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THE EVOLVING TRANSFORMATION OF GAS-FIRED POWER PLANTS TOWARD A SUSTAINABLE AND PROFITABLE GENERATION SYSTEM

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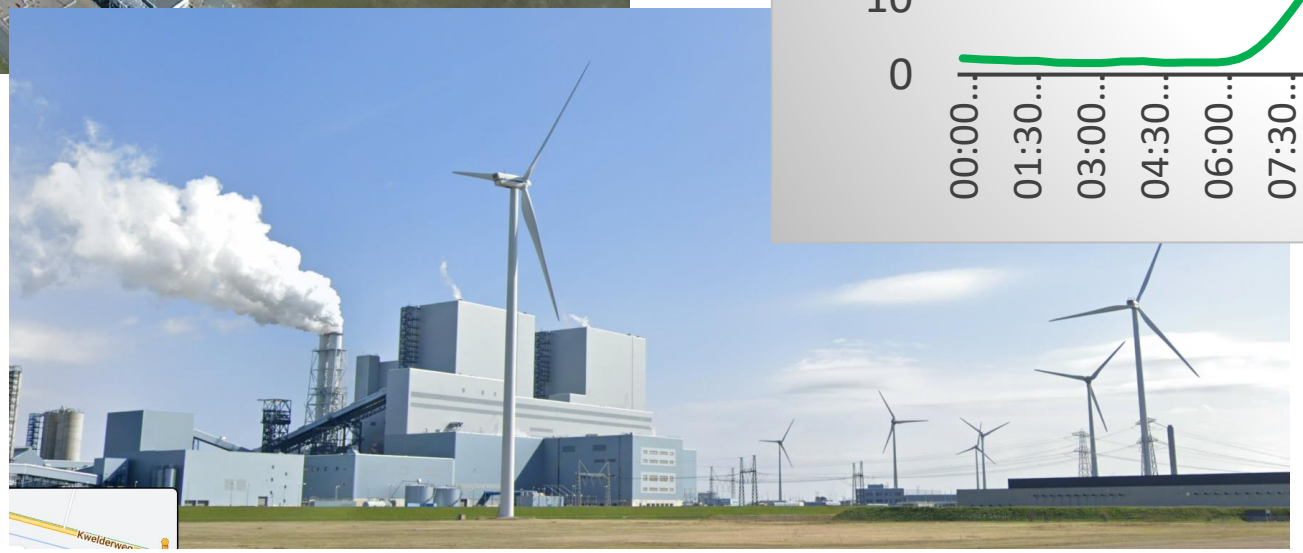
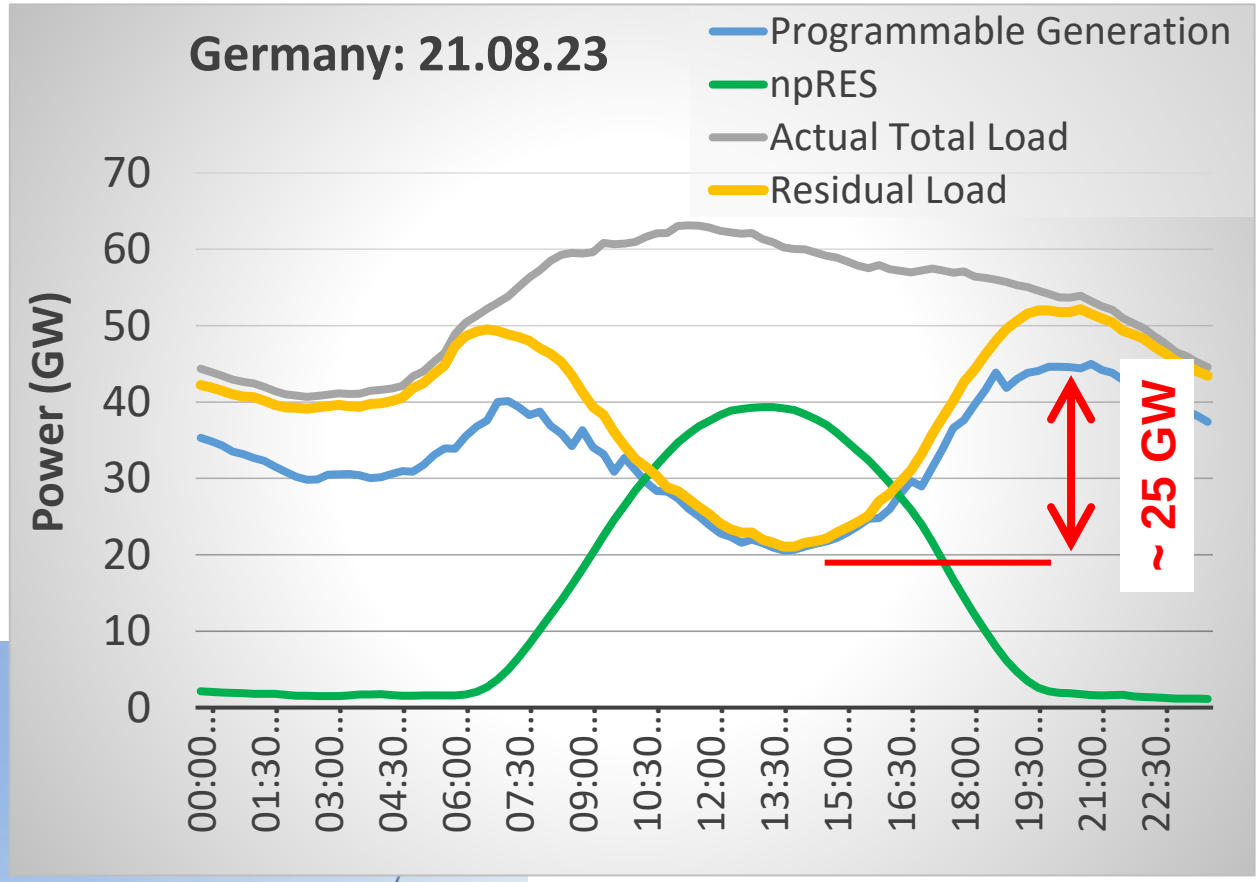
CCGT: from Duck Curve to Canyon Curve





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THE EVOLVING TRANSFORMATION OF GAS-FIRED POWER PLANTS TOWARD A SUSTAINABLE AND PROFITABLE GENERATION SYSTEM

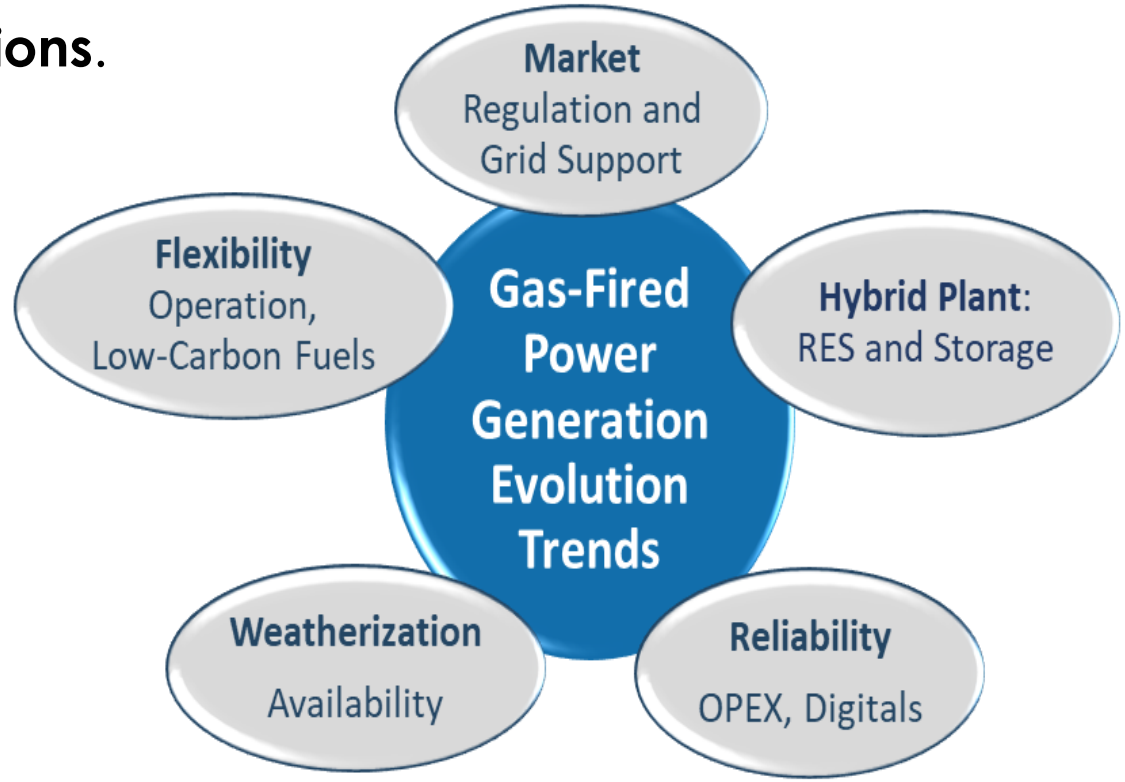
Content

GAS-FIRED POWER GENERATION CHALLENGES AND EVOLUTION TRENDS

Gas-fired power plants will have to meet more stringent performance **requirements**, environmental **constraints**, and updated **regulations**.

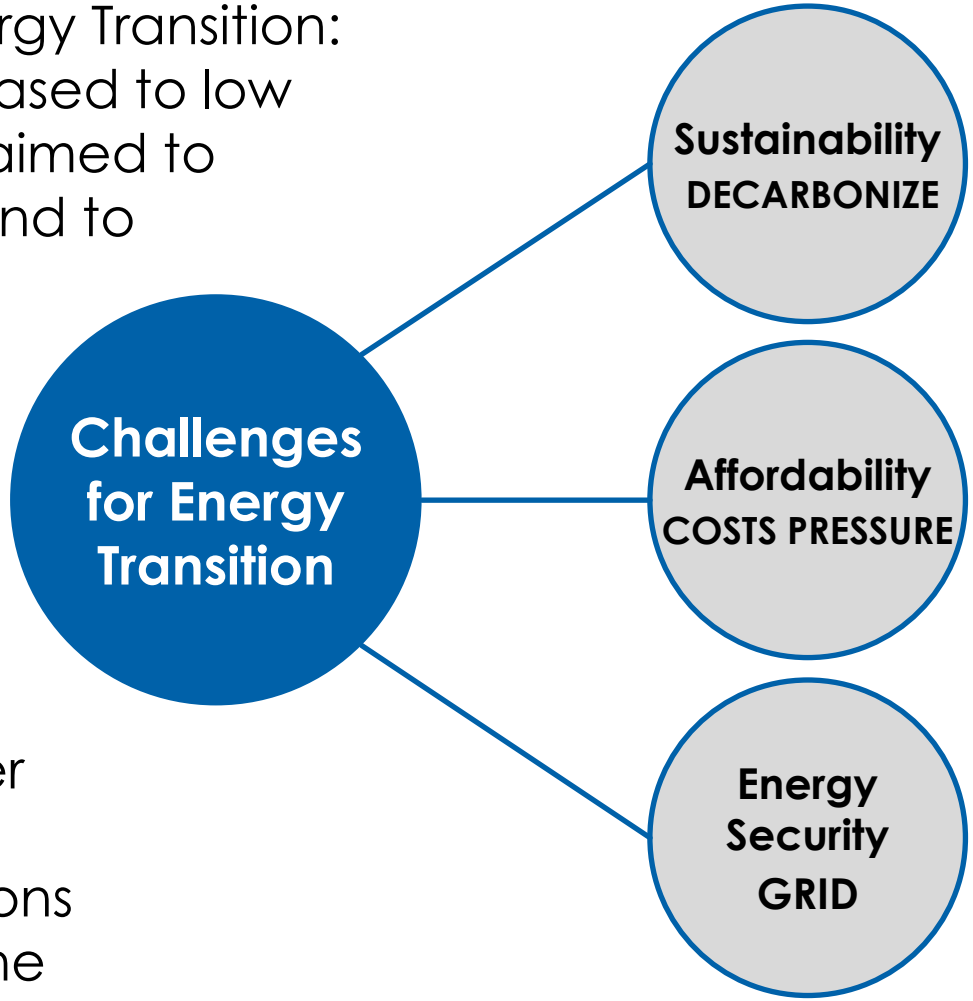
New or updated capabilities:

- Improved plant flexibility and reliability: minimum-load and part-load performance.
- Increased revenues and reduced operation costs.
- Ability to stack multiple revenue streams: grid support and ancillary services.
- Plant hybridization and operation optimization: energy storage and coupling with RES.
- Use of non-fossil fuels: (green) hydrogen, e-fuels, biofuels.
- Resilience to extreme weather conditions: cold / hot.



TRANSITION AND ENERGY TRILEMMA

Power generation and Energy Transition: transformation from fossil-based to low or zero-carbon electricity, aimed to reduce carbon emissions and to mitigate the effects of climate change.



- Efficiency Improvement
- Fuel flex and switch to Hydrogen
- Renewables - Hybridization

- Advanced Plant Operation
- Digital Services

- Storage
- Capacity
- Ancillary Services
- Adequacy

In the pathway toward the Energy Transition, power generation faces the big challenges of finding solutions to cope with each leg of the Energy Trilemma.

LANDMARK EXPERIENCES

FUTURE-PROOFING GAS POWER PLANTS

Different (but complementary) routes toward future-proofing the new and existing gas power plants have been adopted by Ansaldo during last years.

For each approach, a related landmark AE project is presented.

These landmark cases are exemplary accomplished projects, and they are the result of the synergy between the Research and Development strategies and directions and the multi-decade knowledge and capability on the design, construction, and management of a large fleet.

1. Hydrogen Pilot Project

2. AE94.3A Peaker

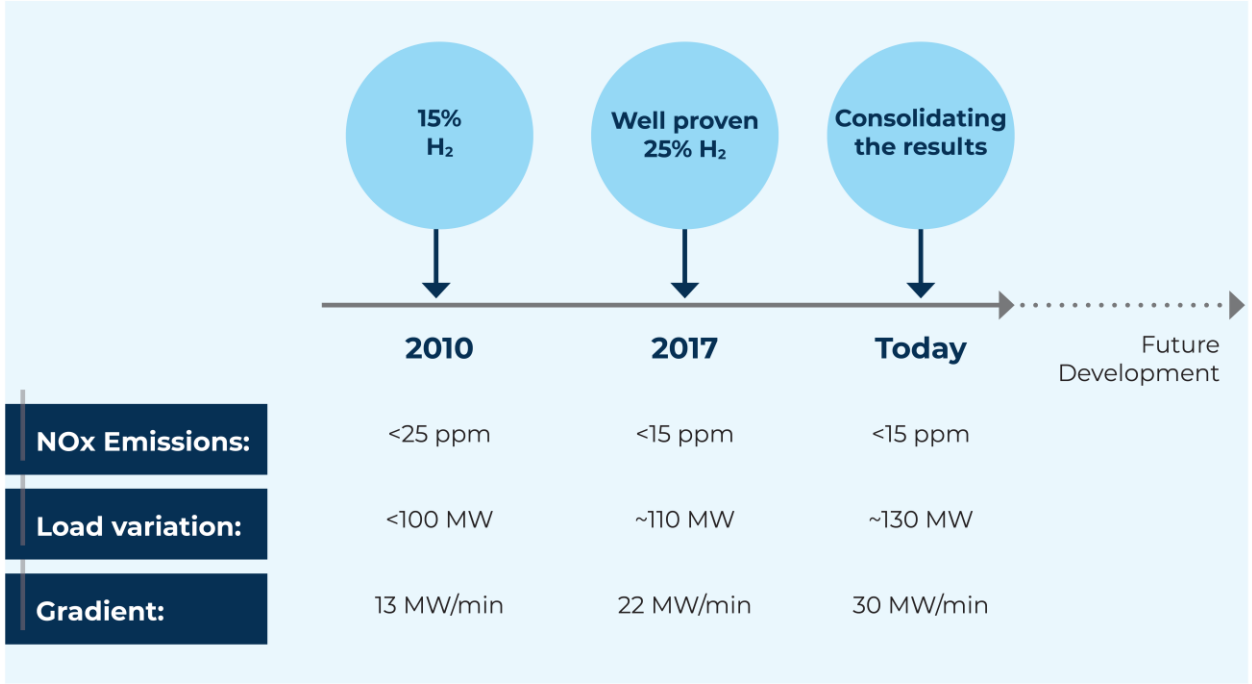
3. GT26 Enhanced Flexibility Package

4. Plant Renewal and Replacement

#1 - HYDROGEN PILOT PROJECT

- Since 2006, Ansaldo Energia is partnering with a major Customer to feed with a hydrogen-enriched NG in two of the plant's AE94.3A units (Southern Italy).
- OffGas (OG) is a waste gas produced by nearby refinery plant, mainly including H_2 and Light Hydrocarbons.
- The H_2 content in OG can vary, according to the refinery process.
- The two units are in commercial operation since 2006, with different H_2 mixture in premixed mode.

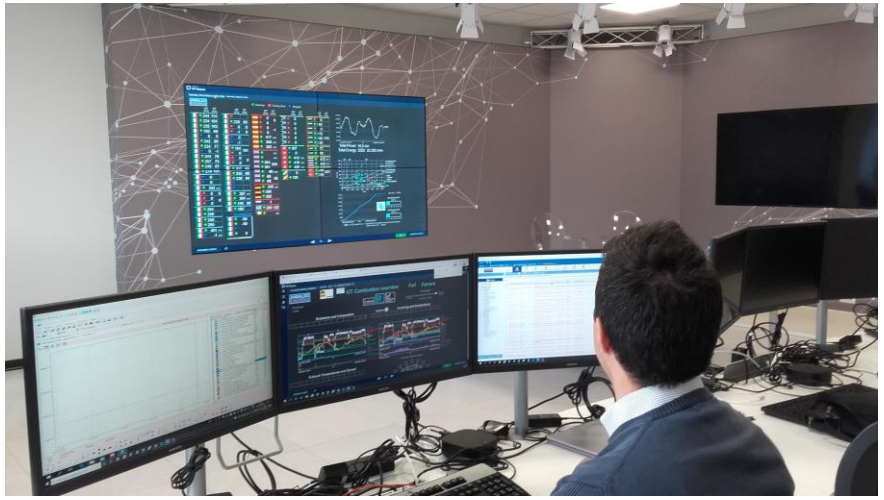
Hydrogen Pilot Project roadmap and achievements.



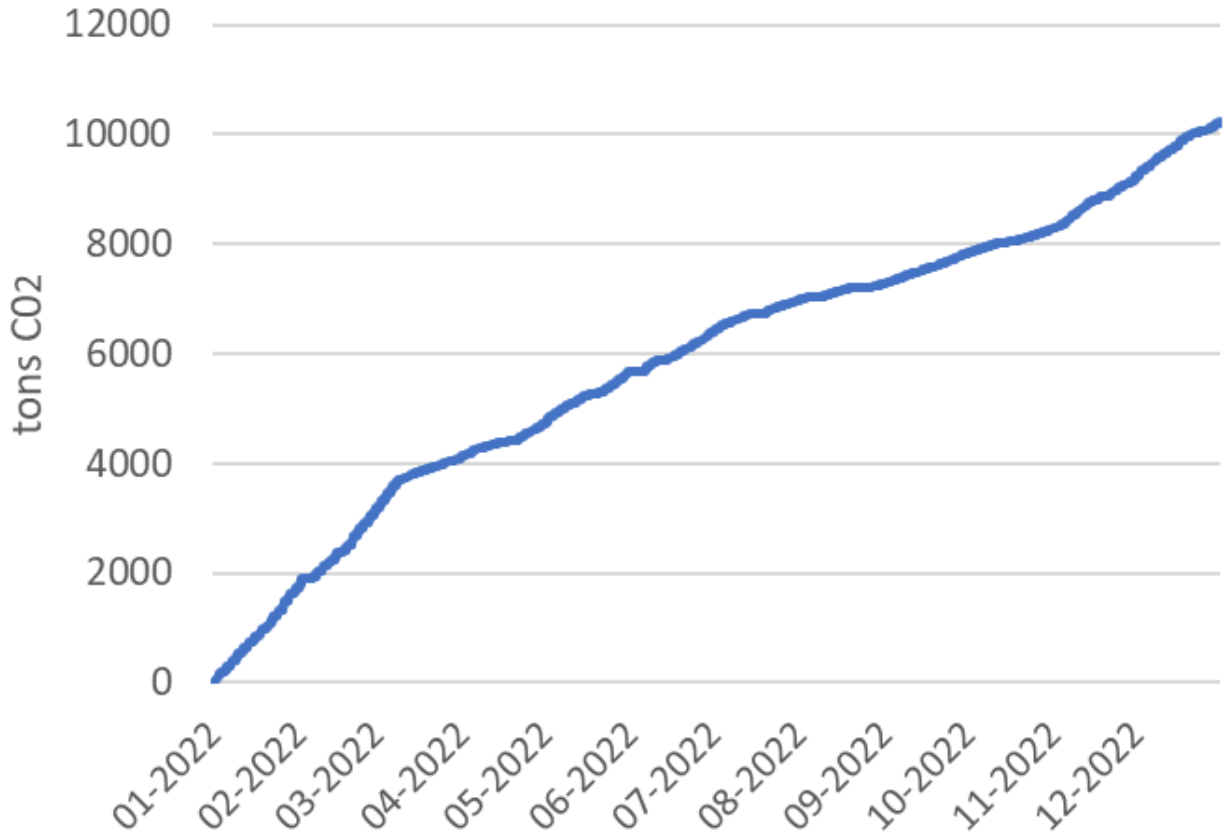
#1 - HYDROGEN PILOT PROJECT

Project's Outcomes

2 units are safely operating with a record of more than **265.000 EOH** and more than **670 starts**, burning a OG-NG mixture containing H_2 between 15% and 26% vol.



IPS control room in Genoa main AE facility.

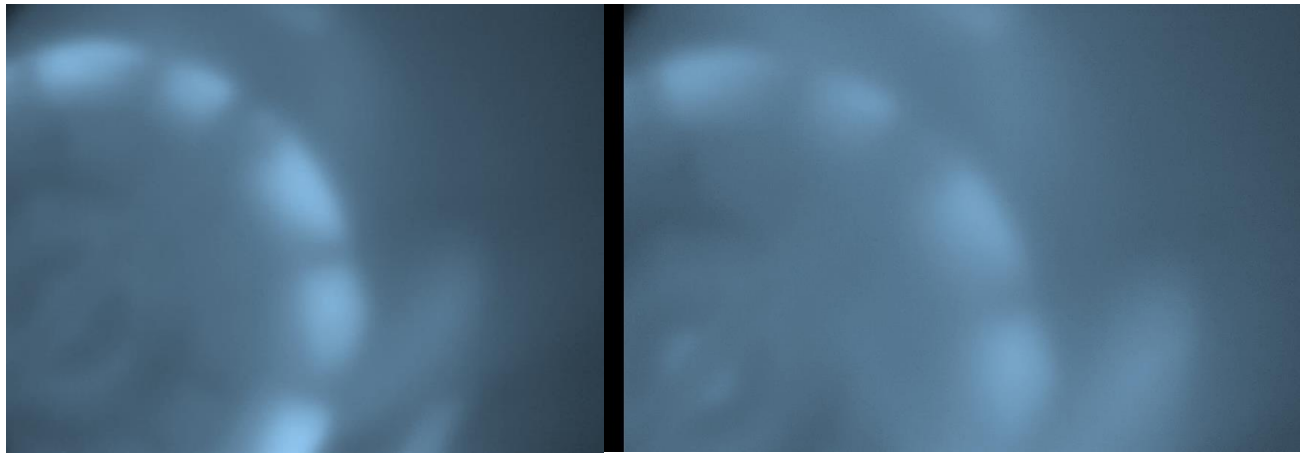


Pilot power plant: **10220 tons** overall saved CO_2 emission during 2022.

#1 - HYDROGEN PILOT PROJECT

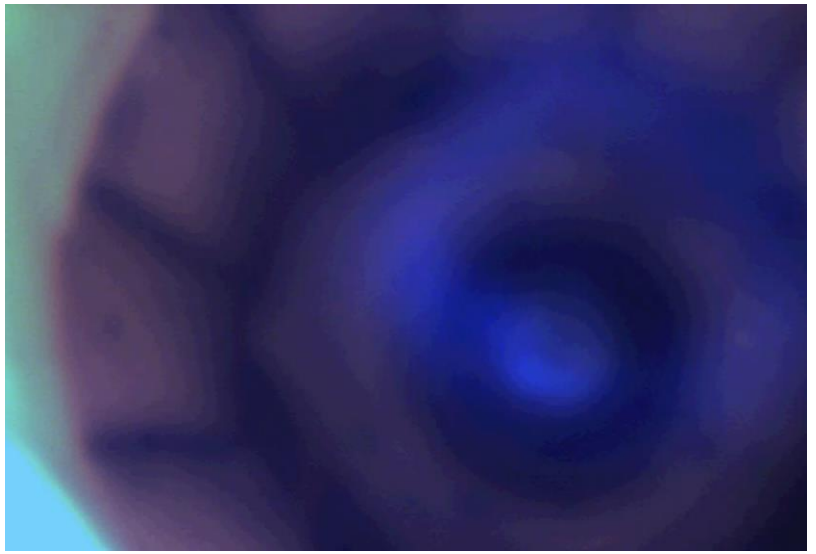
High Pressure Rig Tests

- H2 to all burner lines
- Operation with maximum H_2 content achieved: 50%vol. H_2 without derating
- Minimal or no increase in NOx emissions up to 30% vol. H_2.



0%vol. Hydrogen

40%vol. Hydrogen



50%vol. Hydrogen

Camera-taken flame inside the actual GT burner

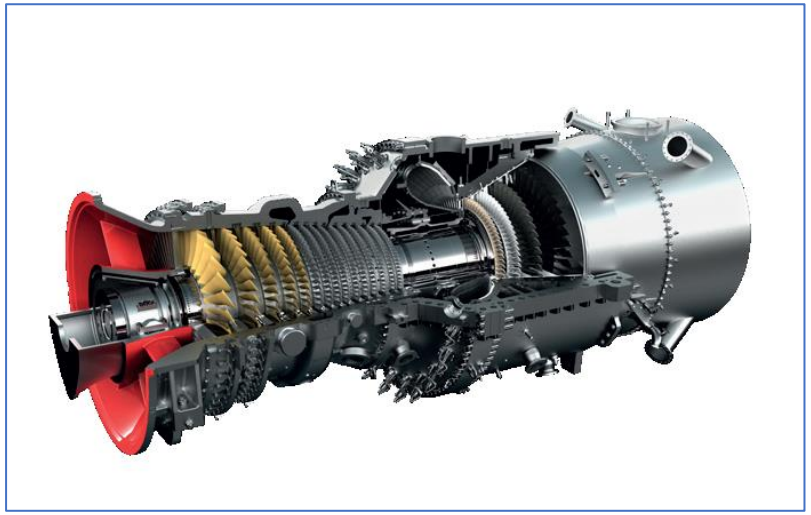
#2 - AE94.3A PEAKER

A new AE94.3A unit has been recently put in open-cycle operation in Southern Germany for a main energy Utility

- AE worked as the EPC contractor and equipped the plant with AE94.3A gas turbine, generator and auxiliary systems, for a total power of 300 MW.
- The plant is part of the German TSO TenneTgrid reserve project (bnBm) and aims to ensure a reliable supply of electricity, as part of the country's transition strategy, which requires ever-growing support for the stability of the grid.

Project:

- Site: open-cycle power plant (Germany)
- Gas Turbine: AE94.3A
- New plant
- Plant Operation: reserve



The AE94.3A gas turbine

#2 - AE94.3A PEAKER

- The plant requirements include the ability of a fast start-up to ramp up from "ready-to-start" GT condition to full Base Load within **26 minutes**.
- **AE94.3A** is a fast-start gas turbine: it can quickly reach baseload via a steep load ramp up to **45 MW/min**.
- The gas turbine is fired by natural gas, adopts best-in-class combustor technologies, and is required to achieve low NOx emissions within **35 mg/Nm^3**.
- The AE94.3A light rotor and radial clearance gap optimization during transient phases result in balanced thermal distribution throughout the entire engine. When combined with extreme operating simplicity, this gives the GT high cycling **capability** and plant **availability**.

- With its **extended time** between maior overhauls (up to 5 years, depending on operating conditions), the durability of hot gas path parts and quick on-site activities, the AE94.3A has a beneficial effect on **operating and maintenance costs**, and offers the most profitable solutions for peaker plants.

#3 - GT26 ENHANCED FLEXIBILITY PACKAGE

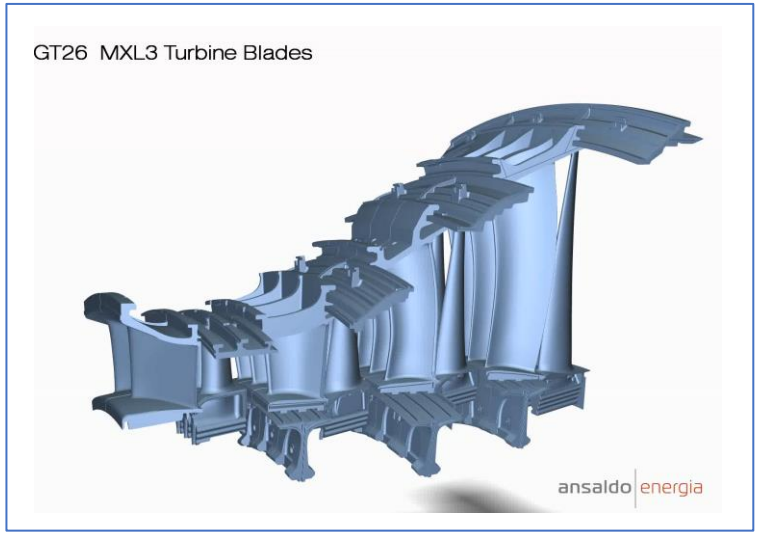
AE MXL3 PACKAGE

Project:

- Site: combined-cycle power plant (Netherlands)
- Gas Turbine: GT26
- Plant Operation: intermediate cycling regime
- MXL3 installation: during a scheduled major inspection.

MXL3 Package Performance and Purpose:

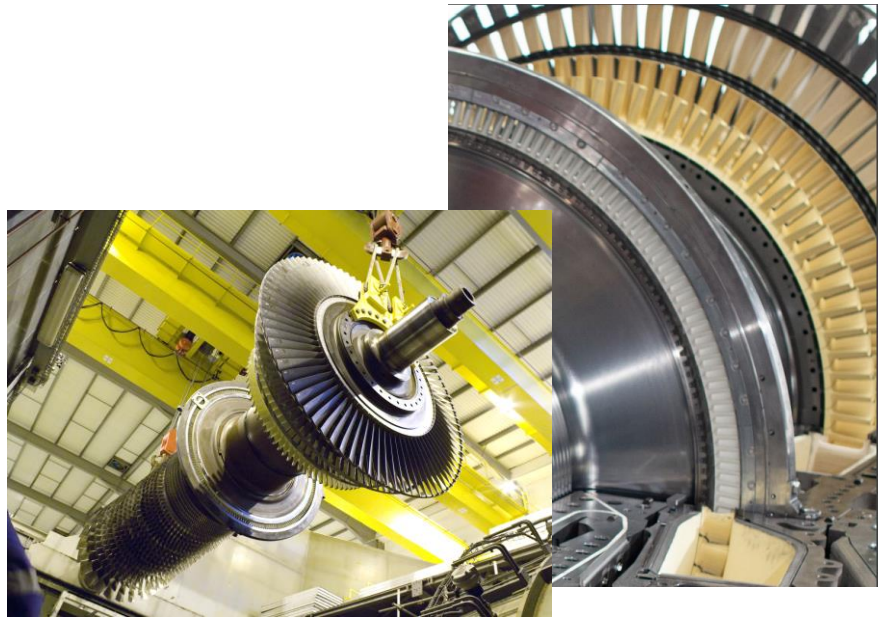
- increased power and efficiency
- reduced CO_2 footprint
- H_2 co-firing readiness (up to 45%vol)
- reduced maintenance costs

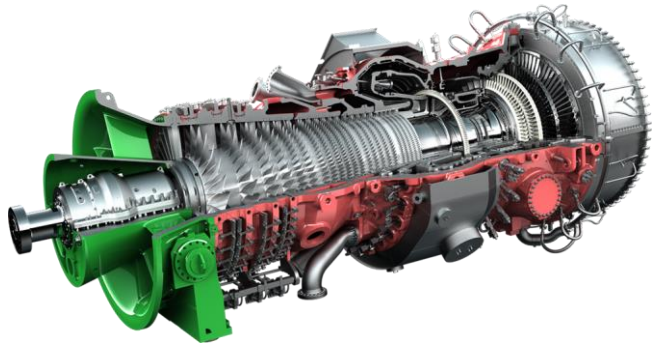


#3 - GT26 ENHANCED FLEXIBILITY PACKAGE

AE MXL3 PACKAGE

- **MXL3 Package** grants power plant operators the full benefits of performance, extended turndown ratio and high availability.
- It allows extensive **operational flexibility** by switching between 'performance' optimized M mode and 'maintenance cost' optimized XL mode, depending on the market requirements.
- In **M mode**, power output in combined-cycle can be increased by up to 35 MW and the efficiency by up to 1.6%. Maintenance intervals are extended by 4000 operating hours.
- In **XL mode**, maintenance intervals are further extended up to 12000 operating hours, resulting in increased availability and a reduction of maintenance costs. The overall plant power output can be increased by up to 22 MW and the combined-cycle efficiency by up to 1.3%.





The GT26 gas turbine

#3 - GT26 ENHANCED FLEXIBILITY PACKAGE

MXL3 upgrade key points

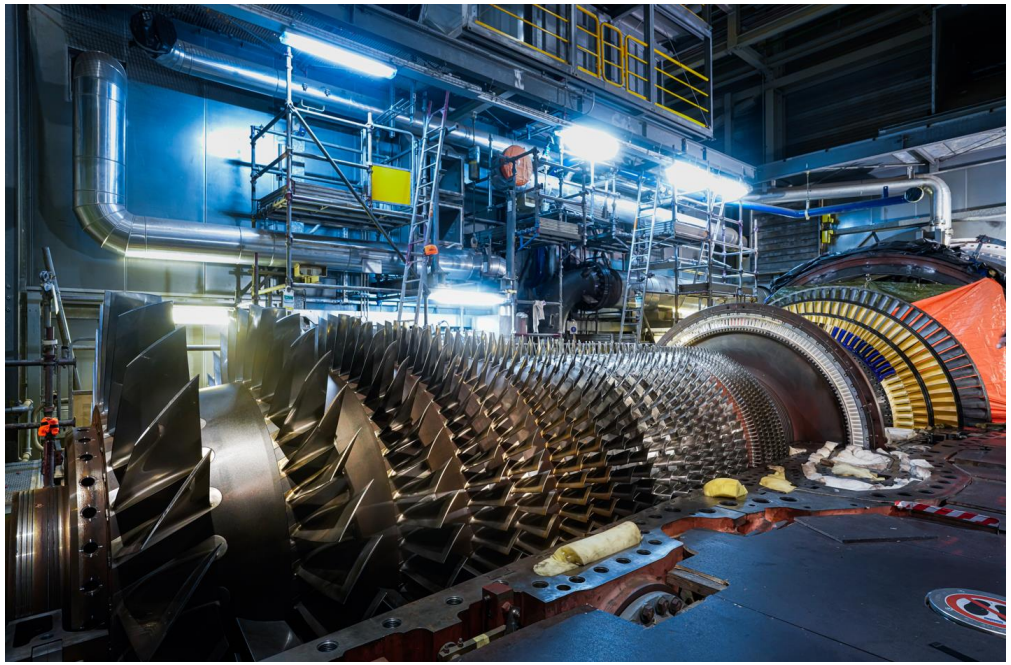
- Boundary conditions remained the same
- GT upgrade only, no plant modifications

- F-class upgrade - Injected latest H-class technology
- Exploited the plant limits margin of existing CC units

- Maximization of efficiency for carbon footprint and OPEX reduction

- H2 ready – Possible up to 45% vol.

- Maximum performance or extended maintenance interval
- Flexibility to reduce maintenance cost, by extended intervals

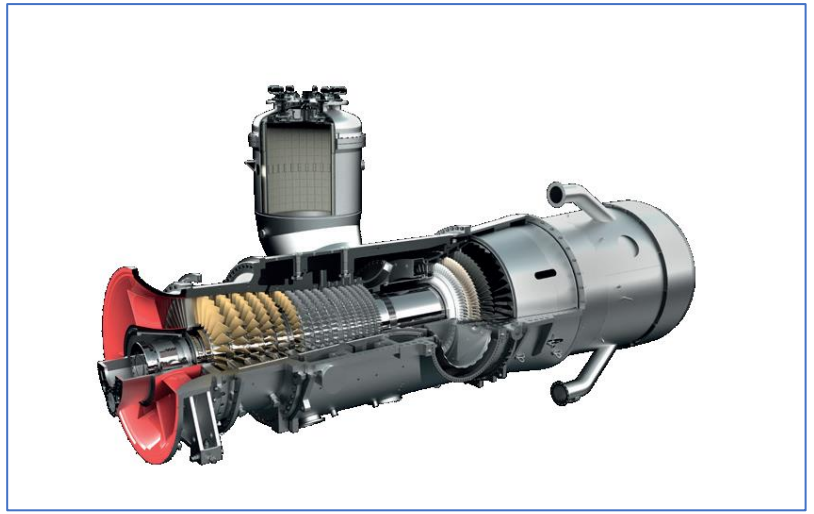


Advantage	
Increased Power Output	☑
Increased Combined Cycle efficiency	☑
Increased part load efficiency	☑
Maintenance cost reduction	☑
Intervals extension	☑

#4 - PLANT RENEWAL AND REPLACEMENT

Project

- Site: CHP power plant (Italy)
- Gas Turbine: AE94.2
- Plant Operation: Base Load
- Gas Turbine replacement



The AE94.2 gas turbine

Main project milestones and achievements

December 2016	Supply Contract and Notice to Proceed signed
September 2017	Beginning of commissioning activities
November 2017	Gas turbine first firing
January 2018	Performance Guaranteed Tests successfully performed
January 2018	Issue of Provisional Acceptance Certificate

#4 - PLANT RENEWAL AND REPLACEMENT

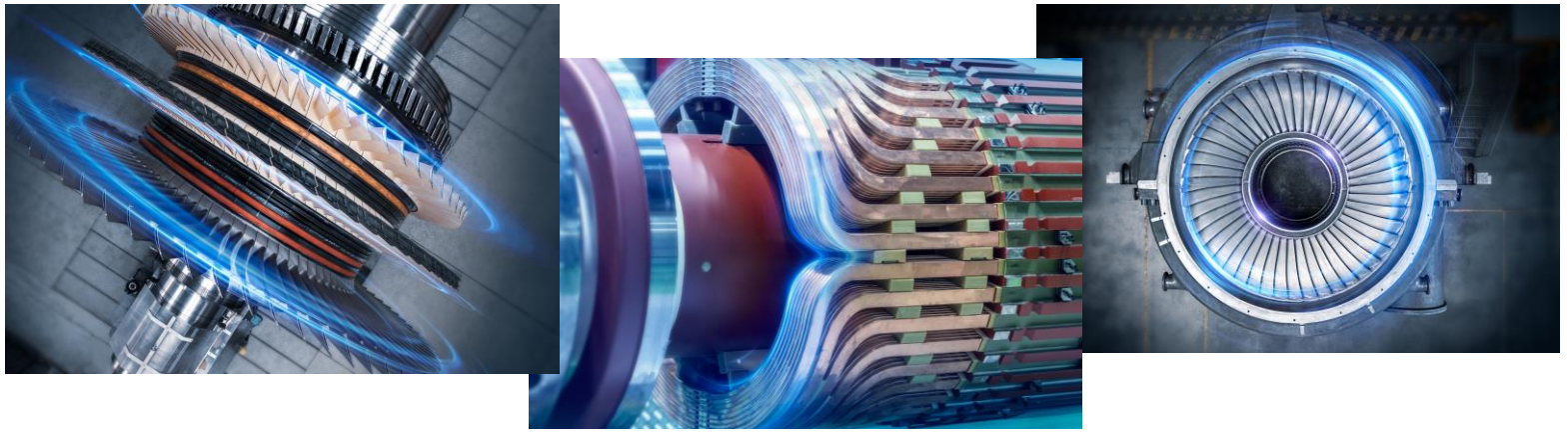
Project Details and Achievements

- The upgraded plant configuration features the new GT1 unit connected to the existing HRSG, with **all the steam** being delivered to the chemical plant: the old ST has been removed.
- Project implementation requirements: carrying out the works within a **very short timeframe**, in narrow or **confined spaces** and giving top priority to workforce **safety**.
- An **optimized** activities **schedule** was adopted to minimize the overhaul timing and reduce the off-line of the system.
- The final engine **fully complied** customer's requirements, constraints and targets and it **overcame** the guaranteed contractual performance.

Gas Turbine performance after replacement	
Type	Ansaldo Energia AE94.2
Fuel type	Natural gas
Final Gross Electrical Power	Above guaranteed values
Final Gross Efficiency	Above guaranteed values

CONCLUSIONS

- The **Target** of gas-fired power generation plants is to keep providing, in the next and medium-term future, the **reliable supply** of **programmable power** to the grid, to **profitably** participate in the electricity market and to ensure the **safe operation** of the power system.
- A **Suitable Combination** of advanced engine and controls upgrades, innovative operation schemes and smart fitting with storage systems will allow existing and new gas-fired power plants to keep their role in the **dispatching** and regulation **merit order**.
- The **OEMs** must provide the Customers with **updated power** solutions able to fulfil the market requirements and the evolving energy scenarios through the **continuous development** of their products.



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