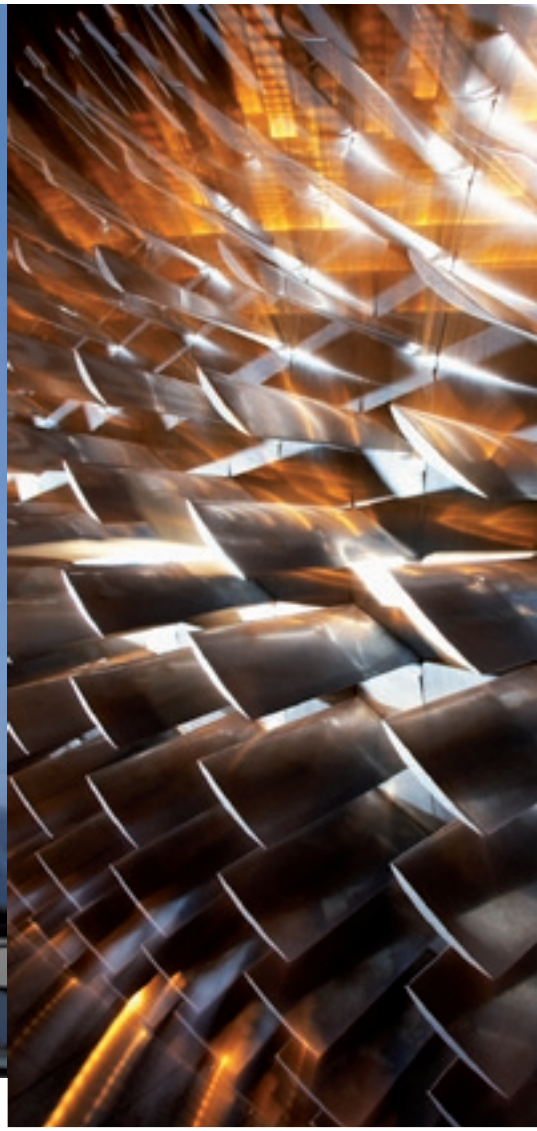
GAS POWER PLANTS



POWER

we are shaping the future

ALSTOM

Optimised **Clean, Integrated and Flexible**

Exceptional performance and operational flexibility

In today's market place, there has never been a greater need to optimise a power plant's total life-cycle costs whilst ensuring preservation of the environment. Alstom is not only one of the world-leading turnkey suppliers of gas power plants, with over sixty years experience, but also one of the world leading OEM suppliers, with a particularly broad range of power products, systems and services. This, supported by Alstom's Plant Integrator™ approach, offers exceptional power plant performance and operational flexibility. In addition, an extensive range of environmental solutions enables Alstom customers to supply cleaner power than ever before.

Alstom's experience

- Designing, manufacturing and supplying gas power plants for over sixty years, today a world leader
- World's first industrial gas-turbine power plant (Neuchâtel, Switzerland in 1939)
- Over 200 gas power plants delivered worldwide on a turnkey basis

Alstom is a global leader in power generation

The company sets the benchmark for innovative technologies that provide clean, efficient power for its customers.

Having supplied more than 25% of the world's installed power-generation base, Alstom designs, manufactures, supplies, installs and services the broadest range of systems for power generation and industrial markets, with a product portfolio that extends across the entire energy value-chain for all fuel types, from fossil to biomass to nuclear and renewables.

Alstom can supply these products as single components or as complete turnkey power plants, which, through its Plant Integrator™ approach and smart grid solutions, are optimised to deliver maximum value for the customer throughout the plant's lifetime.

Alstom's specialists have developed extensive experience in engineering, procuring and constructing new plants as well as retrofitting, servicing and modernising existing ones.

Operating in more than 70 countries, Alstom is always close enough to the customer to ensure rapid response with a high level of service excellence.

Power Generation

Unprecedented changes and challenges are faced by utilities, independent power producers and merchant power producers:

- **Deregulation and tougher competition** with an increasing number of liberalised electricity markets
- **Shifting consumption trends** with an ever-greater need for operational flexibility and efficiency
- **Increase of renewables** in the power generation mix, resulting in a growing need for production flexibility between fuels
- **More stringent emissions legislations**
- **Gas price volatility** and sourcing uncertainties
- **Flexibility in handling variations of gas composition** at a time of growing global transport of fuel gas

Alstom gas power plants: the benefits

High efficiency in both base and part load

Alstom gas power plants are designed to reach net plant efficiencies up to 59% and above at base load. They also offer highest part-load efficiency. This is essential today, as gas power plants operate mostly at intermediate loads, a consequence of deregulated markets and of grids where the share of not-continuously-available wind and/or solar based power is increasing.

Clean power generation

Thanks to their high efficiency, Alstom gas power plants offer low CO_2 emissions. In addition, low NOx emissions are achieved as a result of the unique combustion technologies used in Alstom gas turbines, such as sequential combustion and annular combustors with standardised EV-Burners (EnVironmental Burners).

Outstanding operational flexibility

Alstom plants enable continuous operation down to 40% relative load and below, while maintaining low emissions, as well as solutions for increased power capabilities. Technologies used include gas-turbine air-inlet cooling features, gas-turbine peak-firing capabilities and duct firing for Alstom's heat-recovery steam generators.

Full turnkey, Engineering, Procurement and Construction (EPC)

Speaking with one voice to the customer, Alstom's teams manage whole-plant projects from initial design to commissioning, even operation and maintenance, too. More than 19 GW of gas-fired power plant capacity have been awarded to Alstom in the last 3 years*.

Integrated power generation

Using its Plant Integrator™ approach, Alstom provides customers with tailor-made solutions that optimise each plant to local conditions and specific business environments. Proposed solutions are based on pre-engineered reference plants, using Alstom's unique portfolio of in-house gas-power-plant technology for all key components.

* from 1st May 2006 to 30th April 2009.

Creating Additional Value with **Alstom's Plant Integrator™** Approach

Alstom wants to assist customers in optimising complete power plants. This process starts with the integration of Alstom components and the goal of optimising the entire plant rather than optimising only the respective components therein, to create the best fit of customer needs and market conditions.

For a complete power plant over its entire lifecycle, Alstom's offerings contribute to 'added value'. Customers can take advantage of Alstom's unique blend of core competencies to allow faster completion of projects, improved performance, reduced risks and lower costs.

Alstom's Plant Integrator™ approach is based on the belief that the **"Net Present Value" (NPV)** of the power plant over its lifetime is the best way to **measure the value of a given construction project.**

To increase NPV, as calculated via conventional methods, Alstom has identified **six key factors**:

- **Investment**
- **Lead-time**
- **Performance**
- **Availability & operational flexibility**
- **Retrofit capability**
- **Life extension capability**

Other areas that sometimes can matter are also considered, e.g. the compliance with or anticipation of environmental regulations or the ability for fuel flexibility. Still, these conditions always can be translated into one or several of the above-mentioned factors of value.

Alstom's
Reference Gas Power Plants

Alstom offers a whole range of reference power plants for **50 Hz and 60 Hz markets**, as **single-shaft or multi-shaft configurations**. They are designed to operate **on daily start & stop or base load regime**. The following plant types and solutions are offered:

Simple-cycle
- SC13E2 (50 Hz)

Combined-cycle
- KA26 (50 Hz)
- KA24 (60 Hz)
- KA13E2 (50 Hz)

Add-on (or steam tail)
- Retrofit of a simple-cycle power plant into a combined-cycle power plant

Repowering
- Conversion of an existing steam power plant into a combined-cycle power plant

Industrial solutions
Captive plants for:
- Steel plants
- Aluminium plants

Cogeneration
Steam extraction for
- District heating
- Desalination
- Other industries requiring power and heat

Examples of Alstom's gas power plant configurations

Different types of cooling systems
- Air cooled condenser
- Mechanical draft wet cell-type cooling tower
- Natural draft circular cooling tower
- Direct cooling

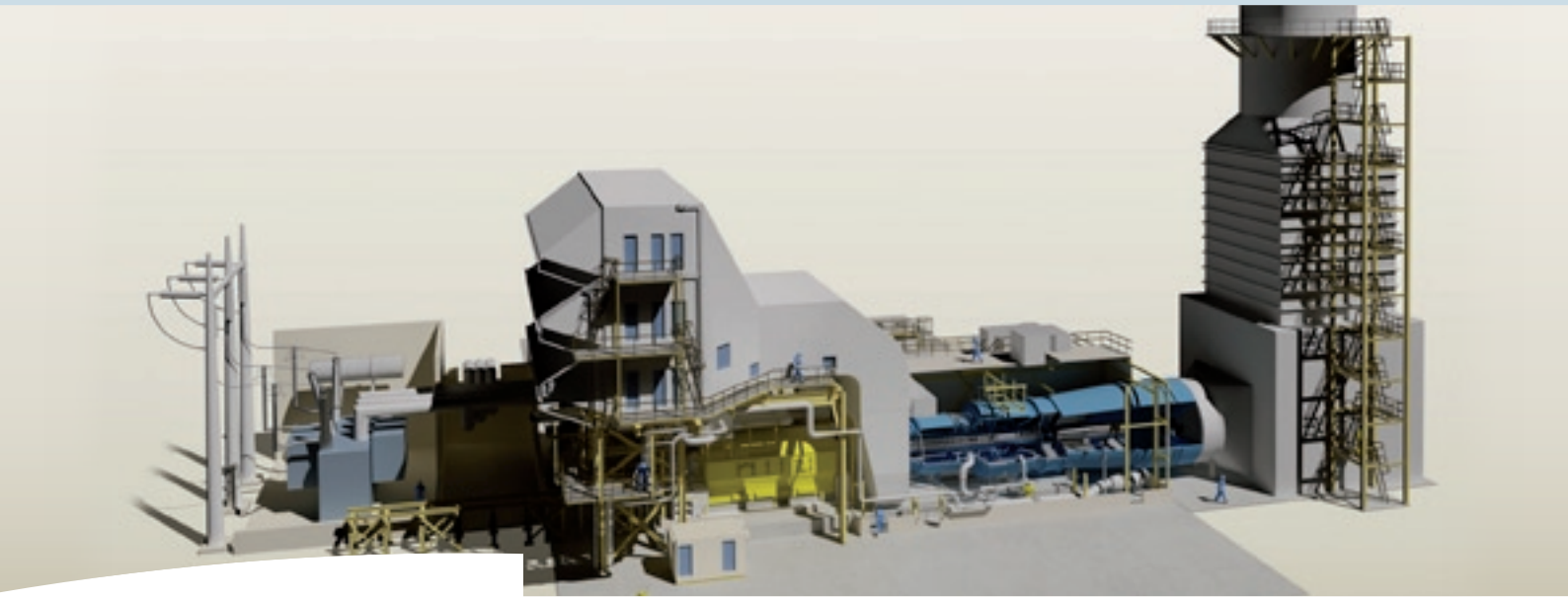
Different shaft configurations
- One on One single-shaft
- One on One multi-shaft
- Two on One multi-shaft
- Three on One multi-shaft

Different arrangements
- Indoor
- Semi outdoor
- Outdoor

Any site location
- Tropical or cold climate
- Greenfield or brown field
- Remote or populated area

Simple-Cycle Power Plant

The best solution in the conventional class,



KEY FACTS

Alstom offers the simple-cycle reference plant SC13E2 in various configurations, with a **high degree of customisation** to meet wide-ranging customer requirements.

Simple-cycle power plants typically are offered for peaking operations:

- Cost of fuel is not a critical factor, compared to value of the power produced
- Construction sites are very small

Main configurations

- **Single or multiple GT13E2 gas turbines** with an Alstom air-cooled TOPAIR turbogenerator

Special configurations

- **Cogeneration** configurations (e.g. water desalination, process heat) with a wide range of steam production
- Inclusion of Alstom's **Heat Recovery Steam Generators** (HRSG)

Options

- Power augmentation options up to more than 15% of plant output through GT13E2 peak firing and/or air inlet cooling (evaporative cooling/fogging/high fogging) and/or water injection
- Supplementary firing for cogeneration applications
- Indoor, semi-outdoor or outdoor installation
- Fuel oil capability (as back-up)

SC13E2

50 Hz market to meet specific project requirements

Key references

F'KIRINA
Algeria
2 x GT13E2 – 292 MW

BRAEMER
Australia
3 x GT13E2 – 450 MW

RUWAIS
United Arab Emirates
4 x GT13E2 – 500 MW + 8 MIGD* fresh water

CUSTOMER BENEFITS

Operational flexibility

- Designed for cyclic as well as base-load operation
- 2 different operation modes in one hardware, with on-line switch-over capability:
  - **Power optimised operation mode** for standard hot-gas-path inspection intervals of 24,000 Equivalent Operating Hours (EOH)
  - **Lifetime optimised operation mode**, with extended hot-gas-path inspection intervals of 36,000 EOH, yet only 2.9% lower plant output and 0.2% lower plant efficiency
- Proven frequency response offered to support small/industrial grids
- GT island mode operation capability
- Fast startup capability and high startup reliability
- Excellent fuel flexibility: can operate on a wide range of gas fuels, with high hydrocarbon content, and can accept wide fluctuations of the Wobbe Index (±10%)
- Dual fuel capability, with on-line switch-over possible between gas and liquid fuel over a wide load range

Performance

Highest efficiency in the conventional class market

Reliability & availability

According to the Operational Reliability Analysis Program (ORAP**), the GT13E2 performs better than the industry average on mean time between failures, mean time to repair, service factor and service hours per start.

Low emissions

Dry low NOx performance:
<25 vppm (at 15% O_2 dry) on fuel gas

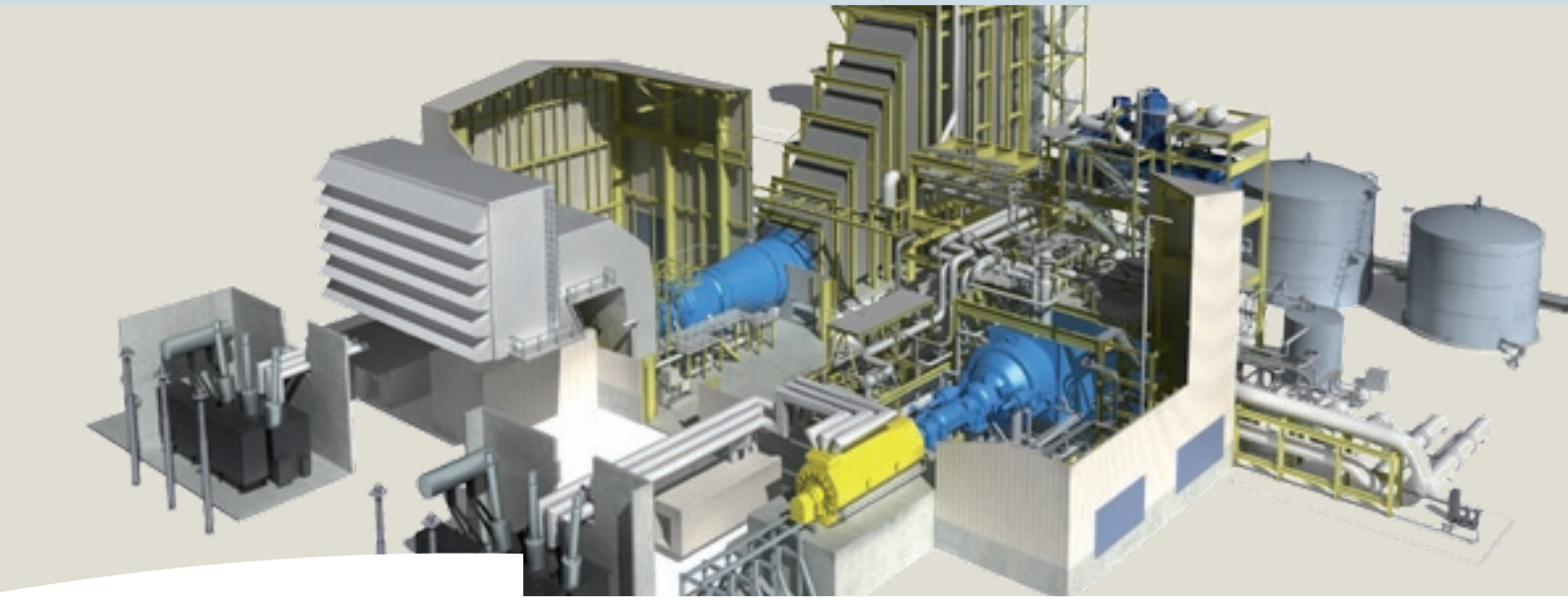
Proven experience

GT13E2 installations number over 140 worldwide, in a broad range of applications, fuels and configurations, demonstrate very good reliability and availability in over 6,000,000 operating hours (including more than 500,000 hours on fuel oil) and have made more than 40,000 starts. The GT13E2 fleet leaders have clocked more than 120,000 operation hours on gas and more than 36,000 operation hours on fuel oil.

* Million Imperial Gallons of water/Day
** ORAP is owned by Strategic Power Systems Inc. (Source: Report Aug 2009)

Combined-Cycle Power Plant

The flexible and reliable high performance solution



KEY FACTS

Alstom's combined-cycle reference plant KA13E2 offers extended operation time between overhauls with a **free choice** between a **power-optimised operation mode** or a **lifetime-optimised operation mode.**

This reference plant, with its conventional class gas turbine GT13E2, is the optimal solution for:

- Industrial and cogeneration applications
- Regions where the cost of fuel does not require advanced-class gas turbines with their higher investment and operational costs

Main configurations

- **Multi-shaft arrangement**, using up to 3 gas turbines, with a dual pressure Alstom HRSG per block, an Alstom COMAX non-reheat steam turbine, all of them driving Alstom air-cooled TOPAIR turbogenerators
  - KA13E2-1 1 GT / 1 ST
  - KA13E2-2 2 GT / 1 ST
  - KA13E2-3 3 GT / 1 ST

Special configurations

- **Cogeneration** configurations (e.g. industry, aluminium smelters, district heating, desalination) with a wide range of steam extraction capabilities
- **Repowering** (conversion of a simple-cycle power plant into a combined-cycle power plant)

Options

- Power augmentation options of up to 10% plant output, through GT13E2 peak firing or air inlet cooling (evaporative cooling/fogging/high fogging) or water injection
- Supplementary firing
- Indoor, semi-outdoor or outdoor installation
- Phased construction concept with or without bypass stack
- Fuel oil capability (as back-up), with on-line switch-over capability

KA13E2

in the conventional class, 50 Hz market

Key references

PELICAN POINT
Australia
1 x KA13E2-2 – 480 MW

MUARA TAWAR 5
Indonesia
1 x KA13E2-1 – 234 MW
(in construction)

NHON TRACH 1
Vietnam
1x KA13E2-2 – 460 MW

CUSTOMER BENEFITS

Operational flexibility

- Designed for cyclic as well as base load operation
- 2 operational modes in one piece of hardware, with on-line switch-over capability:
  - **Power optimised operation mode** for standard hot-gas-path inspection intervals of 24,000 Equivalent Operating Hours (EOH)
  - **Lifetime optimised operation mode**, with extended hot-gas-path inspection intervals of 36,000 EOH, with plant output reduced only 3.2% and plant efficiency reduced only 0.3%
- Proven frequency-response capability offered to support small/industrial grids
- GT island mode operation capability
- Fast start-up capability, high start-up reliability
- Excellent fuel flexibility: can operate on a wide range of gas fuels, with high hydrocarbon content and accept wide fluctuations of the Wobbe Index (±10%)

Power output flexibility

Depending on the amount of extra power required, different solutions can be offered, ranging from mild-duct firing that keeps reference plant configurations virtually unchanged, to maximum power output with special steam tail design and optimisation.

Performance

High combined-cycle power plant performance with 53+% net efficiency, based on conventional class simplicity and high reliability.

Reliability & availability

According to the Operational Reliability Analysis Program (ORAP*), the GT13E2 performs better than the industry averages for: mean time between failures, mean time to repair, service factor and service hours per start.

Low emissions

Dry low NOx performance:
<25 vppm, 15% O_2 dry on fuel gas

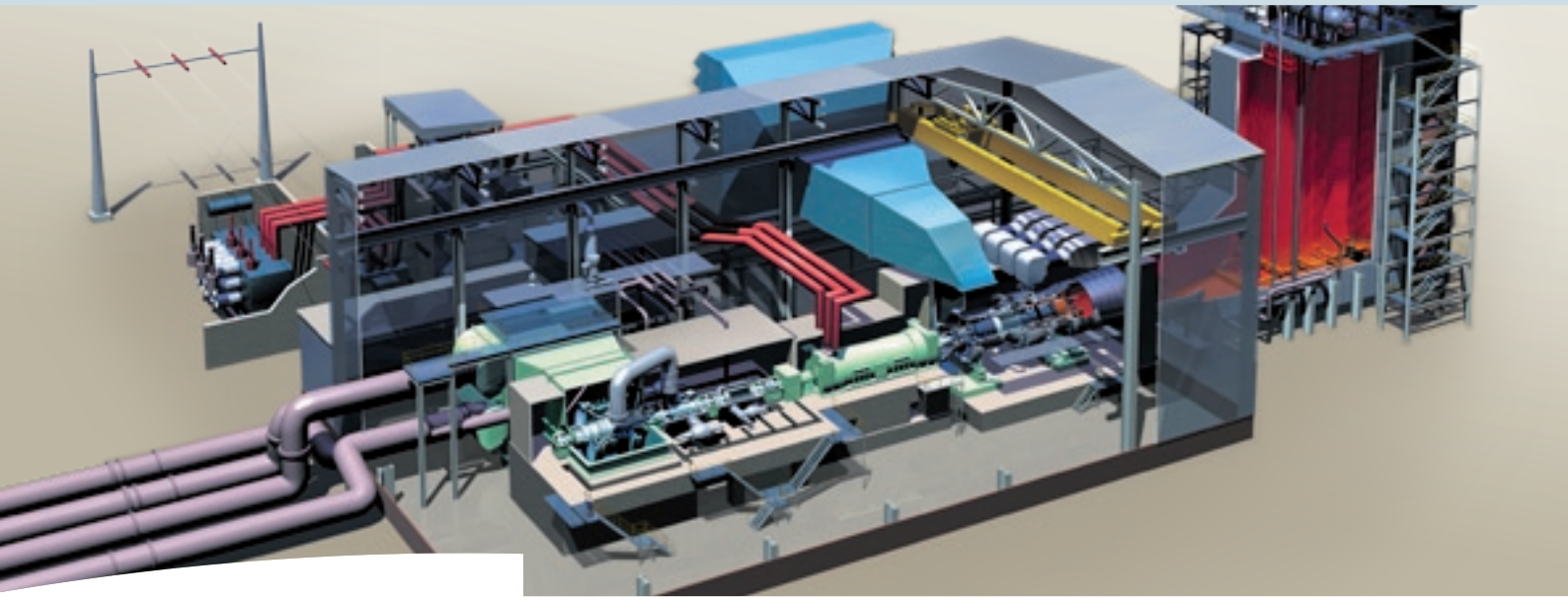
Proven experience

More than 40 KA13E2 combined-cycle blocks installed throughout the world, in a wide range of applications, fuels and configurations, demonstrating very good reliability and availability on fuel gas and fuel oil.

* ORAP is owned by Strategic Power Systems Inc.
(Source: Report Aug 2009)

Combined-Cycle Power Plants

Probably the most flexible power plants in



KEY FACTS

The KA24 and KA26 reference plants have at their cores, respectively, the Alstom GT24 (60 Hz) and the Alstom GT26 (50 Hz) advanced-class gas turbines, featuring unique, sequential combustion technology. The plants offer **leading operational flexibility, highly competitive base and part load performance, reliability and low emissions.**

Main configurations

- **KA24-2 MS** (multi-shaft arrangement), consisting of 2 GT24 gas turbines with 2 Alstom triple-pressure reheat drum-type HRSG's, 1 Alstom STF30C steam turbine, all of them driving 1 Alstom air-cooled TOPAIR turbogenerator
- **KA26-1 SS** (single-shaft arrangement), consisting of 1 GT26 gas turbine with 1 Alstom triple-pressure reheat drum-type HRSG, 1 Alstom STF15C steam turbine, both driving 1 Alstom hydrogen-cooled TOPGAS turbogenerator on a common shaft-line with a SSS-clutch*
- **KA26-2 MS** (multi-shaft arrangement), consisting of 2 GT26 gas turbines with 2 Alstom triple-pressure reheat drum- or once-through-type HRSG's, 1 Alstom STF30C steam turbine, all of them driving 1 Alstom air-cooled TOPAIR turbogenerator (hydrogen-cooled TOPGAS available as option)
- **Alternative configurations for the 50 Hz market:** depending upon customer requirements, Alstom may offer a KA26-1 multi-shaft concept along-with a KA26-3 multi-shaft concept

* SSS-clutch: Self-Shifting Synchronous

Special configurations

- **Cogeneration** configuration (e.g. industry, district heating, desalination) with a wide range of steam extraction capabilities
- **Repowering** (conversion of a simple-cycle into a combined-cycle power plant)

Options

- Power augmentation options up to 10% of plant output through air inlet cooling (evaporative cooling/fogging/high fogging)
- Supplementary firing in HRSG
- Indoor, semi-outdoor or outdoor installation
- Fuel oil capability (as back-up)
- Low Load Operation Capability

KA24/KA26

the high efficiency, advanced class market

Key references

HAI FU
Taiwan
2 x KA24-2 MS – 950 MW

GISSI
Italy
2 x KA26-1 SS – 760 MW

LANGAGE
UK
1 x KA26-2 MS – 885 MW

CUSTOMER BENEFITS

Optimised reference-plant design concept

- Optimised topping and bottoming cycle for high all-round performance at base load and part load
- High cycling capability 'designed-in' for today's dynamic operating regimes
- No requirement for an auxiliary boiler to assist in start-up of the power trains
- No loss of complete power train in the event of a steam turbine trip. In both single-shaft and multi-shaft configurations the gas turbine generator unit continues to operate and generate power, whilst the steam is directed to the steam bypass system until the steam turbine is ready to re-start

Innovative design concepts

- Sequential combustion technology in gas turbines for high all-round performance and flexibility
- The KA26-1 single-shaft plant has Alstom's patented moveable generator-foundation platform for simplified generator rotor removal, when needed for maintenance

Low emissions

Dry low NOx performance (<<25 vppm) over a wide load range (from 100% down to 40% or less) on fuel gas as well as in low load operation

High base and part load performance

The combination of the unique Alstom sequential combustion gas turbine with Alstom's know-how in designing optimised water-steam cycles provides a CCPP that is not only able to deliver high efficiency at base load but also at part load. This means higher customer Net Present Value (NPV) when operating in liberalised power markets demanding high load flexibility.

Excellent fuel gas flexibility

GT24/GT26 gas turbines are able to handle different gas compositions with wide-ranging, high hydrocarbon content and an excellent Wobbe Index tolerance of up to ±10% without the need for hardware changes in the combustion system.

Low Load Operation Capability (LLOC)

- Unique option allows customers to keep the entire combined-cycle plant running during low demand periods at very low load (at about 20%)
- The LLOC offers customers the additional option of parking the plant during off-peak periods (e.g. overnight) at a fixed minimum CCPP load, with low fuel consumption and the possibility of a very fast re-loading
- This proves valuable when market conditions dictate that the plant should remain on-line during low demand periods (such as night time), yet the customer aims to minimise fuel consumption

Industrial Power Solutions:

KEY FACTS

The increasing price of electricity is leading to energy optimisation in steel plants and the use of **Blast Furnace Gas (BFG)** in gas turbines, which is more efficient than in boilers.

The KA11N2 LBtu has been adapted specially to burn waste gases from steel making. These gases can be used very efficiently to generate power and steam. With Alstom's Plant Integrator™ approach, each power plant is tailor-made to site requirements and integrated into the steel plant – to provide maximum value for the steel plant operator, in both 50 Hz & 60 Hz markets.

Alstom's KA11N2 LBtu combined-cycle power plant is the **ideal choice for industrial customers with demand for additional power**. It can be used for **existing or new steel plants**, even where natural gas is very expensive or unavailable.

Steel Industry

KA11N2 LBtu: a reliable, proven power plant for steel mills

Key references

TKS CSA RIO DE JANEIRO
Brazil
1 x KA11N2-2 LBtu – 497 MW

BAO SHAN
China
1 x KA11N2-1 LBtu – 150 MW

MIZUSHIMA
Japan
1 x GT11N2 LBtu Cogeneration – 90 MW

CUSTOMER BENEFITS

Fuel flexibility

- All waste gases from a steel plant can be burned.
- With a minimum LHV of 1800 kJ/kg (660 kcal/Nm3) even pure Blast Furnace Gas (BFG) can be burned
- No need to use natural gas or expensively cleaned Coke Oven Gas (COG) for the gas turbine after start-up
- Independent of natural gas and COG – achieves low fuel cost
- Rugged combustor, high fuel flexibility, with ability to burn mixed gases even at ± 15% calorific variation

Operational flexibility

Stable operation at low and part load conditions (operation of GT from 0 to 100% load on BFG)

High efficiency

- Higher efficiency than conventional BFG boiler/steam turbine solutions
- More power generated from the same amount of waste gas with lower CO_2 emissions per MWh

Low emissions

Low NOx and CO values even at part load

Proven experience

- Successful operation for over 10 years in steel plant applications: first KA11N2 LBtu started operation in 1997, mono-firing BFG LBtu gas
- 21 similar applications using Alstom LBtu-burner technology, with more than 2 million fired hours

Industrial Power Solutions:

KEY FACTS

Aluminium production is power intensive; therefore low-cost electricity is very important.

Moreover, the load of an aluminium smelter changes frequently: load swings occur due to anode effects or trips of pot lines. The power plant supplying the facility must be able to maintain a stable industrial grid frequency, independent of the electrical grid. So the power supply must be very reliable, because pot lines cannot stop operation for more than two hours, or else the aluminium will solidify, requiring an extensive pot line repair.

The KA13E2 provides a unique combination of **robustness, reliability and best-in-class efficiency, enabling low cost power generation for aluminium producers.**

Aluminium Industry

KA13E2: the ideal power plant for the aluminium industry

Key references

DUBAL GTX EXTENSION
UEA
1 x GT13E2 cogeneration – 150 MW

DUBAL PP Ext CCPP22
UEA
1 x KA13E2-2 – 430 MW

SOHAR APP
Oman
2 x KA13E2-2 – 1000 MW

CUSTOMER BENEFITS

Low cost of electricity

Alstom's KA13E2 power plant is based on the GT13E2 gas turbine, which has the highest efficiency in its class and a possible hot-gas-path inspection interval of 36,000 Equivalent Operating Hours (EOH).

Robustness and reliability

- The stable EV (EnVironmental) combustion system and conventional firing temperatures of the GT13E2 support fast load changes up to 6 MW/s – without penalisation of the engine lifetime
- The block size of 250 MW gives high redundancy (N-1 and N-2) even to medium-size plants or retrofits

Flexibility

- The GT controller is optimised for fast load changes in island operation mode. At the same time, the Plant Master controller distributes load between the different units to maximise efficiency
- Several fuels can be used (natural gas, gas with high hydrocarbon content, fuel oil). On-line fuel changeover to fuel oil is possible in the case of a gas shortage

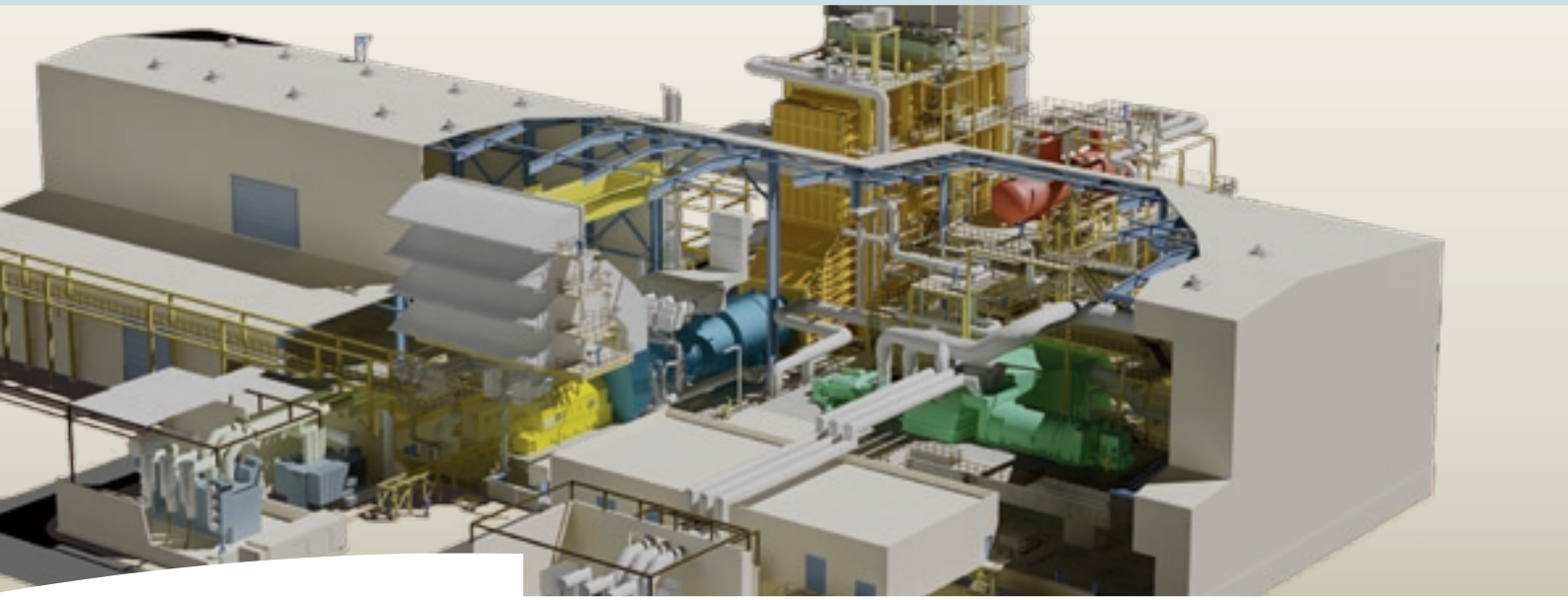
Modularity

- For additional power, several augmentation options and peak firing capability are available
- Phased construction capability allows fast construction and start of plant operation in simple-cycle operation

Proven experience

- The KA13E2 is well proven in the aluminium industry: 6 dedicated plants power smelters, representing 14 GT13E2 units
- Alstom Power's customers include major aluminium producers such as ALBA, DUBAL, SOHAR Aluminium and Rio Tinto Aluminium

Industrial Power Solutions: **Desalination, District**



KEY FACTS

Preservation and efficient use of natural resources are important. Cogeneration is a very efficient way for combined generation of electricity and heat (steam). Very high fuel utilisation – as high as 90+% – is being achieved with the use of waste heat from power generation.

Cogeneration plants based on Alstom equipment operate in many industries requiring both power and steam:

- Desalination
- District heating
- Chemical and petrochemical plants
- Refineries and oil & gas production
- Pulp and paper
- Other processes requiring heat (e.g. hot water production for Liquefied Natural Gas (LNG) terminals)

All Alstom combined-cycle gas power plants are suited for cogeneration applications, with **successful references all over the world.**

Cogeneration for Heating, Steam for Industries

Key references

MOSCOW TPP26
Russia
1 x KA26-1 MS – 420 MW
District heating

FUJAIRAH F2
UAE
2 x KA26-2 and 1 x KA26-1 – 2000 MW
Steam for desalination

GRAIN
UK
3 x KA26-1 SS – 1275 MW
Hot water for LNG terminal

CUSTOMER BENEFITS

Higher efficiency

- Use of waste heat from power generation gives higher efficiency (up to 90% and above) than separate power and heat production
- Lower cost of electricity and heat

Additional revenues

- Two separate revenue streams: power and heat
- Lower risk for owner/operator, compared to dependence on power or heat only

Green power

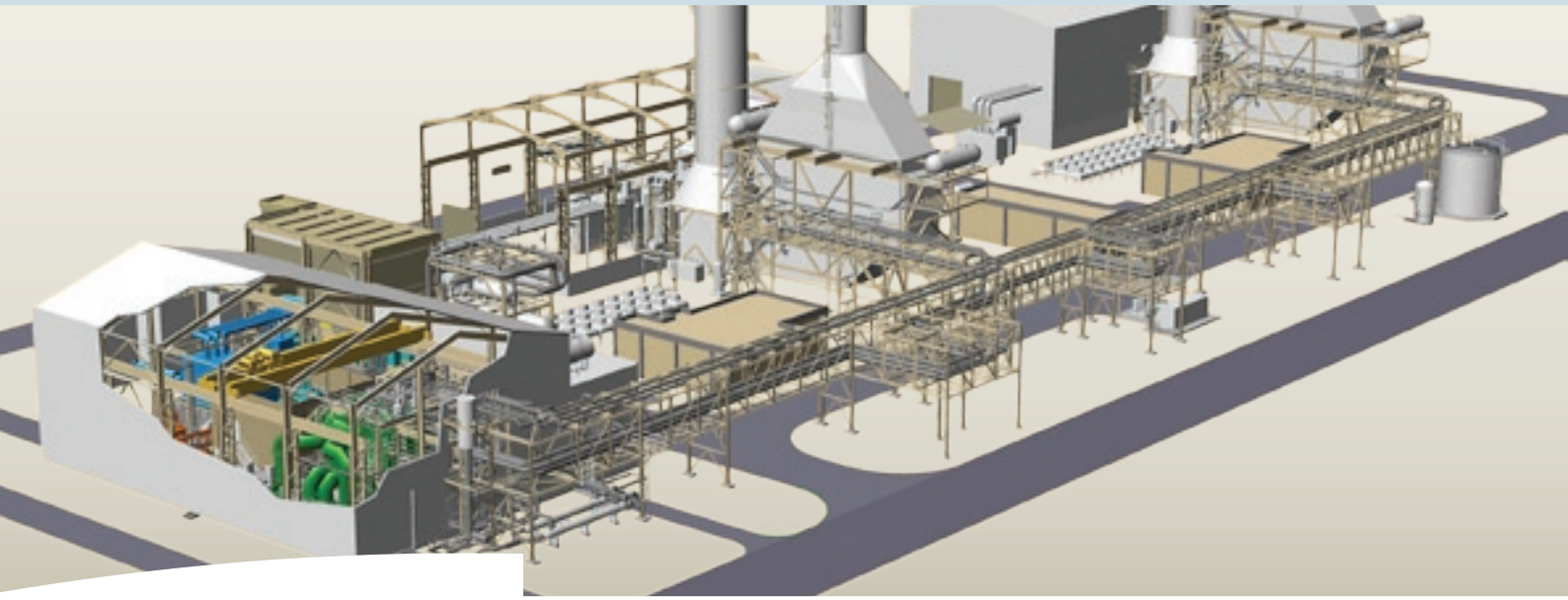
Environmentally-friendly power and heat production, with certificates of origin for produced power available in the EU under the Cogeneration Directive

Optimised concepts

- Large operational range of power plants from 100% load to below 40%
- Gas turbine with high efficiency, even at part load (3 compressor inlet guide vanes to maintain high GT exhaust temperature, sequential combustion)
- HRSG specially designed for cyclic operation, as needed in cogeneration applications
- Steam turbine with controlled steam extraction, providing flexibility between power and steam production
- Single-casing condensing steam turbine with controlled steam extraction – a highly efficient, compact and proprietary design
- Heating condenser specially designed for district heating, or special condenser for warm water production to recover additional heat

Add-on

Conversion of a simple-cycle into a



KEY FACTS

Add-on means conversion of a simple-cycle plant into a combined-cycle plant. A so-called “steam tail” is integrated into an open cycle GT plant. Main equipment of add-on are heat recovery steam generator (HRSG), steam turbine and related generator. An add-on increases power and efficiency of the plant, with no additional emissions and no additional fuel consumption.

With great experience as a manufacturer of customised steam turbines, Alstom offers steam turbines that fit optimally with the characteristics of every gas turbine currently in operation. The company also has capacity to integrate all additionally required equipment (Balance of Plant).

Alstom can supply **add-on retrofits of existing simple-cycle power plants from 10 MW upwards.**

Offering

Alstom’s add-ons, based on the company’s large steam turbine portfolio, include:

- **Equipment** → Steam turbines: COMAX STF15C and STF30C, from 80 to 400 MW, and steam turbines GRT or MT, from 10 to 80 MW
  → Associated Alstom turbogenerator and HRSG
- **Construction** → Installation and commissioning, depending on customer requirement

combined-cycle power plant

Key references

CONDOR/KESTREL
Dubai
125 MW add-on for 2 x GE 9E

PHU-MY
Vietnam
170 MW add-on for 2 x V94.2

OKPAI
Nigeria
160 MW add-on for 2 x GT13E2

CUSTOMER BENEFITS

Increased efficiency
And decreased fuel-related specific operating costs (€/MWh)

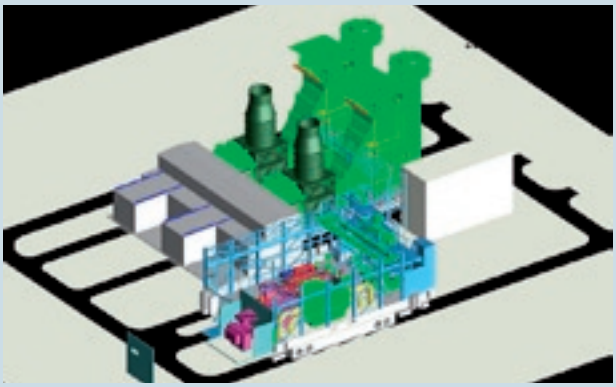
Increased power output
Plus additional revenues from additional power generated

Low emissions
Lower NOx/CO/CO_2 emissions per kWh

Flexibility
Flexible operation and fast start up capability (in case of bypass stack) are maintained

Proven experience
- 17 add-ons installed since 1990
- Almost all add-ons executed as turnkey projects, integrating Alstom and non-Alstom gas turbines with Alstom high efficiency steam turbines

Add-on concept

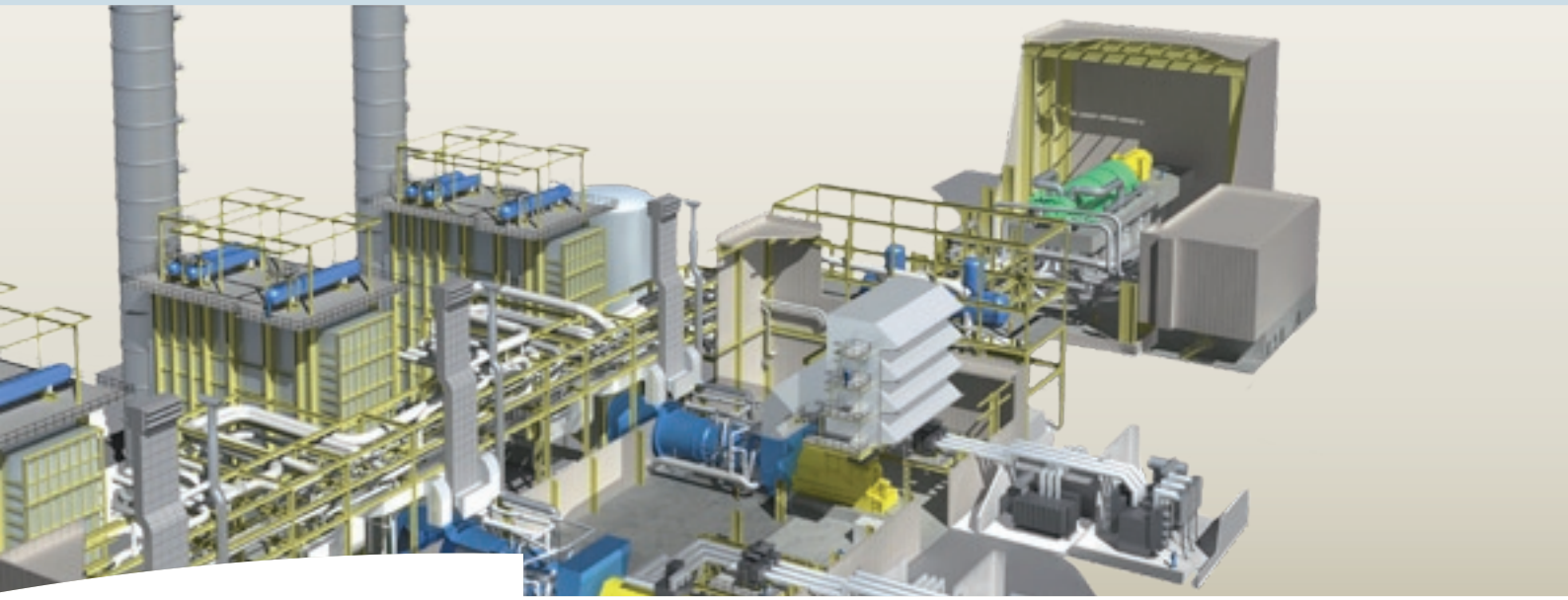


In colour
The main add-on equipment (including bypass stack, HRSG, steam turbine, Balance of Plant and civil structures)

In grey
The existing plant equipment (2 gas turbines, gas turbine hall and control room)

Repowering

Transformation of a steam power plant into a



KEY FACTS

Repowering includes the installation of new gas turbines, turbogenerators and Heat Recovery Steam Generators (HRSG's). The original steam turbine, cooling system and some additional plant equipment/ infrastructure are retained.

There are 2 types of repowering:

- **Hybrid repowering:** The existing boiler remains in operation besides the new HRSG
- **Full repowering:** The existing boiler is decommissioned or removed to re-use the space

Alstom can **repower existing steam power plants** with turbines from 50 MW (60 Hz) / 80 MW (50 Hz).

Offering

- **Equipment** → Gas turbine(s) based on Alstom portfolio (GT26, GT24, GT13E2, GT11N2)
  → Associated turbogenerator and HRSG
  → Retrofit capability of any OEM steam turbine
- **Engineering** → Integration of new equipment onto existing steam plant components
- **Construction** → Installation and commissioning, depending on customer requirements

combined-cycle power plant

Key references

CLAUS C
The Netherlands
1 x KA26-3 MS – 1280 MW at 59%
net eff. from 640 MW gas fired STPP

SENOKO
Singapore
1 x KA26-1 MS – 360 MW +
2 x KA26-1 MS – 740 MW at 56%
net eff. from 3x 120 MW oil fired STPP

BAYSIDE
Canada
1 x KA24-1 MS – 265 MW at 56%
net eff. from 100 MW oil fired STPP

CUSTOMER BENEFITS

Huge efficiency increase
And up to 40% decrease in fuel-related specific operating cost

Increased power output
And additional revenues from additional power generated (up to +200%)

Low emissions
Less NOx/CO emissions per kWh (less SOx in case of fuel conversion from oil or from coal), plus lower CO_2 emissions per kWh

Flexibility
- Operating flexibility (easy part-load operation and load-swing handling)
- Fuel flexibility (in the case of hybrid repowering)

Longer lifetime
Repowering allows customers to modernise and therefore extend the lifetime of his existing plant. Main equipment can be re-used, including the steam turbine, associated steam path and cooling system (cold end).

Minimised investment
- Reduced investment compared to a new plant
- Easier and faster permitting than required for a new plant
- Less space required than for a green field plant

Proven experience
- 15 repowered plants, located around the world
- Overall repowered capacity of 7730 MW
- Recent plants include GT26, GT24, GT13E2 and GT11N2 gas turbines, at both 50 Hz and 60 Hz
- Integration of new gas turbines with existing Alstom or non-Alstom steam plant equipment

A Entire Range of
Services Over Life Cycle

Alstom offers **extensive service solutions** in power generation based on our **comprehensive knowledge** of product and component integration and our **global fleet experience**. From spare parts supply to full plant operation, **we offer effective solutions for gas turbines and combined-cycle plants**, for our own fleet and for other manufacturers' plants.

With 17,000 service specialists in over 60 local service centres covering 70 countries, we provide local expertise and facilities to meet customers' needs.

We also innovate. Alstom's commitment to service and product R&D allows us to deliver cutting-edge solutions, not only enhancing efficiency and reducing life-cycle costs, but also minimising environmental impact.

Our service offering includes:

- **Parts & upgrade solutions – to improve competitiveness constantly over the whole plant life cycle.** We offer highest quality and state-of-the-art technology for performance upgrades, life-cycle cost optimisation, lifetime extensions and emission reduction packages.
- **Field services – global competence, local presence:** Our vast technical and outage management experience allows us to service, upgrade or repair customer plants all over the world.
- **Reconditioning services – repair technology leadership that puts quality first:** Extending operating life of hot-gas-path components is key to optimising plant life-cycle economics and minimising total cost of ownership.
- **Plant services – total plant knowledge for integrated solutions:** From initial studies or plant assessments to selecting new technologies to project execution, Alstom's Plant Services are tailored modular packages that identify specific measures to increase a power plant's profitability.
- **Service contracts – customised solutions in long-term partnerships:** Alstom's long-term service contracts are tailored to meet all our customers' operational, maintenance and support requirements. They are flexible in scope of services and equipment covered as well as in contract duration and risk sharing.

Best-of-Class
R&D Capabilities

Alstom's R&D is **market and customer oriented**, focused on **creating innovative technologies** for all stages of our products' life cycles.

We aim for **best utilisation of customers' investment**, through efficiency, availability and cost reduction. Increasing environmental concerns have lead Alstom to focus on minimising CO_2 emissions through development of **technologies that can be applied in new and retrofit installations**.

Alstom Power employs 4000 people in engineering and 1500 in R&D in over 20 R&D centres. There are more than 10 laboratories with dedicated infrastructure, equipment and testing facilities.

Alstom Power's R&D takes a global approach that generates several benefits. First, it places work where the expertise is. Second, it nurtures close contacts to universities and design institutes that complement our in-house efforts. Third, it enables Alstom teams to **stay in touch with global customers' expectations, to anticipate their needs and to lead trends in technology**.

Alstom Power works with more than 30 universities worldwide. Long-term links are established with the Massachusetts Institute of Technology (MIT), Stanford Research Institute on CO_2, Grenoble and Lausanne universities on hydro turbines, Cologne's Deutsches Zentrum für Luft- und Raumfahrt (DLR) on combustion, Oxford University on heat transfer and with engineering institutes in China, India and Russia.

As an international collaboration, Alstom Power has played a **leading role in establishing the European technology platform for Zero Emission fossil fuel Power generation (ZEP)**.

The gas turbine test power plant

Located in Birr, Switzerland, this provides a unique environment for maintaining Alstom's competitive advantage through product improvement, and it is close by to Alstom's R&D facility, the gas turbine development department and the manufacturing plant. The test facility has a dual fuel GT26 and a dual fuel GT8C2 gas turbine, both operating in simple-cycle mode and dispatching to the Swiss electrical grid.

The shortened feedback loop (in time and distance) of field experience speeds design validation and implementation in Alstom's gas turbine fleet. The test plant, together with the product support organisation and the GT development department, allows Alstom to insure seamless implementation of evolutionary product improvements, based on the GT24/GT26 fleet experience.

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