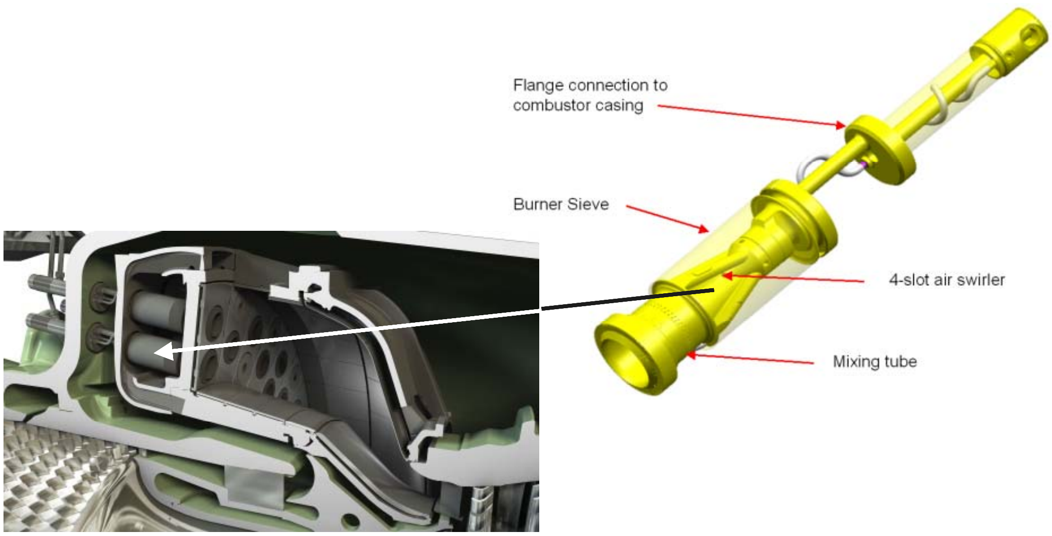

Figure 4.3: AEV burner design features

The integration of the mixing section downstream of the swirler in the burner body ensures an almost perfectly homogeneous mixture of fuel and combustion air, resulting in very low NOx emissions on both gas and oil operation.

For oil operation, the mixing section provides sufficient residence time for atomization, pre-vaporization and mixing of the liquid fuel. As a consequence less than half of the water is consumed for control of the NOx emissions compared to the EV burner.

An important feature of the AEV burner is the front stage gas injection through multiple nozzles, which are arranged circumferentially around the burner exit plane. With this solution the stability of the flame generated by the internal fuel stage is increased against flame extinction and pulsations. Hence the AEV burner system can be permanently operated over the entire load range with low NOx emissions.

A robust combustion is obtained by the presence of the mixing section, the flame front being insensitive to variations of air temperature and humidity as well as natural gas composition and gas temperature. Therefore, the GT13E2 upgrade with AEV burner sees its fuel and operational flexibility further enhanced. As a direct consequence of the AEV operation concept, the fuel system is simplified.

Other improvement areas

Further to the major changes on the compressor and combustor as described above, the GT13E2 upgrade can benefit from of a number of small design improvements and refinements:

- The same turbine from the 2005 rating is used for this upgrade, as the large cross sectional flow of the last turbine stage allows accommodating the higher mass flow from the compressor. Because of the change of the firing temperature by less than 20°C, the first blade row received full thermal barrier coating (TBC) coverage for improved lifetime

- A larger type of TOPAIR air-cooled generator is used to accommodate the higher power output of the gas turbine, with margins for power augmentation. It can be optimized to allowing for 3 different ratings in the range of 255 to 280 MVA, hence enabling adjustment to plant specific requirements at maximized generator efficiency
- The arrangement of the gas turbine auxiliary systems has been optimised with increased modularization through the use of pre-engineered and factory tested functional modules
- Further, to reduce and simplify maintenance several small improvements have been brought to the gas turbine to facilitate tasks like alignment or lifting of components

5 GT13E2 Benefits

Performance

The GT13E2 upgrade brings performance improvements in many regards:

- Engine nominal output and efficiency
- Combined cycle plant output
- Simple cycle and combined cycle part load efficiency
- Engine performance at high ambient conditions

Nominal performance

Since its first operation in 1993, the GT13E2 could claim the best performance in it class. With the new upgrade, it becomes even better: 202.7 MW / 38% gross engine performance at generator terminals, i.e. a 10% power output increase, and +0.2%-pt efficiency improvement.

The combined cycle plant performance is also boosted, gaining 48 MW in a 2-on-1 plant configuration, with net plant efficiency maintained at high level.

GT13E2 Engine Performance

Gross electrical output	MW	202.7	
Gross electrical efficiency (LHV)	%	38.0	- ISO Conditions
Gross heat rate (LHV)	kJ/kWh	9476	- Natural gas
	Btu/kWh	8982	- Gross performance at generator terminals no inlet/outlet losses

KA13E2-2 Combined Cycle Power Plant Performance

Net plant electrical output	MW	565	- ISO Conditions
Net plant electrical efficiency (LHV)	%	53.8	- Natural gas
Net plant heat rate (LHV)	kJ/kWh	6696	- Double pressure non reheat CCPP configuration
	Btu/kWh	6347	- Net plant performance at main step-up transformer HV terminals

Part load behaviour

The use of the GT26 low-pressure compressor with 3 variable guide vanes (VGV's) instead of just one results in a better part-load efficiency characteristics for both simple cycle and combined cycle applications. The improved part-load performance permits to generate significant fuel savings. As an example, the GT13E2 upgrade operating on gas at 75% GT load will consume about 2% less fuel than with the previous rating, therefore positively contributing to any project economic results.

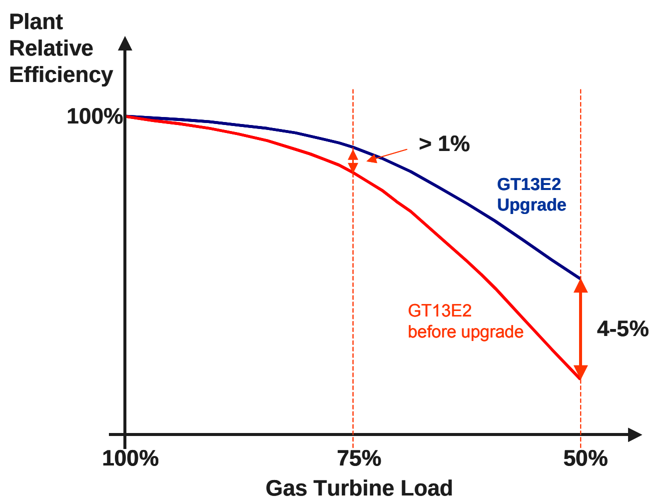

Figure 5.1: KA13E2-2 part load behaviour

Figure 5.1 shows the gain in efficiency of a KA13E2-2 combined cycle 2-on-1 plant configuration. The part load behaviour of the upgrade permits to save more than 1% fuel when operating at 75% GT load, and as much as to 4-5% at 50% GT load.

Performance at hot ambient conditions

While the GT13E2 efficiency at low ambient conditions remains significantly better than any comparable machine, the characteristics of the 2012 upgrade permits to offer better efficiency at high ambient conditions. This is especially valuable in typical hot climate countries where hot summer conditions also mean the highest power demand, because of air conditioning loads. As an example, at 45°C ambient temperature, the new upgrade will still have 16 MW more power than the previous rating in simple cycle, with an efficiency benefit of more than 0.8%-pt.

In addition, the range of air inlet cooling options (evaporative cooling, fogging, high fogging) permit to keep the power output characteristics flat over a wide range of ambient temperature.

Emissions

The introduction of the AEV burners permits to significantly improve the environmental performance of the machine: Running on natural gas, the full load NOx emissions are reduced from 25 vppm[1] down to 15 vppm. The turndown is also improved, since the GT13E2 upgrade is able to operate down to 70% load meeting the low 15 vppm NOx emissions, and further down to 50% GT load not exceeding the 25 vppm NOx World Bank standards.

The AEV burner brings also important benefits when running on #2 oil, as the GT13E2 is now able to run with 25 vppm NOx emission in the 100% down to 70% GT load range. The 42 vppm (typical European standard requirement) can even be met down to 50% load. NOx control on oil operation is by water injection, which could be strongly reduced. The amount of water required to meet 42 vppm NOx is about 60% lower.

The AEV burner environmental performance is almost immune to variations of the air conditions at GT inlet, meaning that the gas turbine can deliver clean power at low ambient conditions as well as in hot climate, even with air inlet cooling systems in operation.

Finally, it must be mentioned that the CO2 emissions are reduced as a direct consequence of the better efficiency of the gas turbine - both at full load and at part loads.

Fuel flexibility

The superior fuel flexibility demonstrated already with the GT13E2 fleet in operation is fully achieved with the AEV-equipped GT13E2 upgrade as well. The experience range with respect to the Wobbe Index extends from 31 MJ/m^3 to 49 MJ/m^3, i.e. a ±23% range. In terms of C2+ content, values of up to 25% in volume are demonstrated without negative impact on performance, reliability and compliance with emission requirements. The robustness of the combustion system and the associated control system allows these engines to operate under these varying conditions without the need for re-adjustment of settings or changes of hardware. The GT13E2 is not only capable to run on a wide range of fuel gas compositions, it can also allow fast and wide variations in the fuel gas quality.

On-line fuel switch-over

In case of decreasing fuel gas supply pressure, fast fuel switch over from gas to oil operation ensures uninterrupted stable power supply. Such fuel switch over can be executed while the machine remains at full load. Switch over at constant load is also possible at part loads down to 40% GT load.

[1] Note: vppm to be read as vppm, dry (corrected to 15% O2)

Start-up

The permanent operation of the AEV burner with two fuel stages allows a fast adjustment of the combustion resulting in an improved behaviour for transient operation conditions such as fast loading, frequency response or load rejection.

The standard start-up time is 25 minutes from start initiation (push button) to more than 200 MW at the generator terminals (ISO conditions). With the upgrade GT13E2 the start-up time can be even reduced to 15 minutes (figure 5.2). This is done through increased start-up power during the rotor acceleration phase combined with a smart ramp-up load control, allowing for higher loading gradients within a selected load range. Warm and hot start-up times of 15 minutes are possible without additional lifetime counting on the gas turbine as compared to the 25 min start. By making use of an optional roller shutter in the air intake, the status "warm engine" can be extended up-to 60 hours from shut-down.

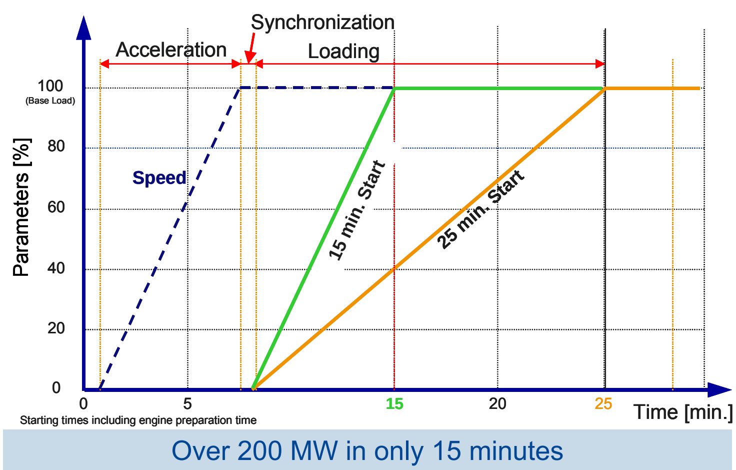

Figure 5.2: GT13E2 start-up

Operation at low ambient conditions

Reliable operation at very low ambient condition is no exceptional feat for the GT13E2 upgrade, which became even more robust, and saw its capability at very low ambient conditions improved:

- Emission compliant operation without air pre-heater down to -10°C ambient temperature down to 50% relative GT load; as a consequence, the pre-heater size can be reduced for lower ambient temperatures as only -10°C must be achieved at GT inlet
- Cold starts are allowed down to –30°C ambient temperature without air pre-heater in operation
- With pre-heater the gas turbine is operational down to -50°C

Cogeneration operation

Cogeneration (CHP – Combined Heat and Power) operation very often requires that the heat supply can be ensured independently of the gas turbine power output. Also, the steam parameters must normally be kept constant so that the operation of the process using the steam is not disturbed.

The use of three rows of variable guide vanes not only offers superior part load performance, but it also ensures that the gas turbine exhaust temperature remains high over a wide range of GT operating loads. This generally represents a key benefit for CHP plants, as it permits to keep the steam parameters constant independently of the gas turbine power output, over a wide load range.

Maintenance improvements

A number of small refinements and improvements have been made so as to increase the ease of maintenance. Measures have been taken to facilitate maintenance tasks such as alignments and lifting of components. Pre-engineered functional modules have been introduced for the auxiliary systems, and the fuel system has been simplified. Together with the reduction in the number of parts (e.g. from 72 EV burners down to 48 AEV burners), the duration of the maintenance work and effort is reduced.

Further benefits of the GT13E2

In addition to the specific benefits of the GT13E2 above described, this machine also features many advanced characteristics inherited from the previous GT13E2 rating, such as:

Flexible operation modes

The GT13E2 can be operated either in the so-called “Performance Optimized” (PO) operation mode or in the “Maintenance Cost Optimized” (MCO) operation mode. For a slight decrease in the performance (<5% power, <0.5%-pt. efficiency), the intervals between inspections can be increased up to 50%. The operator can switch between the two operation modes at any time and, as a consequence, optimize the plant economics. The benefits of an operation in the MCO operation mode applies automatically at part load of less then around 95% GT load.

Power augmentation options

Like the previous rating, the GT13E2 can be equipped with an air inlet cooling system (evaporative cooling, fogging or high fogging) to further increase power output at high ambient temperatures. Alstom has developed in-house the systems using fogging or high fogging devices with the clear advantage of being designed and integrated by the gas turbine equipment manufacturer itself:

- no impact of the inlet cooling system operation on interval between inspections
- the compressor surge margin is maintained within safe limits at all operation points
- the control and protection systems of both gas turbine and inlet cooling equipment are fully integrated
- performance guarantees available for full Alstom air inlet cooling portfolio

GT13E2 based combined cycle power plants can easily be fitted with large supplementary firing, allowing high power supply flexibility, and increased power vs. heat production flexibility for CHP plants.

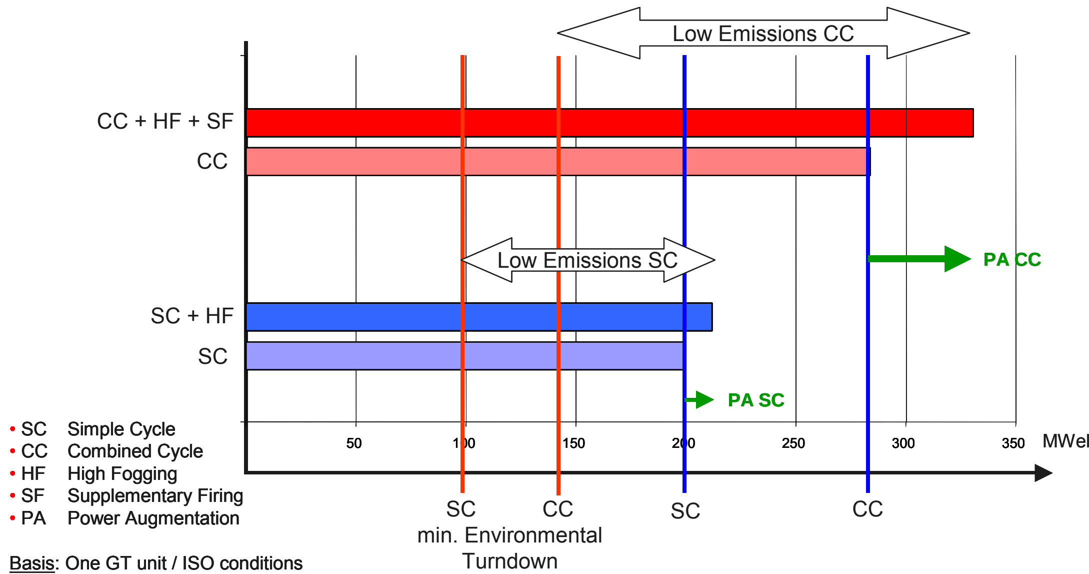

Figure 5.3: SC13E2 / KA13E2 high power output flexibility

Figure 5.3 shows the wide power output range at ISO conditions of the simple cycle and 1-on-1 combined cycle configurations. The emission-compliant range extends for the combined cycle case from 50% (min. environmental turndown) to + 118% (full load combined cycle power output, with HF and SF). This range increases at high ambient conditions, as the air inlet cooling will become more effective.

6 Field Experience

Compressor

The first 16 stages of the well-proven GT26 compressor are now used for the GT13E2 upgrade development. Extensive compressor testing, including surge test have been performed in 2002 at the Alstom test GT26 test power plant in Birr, Switzerland. This compressor design is now installed and running in more than sixty GT26 gas turbines where it could demonstrate its reliability. Today, the cumulated experience amounts to over 1.2 million fired hours, with the fleet leader having achieved more than 60'000 operating hours.

Combustor

After full-scale tests in the Alstom GT8C2 Test Power Plant, the AEV combustor upgrade package has been installed in three GT13E2 customer units, the first already in 2006, and was very successfully validated, demonstrating the improved operational flexibility and the reduced emissions. At different ambient conditions stable low NOx emissions well below the emission permit levels on gas fuel and on fuel oil could be demonstrated without any need for re-adjustment of the engine or tuning of the combustor system.

Figure 6.1 – Alstom GT8C2 Test plant

Figure 6.2 – Vattenfall' Berlin Mitte Power Plant

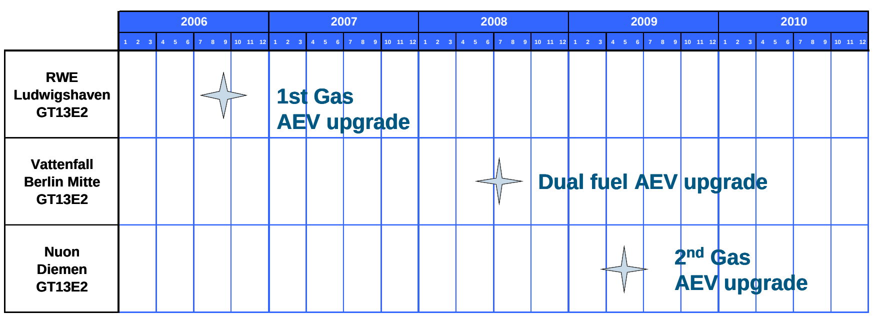

Figure 6.3 – Plants operating with AEV Retrofit Upgrade

To date the total operation experience with the AEV burners on GT13E2 gas turbines has exceeded 80'000 operation hours. The GT13E2 gas turbine with dual fuel operation is operating reliably for more than two years and has accumulated more than 16'500 OH with the AEV dual fuel burner. The AEV Burner is now offered both as retrofit to the existing fleet, as well as standard component for the new GT13E2 engines.

7 Service Offering

Alstom has more than 100 years of experience in engineering, procurement and construction (EPC) of new power plants, and our engineers are also experts in retrofitting, modernizing and servicing existing plants. With operations in over 70 countries, Alstom is close to their customers all over the world, ensuring rapid response and service at all times. Utilities, independent power producers and merchant power generators are all looking to maximize the returns on their investments, by optimizing operations and managing risks. As a leading Gas Turbine Original Equipment Manufacturer (OEM) and turnkey power plant provider, Alstom possesses the unique extensive technical expertise and equipment know-how to ensure that their client's equipment remains competitive throughout the lifecycle of the product.

The OEM commitment to continuous development efforts on all major equipment products, such as performance upgrade packages using the latest state-of-the-art gas turbine and combustion technology help the plant owners to produce more power, while using less fuel and reducing emissions. Extending operation intervals between scheduled outages enables more production and lower maintenance costs. Innovative reconditioning of hot gas path parts uses the latest proven technology to keep engines operational, with a quality assurance that can only be provided by the OEM supplier.

Alstom's flexible and customized expert services cover solutions at all stages of the plant lifecycle, including:

- New and improved parts, reconditioning of parts
- Advice and operational support
- Field service
- Performance improvements on components and full plant
- Plant integration capabilities
- Service contracts, also on other OEM gas turbine equipment

Alstom's service contracts for GT and CCPP are tailored to meet the needs of all operational, maintenance and support requirements. From Long Term Agreements (LTA) covering the supply of parts and provision of services, to Operation and Maintenance (O&M) contracts, which allow plant owners to devise completely new management strategies by outsourcing risks and responsibilities, Alstom's O&M contracts allow clients to take advantage of performance and availability guarantees through tailored agreements that perfectly suit the required service and equipment scope.

With existing commercial power plants in Armenia (Hrazdan, Yerevan), Belarus (Minsk) and Russia (Moscow), and a rapidly expanding GT13E2 fleet in Russia, Alstom's commitment to provision of local services in Russia and CIS countries is in direct focus. The availability of local services from Russian-speaking teams is considered to be of vital importance to provide the necessary OEM support for the growing fleet.

8 Summary & Conclusions

The very successful Alstom GT13E2 gas turbine with best-in-class performance, high reliability, high operational flexibility and unique versatility to adapt to a broad range of applications and operation conditions has been further improved. The GT13E2 upgrade significantly extends the already well-recognized benefits of the machine:

- Increased simple cycle performance – more than 200 MW at 38% gross efficiency (+10% output / + 0.2%-pt efficiency)
- Improved net combined cycle plant performance - 565 MW / 53.8% (+9% output / + 0.2%-pt efficiency) for a 2-on-1 power plant configuration
- Improved part load efficiency
- Improved high ambient temperature performance / improved low ambient temperature capability
- Reduced emissions levels, improved environmental turndown and environment compliant power augmentation solutions
- Fast GT start with >200 MW available in 15 minutes, without additional lifetime counting vs. 25 min. start, for warm and hot starts
- High fuel composition flexibility without hardware changes
- On-line fuel switch-over at constant load, for gas turbine loads between 40% and 100%
- Switchable (on-line) operation modes to adjust the gas turbine performance according to market requirements and, therefore, optimize the plant economics
- Improved capability for cogeneration operation, due to the improved gas turbine exhaust gas temperature characteristics
- Full range of power augmentation options with guaranteed performance and no impact on intervals between inspections
- Reduced maintenance requirements

The development of the 2012 upgrade was entirely based on an evolutionary approach, making full use of the well-proven GT13E2 platform, together fully validated components:

- The first 16 stages of the GT26 compressor design used for this upgrade is operating in more than sixty GT26 units, totalling more than 1’200’000 running hours experience.
- The Advanced EV burner (AEV burner), a further development of the standard EV burner used in all Alstom gas turbines, is operating commercially in three customer engines, with more than 80’000 fired hours experience.

...The Best becomes Better!

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