

DOOSAN POWER SERVICES

Catalogue
2019



Doosan Power Services Total Solution Provider

In order to cope with ongoing changes and fluctuations in demand for power, as well as stricter environmental regulations, Doosan continues to make existing power plants more economical and environment-friendly by developing comprehensive and affordable solutions across the entire range of power services and products.

Our expertise is built on many decades of experience in the manufacturing and innovation of power plant equipment. The production knowledge that we have accumulated in that time is incorporated into our product designs today, helping us to deliver reliable, efficient, and innovative technologies and unique, tailor-made power solutions.





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Interactive PDF This catalogue has been published as an interactive PDF, allowing readers to move quickly and easily to reference pages, and including shortcuts to related web pages and other documents.



SERVICES

What we offer for your power plants

Doosan understands the operational challenges you face on a day-to-day basis, which is why we offer a complete range of solutions and services to help our customers get the most from their plants. We stand ready to assist our customers and resolve any problems that they may encounter.

Please check this list to find the answer you need from our selection of solutions and services.

Plant Upgrades

Doosan offers comprehensive solutions and services for plant upgrades to improve the capacity and flexibility of your power plants.

The global power industry is changing rapidly. Today's power plants are required to operate in new and unconventional ways. Doosan's comprehensive power plant upgrade services can help improve the capacity and flexibility of your power plants, and ensure a successful future. If you need more output, greater efficiency, fewer emissions, an extended lifetime for your assets or enhanced flexibility to operate at lower loads or on a lower grade fuel, Doosan can provide customized solutions to meet all your requirements.

- **Total plant upgrades** ranging from plant assessment to upgrades including boilers, TG, AQCS, plant BOP and digitalization
- **10%+ efficiency/output improvement**
- **15 years+ life extension**
- **Safer and faster cycle operation**
- **Resolution of chronic maintenance issues**



PROJECT STORIES

OUR SOLUTION SETS DESIGNED FOR



Boilers



BTG power block



Turbines



Total plant turn-key



Generators



Plant digitalization



AQCS



SERVICES

KPI

PRODUCTS & SOLUTIONS



Plant Upgrades

Outage Services

Plant Assessment & Engineering

O&M

LTS

SSD

Asset Management

Digitalization

Outage Services

Doosan offers a customized set of outage services tailored for each power plant, and has been executing a number of outage services.

As an original equipment manufacturer (OEM), we provide outage services across various power sectors that meet the specific requirements of each customer. Our spare parts programs and technical advisor (TA) services are customized to better maintain your power plants, which in turn prevents the substantial financial losses that can result from forced outages.

- **Complete spare parts solutions**
- **Dedicated staff to overhaul**
- **Safety first, zero accidents**
- **On-time delivery**
- **Zero defects in quality management**



PROJECT STORIES

PARTS SERVICES

Getting the right spare parts is essential in maximizing the uptime of power plants. We recommend optimized sets of spare parts to maximize plant availability, and also provides a spare parts list that is categorized by both system and by frequency of replacement, so that our customers can undertake better parts planning prior to any scheduled maintenance. Doosan supports your inventory planning, and can provide a long-term spare parts stocking program for the major equipment at your plant.

OVERHAUL SERVICES

We utilize our procedures, quality control programs and know-hows to provide overhaul work during outages to ensure reliable operations until the next planned maintenance. We provide inspection and repair/replacement services according to our maintenance protocols, and also supply any parts and consumables that are required for the service.

TA SERVICES

Our TAs have extensive hands-on experience and expertise and will coordinate progress in the field. TAs inspect the dis-assembled parts and measurements, and review the relevant test reports. TAs also write fact-finding reports which set out all the corrective actions required before and during re-assembly.

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Plant Assessment & Engineering

Doosan offers its clients comprehensive front-end engineering design (FEED) studies and plant assessment, as well as engineering services.

Our plant assessment & engineering services support trouble-shooting at plants, and provide customized solutions for the renovation and modernization of power plants, including repair, upgrade and planning for life extension, thereby helping customer's value creation. Renovation and modernization of plant assets, including boilers, steam turbines, generators, emission control systems and other plant equipment, can have a significant impact on plant productivity and life. This is typically achieved by enhancing and upgrading the original design equipment.

Our technical experts have the detailed technical knowledge and state-of-the-art tools to deliver the necessary outcomes and create solutions for all technical challenges, when and where they are needed.

- **Experienced skill sets**
- **Value engineering** backed by comprehensive OEM knowledge
- **Customized solutions** with financial analysis
- **Further cooperation** in execution phase

OUR SOLUTION SETS DESIGNED FOR



Boilers

Combustion system, pressure parts, structure, etc.



AQCS

SCR, ESP, FGD, NLGGH, ash handling system, etc.



Turbines

HP/IP/LP blade and steam path, rotor, casing, etc.



Generators

Stator, rotor, etc.



Plant BOP

HP/LP bypass valve, auxiliary steam path, etc.



EC&I

Transformer, SWGR, control system, instrument, cable, etc.



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Operation & Maintenance

Doosan has put into place the most comprehensive, efficient, and safe practices so that we can deliver our O&M services in the most profitable way.

We have leveraged our knowledge as an OEM to develop an O&M strategy which manages key O&M risk factors through optimized maintenance programs comprised of asset life management and maintenance planning.

- **90%+ availability** by O&M professionals
- **0.5-1% efficiency improvement** by in-house digital solutions
- **1,700+ engineers** to support during O&M
- **24/7 monitoring coverage** by RMS

Doosan provides turn-key O&M services and/or tailored solutions according to customer requirements, across the following areas:

- Site management, including managers, environment/health/safety (EHS), quality control, procurement, warehouse management and site security
- Plant operations with a full operating crew (shift charge, board operators, field operators, chemists)
- Maintenance team with engineers, supervisors and technicians
- Training on power plant operation theories and simulation training
- Remote monitoring from the Doosan Monitoring Center to identify early warning signs of problems and reduce the risk of forced outages
- Digital solutions that enable reductions in NOx, optimize combustion, predict boiler tube failure, as well as analyze and resolve vibrations

KEY BENEFITS

- Minimize initial stabilization period
- Maximize plant availability
- Enhance heat rate
- Minimize performance degradation and fuel consumption



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Long Term Services

Doosan offers long term services (LTS) programs in order to ensure the extended and reliable operation of power plants.

Our LTS can be tailored to offer resident engineers on-site, O&M support, periodic overhaul work, TA services and long-term parts supply. The aim of our LTS is to help and support customers by maintaining better plant performance throughout the entire lifecycle of the plant.

Our long-term services include appointment of a site service director (SSD) and supporting staff to help site workers on both commercial and technical matters. The SSD is the single point manager responsible for managing assets and ensuring the supply of spare parts. The SSD will monitor the status of operations, assist in maintenance planning and recommend any materials or technical services that are required.

Spare parts and technical advisory services that are undertaken without specific pre-agreement will only receive minimum transaction time, as priority is given to LTS sites.

KEY BENEFITS

- Ensure clearer and faster communication through single direct contact with Doosan SSD
- Minimize future uncertainties through stable and predictable cash flow
- Spare parts supply at lower prices
- Reduce unplanned maintenance time at early operating stage through early communication and trouble-shooting by on-site team
- Reduce stabilization period from 5 years or more to less than 3 years¹⁾
- Continuous monitoring and caring of site throughout total life cycle under LTS²⁾



¹⁾ Vary depending on LTS scope and involvement

²⁾ Vary depending on LTS period and RMS or other Doosan digital solution installation



PROJECT STORIES



EXPERIENCE LIST



SOLUTION STORIES

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Site Service Director

Doosan provides a site service director (SSD) as one of our key long-term services for power plants.

Our SSD remains on-site to provide technical advice and engineering support for operations and maintenance at the plant, thus ensuring reliable long-term plant operations, which is a key target of our LTS program. The SSD is available on-site throughout a contract period, and will work to meet and exceed customer expectations of higher utilization and optimized plant performance.

We have established a single direct communications channel, enabling clearer responses and quicker action. In addition, we offer support for spare parts management, preparation and mobilization for overhaul programs, a full range of trouble-shooting for plant equipment, and any assistance needed in expediting back office/HQ reviews and approvals.

- **Life-long OEM care**
- **On-site and round-the-clock supports**
- **Commitment** to performance improvement
- **Single point of contact** for all requirements

KEY BENEFITS

- Execute contract obligations to achieve a financial operating plan
- Provide information regarding the latest advancements in conversion, modification and upgrade opportunities to the owner
- Maintain unit operations history and parts life history
- Maintain record of parts currently installed in each unit
- Provide customer supports for forced, unplanned and planned unit outages
- Build strong partnerships with organizations in the value chain which is extremely important to ensure high-quality services

Asset Management

Doosan provides asset management consultancy and technical expertise across the nuclear, thermal, process, marine and renewables sectors. We combine our engineering knowledge and product portfolio to create innovative solutions that deliver optimized performance, integrity and reliability.

- **100+ years of experiences** in providing asset management services to OEM and non-OEM customers
- **15+ years of lifetime extension** of assets expected
- **Over 30% cost savings** through novel phase array techniques in testing and inspection programs
- **Over 50% reduction** in operational downtime expected
- **30+ years of experiences** in providing testing and equipment qualification services
- **Over 60% increase in the production** of a customer's asset through asset performance management



PROJECT STORIES

NUCLEAR POWER ASSET MANAGEMENT

Our 60-year track record includes supporting the installation of the world's first commercial nuclear reactor, and asset management and through-life integrity management for the end of generation at Sizewell. We are EDF Energy's long-term strategic partner, and leverage our fleet knowledge to understand the requirements of the next generation of nuclear new-build projects.

THERMAL POWER ASSET MANAGEMENT

We have 100 years of OEM heritage, and market-leading knowledge of through-life integrity and performance management. This enables us to deliver through-life management and life extension of coal gas and biomass units globally for both OEM and non-OEM assets.

PROCESS ASSET MANAGEMENT

For 40 years we have supported upstream customers in addressing industry challenges, and also contributed to industry guidelines. In the downstream and petrochemical sectors, we deliver turnaround optimization, process improvement and risk-based inspection programs. Our unique small- and large-scale equipment testing and qualification services prolong the life of offshore facilities.

MARINE FLEETS ASSET MANAGEMENT

We are a long-term partner for marine clients around the globe, managing and upgrading their steam plants aboard carrier vessels. As an OEM partner for our clients, we are able to deliver through life-integrity management and fuel conversions.

RENEWABLES ASSET MANAGEMENT

Our testing and equipment qualification services support offshore wind testing and equipment qualification programs in the UK. This enables the UK power industry to deliver cost-effective and reliable sources of renewable energy.

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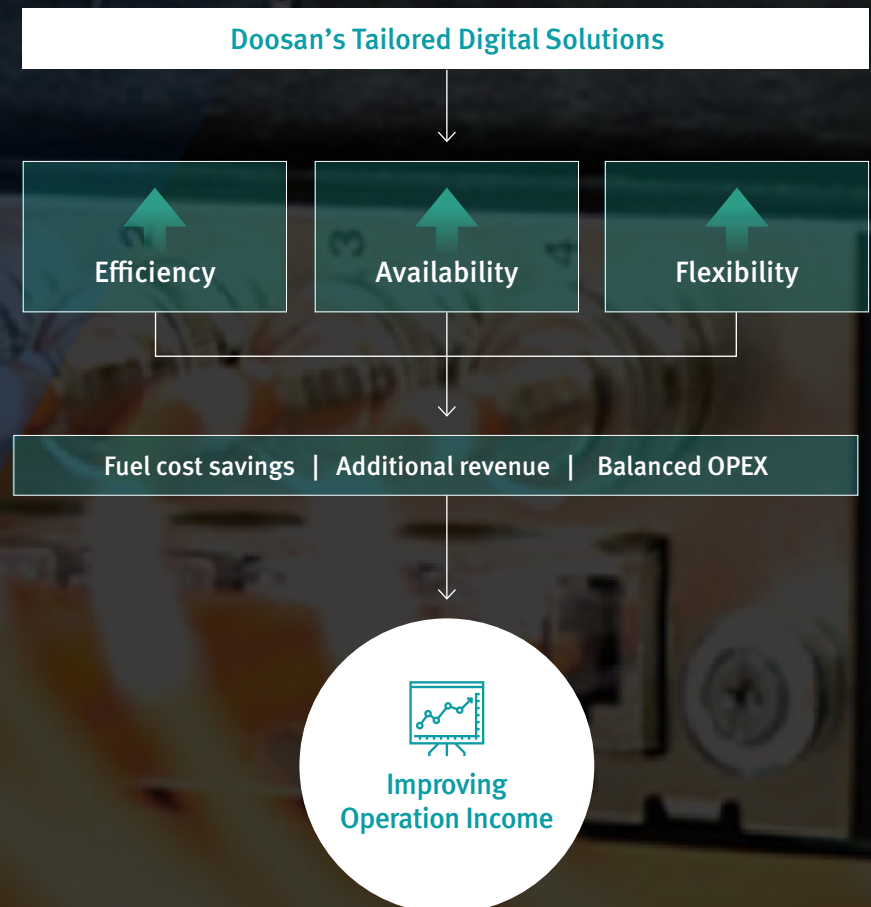
Digitalization

Doosan adds advantages in plant operations through digitalization, which in turn enables our clients to make their plants more efficient and available.

DIGITAL ADVANTAGE IN PLANT OPERATIONS

	Digital Solution	Conventional O&M
Responsive & Real-time	Digitalization enables real-time data-based monitoring and diagnosis	Based on sample data, and executed during operation intervention
Predictive & Focused	Digital solutions identify pain points, while also minimizing unnecessary works and overhaul	Corrective maintenance, simply reacting to errors and issues
Optimized & Scalable	Automated update on software and algorithm guarantee optimized and scalable solutions	Additional resources required for customization and update
Flexible Biz. Model	Payment scheme may vary flexibly depending on period, performance, etc.	Based on a fixed year contract defined by scope and duration rather than performance

OPERATIONAL AND FINANCIAL BENEFITS FOR TPP



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What we offer for your power plants

Doosan understands that customers' needs for their plants vary greatly, which is why we provide a range of tailored solutions. We are ready at all times to help our customers, and work in partnership with them to solve any problem they may encounter.

Please check this list to find the answer you need from our selection of solutions and services.

Output

One of the most effective ways for customers to lift revenues and create more business opportunities is to increase a plant's output. Doosan's output solutions enable customers to increase sales volumes at their plants and increase capacity at each facility to create a stable business model.

Increase your output by taking advantage of our output solutions.

Applicable Solutions



PROJECT STORIES

KEY BENEFITS

- Increased output leading to higher revenues
- Stable plant operations thanks to increased facility capacity

SUCCESSFUL ACCOMPLISHMENT

Plant Upgrade

Earing 1-4 (Australia, 660MW x4)

- Scope: BLR upgrade, TBN upgrade, GEN upgrade
- Result: 660MW → 750MW (Approx. 13% increase)

Boiler Upgrade

Poryoung 1,2 (Korea, 516MW x2)

- Scope: Boiler upgrade, Steam turbine SPU
- Result: 516MW → 535MW (Approx. 3.7% increase)

Turbine Upgrade

Sabarmarti (India, 110MW x2)

- Scope: BLR heating surface increase, TBN SPU
- Result: 110MW → 121MW (Approx. 10 % increase)

Output

Efficiency

Availability

Flexibility

Emissions

Life Extension



SERVICES

KPI

PRODUCTS & SOLUTIONS

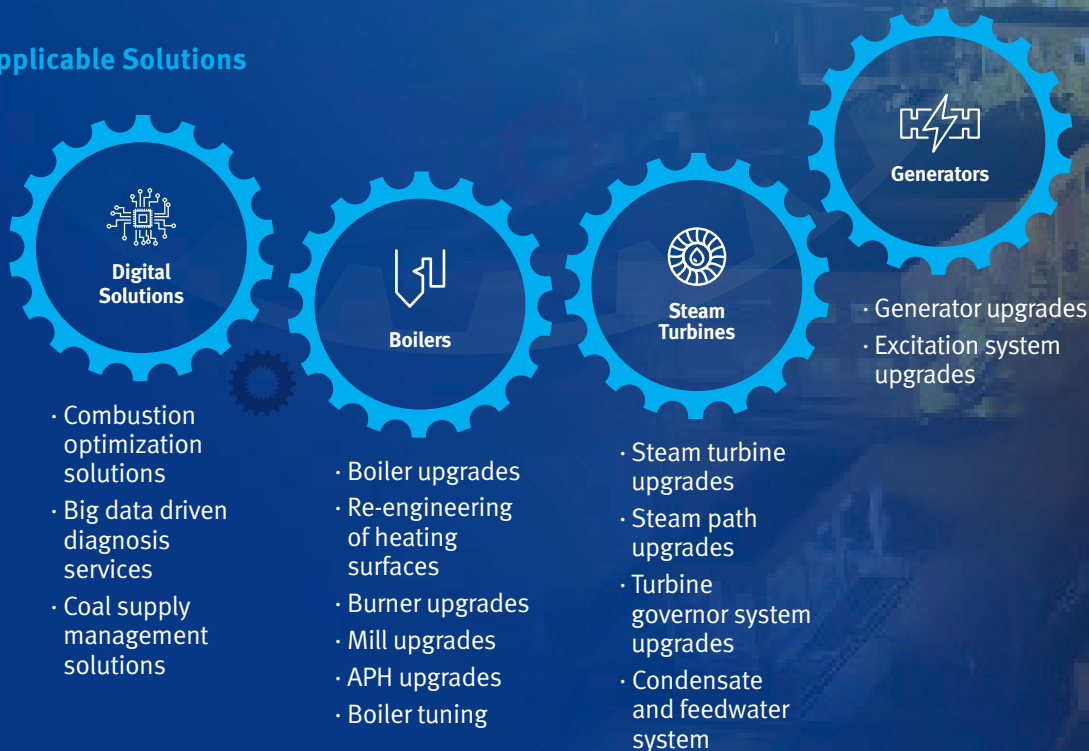


Efficiency

Plant efficiency is one of the most important factors in plant operations, especially as fuel, maintenance and operating costs continue to rise. Doosan therefore offers a range of efficiency solutions to increase customer profitability, from small device replacements to complete digital solutions for the entire operations of a plant.

Increase your efficiency by taking advantage of our efficiency solutions.

Applicable Solutions



KEY BENEFITS

- Heat rate reduction
- Performance upgrade of major equipment

SUCCESSFUL ACCOMPLISHMENT

Plant Efficiency Increase

Bandel #5 (India, 210MW x1)

- Scope: BLR upgrade, TBN upgrade, GEN upgrade
- Result: Heat rate reduction (Approx. 22% decrease)

Turbine Upgrade

Sabarmarti (India, 110MW x2)

- Scope: BLR heating surface increase, TBN SPU
- Result: Heat rate reduction, Turbine efficiency increase



PROJECT STORIES

Output **Efficiency** Availability Flexibility Emissions Life Extension



SERVICES

KPI

PRODUCTS & SOLUTIONS

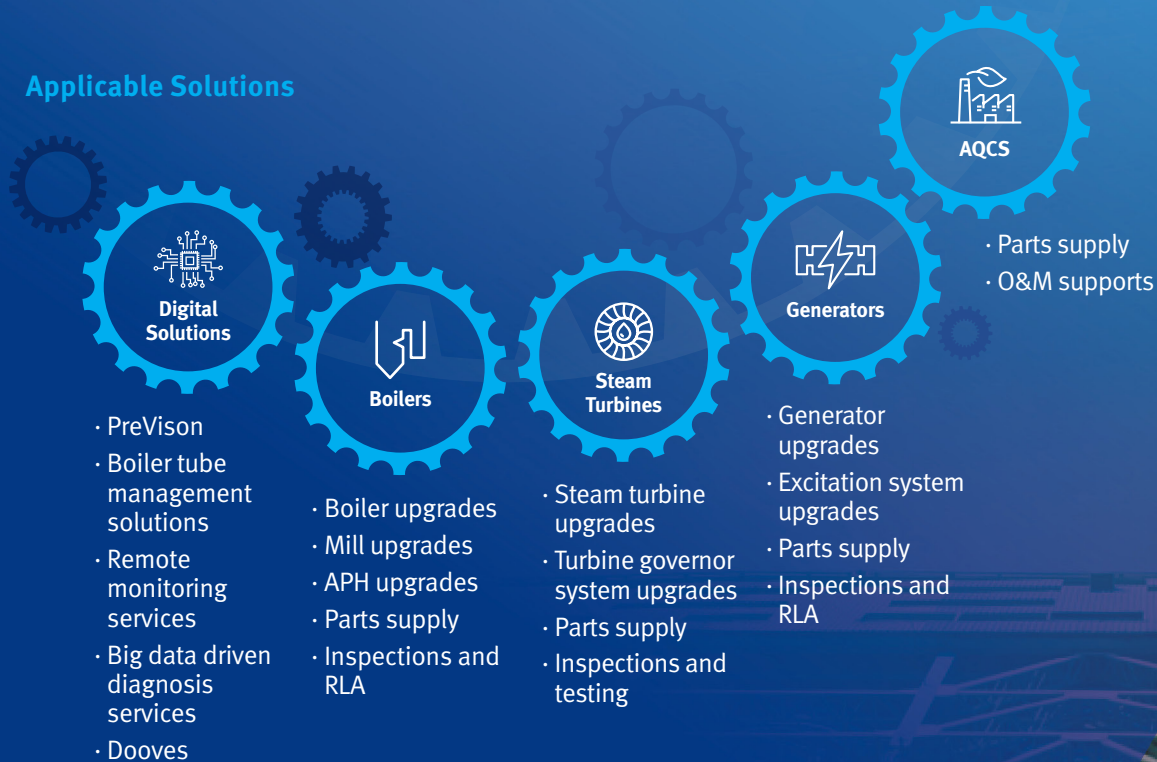


Availability

Continuous and stable operations are top priorities in base load generation. Frequent maintenance or emergency shutdowns at plants responsible for the baseline load can result in immediate operational losses and undermine confidence in the plant itself. Therefore, to ensure continuous and stable grid operations, Doosan offers effective availability solutions that enhance a plant's ability to generate profits.

Increase your availability by taking advantage of our availability solutions.

Applicable Solutions



PROJECT STORIES

KEY BENEFITS

- Increase plant lifetime
- Consistent profit generation through continuous operation

SUCCESSFUL ACCOMPLISHMENT

Plant Upgrade

Morupule 1-4 (Botswana, 33MW x4)

- Scope: BLR upgrade, Steam TBN upgrade, GEN upgrade
- Result: Capacity increase, Life extension (20 years+)

O&M

Oseong CCPP (Korea, 771MW)

- Scope: Complete operation and maintenance
- Result: Profit maximization through stable operations

Plant Efficiency Increase

Bandel #5 (India, 210MW x1)

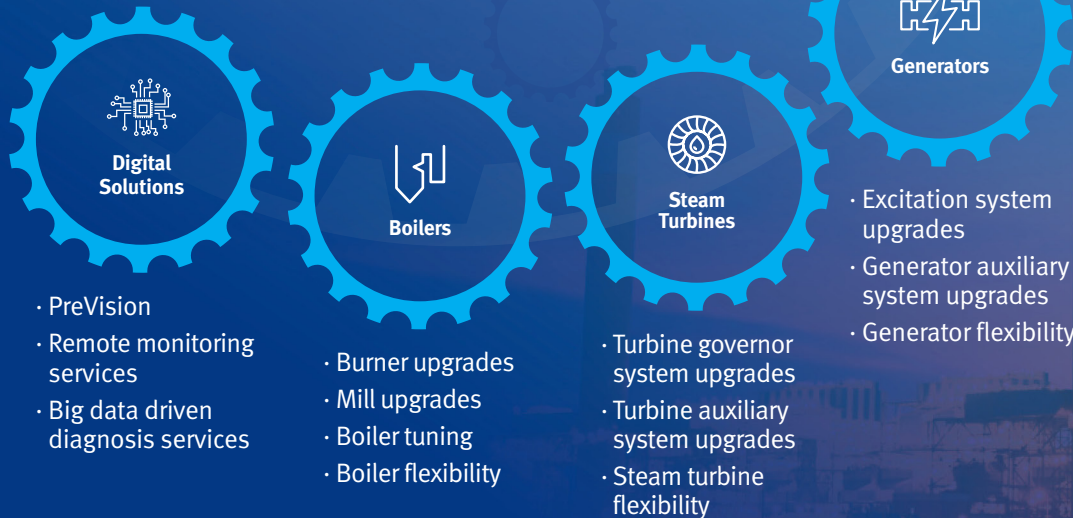
- Scope: BLR upgrade, TBN upgrade, GEN upgrade
- Result: Heat rate reduction (Approx. 22% decrease), Life extension (20 years+)

Flexibility

With renewable energy becoming ever more important worldwide, the thermal power plants which are responsible for grid stability need to be highly responsive to fluctuations in renewable energy. Against this backdrop, steady operations lead to a steady stream of revenues, and Doosan's flexibility solutions help customers achieve sustainable and reliable operations across a range of operating conditions.

Increase your flexibility by taking advantage of our flexibility solutions.

Applicable Solutions



KEY BENEFITS

- Stable operations under various operating conditions without plant shutdown
- Extension of operation range thanks to minimization of operation load
- Flexible operation through fuel diversification

SUCCESSFUL ACCOMPLISHMENT

Steam Turbine Upgrade

Eraring 1-4 (Australia, 660MW x4)

- Scope: Steam path upgrade
- Result: Control load range extension

Biomass Conversion

Yeongdong 1 (Korea, 125MW x1)

- Scope: Firing system modification
- Result: 100% fuel conversion

Remote Monitoring System

Hanam CHP (Korea, 400MW)

- Scope: Remote monitoring
- Result: Increase in starting reliability, Prevention of emergency shutdown



PROJECT STORIES

Output | Efficiency | Availability | **Flexibility** | Emissions | Life Extension



SERVICES

KPI

PRODUCTS & SOLUTIONS



Emissions

Emissions regulations around the world are getting ever stricter as countries seek to prevent environmental pollution. As a result, power plant operators are facing challenges as their power plants age. These challenges include rising fuel prices, demand for lower quality fuels, and the growing pressure of environmental regulations. In order to strike the most effective compromise between environmental protection policies and efficient power plant operations, Doosan offers its customers a range of emission trouble-shooting solutions to find the key to sustainable plant operations.

Optimize and minimize emissions by taking advantage of our emission solutions.

Applicable Solutions



KEY BENEFITS

- Compliance with environmental standards around the world
- Upgrade to ensure longer AQCS plant life

SUCCESSFUL ACCOMPLISHMENT

TPP Emission Control

Castle Peak (Hong Kong, 660MW x4)

- Scope: Firing system modification, SCR add-on
- Result: 75% reduction of NOx emissions

SCR Add-on

Ratcliffe SCR (UK, 500MW x4)

- Scope: SCR add-on
- Result: NOx emissions reduction to under 100mg/Nm³

FGD Add-on

Orot Rabin 5, 6 (Israel, 575MW x2)

- Scope: FGD system add-on
- Result: SOx emissions reduction to satisfy regulation



PROJECT STORIES

Output | Efficiency | Availability | Flexibility | **Emissions** | Life Extension



SERVICES

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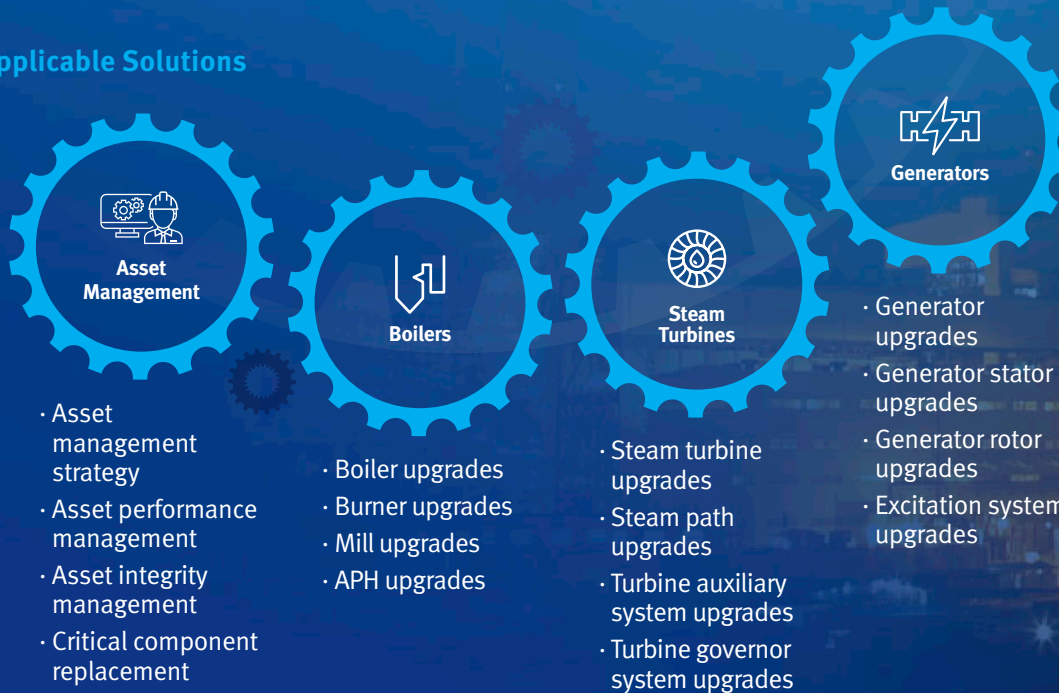
PRODUCTS & SOLUTIONS



Life Extension

The changing energy mix globally is seeing a requirement for many power generation assets to remain available beyond their originally intended design life. Plants originally designed for base load operation are being asked to operate in a more flexible manner, often as backup capacity to cope with intermittent renewable energy sources. Owners and operators are required to consider many factors before and during a life extension, to ensure that integrity, reliability and performance remain optimised for the proposed regime, and any emergent risks are identified and mitigated.

Applicable Solutions



KEY BENEFITS

- Asset life extension with enhanced system reliability, Integrity and performance

SUCCESSFUL ACCOMPLISHMENT

Asset Life Extension

Eggborough Power Station (UK, 500MW x4)

- Scope: Boiler Technical Services Agreement
- Result: 100,000hr Life Extension via Asset Integrity Management and Critical Component Replacement

Castle Peak B Station (Hong Kong, 660MW x4)

- Scope: Boiler Life Management
- Result: Through-Life Management of Critical Components beyond Design Life with Strategy for Further Life Extension

Life Extension Feasibility

Taweelah A2 (UAE, HRSG x 3)

- Scope: Life Extension Feasibility Study
- Result: Detailed Plant Risk Profile and Investment Strategy to Facilitate 20 year Life Extension



PROJECT STORIES

Output | Efficiency | Availability | Flexibility | Emissions | **Life Extension**



SERVICES

KPI

PRODUCTS & SOLUTIONS



PRODUCTS & SOLUTIONS

Find answers to all your power plant requirements from our extensive product offerings

A plant consists of an array of components, and generates revenues through the efficient operation of each component. To ensure that the entire plant operates seamlessly while generating sales in a stable manner, it is essential to accurately identify each unit of equipment and select the right method of operation. Doosan's extensive range of products offers our customers the right equipment to assist them with any difficulties they are experiencing at their plants.

Total Plant Upgrade

Doosan's total plant upgrade includes plant assessment and residual life assessment (RLA), the development of upgrade solutions, upgrade work, plant digitalization and long-term services (LTS), as well as the use of state-of-the-art technologies to improve asset performance at all OEM and non-OEM plants.

Our total plant upgrade offers turn-key solutions for both complete power plant systems and also on a lot-by-lot basis. Our solutions for total plant upgrade begin with an accurate assessment and diagnosis of issues at the plant. We propose a customized upgrade scope and develop the most techno-commercial solution to meet the objectives for improvements at your power plant.

KEY BENEFITS

- Single responsibility in BTG system integration
- Seamless technical supports from planning to execution
- Professional FS & FEED studies backed by OEM knowledges
- Multi-scope recommendation for customization



Plant Assessment & Engineering

- Boiler performance assessment, RLA
- Turbine performance assessment, Steam path audit
- Generator inspection and assessment, RLA
- AQCS inspection and assessment
- EC&I assessment and re-engineering
- Plant BOP assessment and re-engineering



Boilers

- Re-engineering of heating surfaces
- Combustion system upgrade (LNB & OFA, Mills)
- Draft system upgrade (Air & Flue dusts, Fans, APH)
- DCS/BMS/Protection system upgrade
- Digital solutions (RMS, BTMS, Combustion optimization, etc.)



AQCS

- De-SOx solutions (FGD add-on and capacity upgrade)
- De-NOx solutions (Primary and secondary measures)
- De-Dust solutions (ESP capacity upgrade)
- Non-leakage GGH, EME-wet ESP, ZLD for further improvement



Turbines

- Advanced steam path upgrades
- Complete turbine replacement with original foundation
- Re-blading applying state-of-the-art technologies
- Condenser, Valves, TCS upgrade
- Digital solutions (PreVision, Dooves, etc.)



Generators

- Stator rewinding
- Rotor rewinding, Re-insulations
- Generator complete replacement with auxiliary systems
- Excitation system upgrade



Plant BOPs & EC&I

- Condensate/Feedwater system (including heaters, BFP, etc.)
- Circulating water/Closed cooling water system, etc.
- Package system (WTS, FF, AHS, Comp. air, etc.)
- Plant DCS/C&I, LV/MV switch gears, GCB, MCC, DC & UPS system



PROJECT STORIES



EXPERIENCE LIST

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



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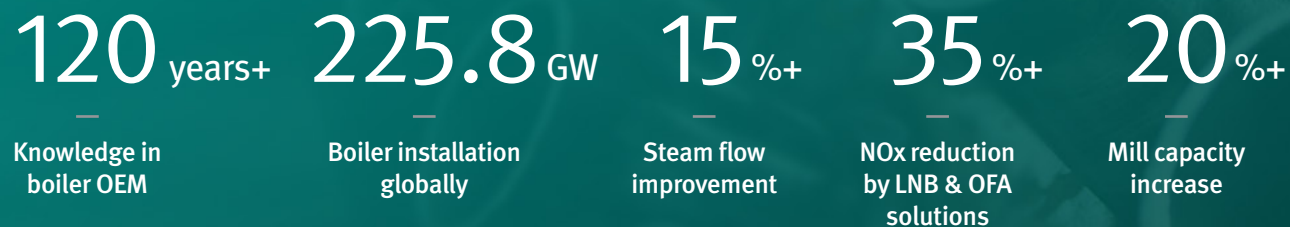
PRODUCTS & SOLUTIONS



Boilers

Doosan provides high-quality and cutting-edge boiler services by leveraging its boiler OEM technology along with extensive experiences and references from around the world. We have a full range of product line-up for boilers and burners to meet all client requirements, and our total boiler solutions offer reasonable prices, fast delivery and trustworthy after-sales services.

We have designed and manufactured a full range of subcritical and supercritical boilers, including drum, once-through and circulating fluidized bed (CFB) units that are designed to burn coal, oil, gas or biomass efficiently. Based on these OEM technologies, we have successfully undertaken retrofits and upgrades of pulverized coal-fired (PC), gas-fired, oil-fired, CFB and WtE boilers for both our own products across the globe and also at non-OEM plants.



OUR KEY SOLUTIONS INCLUDE

UPGRADES

- Boiler upgrades
- Re-engineering of heating surfaces
- Burner upgrades
- Low NOx wall-firing, T-firing
- Mill upgrades, E-mill upgrades
- Fuel conversion – Biomass, NG & Oil
- APH upgrades
- CFB biomass applications
- WtE offerings

OUTAGES/O&M

- Parts supply
- Inspections & RLA
- Field services
- Boiler tuning
- Boiler flexibility



PROJECT STORIES



EXPERIENCE LIST



WORKSHOP & FACILITIES

Total Plant **Boilers** AQCS Steam Turbines Generators Plant Assessment Gas Turbines AM Services Digital Solutions



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PRODUCTS & SOLUTIONS

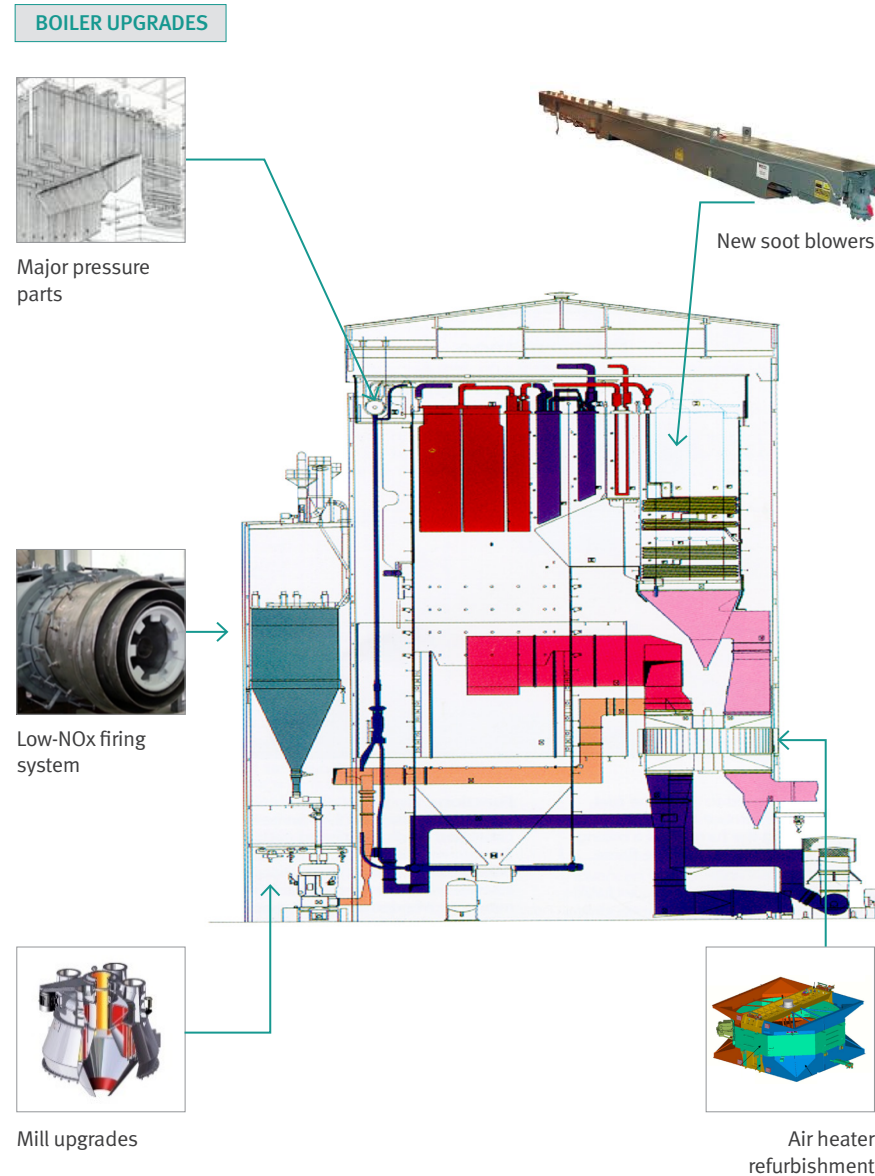


UPGRADES

Boiler Upgrades

Doosan offers boiler upgrade solutions that are based on its boiler assessments and engineering services. Upgrades for each boiler can vary and are designed for the specific needs of each customer. Doosan has capabilities, experiences and expertise to upgrade both OEM and non-OEM boilers.

There are numerous ways to upgrade boilers. First of all, replacing existing old and damaged parts is essential in improving boiler lifetime and availability. Doosan is fully equipped to offer highly effective upgrade solutions created by our skilled engineering teams, using sophisticated tools and other devices for reverse engineering. The following is a list of typical boiler upgrade solutions which can be optimized for your specific operating conditions.



UPGRADE SOLUTIONS

- Replacement of heating surface (S/H, R/H, ECO) along with additional soot blowing system
 - Material upgrade, Heating surface increase
- New combustion system
 - Fuel conversion (biomass, oil, gas)
 - Low NOx burner, Oil burner
 - Modification of ductworks (wind box, OFA, BOFA)
- Replacement or modification of pulverizer
 - Improvement of capacity and fineness (dynamic classifier change)
 - PF pipe modification
- Fan upgrade (PA, SA, ID, GR)
- Fire protection system
- Ash handling system

CUSTOMER BENEFITS

- Capacity increase by up to 15%
- Efficiency increase by approximately 1-2%
- Life extension by up to 20 years
- Eco-friendly technology application (low NOx, UBC)
- Availability and reliability improvement
- Reduced maintenance cost and optimized trouble-shooting
- Incorporation of modernized technologies

UPGRADES

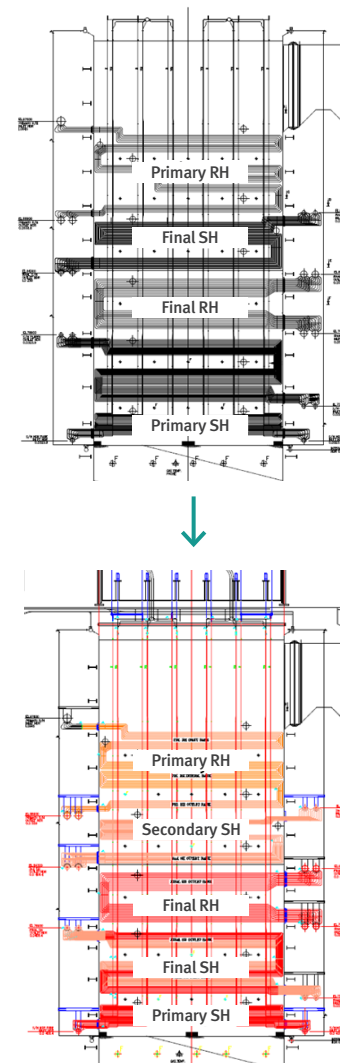
Re-engineering of Heating Surfaces

Doosan offers boiler heating surface re-engineering solutions through boiler performance analysis to ensure optimum turbine heat balance by using our in-house OEM tools. Pressure parts can be replaced, rearranged, added or removed, depending on the purpose of the plant modification. Doosan has successfully completed many projects around the world to make retrofit improvements to both existing OEM and non-OEM power plants, utility and industrial boilers with an aim to enhance equipment performance and reliability.



Rabigh Unit #1 RH replacement (Saudi Arabia)

PRESSURE PART MODIFICATION (Boryeong #3, Korea)



UPGRADE SOLUTIONS

- Life extension
 - Replacement with same or upgraded materials
- Fuel conversion (coal to biomass, oil or gas)
 - Change, re-arrangement, addition, and/or removal of heating surfaces
- Power uprating
 - Steam pressure/temperature change
 - Change, re-arrangement, addition, and/or removal of heating surfaces
- Efficiency increase

SERVICE AREAS

- Tube
 - Furnace wall
 - Economizer
 - Hanger tube
 - Primary, Platen, Final SH
 - Primary, Final RH
- Header
 - Economizer in/out
 - Hanger tube inlet
 - Primary SH outlet
 - Platen SH in/out
 - Final SH in/out
 - Primary SH in/out
 - Final RH in/out
- Link
 - Economizer outlet to furnace inlet
 - Primary SH to platen SH
 - Platen SH to final SH
 - Primary RH to final RH

UPGRADES

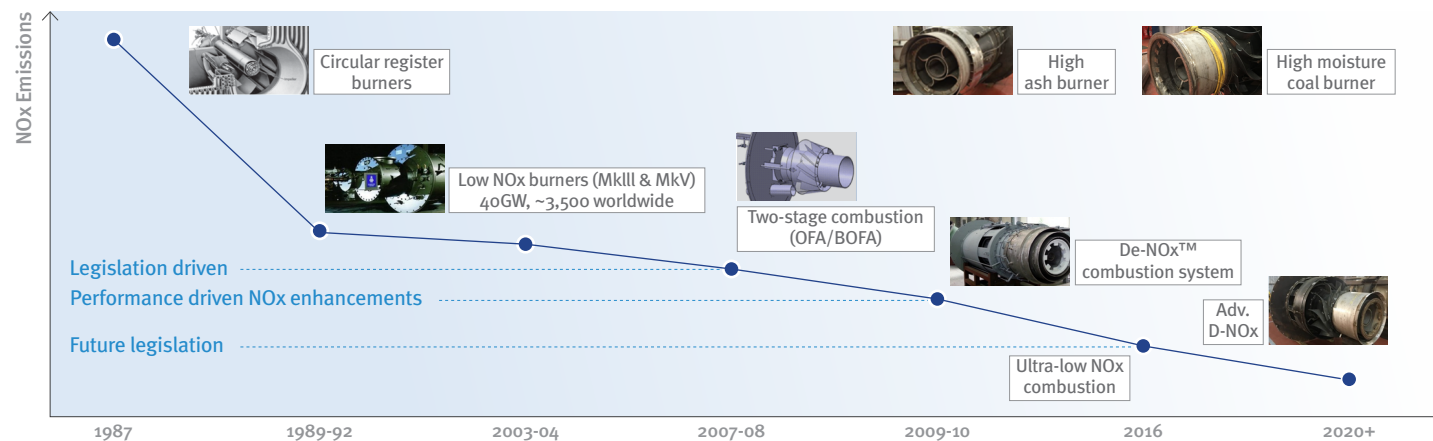
Burner Upgrades

Doosan is a trusted partner for the delivery of reliable and efficient steam production. Over a century of innovation is reinforced by our investments in research and development to ensure that we remain at the forefront of innovative burner technologies. We leverage our experiences in burner design to provide combustion technologies that maximize your plant performance. From retrofit and upgrade to new boiler applications, we have got you covered.

We can supply special purpose burners to satisfy client needs for fuels of varying properties and requirements for low emissions. In retrofit solutions, we design customer-oriented burner systems that require minimum modifications to the existing boiler systems, including both t-firing and wall-firing systems. Doosan has recently developed an advanced D-NOx burner for bituminous and sub-bituminous coal in wall-firing systems. If old plants need solutions to reduce NOx, we can solve the problem by changing only the low NOx burner without changing the post D-NOx systems such as SCR/SNCR. In addition, a two stage OFA system can further reduce NOx emissions with the same or a lower level of unburned carbon.

Our high ash coal (HAC) burner, which is focused on the Indian market, has been developed for coal with over 40% ash content, and its design features erosion prevention and flame stability. In addition, our high moisture coal (HMC) burner was developed to directly burn up to 40% of total moisture without using a coal drying system, which means that it can be used for the direct firing of high moisture coal without the need for a CFB boiler.

DOOSAN WALL-FIRING LOW NOx BURNER DEVELOPMENT HISTORY



UPGRADE SOLUTIONS

- Fuel flexibility and strong performance for different fuel types
- A one-stop shop for conversion from design and planning to installation and product lifetime support
- Integrated milling, fuel handling and distribution capabilities
- A trusted partner for combustion troubleshooting

CUSTOMER BENEFITS

- Supply of state-of-the-art special burner to meet customer needs
- Minimum modifications of existing combustion system
- Guarantee included for NOx emission reduction

UPGRADES

Low NOx Wall-firing Solutions

Doosan provides low NOx burners (LNB) and over fire air (OFA) solutions for wall-firing combustion systems of various capacities. Customers can deliver on their environmental, efficiency and operational goals using our precision wall-firing combustion systems for cleaner, greener nitrogen oxide (NOx) reduction. From troubleshooting and optimizing combustion systems to a full engineering of NOx reduction, you can rely on Doosan's experience and global capabilities.

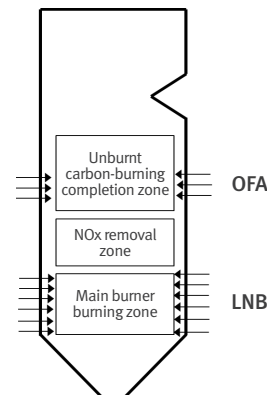
Building on more than 100 years of experiences in combustion and continuous R&D investment in firing technologies, we deliver cutting-edge combustion for your plant-based NOx control technologies. Optimized for NOx control without compromising output or efficiency, our firing range includes:

- LNB and advanced LNB
- OFA and boosted over fire air (BOFA)

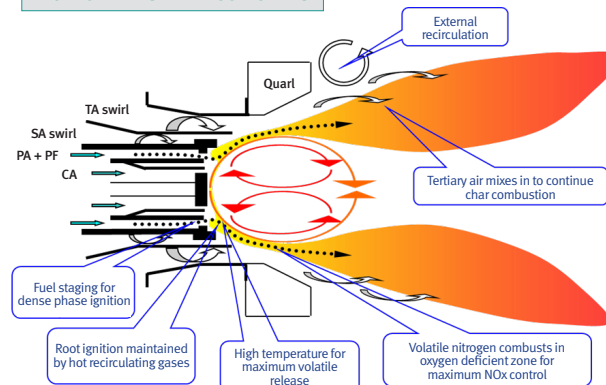
Our wall-firing advanced D-NOx combustion system, which maintains competitive position in the market, enables us to continue the development of low NOx pulverized coal burner technology by delivering an improved combustion performance. Low NOx coal burner concepts include:

- Fuel staging combustion
 - Make flame stabilized to stage fuel rich and fuel lean areas
- Air staging combustion
 - Make oxygen-deficient (fuel rich) area in the primary zone to minimize NOx
 - Supply sufficient combustion air around burner to enhance char-combustion
- Air swirl
 - Swirling of combustion air to maximize fuel and air mixing efficiency

IN-FURNACE NOx REDUCTION SCHEME (LNB + OFA)



De-NOx™ BURNER CONCEPTS



CUSTOMER BENEFITS

- State-of-the-art advanced LNB replacement with minimum modification
- Two-stage OFA enhances mixing to reduce UBC
- Guarantee included

UPGRADES

Low NOx T-firing Solutions

Doosan provides LNB and OFA solutions for tangential corner-firing combustion systems of various capacities. Fulfill your environmental efficiency and operational goals with our precision T-firing combustion systems for cleaner, greener NOx reduction. From trouble-shooting and optimizing combustion systems to a full engineering of NOx reduction, you can rely on Doosan's experience and global capabilities.

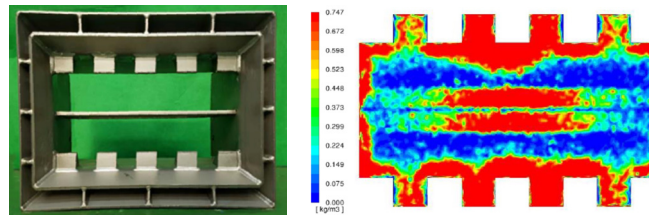
We provide optimum NOx control without compromising on combustion efficiency in a variety firing range through:

- Low NOx T-firing nozzle tip
 - Increase flame stability through well-mixed fuel/air
 - Reduce NOx emissions
 - Increase combustion efficiency
- Advanced over fire air (OFA)
 - Good air penetration
 - Enhanced De-NOx ability

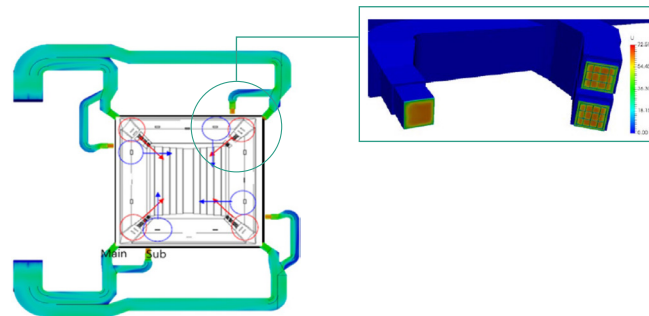
Low NOx coal burner concepts include:

- A nozzle tip reduces local high temperatures and the high oxygen zone, which is achieved by placing a pair of deflectors and flame teeth into the nozzle to divert the flow of particles outwards
- Sub-stoichiometric conditions can be achieved in the burner zone, which in turn results in the creation of NOx reducing agents
- NOx can be significantly reduced by ensuring sufficient residence time using the advanced OFA system, and unburned carbon can be completely combusted through optimized mixing effect

LOW NOx T-FIRING NOZZLE TIP



ADVANCED OFA SYSTEM



CUSTOMER BENEFITS

- Advanced fuel nozzle tip replacement with minimum modification
- Advanced SOFA enhances mixing to reduce UBC
- Guarantee included for NOx emission reduction

UPGRADES

Mill Upgrades

Doosan offers flexible, individualized service packages that cover in full exactly the services you need. Create your own service package by choosing the services you need from the full range offered by Doosan, including services from Loesche, GE, MHPS and others.

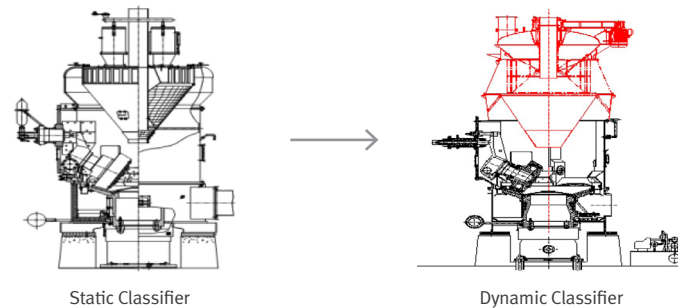
We upgrade mill capacity and/or its fineness by changing few components and optimizing them within the existing mill system. This newest solution package will significantly enhance mill performance, including throughput and fineness.

Modification areas include:

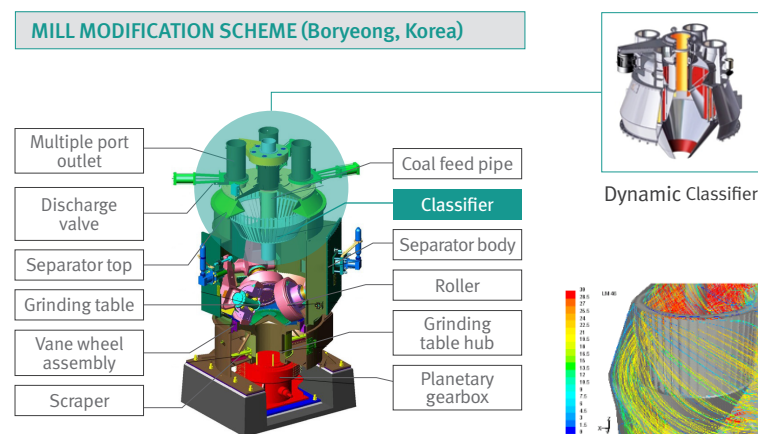
- Dynamic classifier change
- Motor change (Power increase)
- Installation of discharge valve
- Electric and control part (Add)
- Seal air system
- Exit coal pipe change

Advantages of dynamic classifier include:

- Rotor + swirl vanes
- Control of rotation speed
- High separation efficiency of coarse coal
- Energy savings
- Fine particles not returned to mill, Increasing mill capacity



MILL MODIFICATION SCHEME (Boryeong, Korea)



CUSTOMER BENEFITS

- Energy savings
- Easier maintenance
- Enhanced life cycle for wear parts
- Enhanced plant availability
- Improved electrical, control and instrumentation systems
- Enhanced plant productivity
- NOx reduction

UPGRADES

E-mill Upgrades

Doosan offers the Babcock & Wilcox E-mill system for flexible, individualized service packages that ensure customers receive exactly the services they need. We upgrade mill capacity and/or its fineness by changing few components and optimizing them within the existing mill system. When combined with optimized components, this newest solution package will significantly enhance mill performance.

E-mill upgrade solutions increase mill capacity within the same family models while repairing rolls and wear parts by utilizing advanced metallurgy. Furthermore, high efficiency dynamic classifiers can simultaneously increase capacity and enhance coal fineness.

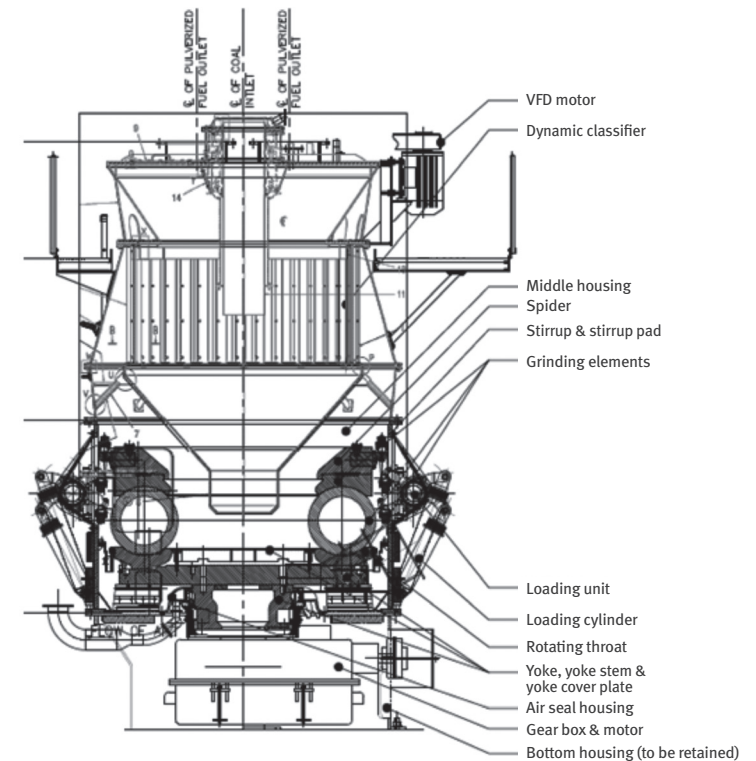
Milling system up-rating modification areas include:

- Raw coal feeders
- Mill (8.5E10 → 8.5E9)
- Dynamic classifier (Static → Dynamic)
- PA fans/piping
- Seal air fans

UPGRADED MILL COMPARISON

Description	Unit	8.5E10	8.5E9
Type		Vertical Spindle (Large ball slow speed)	
Capacity	t/h	25	30.3
Coal Size	mm	20-37	25
P.F Grading	%	65% (200 mesh)	80.9% (200 mesh)
Motor Rating	HP	290	348
Motor Speed	rpm	970	987

ARRANGEMENT OF RETRO-FITTED 8.5E9 MILL



UPGRADES

Fuel Conversion – Biomass

Coal-to-biomass fuel conversions gives customers access to both efficient power generation and lower emissions. Doosan has decades of experiences in developing 100% biomass and biomass co-firing combustion systems, including large-scale projects across Europe, North America and Korea. Our biomass burners and co-firing systems feature innovative low NOx designs, enabling customers to produce ever more efficient renewable energy.

Doosan offers a full line-up of biomass technologies for existing plants no matter geographical locations or customer requirements. We can provide fuel handling and milling systems for any range of applications, including both low and high levels of co-firing as well as full conversions. We also undertake assessments of plant performance and conditions, which offer optimized air quality control systems (AQCS) and integrated steam turbine retrofits in order to improve plant performance.



Yeongdong #1 Biomass TPP (1x125MW)



SOLUTION STORIES

Total Plant **Boilers** AQCS Steam Turbines Generators Plant Assessment Gas Turbines AM Services Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



TYPICAL CONVERSION SCOPE (need to be modified/replaced)

- Fuel handling system with fire and explosion suppression
- Vertical spindle or hammer mills as appropriate
- Burners: Larger particle size of pulverized wood (alternatively a new low NOx biomass combustion system)
- Primary or secondary NOx control technologies: OFA, BOFA or SNCR
- Bottom ash systems
- Primary air fans: Higher press, Drop in transportation of biomass
- Additional water lances or soot blowers: Control ash coatings on heating surfaces

CUSTOMER BENEFITS

- CO₂-neutral firing system
- Lower SOx, NOx and ash
- Support for co-firing or 100% biomass conversion to meet client's need

REFERENCES

- Ironbridge, UK: 2x350MW, 100% conversion
- Tilbury, UK: 3x300MW, 100% conversion
- Drax, UK: 1x660MW, 100% conversion, 6x660MW, 10% direct injection co-firing
- Gardanne, France: 170MW, 100% conversion
- Atikokan, Canada: 200MW, 100% conversion
- Yeongdong, Korea: 125MW, 100% conversion

UPGRADES

Fuel Conversion – NG/Oil

Coal-to-gas and coal-to-oil fuel conversions give customers access to efficient and fuel-flexible power generation as well as lower emissions. Doosan has decades of experiences in firing natural gas or oil for utility and industrial fossil fuel steam units. Our experiences include firing natural gas or oil as the main fuel, co-firing natural gas with multiple fuels, and adding gas firing to existing units. Doosan has extensive experience in converting both tangential-fired and wall-fired units for both OEM and non-OEM technologies.

We offer a full line-up of oil & gas combustion technologies for existing plants no matter geographical locations or customer requirements. We can provide fuel supply systems to meet your co-firing requirements as well as full conversion. We also undertake assessments of plant performance and conditions, which offer optimized AQCS and integrated steam turbine retrofits in order to improve plant performance.



Castle Peak Thermal Power Plant (4x680MW)

TYPICAL CONVERSION SCOPE (need to be modified/replaced)

- Utility NG/Oil supply
- Utility metering, regulating and custody station
- NG/Oil burners and ignitors
- Flame scanners and electronics
- Pressure reducing valve (PRV) station
- Foundations
- NG/Oil distribution piping
- Vent piping
- Instrument air system modifications
- Scanner cooler air modification, etc.

CUSTOMER BENEFITS

- Lower NOx, particulate, SOx and ash
- Higher turndown ratio, depending on fuel supply pressure at the burner front and equipment configuration

REFERENCES

- Didcot, UK: 4x500MW, 100% conversion
- Castle Peak B, Hong Kong: 4x680MW, 100% conversion

UPGRADES

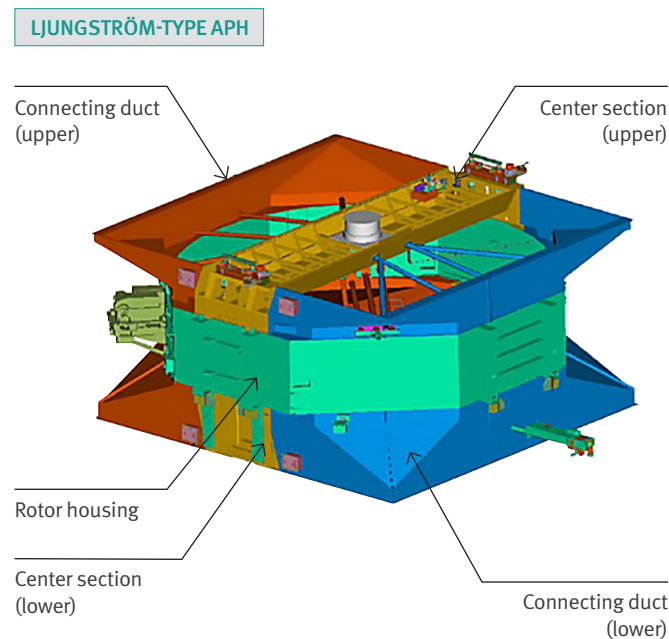
APH Upgrades

Doosan offers tailor-made engineering and design solutions for the upgrading of regenerative air preheaters (APH) in order to achieve higher thermal efficiency, lower leakage rates, higher availability and lower operating costs. The APH on a commercial boiler reduces fuel consumption and contributes significantly to overall boiler efficiency while representing only a fraction of the total investment.

Engineered to our proven design standards and constructed with minimal installation costs, Doosan's APH will operate over extended periods, with durable, uninterrupted services. The Ljungström-type APH is more widely used than any other rotary heat exchanger in the steam generating industry.

This is due, in part, to:

- High thermal effectiveness and proven performance
- Advanced heat transfer surfaces
- Bi-, tri- and quad-sector duct configurations
- Rotor and sealing system options with effective leakage control
- Outstanding reliability and availability
- Compact design



APH COMPONENTS

- Casing, rotor and bearing
- Heating elements
- Sealing frame adjusting device
- Rotor drive unit (electric motor, air motor, pinion gear)
- Soot blower
- Water washing, fire detecting, no rotation detection system, etc.

CUSTOMER BENEFITS

- Specialized assessment and engineering services
- Suggestion of best integrated upgrade plans and solutions
- Warranty

SERVICE AREAS

- Erection: We undertake the complete turn-key erection of gas air heater (GAH), or we provide erection supervision services
- Commissioning: Experienced and qualified commissioning engineers are available to undertake cold and hot commissioning works and GAH performance testing
- After-sales Services: Our team of engineers and technicians perform routine maintenance inspections, report on their findings and ensure that the heat exchanger continues to operate at optimal efficiency
- Upgrade Services: We offer anti-blocking ash, leakage prevention and thermal element upgrading solutions to increase APH efficiency

UPGRADES

CFB Biomass Applications

Doosan has more than 25 years of experience in global biomass, including new build and conversion projects. Thanks to its flexibility, circulating fluidized bed (CFB) technology can also burn renewable fuels, such as biomass, which reduces future reliance on fossil fuels and also improves the environmental performance of your plant.

Biomass is an ecologically acceptable energy source, and thus contributes towards a greener and cleaner planet for generations to come. The ecological footprint of this practically CO₂-neutral fuel is one-tenth to as low as one-fifteenth compared to electricity generated by coal, while delivering on efficiency targets. These are critical factors in ensuring a long-term, reliable power supply and compliance with even the most stringent environmental standards – now and in the future.

At Doosan, we understand that there are different types of biomass, ranging from clean, relatively safe wood and forest residues to highly corrosive demolition wood and high alkali agricultural products. Depending on its respective characteristics, each type of biomass requires CFB design to be individually adapted, which is why we provide our customers with tailor-made solutions that can flexibly meet even the most demanding combustion requirements at each individual biomass plant.



Gardanne (170MW) Biomass-firing CFB Boiler

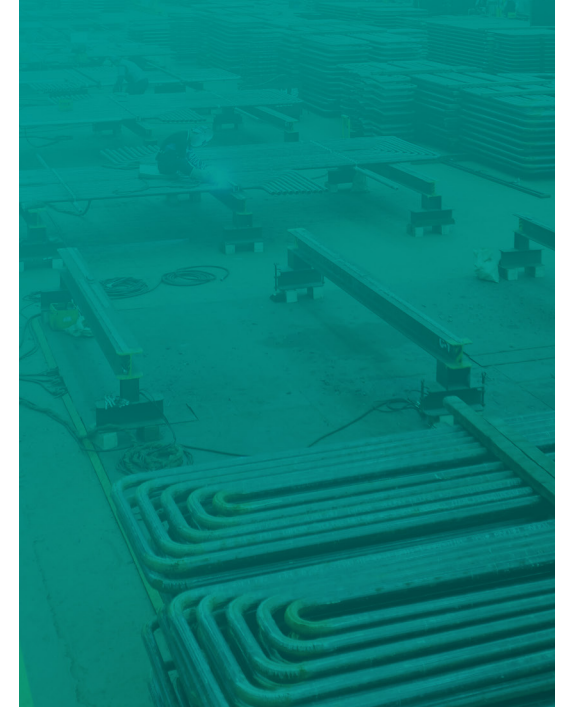
REFERENCES

Strongoli, Italy

- Contract award: 1997 (Newly built)
- Main fuel: Italian and imported biomass
- Technical data
 - Electrical capacity: 2 x 23 MWe
 - Thermal capacity: 2 x 68 MWt
 - Live steam: 81t/h; 515 oC; 95 bar

Gardanne, France

- Contract award: 2012 (Biomass conversion)
- Main fuel: Biomass, waste wood (11%-th), discard coal (13%-th)
- Technical data
 - Electrical capacity: 1 x 170MWe
 - Thermal capacity: 1 x 386MWt
 - Live steam: 441t/h; 566 oC; 165 bar



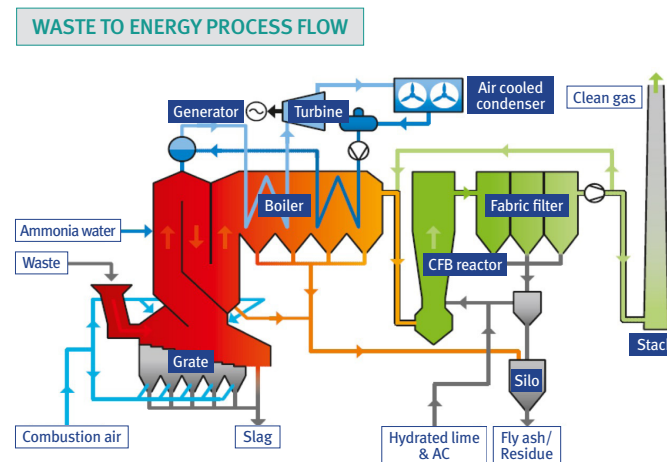
UPGRADES

WtE Offerings

Doosan is a one-stop partner for all your waste-to-energy (WtE) needs, offering a wide range of products and services. Our leading technologies in incineration, flue gas cleaning and steam generation are complemented by the latest steam turbine design. The most common thermal treatment for wastes worldwide is incineration, but there is no 'one size fits all' solution. Doosan's WtE engineering services use optimized technologies that are customized to the size and site conditions of each plant.

WtE Applications

- World-class grate combustion (reciprocating, counter-reciprocating and roller grate type) solutions
- Compliance with the most stringent international emissions reduction requirements through flue gas cleaning (FGC) solutions
- Our efficient residue treatment processes help customers recover recycling materials or stabilize residues from WtE process
 - Bottom ash treatment for the recovery of ferrous and non-ferrous metals
 - Solidification of residues
 - Waste-water treatment
 - Waste pretreatment and handling: Material recovery facility (MRF), Shredder, Baler, Bunker, Cranes
 - Combustion/Steam generation: Feeder, Grate, Boiler
 - Power generation: Steam turbine, Generator
 - Balance of plant: ACC, Compressor, Water treatment systems, etc.
 - Residue treatment: Ash solidification, Slag treatment



REFERENCES

Krakow, Poland

- Contract award: 2012
- Main fuel: Municipal, bulky and similar pretreated waste
- Waste capacity: 220,000 t/a



Krakow WtE

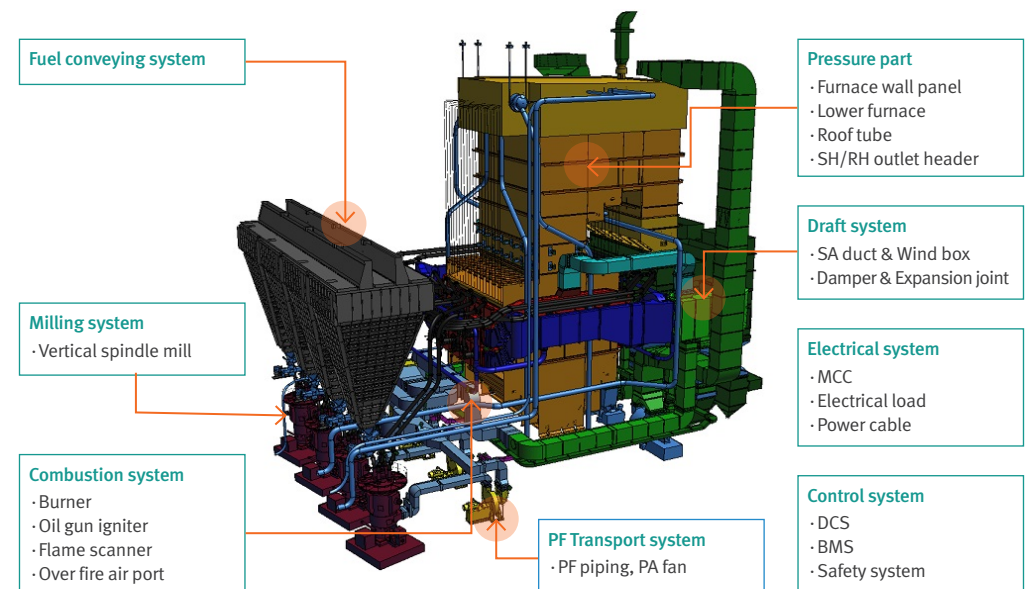
OUTAGES/O&M

Parts Supply

Doosan offers one-stop solutions to fulfill all your boiler servicing and component needs. We meet the diverse requirements of our customers by replacing boiler parts in order to maintain plant competitiveness and extend equipment life. Our part replacement/upgrade services provide state-of-the-art technologies and materials to ensure better performance and decreased outage times. We can also offer a range of end-of-life plans for boilers, supported by the expertise of our plant specialists.

To improve equipment reliability and reduce outage duration and frequency, we offer the following parts-related services for all OEM and non-OEM major boiler manufacturers:

- **Combustion Systems**
 - Wall and T-firing burners, Oil guns, Coal piping and elbows, Tips, Nozzles, Wind boxes, Dampers
- **Pulverizers**
 - Static and dynamic classifiers, Grinding elements, Vane wheels, Motors
- **Pressure Parts**
 - Boiler tubing, Superheater, Reheater, Economizers, Headers, Panels, Desuperheaters, Drum internals
- **Electrical, Control & Instrument (EC&I)**
 - Boiler electronic products, Flame scanners, Control cabinets, Process instruments, Burner management systems, etc.



SOLUTION STORIES

OUTAGES/O&M

Inspections & Residual Life Assessment

Doosan conducts residual life assessment (RLA) of a boiler tube. In order to ensure the integrity and safe operation of high pressure, high temperature pipework, pipe components within boilers need periodic RLA by experts, which is why we offer RLA services for high temperature pipework that operates at elevated temperatures within the creep range of construction materials for a long time. This includes main steam, hot reheat, HP/LP bypass lines and loop pipework.

Components of all types of boilers work in adverse operating conditions, such as high temperatures, stress and cyclical loading, which eventually lead to failures at some point. The most common causes of these failures are as follows:

- Stress rupture
- Fatigue (Thermal and mechanical)
- Erosion (Ash)
- Water side corrosion
- Fire side corrosion (High temperature corrosion)
- Lack of quality control (Shop weld failures or mixing of carbon steel with a Cr-Mo alloys)



Non-destructive Evaluation (NDE) Test

RLA SCOPE

- Visual inspection
- Hardness
- Structural integrity by NDT and dimensional measurement
- Metallographic replication
- Material sampling and accelerated creep rupture testing
- Verification of mechanical properties and analysis of results
- Material degradation due to transformation of micro structure

CUSTOMER BENEFITS

- Identify current asset conditions
- Provide an indication of residual life
- Inform repair or replacement decisions
- Early warning of service issues
- Minimum risks to personnel

OUTAGES/O&M

Field Services

Doosan's field engineers have extensive experiences and technological expertise, which enables them to provide customers with the very best in field services for the maintenance and improvement of boilers, pulverizers and auxiliary equipment, ensuring customer proximity. Our expertise has been built over many years with many customers at plant sites around the world as we have solved both common problems and unique ones. We have gained our experiences across a variety of equipment types and brands, including utility services, waste-to-energy, petrochemical, pulp and paper and a range of industrial sectors. We can also help with all fuel types.

Doosan can perform detailed analysis on power plants for multiple operational conditions. The following considerations shall be made:

- Original design and upgraded heat balances
- Model calibration to as-is equipment conditions
- OEM and model-based upgrade potential for major equipment
- Balance of plant systems and components capability



SERVICE ITEMS

- Consulting
 - Operational review
 - System evaluations
- Inspection & Technical Supervision
 - Equipment/Systems on-site testing
 - Control/Combustion tuning
 - Commissioning
- Plant Assessment & Engineering
 - Field inspection & assessments
 - Root cause determination
 - Suggestion regarding upgrade solutions

CUSTOMER BENEFITS

- Specialized plant assessment and engineering services
- Inspection reports
- Suggest integrated upgrade plans and solutions

OUTAGES/O&M

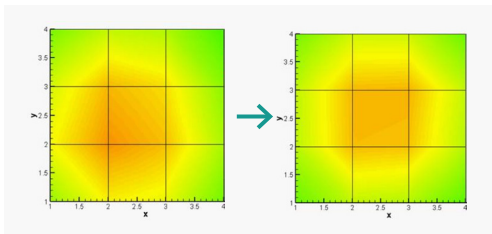
Boiler Tuning

Doosan's plant assessment and engineering services include boiler tuning which improves availability of boiler operations, to maintain stable operating conditions, increase efficiency and reduce emissions. By analyzing and reporting on critical operating data, we can help enhance boiler performance at your plant. As well as tuning, we also offer inspections, maintenance, repairs and a suggestion for customized upgrade solutions.

Analysis of boiler operating data makes it possible to fine-tune boiler performance, ensuring the efficient and reliable operation of plant equipment. Doosan provides OEM technology support which shortens the time needed for plant assessments, improves efficiency and operational stability, and reduces emissions. Our computational fluid dynamics (CFD) modeling techniques are highly developed, making it possible to analyze and predict such negative phenomena that may occur within boilers as furnace corrosion, slagging, erosion, fouling and emissions (CO, NO, UBC). Compared to a site assessment, CFD can produce more affordable solutions within a shorter period of time.

Boiler tuning is closely related to the boiler control system, which sets combustion air flow characterization curves, air fuel ratios and flue gas oxygen set point curves for various fuels. It is also important to minimize NO_x production over-fire air damper curves. We check steam flow to boiler feedwater feed-forward curves, steam superheat and reheat temperature feed-forward curves as well as many other steam pressure and temperature conditions. This ensures safe and efficient operations of boilers, which in turn enhances boiler efficiency.

Doosan also offers digital solutions for combustion optimization, tube management system and remote monitoring system (RMS) which support real-time analysis and suggest a boiler tuning strategy that is optimized for safer operations.



T-firing Fire Ball Position Moving after Fine Tuning



Optimize Boiler Control System

CUSTOMER BENEFITS

- Increased availability
- Better ramp rates
- Extended useful life of equipment
- Safer working environment
- Compliance with environmental regulations
- Reduced unit trips
- Improved heat rate and unit turndown



SOLUTION STORIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



OUTAGES/O&M

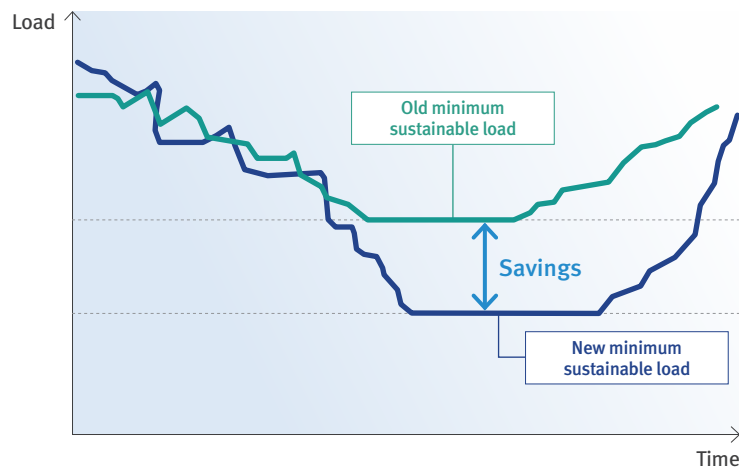
Boiler Flexibility

Today's renewable energy sources (RES), gaining scale and backed by preferential dispatch, bring in an impact of variability and uncertainty into the grid due to their nature of generation. With increased influx from RES, conventional power plants are required to operate in more cycling and with higher flexibility, which impacts efficiency, reliability and lifetime of power plant equipment. Most of the conventional thermal plants were designed for base load service, moderate load following and occasional on-off cycling, but flexible operations call for faster start-up and shutdowns, wider ramp-up/down rates, increased capabilities of partial load operation in compliance with emission as well as maintenance of efficiency. As a total plant service provider and boiler original equipment manufacturer (OEM), Doosan offers packages that improve the operational flexibility of your boiler.

Each plant has its own characteristics in operations, such as fuel, equipment design, output, etc., and has different needs for flexible operation. Thus, each set of flexibility solutions for a specific plant should be customized and designed for each unit, which means there is no 'one-size-fits-all' solution.

The first step to develop each solution set is to systematically assess the design and identify areas that are prone to accelerated damages (fatigue, creep-fatigue, corrosion, expansion) as a result of more frequent cycling operations.

MINIMUM LOAD REDUCTION



TYPICAL SOLUTIONS FOR FLEXIBLE BOILER OPERATIONS

• Coal-firing System

- Enhanced flexibility in combustion systems
- Firing down to very low rate is required (High turn down ratio)
- Indirect firing system enables 10% load or even lower
- Reduction in inertia of system allows firing ramping rate

• Improvements to boiler pipework for greater flexibility

- Increase ramp rate by reducing thermal gradients
- Use new steel to allow reduced metal thicknesses
- Increasing number of headers
- Reduce the minimum load
- Evaporator design, such as rifled tubing
- Economizer or feedwater heater bypasses

• Control System

- It is generally worthwhile to replace control and instrumentation systems in order to increase plant efficiency and flexibility
- These retrofits provide faster ramp rates and lower minimum loads

CUSTOMER BENEFITS

- Faster startup and shutdown
- Wider ramp rate
- Minimization of lifetime impact on critical component through flexible operations
- Technical supports to ensure proper cycling operations and respond to any issue during operations



Air Quality Control System

Doosan specializes in air quality control system (AQCS) across power and industrial sectors. Our AQCS technologies help customers all over the world to enjoy a greener and cleaner life. We invest in the latest innovative technologies in order to provide our customers with optimal solutions, in our efforts to be the best business partner by finding new ways to meet ever-changing market requirements.

Our AQCS solutions have been developed in-house, alongside our boiler fuel combustion technologies. We offer a wide range of site-specific portfolio solutions for AQCS upgrades and O&M.

We leverage our extensive engineering, procurement and construction (EPC) project experience to offer a variety of solutions to increase equipment capacity and ensure efficient operations, within a limited footprint in order to meet the most stringent regulation for power plants emissions. Our customers benefit from low O&M costs and longer lifetime that comes from reliability, availability and maintainability (RAM).

OUR KEY SOLUTIONS INCLUDE

UPGRADES

- De-SOx solutions
- De-NOx solutions
- De-dust solutions
- GGH & Non-leakage GGH
- Wet ESP – EME
- Zero liquid discharge (ZLD)

OUTAGES/O&M

- Parts supply
- O&M supports



Comprehensive
FGD line-up

99%+

SOx removal efficiency
through WFGD

Less 10 mg/Nm³

Less 10mg/Nm³ PM
at ESP outlet

90%+

NOx removal efficiency
through SCR



Complete coverage
for AQCS solutions



PROJECT STORIES



EXPERIENCE LIST

Total Plant | Boilers | **AQCS** | Steam Turbines | Generators | Plant Assessment | Gas Turbines | AM Services | Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



UPGRADES

De-SOx Solutions

Doosan has adopted the wall rings and tray system to provide an environmentally-friendly and high efficiency flue-gas desulfurization (FGD) upgrade solutions through advanced absorber technologies, thus meeting very strict SOx emission limits with minimum parts replacement of existing absorber design. In addition, we leverage our complete FGD line-up to offer add-ons for plants with no FGD currently installed, according to site location and specific requirements.

Our various FGD line-up, with flexible design and low power consumption resulting in low OPEX, enables customers to meet stringent gas emission standards.

- Comprehensive line-up for FGD add-on solutions
 - Wet FGD, Seawater FGD, Dry FGD

FGD upgrade solutions lead to longer lifetimes and lower SOx emissions, as well as lower operation and maintenance costs.

- Advanced absorber technologies for higher efficiency
 - Gas flow distribution optimization and effective gas-liquid contact
 - Spray nozzle type and arrangement, Wall rings, tray system, CFD analysis
 - Optimization of existing FGD system
 - Number of operated pumps, Oxidation air system, Pressure drop, Power consumption, Lower building height, Less external and recirculation piping
 - System modularization, Convenient inspection and maintenance



Absorber Tray



Absorber Wall Rings

CUSTOMER BENEFITS

- Homogenized SOx clean gas distribution
- High SOx removal efficiency with low L/G ratio
- Minimized replacement of existing absorber



SOLUTION STORIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



UPGRADES

De-NOx Solutions

Doosan offers various De-NOx solutions to meet and exceed strict gas emissions standards. We design De-NOx solutions that are optimized to meet different requirements at each power plant by combining various technologies related to boiler structure steel analysis, De-NOx primary measures (LNB & OFA) and secondary measures (SCR & SNCR) and other technologies as required. This enables us to provide customized De-NOx solutions with lower capital expenditure (CAPEX) and lower operating expenditure (OPEX).

Doosan supplies high-performance De-NOx systems to coal-fired and oil-fired power plants worldwide. Our technical expertise and experiences in boiler design and manufacturing enable us to customize our De-NOx and SCR systems to the specific needs of our customers.

We are committed to finding the best solution for the reduction of primary and secondary NOx emissions at existing power plants.

- Selective catalytic reduction (SCR)
- Selective non-catalytic reduction (SNCR)
- Combustion control: Low NOx burner, Over fire air systems, Flue gas recirculation, Advanced re-burning systems, etc.



CUSTOMER BENEFITS

- High efficiency of NOx removal (over 90%)
- Applying wide range of reducing reagent
- Outstanding fusion technology between boilers and SCR
- Optimized ammonia distribution technology

REFERENCES

MongDuong #2, Vietnam

- 660MW x 2 Units
- Clean gas NOx values < 375 mg/Nm³



SOLUTION STORIES

Total Plant | Boilers | **AQCS** | Steam Turbines | Generators | Plant Assessment | Gas Turbines | AM Services | Digital Solutions



SERVICES

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PRODUCTS & SOLUTIONS



UPGRADES

De-dust Solutions

Electrostatic precipitators (ESP) upgrades for higher removal efficiencies enable customers to further reduce emissions of particulate matters (PM_{2.5} and PM₁₀). Doosan provides a range of de-dust solutions which offer limited scope of replacement within the existing footprint, in order to meet and exceed stringent gas emissions regulations with low CAPEX and OPEX.

For more than 30 years since 1979, Doosan has helped customers worldwide to meet global environmental regulations. Our tailored solutions will satisfy all your plant requirements.

ESP modification can upgrade existing ESPs, and it also can change a type or combination (MEEP, dual zone type, wet type ESP adding after final field, fabric filter, etc.)



CUSTOMER BENEFITS

- High dust removal efficiency (over 99%)
- Low power consumption by applying the high efficiency transformer-rectifier
- High erosion and corrosion resistance of internal components
- Durable rapping system for CE & DE
- Clean gas values < 10 mg/Nm³ can be achieved

REFERENCES

Dongjin #5-8, Korea

- 500MW x 4 Units
- Clean gas values < 40 mg/Nm³



UPGRADES

GGH & Non-leakage GGH

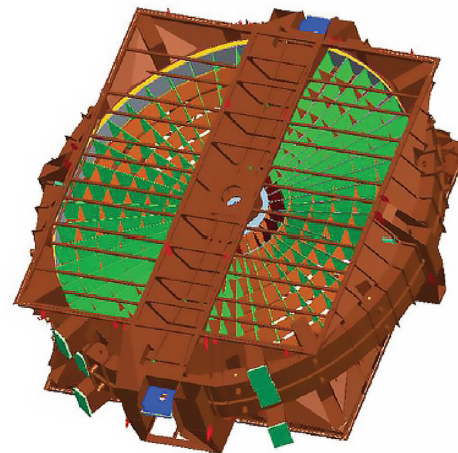
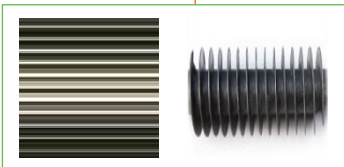
By going through a gas-gas heater (GGH), the temperature of clean gas after desulfurization rises sufficiently to prevent white plume phenomenon. Doosan can supply a full range of GGH.

Non-leakage GGH

The temperature of clean gas is raised sufficiently thanks to a specialized tube designed using Doosan's own technology. This tube is a main factor in the performance of non-leakage GGH. Doosan's non-leakage GGH with our specialized tube enables to gain a competitive advantage in differential pressure and minimize ventilation costs.

Ljungstrom GGH

The heat of flue gases is exchanged by counter-flow in Ljungström GGH. Doosan's Ljungström GGH features a compact design, and thus has a larger heating surface for efficient performance. Doosan supplies the widest range of GGH in the world based on decades of experiences in domestic and overseas projects.

**CUSTOMER BENEFITS****Non-leakage GGH**

- Minimum leakage of 0% achieved
- Minimization of differential pressure
- Long lasting lifetime

Ljungström GGH

- Outstanding track records for all types of fuel and various capacities
- Proven technology through world's largest GGH (20.25m of rotor diameter, Shin-boryeong #1, 2 / 1,000MW x2)
- High efficiency of heat exchange with low CAPEX



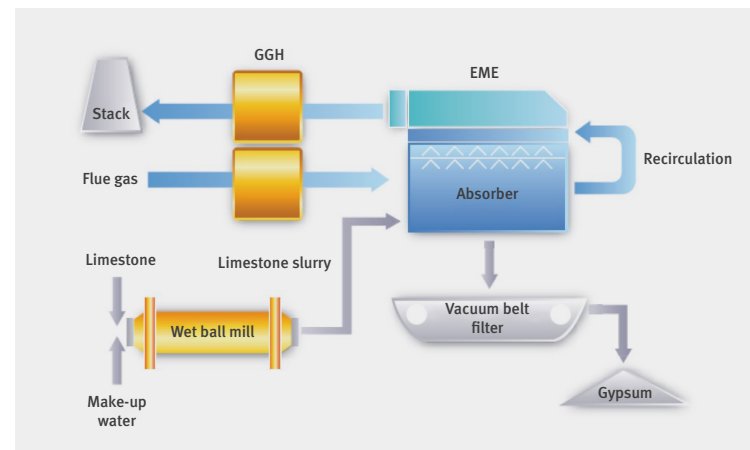
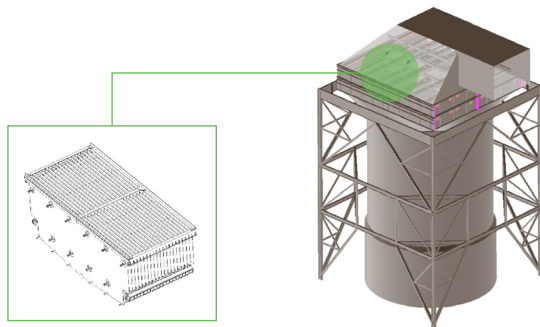
UPGRADES

Wet ESP – EME

The electrostatic mist eliminator (EME) has been developed as an alternative to the wet electrostatic precipitator (WESP) as it offers lower capital costs and pressure drop. It also has a competitive advantage in regions with limited space. This flexible and economical technology can remove from boilers fine particles such as solid particles, metals, mercury, acid mists and liquid droplets in flue gas from a boiler.

The EME system eliminates fine particles in flue gas by using electrostatic force. Its novel discharge electrode design enables the EME to be operated at higher flue gas velocities. A wet limestone FGD system eliminates SO_x in flue gas by using an alkali absorbent such as limestone or lime as the agent. Gypsum is produced as a by-product of this reaction, which can then be further treated to make it into commercial grade gypsum.

Our optimized and advanced design minimizes the consumption of utilities and reduces the need for maintenance of FGD facilities.



CUSTOMER BENEFITS

- High collection efficiency of fine particulates and PM₁₀/PM_{2.5}
- Operations with higher flue gas velocities in the EME
- Collection of particulates and condensables (Acid mist, HAPs, etc.)

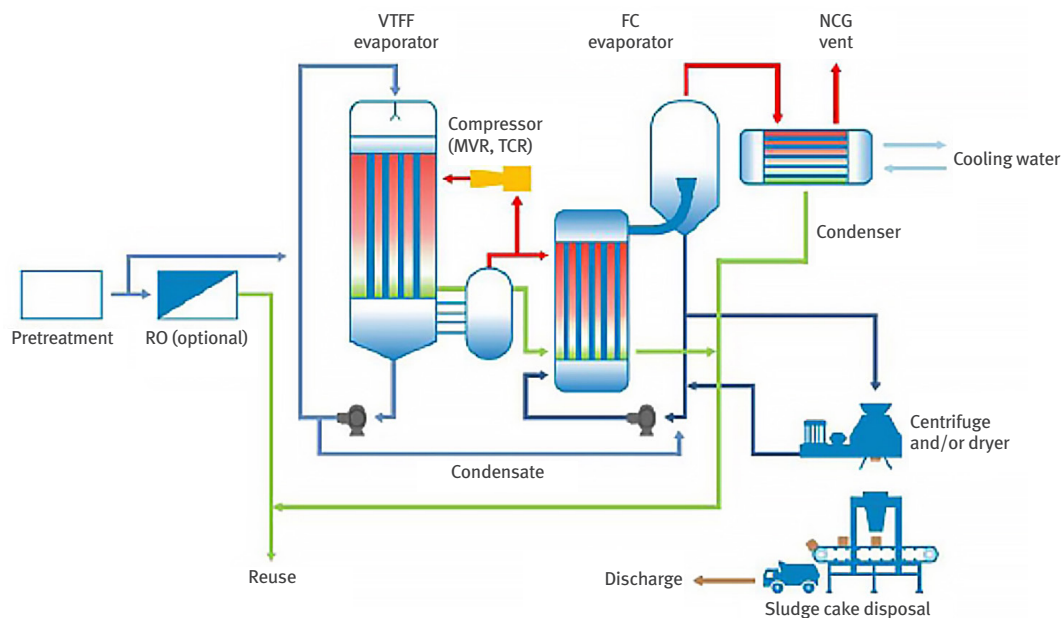


UPGRADES

Zero Liquid Discharge

Doosan's zero liquid discharge (ZLD) system uses thermal evaporation technology to recover most effluent in the form of highly purified distillates. Depending on the water quality of the effluent, the right pre-treatment process is designed to ensure high performance of Doosan's ZLD evaporator.

The ZLD process is the most advanced wastewater treatment technology available as it achieves zero or minimal effluent discharge and the production of highly purified water. It also complies with all regulatory requirements for effluent disposal. In addition, ZLD provides a technically feasible option for dramatically reducing salts in the effluent stream, which in turn provides opportunities for the re-use of treated water.



CUSTOMER BENEFITS

- No waste water discharge
- Highly purified water production
- Small ecological footprints
- Payback of CAPEX/OPEX
- Recovery of commercial grade salts

REFERENCES

Yeongheung Power Plant, Korea

- 800MW x 2 Units + 870MW x 4 Units
- Capacity: 2 x 15m³/h



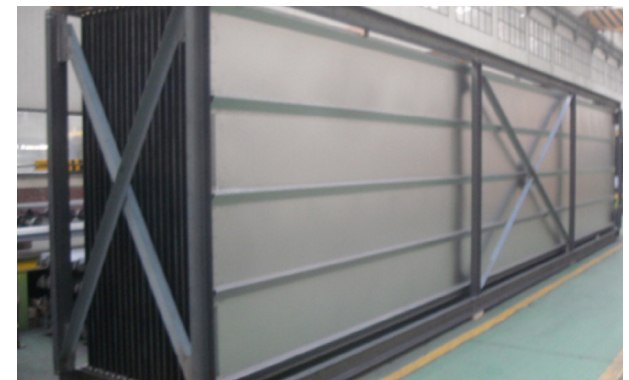
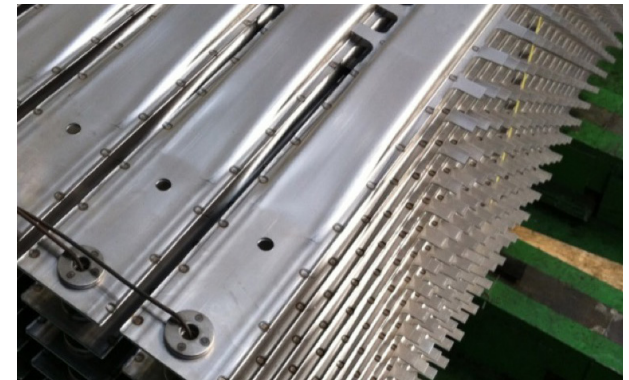
OUTAGES/O&M

Parts Supply

Doosan supplies a wide range of replacement parts and control systems for original and improved components related to dry and wet flue gas desulfurization (FGD), electrostatic precipitators (ESP), fabric filters (FF), selective catalytic reduction (SCR) and ash handling systems (AHS). We are a one-stop solution provider of like-for-like or upgraded parts replacement, on-site replacement work as well as TA services for erection and commissioning.

We provide following replacement parts for OEM and non-OEM boiler manufacturers to improve availability and extend lifetime while reducing shut down period and frequency.

- FGD: Spray nozzle, Pump internal part, Agitator, Ball mill, VBF, Oxidation air blower, Fan
- SCR: Catalyst, Dilution air blower, Sonic horn, Ammonia injection gred
- ESP: Collecting electrode, Discharge electrode, Rapping system, Insulator, Transformer rectifier
- AHS: Bottom ash conveyor system chain, Belt, Liner and tension device, Fly ash transport piping, Blower, Compressor, Bag filter system and aeration device



OUTAGES/O&M

O&M Supports

Doosan specializes in AQCS of the utility, municipality and industrial sectors for OEMs and non-OEMs. We implement environmentally-friendly flue gas cleaning solutions for customers across the world, and we also help them to set up cleaner environmental protection systems. Our vast proprietary product portfolio allows us to select the most advantageous process for each type of application, in an effort to benefit our customers.

We can help our customers with all the challenges that arise at their plants by leveraging our extensive experiences in AQCS assessment. Our operational reliability and innovative skills make us the ideal partner in achieving your environmental and financial goals.

Our expertise and advanced engineering skills cover every aspect of plant engineering, maintenance and modernization through the assessment of existing AQCS systems. We aim to minimize downtime, which in turn ensures cost-effective operations and an optimized cost-benefit ratio.

We can take care of your entire plant requirements from planning to implementing AQCS operation, and our offerings are as follows:


- Checking and reviewing of entire plant AQCS configuration
- Technical solutions for existing troubles
- Optimized concepts for AQCS
- All necessary individual components
- Thorough and individual staff trainings



AQCS ASSESSMENT AREAS

- FGD (sea water, wet limestone, dry) system
- Selective catalytic reduction (SCR) system
- Electrostatic precipitator, Bag-filter
- Bottom/Fly ash handling system





Steam Turbines

As a steam turbine OEM, Doosan is equipped with cutting-edge technologies and expertise in design, manufacturing and services. Our expertise covers repair and upgrade services for various turbine manufacturers, and we offer customized and cost-effective services to customers around the world based on our diagnostic and evaluation capabilities. We also provide long-term maintenance services, including turbine repairs, upgrades, commissioning and the supply of spare parts through our global networks.

There are limits on how long it is possible to maintain the efficient performance of steam turbines by overhauling them or simply repairing components. In particular, it becomes more difficult over time to source required parts for seamless renovation. Doosan's advanced steam path technologies can be used in a range of OEM and non-OEM turbines, giving new life to your steam turbine.

110 years+

Experiences in turbine OEM

13%+

Power uprating at Eraring (660MW → 750MW)

Up to 5%

Efficiency improvement by SPU

15 years+

Lifetime extension through replacement of key components



Resolution of chronic maintenance issues through tailored solutions

OUR KEY SOLUTIONS INCLUDE

UPGRADES

- Steam turbine upgrades
- Steam path upgrades (SPU)
- Key technologies for SPU
- SPU for fossil and nuclear turbines
- SPU for LMZ LP turbines
- Turbine auxiliary system upgrades
- Turbine governor system upgrades
- Condensate & feedwater system

OUTAGES/O&M

- Parts supply
- Inspections & testing
- On-site services
- Workshop services
- Non-Doosan turbine services
- Turbine spares stocking programs
- Steam turbine flexibility



PROJECT STORIES



EXPERIENCE LIST



WORKSHOP & FACILITIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



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PRODUCTS & SOLUTIONS

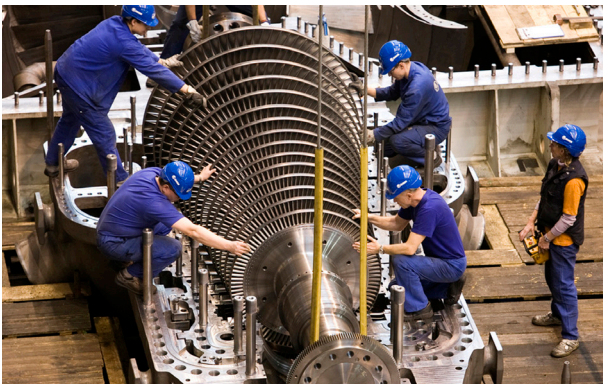


UPGRADES

Steam Turbine Upgrades

Doosan offers a range of solutions to reduce the effects of ageing on steam turbines and to minimize efficiency losses. These upgrades are tailored to each customer's individual requirements.

As part of new solutions for turbine upgrades, it is proposed to replace existing labyrinth seals with seals that have more advanced sealing properties, which can be done through steam path upgrades or complete replacement of the turbine within existing foundations. Doosan is fully equipped to provide highly effective upgrades, with our skilled engineering teams using sophisticated specialist tools and devices for reverse engineering. The following are examples of typical steam turbine upgrade solutions, which can be optimized for the conditions of each turbine.



TURBINE UPGRADES TECHNOLOGY

- Advanced steam path upgrade
- Complete turbine replacement with original foundation
- Re-blading
- LSB group upgrades
- Advanced seal upgrades
- Modernization of turbine control system
- Replacement of re-engineering parts

CUSTOMER BENEFITS

- Efficiency improvement up to 5%+ through steam path upgrades or complete replacement
- Output improvement up to 10%+ through steam path upgrades or complete replacement
- Lifetime extension of main components
- Improvement on reliability and availability
- Maintenance costs reduction

UPGRADES

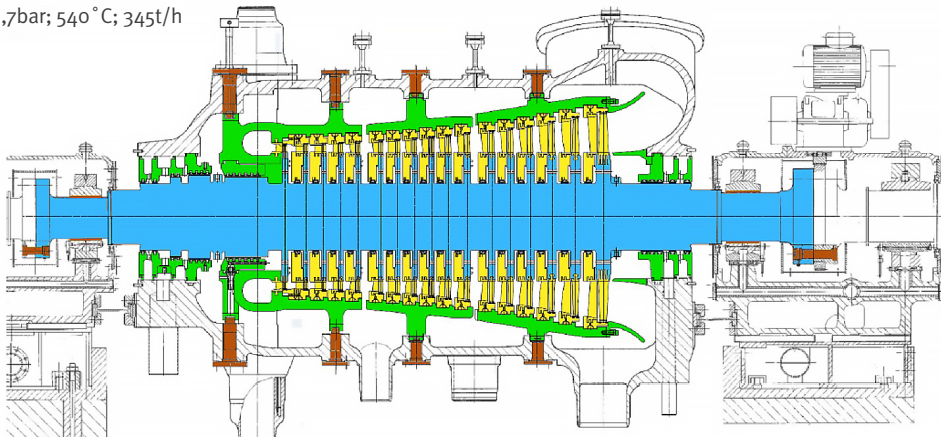
Steam Path Upgrades

Doosan's steam path upgrade (SPU) solutions substantially improve the output and efficiency of steam turbines. Using the latest technologies, these upgrades enable ageing turbines to achieve the same efficiency and performance as the latest new turbines.

If the existing outer casings are able to be reused, SPU can provide customers with the equivalent of a full turbine replacement while reducing costs and the burden of delivery. Doosan has the capability and organization to offer the right turbine upgrade solutions for customers, from site surveying to evaluating turbine conditions and assessing the right solution. We always provide the best turbine solution that meets customer needs.

125MW-IP TURBINE STEAM PATH UPGRADES

45,7bar; 540°C; 345t/h



WIDE RANGE OF SPU

- Fossil steam turbines
- Small/Industrial steam turbines
- Nuclear steam turbines
- LMZ/BHEL LP turbines
- CCPP steam turbines

CUSTOMER BENEFITS

- Efficiency improvement up to 5%+
- Output improvement up to 10%+
- Lifetime extension about 20 years
- Improvement on reliability and availability

UPGRADES

Key Technologies for SPU

Doosan has also applied its advanced technologies, proven in our own turbines, to non-Doosan turbine upgrades.

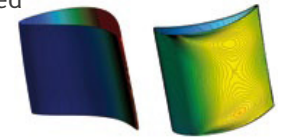
LSB SOLUTIONS

- Improved profile efficiency
- Optimized aerodynamics
- Selection from wide family of LSBs
- Use of approved modular solution
- High availability and long lifetime



3D OPTIMIZED BLADING

- Aerodynamic losses reduction
- Increased efficiency compared to the types of blading previously used
- Improved specific heat consumption



LP DIAPHRAGMS

- Hollow stationary blade with groove for water separation on suction and pressure surfaces
- Welded design
- Moisture removal in the area of last LP stages



SOLID-FORGED AND WELDED ROTORS

- Use of materials that have optimal properties for different parts of rotors at specific operating conditions
- Weight reduction in welded parts
- Higher metallurgical accuracy, Economically attractive solution
- Reduced heat load, Faster startup



HP/IP ASSEMBLED DESIGN DIAPHRAGMS

- Precise assembly
- Bucket-tip, Honeycomb type sealing
- Improved efficiency through reduced clearances
- Spring-back option for sustaining high efficiency during lifetime



ABRADABLE INTER-STAGE LABYRINTH SEALINGS

- Stator coating that creates a rubbing tolerant sealing
- Improved efficiency through reduced clearances
- Minimized damage or wear of sharp edges
- Spring-backed as default solution
- Patented retractable design for peaking and solar turbines



UPGRADES

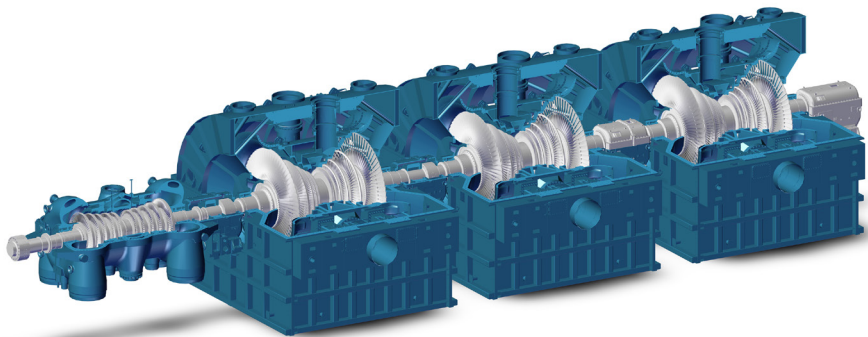
SPU for Fossil and Nuclear Turbines

Doosan is a leader in steam turbine technology for power generation, and has undertaken a wide range of turbine retrofits for various makers. We leverage this experience to provide SPU solutions that meet the specific needs of our customers.

At Doosan, we follow a principle that each turbine's flow part is always designed according to the specific requirements and conditions of each individual project. We combine our modular structure with operationally verified nodes in order to achieve maximum possible efficiency.

Doosan offers a range of last stage blade (LSB) solutions to meet customers' requirements. We have experiences in SPU projects that have increased the stages and active bucket length of Eraring's non-Doosan fossil turbine (660MW x 4units, 3,000rpm/50Hz), with output increased by about 13% and turbine efficiency by approximately 1-3%. We can tailor our fossil steam turbine technologies to fit the requirements of your project (speeds of 3,000rpm or 3,600rpm).

Since the 1960s, Doosan has been a technology leader in saturated steam turbines for nuclear power plants, providing steam path upgrade solutions for various types of nuclear steam turbine. Doosan has optimized its steam path upgrades for the stringent requirements of nuclear technology, and has successfully applied them to South Korea's Nuclear LP turbine (950MW x 2units, 1,800rpm/60Hz). We can tailor our wide range of nuclear steam turbine technologies to fit your requirements (speeds of 1,500rpm or 1,800rpm).



TYPICAL UPGRADE PARTS

- Rotors, Blades, Buckets
- Inner casings
- Nozzles and partitions upgrades
- Bucket covers, Seal strips
- Dovetail upgrades
- Turbine controls, Governing system
- Turbine valves, Auxiliary system, etc.

CUSTOMER BENEFITS

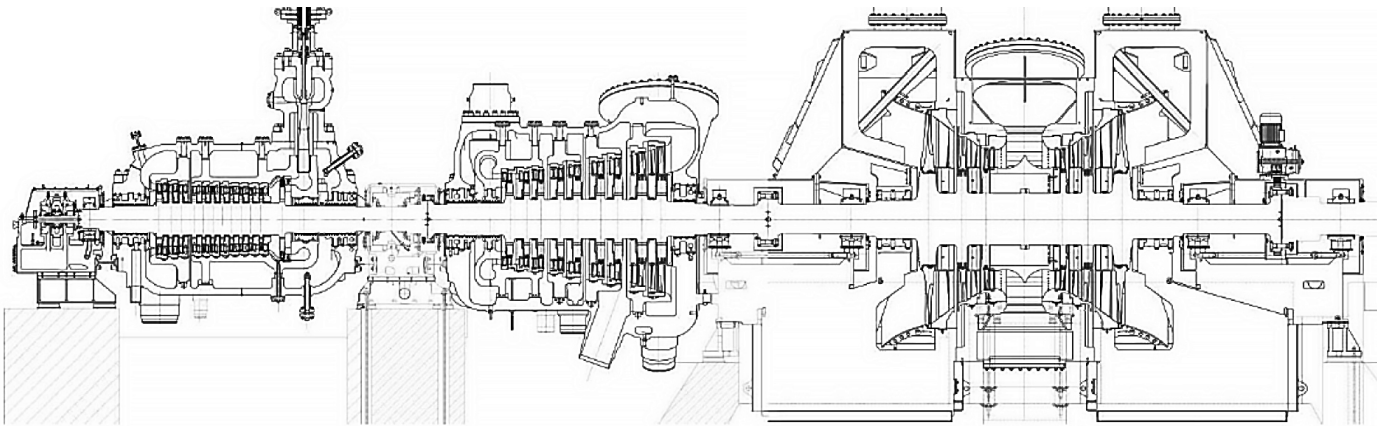
- Output improvement
- Heat rate improvement
- Lifetime extension
- Resolution of chronic maintenance issues

UPGRADES

SPU for LMZ LP Turbines

Doosan offers tailored SPU solutions specifically for LMZ low pressure (LP) steam turbines in India, which have a relatively low efficiency LSB.

Doosan has also established SPU solutions for LP turbines of the Kolkata Unit #1-3 (3 x 210MW, installed with LMZ/BHEL turbines) by leveraging its experience gained on the India Bandel LMZ steam turbine replacement project (1 x 210MW). This will be further applied to other upgrade projects in India as well.

CONVERTED LMZ LP TURBINES**CUSTOMER BENEFITS**

- Heat rate decreases
- Lifetime extension
- Improvement on power output and operational flexibility
- Improvement on turbine durability and availability
- Elimination of restrictions on the operational parameters of turbines
- Improvement on rotor dynamic behaviors

UPGRADES

Turbine Auxiliary System Upgrades

Power grids today need steam turbines to operate flexibly. It is therefore important to upgrade turbine auxiliary systems, including turbine valves, oil systems, warming systems, control systems and others, in addition to main turbines.

Shell Washing Solutions

Doosan has a shell warming system which reduces the temperature difference between the upper and lower shells of turbine casings at cold startup of HP/IP. This can reduce the vibrations caused by shell deflection and also shorten startup time through turbine casing warming. In addition, Doosan offers a shell washing solution for faster startup, which can also be provided as a stand-alone system.



Turbine Valve Upgrade Solutions

Doosan offers state-of-the-art turbine valve upgrade solutions to resolve problems caused when the turbine valves currently installed have technical limitations due to thermal stress damage, creep and fatigue, and shortened life span. Doosan can repair stems and actuators of old turbine emergency stop/control valves, and can also offer upgrades using the latest technologies.



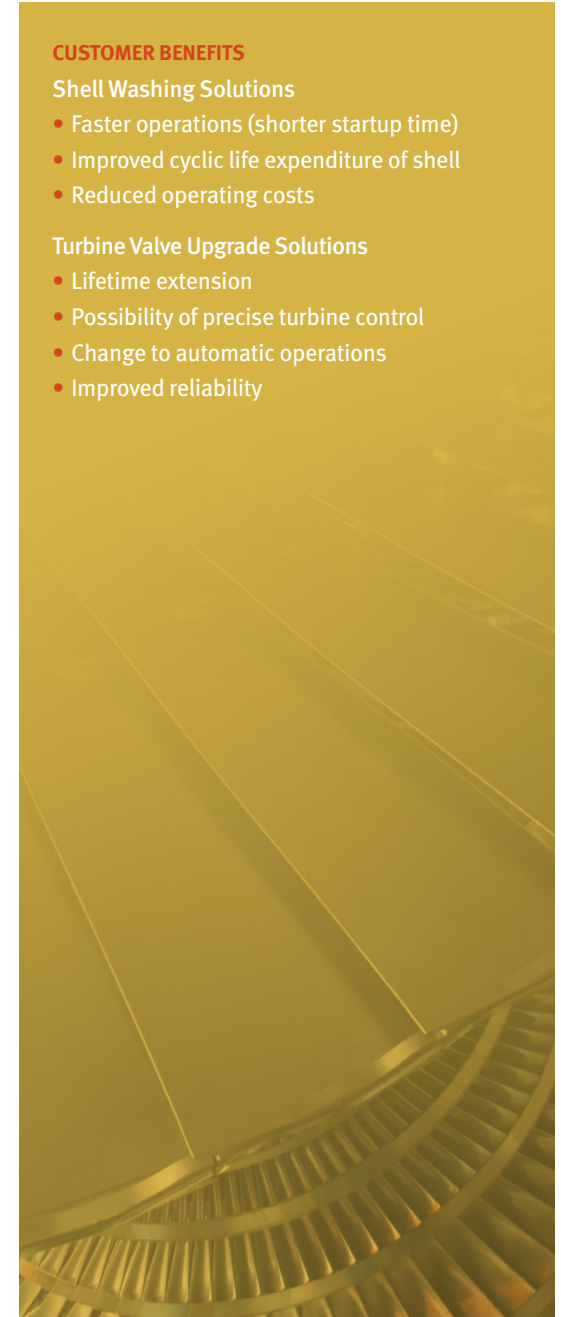
CUSTOMER BENEFITS

Shell Washing Solutions

- Faster operations (shorter startup time)
- Improved cyclic life expenditure of shell
- Reduced operating costs

Turbine Valve Upgrade Solutions

- Lifetime extension
- Possibility of precise turbine control
- Change to automatic operations
- Improved reliability



UPGRADES

Turbine Governor System Upgrades

Reliable turbine fine control is essential for the flexible operation of turbines according to the requirements of grid today, but there are technical limitations in old turbine governor systems. Doosan therefore offers state-of-the-art turbine governor and turbine control system (TCS) replacement solutions.

Doosan offers a solution to upgrade the governor system's mechanical hydraulics actuator to an electro hydraulic converter (EHC), and upgrade the TCS to feature the latest technologies. This leads to improved reliability, accuracy and flexibility, and can be applied to all OEM and major non-OEM steam turbines.

TURBINE GOVERNOR PANEL

**TYPICAL REPLACEMENT**

- Hydraulic governor, Hydraulic amplifier
- Follow-up pistons, Overspeed trip
- Thrust bearing trip
- Main trip device, Manual trip device
- Solenoid valve for MSV

CUSTOMER BENEFITS

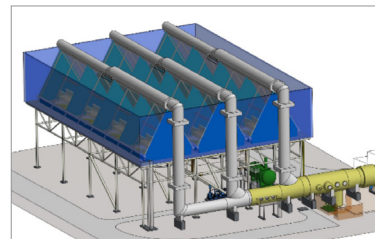
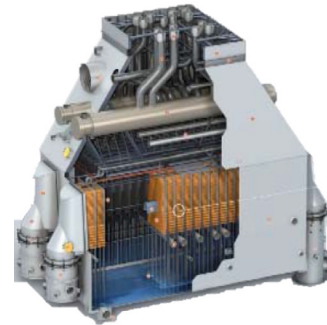
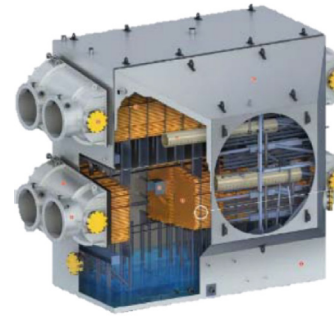
- Operational flexibility
- Improved reliability and availability
- High speed governor

UPGRADES

Condensate & Feedwater System

Doosan provides services for a condensate & feedwater system as a total solution provider. Thanks to the experience and expertise accumulated through years of successfully completing various projects, Doosan has built up the unique technology required to offer a full range of condensate & feedwater system services. This includes design, fabrication, 3D modeling, installation and upgrades.

In addition to the main equipment, boilers and steam turbines, auxiliary facilities, which support these cycles, play a critical role in a power plant's operations. In particular, the feedwater heater and condenser, which are responsible for efficiency and water cycle, are vital in maximizing efficiency and output.



OUR OFFERINGS

- **Surface Condenser (Horizontal/Vertical)**
 - Replacement of condenser tubes
 - Replacement and re-design of condensers
- **Air Cooled Condenser**
 - Replacement and re-design of ACCs
 - Replacement of ACC bundle tubes
 - Replacement of Cooling fans
- **Feedwater Heaters (HP/LP)**
 - Replacement and re-design of feedwater heaters

CUSTOMER BENEFITS

- Optimization of plant efficiency
- Higher plant availability and reliability
- Lifetime extension

OUTAGES/O&M

Parts Supply

Doosan provides a full range of parts supply services, backed by its own skills in steam turbine OEM engineering and manufacturing. Our years of know-how and experience make it possible to provide both parts which are completely identical to existing ones and parts which use new state-of-the-art technologies and improved materials, according to customer requirements. Our proven and reliable parts improve performance and extend outage intervals. We can also provide parts recommendations and the strategic spare parts needed for each unique operational setting. Customers can expect our global facilities and service centers to offer top quality components managed through strict quality controls, as well as on-time delivery service to meet their overhaul schedules.

We offer parts-related services for all OEM and major non-OEM steam turbine manufacturers, in order to improve equipment reliability and reduce the duration of outages. Our offerings include:

- Strategic Spares

- HP turbine: Bucket, Diaphragm, Bearing pad and bush, Packing ring, Spring, Retaining ring, etc.
- IP turbine: Bucket, Diaphragm, Packing ring, Spring, Running key, Retaining ring, Seal fit ring, etc.
- LP turbine: Bucket, Diaphragm, Packing ring, Plate spring, Rupture disc rubber shield, etc.
- Turbine valves: Valve seat, Actuator, Valve disc, Gasket, Sub valve, Strainer, Stem, Servo valve, Seal head and bush, etc.
- Main oil pumps: Thrust seat for MOP/EOP, Mechanical seal for MOP, Impeller, Intermediate coupling, Seal ring, Bearing collar, etc.

- Overhaul Spares

- Complete sets of overhaul parts: Mechanical seals, Bolts and nuts, Gaskets/locking plate/shims, Overhaul consumables, etc.



OUTAGES/O&M

Inspections & Testing

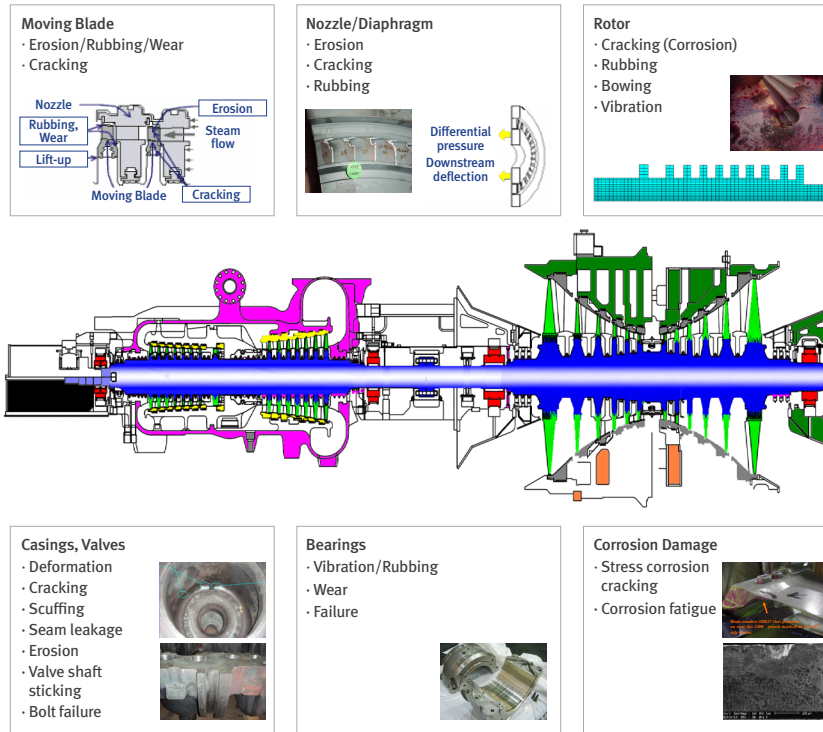
Doosan provides inspections and testing services to evaluate turbine condition, life and performance for various different types of turbine by leveraging its extensive experiences in supplying steam turbine equipment and performing non-Doosan turbine retrofits. These inspections and tests on vulnerable parts can be undertaken during steam turbine overhauls, and we recommend solutions based on the inspection results. The results of periodic turbine inspections and tests can be used as the basis for the long-term planning of the repair and replacement of major turbine parts.

Periodic pre-inspections of the vulnerable parts of a turbine help to prevent unplanned and long-duration shutdowns, thus increasing operational availability and efficiency. Descriptions of possible issues regarding common turbine components are as follows:

TURBINE INSPECTIONS AND TESTS

- **Condition Check**
 - Visual inspection for weakness areas: Rubbing, SPE/Deposit/Leakage/Flow path damage
 - 3D scanning measurement
- **Material Test**
 - Replication/Hardness test
- **NDE**
 - Conventional UT/MPI
 - Bore/Disk inspection
- **Performance Evaluation**
 - Turbine heat balance calculation
 - Steam path audit
 - Stress analysis

POTENTIAL DAMAGES AT EACH LOCATION



OUR OFFERINGS

- Evaluation of remaining life
- Analysis on the causes of performance degradation
- Diagnosis of components, Recommendation on future actions (repair, replacement)

OUTAGES/O&M

On-site Services

Doosan provides fast and cost-effective on-site services, from inspection to site machining, based on its substantial experience in a range of steam turbine retrofits. Our expertise has been built up over many years, with many customers, at many plant sites, and Doosan has been able to solve unique customer problems, as well as more common ones. In addition, Doosan has worked on a variety of equipment types and brands, including services in the fossil fuel, nuclear, boiler feedwater pump turbine (BFPT) and industrial sectors.

Turbine Inspections

Turbine conditions are checked by inspection specialists.

- Visual condition check, Laser measuring
- Operational reviews
- Non-destructive/electromagnetic testing
- Bore scope inspections

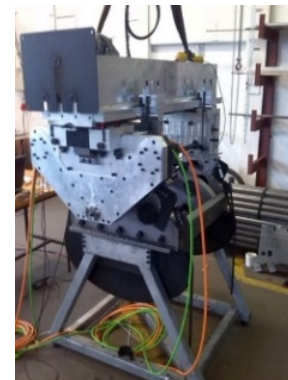
Turbine Repairs

On-site machining is applied at a power plant, where the original equipment modification is required.

- Portable grinding machine
 - Valve set-up: Machine internal and external faces, mainly on valves chambers and flanges
 - Flaps set-up: Contact surfaces and flanges on flaps
- Portable boring machine
 - For the machining on turbine flow parts: Inner and outer casings repairs, grooves and glands
- Portable milling tool
 - For planar milling: Manually controlled, Working in 3 axes system, Repair works on turbine casing planes and similar kind of flat surfaces
- Reaming machine for couplings holes
 - For rotor coupling hole for old rotors



Grinding machine



Reaming machine



Boring machine

OUR OFFERINGS

- High reliability of qualified on-site repair procedure
- Suggest the best integrated upgrade plans and solutions
- Worldwide utilization
- Expert inspection reports

OUTAGES/O&M

Workshop Services

Doosan works in cooperation with branches and local partners worldwide to provide workshop repair services around the world, with its precision machining facilities, highly qualified engineers and high-speed balancing equipment.

Based on our extensive and long experiences, we offer fast and reliable workshop services for when on-site repair is deemed difficult.

Rotor Repairs

- Joining of new forged sections, shaft buttering
- Disc repairs, disc head buildup with new materials
- Techniques to straighten rotors
- High-speed balancing test

Blading Repairs

- Dressing and weld repairs for all types of fixed and moving blades (LSBs)
- Leading edge hardening and shielding
- High-speed balancing test

Casing Repairs

- Correction of minor cracking and change in the geometry of highly stressed areas
- Re-rounding of distorted casings and addition of new weld materials



High-speed balancing test shop

CUSTOMER BENEFITS

- Accurate and reliable repair tools and procedures
- High-speed balancing test to achieve optimal balance at the same speed as the rated operating conditions
- Expert inspection reports



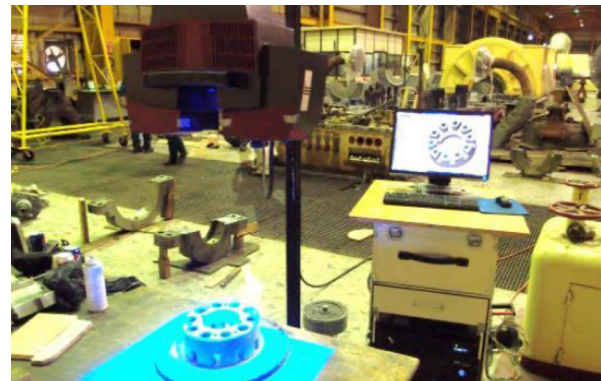
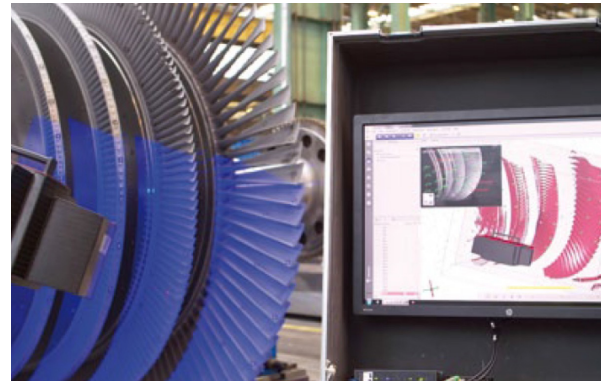
WORKSHOP & FACILITIES

OUTAGES/O&M

Non-Doosan Turbine Services

Doosan also provides global overhaul, on-site services and parts supply for a range of non-Doosan steam turbines. Our non-OEM turbine services include the manufacture and professional repair of all turbine components from individual components, such as blades, to complete new rotors. In addition, we work closely with customers to ensure that they have the right spare parts for turbine maintenance, and we also provide appropriate technical feedback.

Doosan is able to supply most turbine components backed by its extensive experience in various types of steam turbines. If drawings and data are not available, we can reverse-design existing parts through 3D scanning, which allows us to select the best materials and supply the turbine parts required with improved technology.



RELATED SOLUTIONS

- Replacement or repair of turbine parts
- Overhaul and maintenance
- Retrofit or upgrades of steam turbines

CUSTOMER BENEFITS

- Cost-effective parts supply
- Cost-effective integrated solutions
- Advices for stable operations
- Expert inspection reports

OUTAGES/O&M

Turbine Spares Stocking Programs

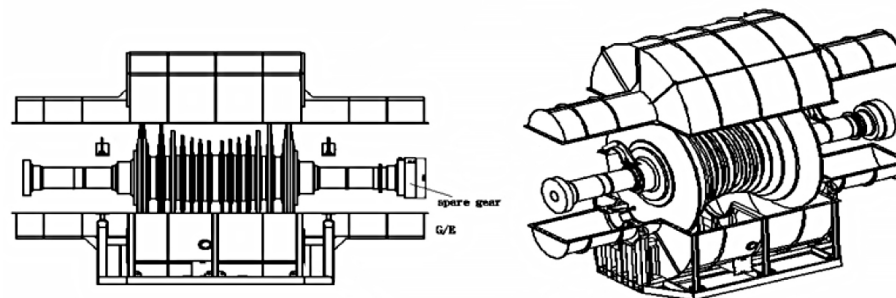
Doosan offers turbine spares stocking programs which are optimized for each customer's specific requirements, helping them to resolve issues regarding long-term storage and professional maintenance methods.

Doosan has developed a 20-year long-term storage technology, employs specialist storage management personnel and ensures a special container design capability, all in our efforts to prevent any damage or rusting caused by the long-term storage of steam turbine spare parts.

We have provided two sets of 500MW steam turbine spare rotors for four Korean companies, as well as 20-year long-term storage services. Based on these experiences, Doosan has developed various turbine spare parts stocking programs as follows:

- Turbine rotors
- Inner casings
- Buckets & Diaphragms
- Bearings
- Packing rings
- Control valves,
- Customized spare parts set

SPECIALY-DESIGNED STORAGE CONTAINER



CUSTOMER BENEFITS

- Operation of systematic spare parts management system
- Manpower and warehouse optimization for spare parts management
- Maintenance of quality spare parts even for the long-term storage
- High-quality spare parts procurement in any necessity
- Replacement, commissioning and technical assistance in any necessity
- Maintenance of high-power plant utilization rate by shortening turbine stopping time

OUTAGES/O&M

Steam Turbine Flexibility

Today's renewable energy sources (RES), gaining scale and backed by preferential dispatch, bring in an impact of variability and uncertainty into the grid due to their nature of generation. With increased influx from RES, conventional power plants are required to operate in more cycling and with higher flexibility, which impacts efficiency, reliability and lifetime of power plant equipment. Most of the conventional thermal plants were designed for base load service, moderate load following and occasional on-off cycling, but flexible operations call for faster start-up/shutdown, wider ramp-up/down rates, increased capabilities of partial load operation in compliance with emission as well as maintenance of efficiency. Doosan, as a total plant service provider and steam turbine original equipment manufacturer (OEM), offers packages that can improve flexibility of your steam turbine operation.

Each plant has its own characteristics in operation i.e. fuel, equipment design, output, etc, and has different needs for flexible operation. Thus, each set of flexibility solutions for a specific plant should be customized and designed for each unit, which means there is no 'one-size-fits-all' solution.

The first step to develop each solution set is to systematically assess the design and identify areas that are prone to accelerated damages (fatigue, creep-fatigue, corrosion, expansion) as a result of more frequent cycling operations.

TYPICAL SOLUTIONS FOR FLEXIBLE TURBINE OPERATIONS

- Appropriate steam path & rotor modification by design study minimizing any lifetime consumption
- Shell warming system retrofit increasing capabilities of wider ramp rate and faster start up
- Modern governor system retrofit enhancing safety on cycle operation
- Modern control and instrumentation systems retrofit achieving stable load changes
- System upgrade with Doosan's digital solutions powering for better monitoring & pre-warning during all courses of operation

CUSTOMER BENEFITS

- Faster start up & shut down
- Wider ramp rate
- Minimization of lifetime impact on critical component through flexible operation
- Technical supports for proper cycling operation & any issues during operation



Generators

Doosan is equipped with cutting-edge technologies and also has extensive in-house expertise in design, manufacturing and services of generators. We offer a complete line-up of generators, including air, hydrogen and water-cooled models, and we have supplied more than 230 units to customers around the world, including new units and retrofits. We have successfully completed a wide range of generator repairs, rewinds and upgrades, supported by our in-house expertise in design, engineering, inspection & testing, diagnosis and evaluation of generators.

Doosan has undertaken projects on generators in thermal, nuclear and combined cycle power plants. We have also successfully completed a number of rewinding projects for non-Doosan generators, including the Eraring (4 x660MW) and Muja (2 x250MW) power plants in Australia, and the MDA (4 x350MW) power plant in Israel.

OUR KEY SOLUTIONS INCLUDE

UPGRADES

- Generator upgrades
- Generator stator upgrades
- Generator rotor upgrades
- Excitation system upgrades
- Generator auxiliary system upgrades

OUTAGES/O&M

- Parts supply
- Inspections & RLA
- On-site services
- Workshop services
- Generator spares stocking programs
- Generator flexibility



Complete generator line-up with air, gas and water-cooled

10%+

Capacity increase by rewinding and replacement

20 years+

Lifetime extension by rewinding stators and rotors

3

Triple-redundant controllers in DS-DEX (DOOSAN-Digital Excitation System)



PROJECT STORIES



EXPERIENCE LIST



WORKSHOP & FACILITIES

Total Plant | Boilers | AQCS | Steam Turbines | **Generators** | Plant Assessment | Gas Turbines | AM Services | Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



UPGRADES

Generator Upgrades

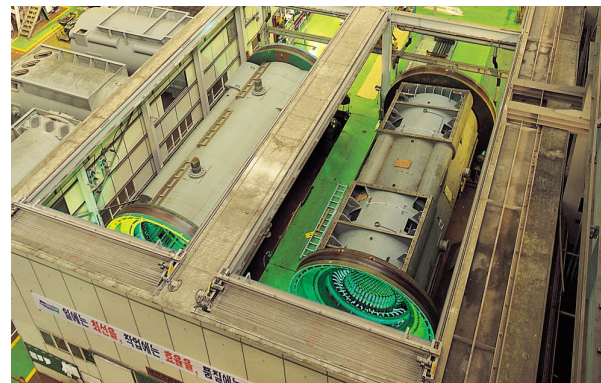
Doosan provides generator upgrades based on its residual life assessment (RLA) of generators. Upgrade solutions vary for each generator, and they are designed for each customer's specific objectives and requirements. Doosan offers skills, experience and expertise needed for the upgrading of both OEM and non-OEM generators.

Selection of Upgrades

- Stator rewinding, Re-insulations
- Rotor rewinding, Re-insulations
- Complete replacement of generator with auxiliary system

Capabilities

- Various generator models from small air-cooled to 1,000MW high-capacity thermal power generators and 1,400MW large generators for nuclear power plants, 50Hz and 60Hz available
- Generator capacity increment by upgrades
- New generators suitable for existing generator foundation
- All auxiliary systems, piping, excitation control related to generator upgrades to be re-engineered and repaired/replaced
- Commissioning after upgrades by specialized professionals



CUSTOMER BENEFITS

- High-quality guaranteed for design, engineering, manufacturing, installation and commissioning
- Various technical support programs through long-term service agreement (LTSA)



REVERSE ENGINEERING

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



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PRODUCTS & SOLUTIONS



UPGRADES

Generator Stator Upgrades

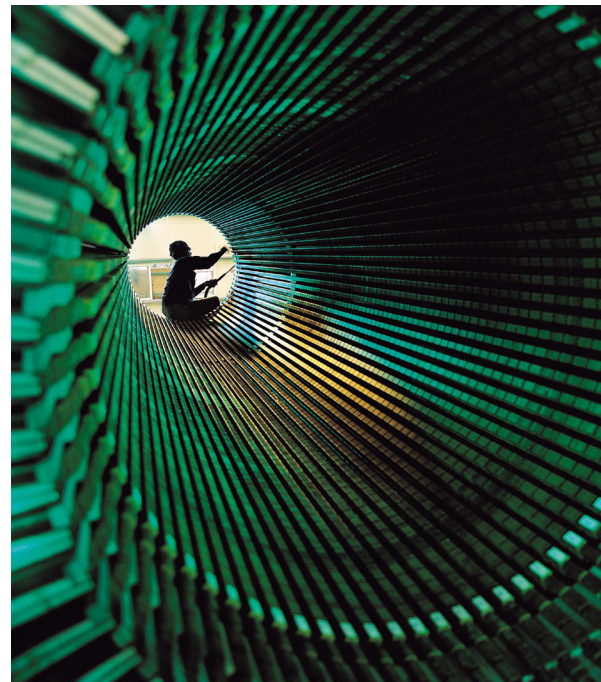
Doosan has implemented a number of generator stator upgrade projects, and based on these experiences, we provide generator stator upgrade programs regardless of the type of a generator. In particular, non-OEM generators can be upgraded through reverse engineering.

Capabilities

- Design and reverse engineering with skilled engineers and the latest design programs
- Lifetime extension and capacity increase through generator stator rewinding
- Strong reliability ensured by using the latest technologies, such as anti-corona system, spring type slot support system and end winding system to reduce vibration
- Experiences in a number of stator upgrade projects, including Hanbit NPP (1,000MW), Boryeong TPP (500MW), Philippines Malaya TPP (300MW), Bundang CCPP (107MW), etc.

Facilities

- Small and large generator stator bar manufacture facilities
- Development and application of vertical brazing system
- Compounding facility for resin-rich insulation system
- Various equipment for inspections and test



CUSTOMER BENEFITS

- Reducing economic losses from generator shutdown
- Ensuring safety and reliability of generators



SOLUTION STORIES



REWINDING PROCESS

Total Plant | Boilers | AQS | Steam Turbines | **Generators** | Plant Assessment | Gas Turbines | AM Services | Digital Solutions



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PRODUCTS & SOLUTIONS



UPGRADES

Generator Rotor Upgrades

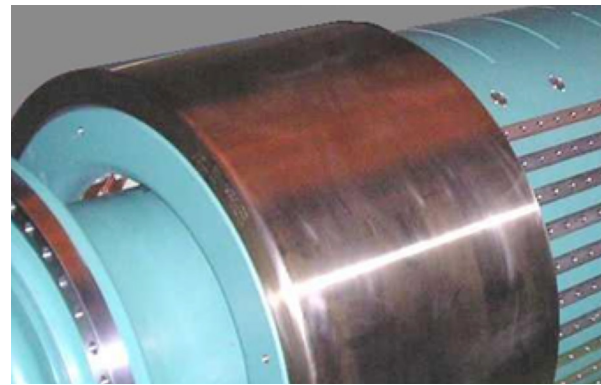
Doosan has extensive technological capabilities and experiences as well as various facilities required for rewinding generator rotors. We have implemented a number of generator rotor upgrade projects, enabling us to provide generator rotor upgrade programs regardless of the type of a generator. In particular, non-OEM generator rotors can be upgraded through reverse engineering.

Capabilities

- Design and reverse engineering with skilled engineers and the latest design programs
- Partial or complete rotor rewinding
- Repair, replacement or upgrades of critical component parts, such as non-magnetic retaining ring, collector ring, etc.
- Experiences in a number of rotor upgrade projects, including Hanbit NPP (1,000MW), Samcheonpo TPP (500MW), Israel Hagit (120MW), etc.

Facilities

- A variety of rotor shaft manufacturing facilities
- Rotor coil manufacturing facilities including square type and c-coil type
- High-speed balancing facilities



CUSTOMER BENEFITS

- Reducing economic losses from generator shutdown
- Ensuring safety and reliability of generators



SOLUTION STORIES



REWINDING PROCESS

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



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PRODUCTS & SOLUTIONS



UPGRADES

Excitation System Upgrades

Doosan developed the DS-DEX (DOOSAN-Digital Excitation) System, a digital excitation system which uses state-of-the-art technologies in 1997. This has enabled us to supply new and retrofitted systems for nuclear, thermal and hydro power plants. Doosan is able to respond quickly to customer requirements and problems in the field thanks to the many years of trouble-shooting experiences that it has accumulated.

Capabilities

- Design and reverse engineering with skilled engineers and the latest design programs
- Triple controller which enables operations through only one controller, even if both the other two controllers fail
- DS-DEX which can be applied to various generator models
- Independently designed and developed system that can be installed from new or retrofitted
- Experiences in a number of excitation system retrofits, including Wolsong NPP (828MW), Boryeong TPP (500MW), Cheongju CCPP (61MW), etc.



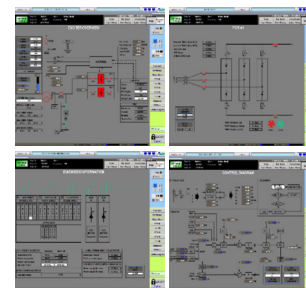
DS-DEX

Facilities

- A variety of excitation system simulation facilities



Triple controller



MMI

CUSTOMER BENEFITS

- Large number of references in new supply and retrofit – 89 units in Korea and abroad – which ensures high quality and reliability
- Doosan's own model that allows continuous upgrades
- Rapid diagnosis and maintenance
- Reducing maintenance costs by using self-diagnosis with on-line maintenance



UPGRADES

Generator Auxiliary System Upgrades

The upgrading of generator auxiliary systems is vital in extending generator lifetime and increasing capacity. Doosan has proven capabilities in auxiliary systems, and we offer parts replacement or an overall system replacement according to customer requirements.

Capabilities

- Upgrade of generator auxiliary systems, such as stator water cooling system, H₂ & CO₂ system, H₂ seal oil system, gas dryer, etc.
- Partial replacement of old auxiliary systems
- Brushless exciter which can be replaced and modified with stator exciter

Facilities

- Extensive supply chain
- Skilled vendors with many references



CUSTOMER BENEFITS

- Operational reliability of generator auxiliary system
- Convenience for maintenance



OUTAGES/O&M

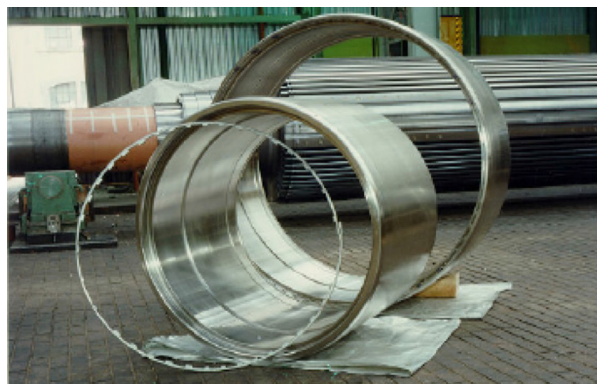
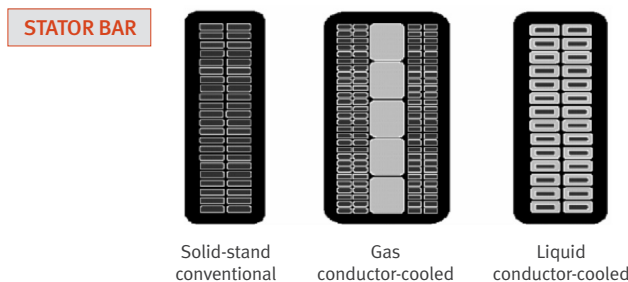
Parts Supply

Backed by its capabilities in generator OEM engineering and manufacturing, Doosan offers a full range of parts supply service to keep your generator operating at optimum efficiency level and to reduce shutdown periods for both forced and planned outages. Leveraging our extensive experiences in generator service, we apply state-of-the-art technologies and enhanced materials to meet each customer's specific requirements. In addition, our special service department stands ready to support our customers in all emergency situations, such as short circuits or ground faults, regardless of the original manufacturer. Doosan utilizes its global facilities and service centers to provide its customers with top quality components that have been subjected to Doosan's quality control standard, as well as on-time delivery services which meet overhaul schedules.

Regardless of the original manufacturer, Doosan offers parts supply services to operators and maintainers, thereby helping them to shorten lead-time and ensuring the restoration of key components to their original condition.

Recommended Spares

- Generator Stator
 - Stator bar, Slot wedge, End winding support, High voltage bushing, Current transformer, Liquid connection, Series loop connection, H₂ cooler
- Generator Rotor
 - Turn insulation, Slot armor, Coil, Collector ring, Retaining ring, Coil wedge, Distance block, Pole to pole connector, Terminal stud bolt, Brush holder rigging
- Monitoring System
 - RTD, TC, Flux probe, PD sensor, End winding vibration, Shaft monitoring system
- All spare parts to be checked before and after replacement work by certified specialists, and the integrity of the replacement parts is verified by testing conditions



Generator rotor retaining ring

CUSTOMER BENEFITS

- Ensuring reliable quality
- Long-term spare stocking program tailored to customer needs
- Expert services provided immediately for any issues during storage and replacement

OUTAGES/O&M

Inspections & Residual Life Assessment

Doosan provides assessment and residual life assessment (RLA) services to estimate conditions and remaining life of generators through its generator diagnostic program which can be conducted during a plant overhaul. The results of the diagnosis are used to recommend a list of parts that need to be repaired or replaced at the next overhaul, which enables customers to plan preventative measures. In addition, our team of experts provides an analysis of the root cause of any generator accidents.

The following is a list of typical tests recommended by Doosan to check the condition of generator stators and rotors. Each set of inspections and testing is individually designed for the specific condition of each generator.

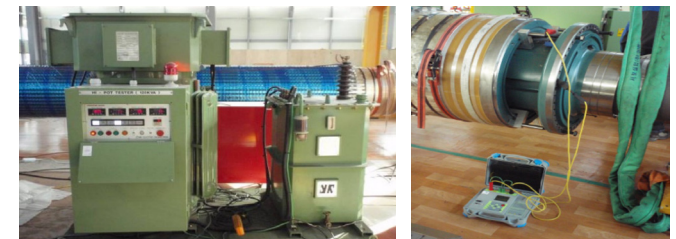
Stator Tests

- **Insulation resistance & P.I** Check conditions of stator winding insulation
- **Winding resistance** Check if the phase resistance value of the stator winding is within the permissible design range
- **High potential test** Ensure insulation to meet the integrity and insulation strength
- **Wedge tightness test** Check wedge assembly integrity
- **Bump test** Determine resonance possibility by measuring the natural frequency that occurs when stator winding ends are struck
- **Water leak test** Confirm the presence of leaking parts in cooling water system of stator winding
- **Water flow line test** Confirm the presence of internal clogging zone in cooling water system of stator winding
- **Dissipation factor test** Check drying, moisture absorption, deterioration state of insulating material and presence of voids
- **AC current test** Check the insulation condition of stator winding after applying AC voltage
- **Partial discharge** Check the deterioration state of insulation by detecting partial discharge
- **Capacitance mapping test** Detect moisture of stator winding insulation

- **Core tightness test** Check the stator core lamination status
- **EL-CID test** Look for eddy current in core and check the status of insulation
- **Ring flux test** Check insulation status of stator core

Rotor Tests

- **Insulation resistance & P.I** Check conditions of rotor winding insulation
- **Winding resistance** Check if the phase resistance value of the rotor winding is within the permissible design range
- **Pole balance and impedance check** Check if the rotor winding is short-circuited
- **RSO test** Check for rotor winding short circuits between turns by using a waveform match
- **Voltage drop test** Check insulation conditions of rotor winding to confirm if it is short-circuited
- **High potential test** Ensure insulation to meet the integrity and insulation strength
- **NDE of retaining ring and other parts**
- **High-speed balancing and run-out test**



OUTAGES/O&M

On-site Services

Doosan's experienced engineers provide a range of onsite services by leveraging the latest technologies. Our solutions can reduce generator downtime and achieve cost savings by providing field-oriented services, such as the periodic inspection and testing of generators, and the repair and replacement of generator stators, rotors and auxiliary systems.

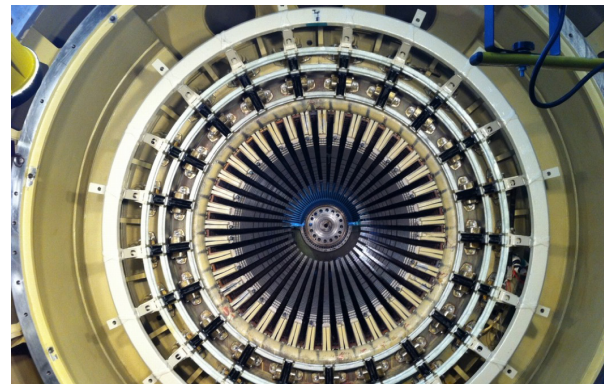
Our on-site services are as follows:

Stators

- Electrical and mechanical inspections and tests
- Full rewinding (replacement of generator stator parts excepts stator core)
- Partial rewinding (performed for maintenance in the event of a local problem with generators)
- Leakage repair (stator bar/water box)

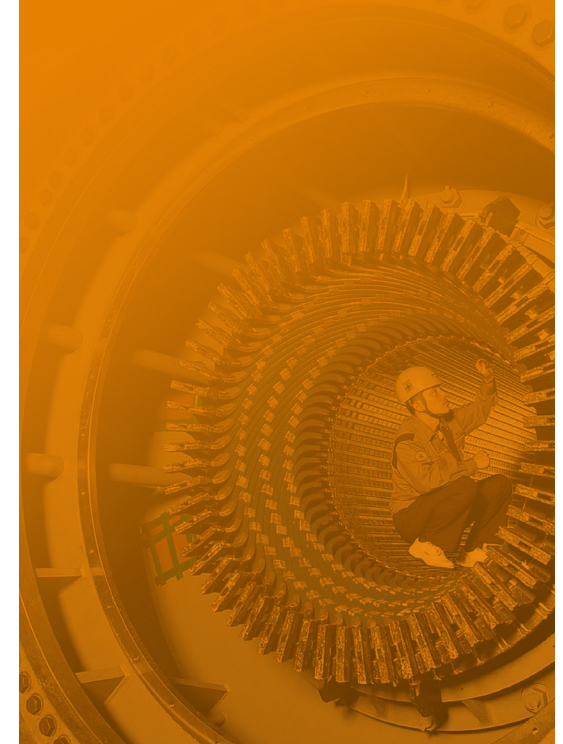
Rotors

- Electrical and mechanical inspections and tests (except high speed balancing)
- Full rewinding (replacement of full rotor coil and coil insulation) and re-insulation (replacement of full rotor coil insulation)
- Partial rewinding/re-insulation
- Journal repair by using high velocity oxygen fuel thermal spray



CUSTOMER BENEFITS

- Faster responses by on-site service professionals (design, quality, process management, etc.)
- Faster solutions that meet customers' specific needs
- Securing of materials needed for recovery



OUTAGES/O&M

Workshop Services

Doosan not only provides on-site inspections, repairs and parts replacement for generators, but also has established specialized workshop facilities which enable us to manufacture and repair generator stator, rotor, exciter and auxiliary equipment. Our workshops are equipped with the latest technologies and efficient work processes, in our efforts to ensure a range of top-quality services.

Our workshop services are as follows:

- All types of electrical and mechanical inspections and tests
- Stator and rotor rewinding/re-insulation works in an air-conditioned clean room
- High-speed rotor balancing tests
- Rotor journal repair by using high velocity oxygen fuel thermal spray
- Techniques to straighten rotors
- Machining works needed for any repair



CUSTOMER BENEFITS

- High-quality diagnosis and repair using specialized equipment
- Reliable and secured quality
- Educational programs for O&M tailored to customers' specific needs



WORKSHOP & FACILITIES

Total Plant | Boilers | AQS | Steam Turbines | **Generators** | Plant Assessment | Gas Turbines | AM Services | Digital Solutions



SERVICES

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PRODUCTS & SOLUTIONS



OUTAGES/O&M

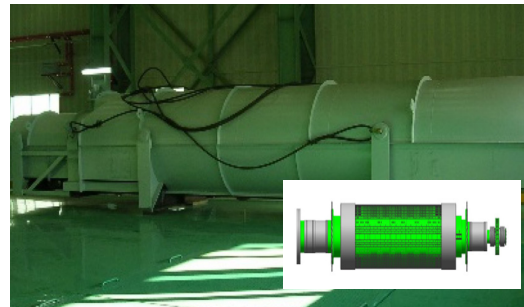
Generator Spares Stocking Programs

Doosan offers generator spares stocking programs that are optimized for each customer's individual requirements. These services enable customers to resolve many issues that arise regarding long-term storage and professional maintenance methods.

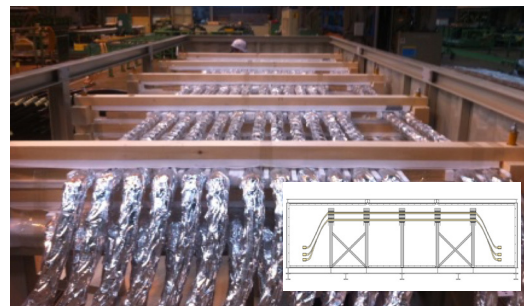
Doosan offers customers a 20-year long-term storage technology, as well as professional management personnel and special container designs that prevent damage and rusting during the long-term storage of generator spare parts. In particular, the container is temperature- and humidity-adjustable, and maintains the best conditions for parts insulation.

We provide a set of 500MW generator spare rotor and stator coil to five Korean companies, as well as 20-year long-term storage services. Based on this experience, we have developed a range of generator spares stocking programs as follows:

- Generator complete rotor
- Stator top/bottom coil
- Stator wedge and slide
- Bearing
- High voltage bushing (HVB)
- Current transformer for HVB
- Customized set of spare parts



Rotor container



Stator coil container

CUSTOMER BENEFITS

- Systematic spare parts management system
- Providing manpower for spare parts management and warehouse optimization services
- Maintaining a quality standard even for long-term storage
- Procuring high-quality spare parts in case of accidents
- Replacement, commissioning and technical assistance in any necessity
- Maintaining power plant utilization rate at a high level by shortening generator stopping time

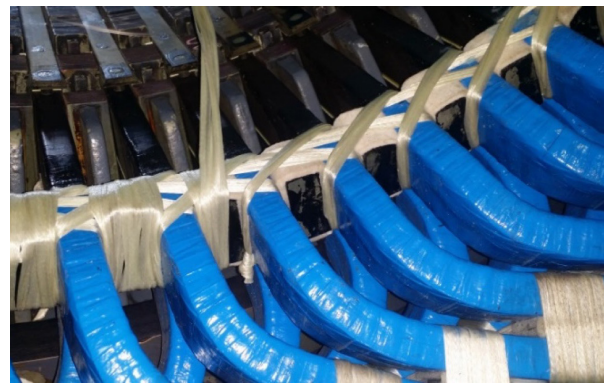
OUTAGES/O&M

Generator Flexibility

Today's renewable energy sources (RES), gaining scale and backed by preferential dispatch, bring in an impact of variability and uncertainty into the grid due to their nature of generation. With increased influx from RES, conventional power plants are required to operate in more cycling and with higher flexibility, which impacts efficiency, reliability and lifetime of power plant equipment. Most of the conventional thermal plants were designed for base load service, moderate load following and occasional on-off cycling, but flexible operations call for faster start-up and shutdowns, wider ramp-up/down rates, increased capabilities of partial load operation in compliance with emission as well as maintenance of efficiency. As a total plant service provider and generator original equipment manufacturer (OEM), Doosan offers packages that improve the operational flexibility of your generator operations.

Each plant has its own characteristics in operations, such as fuel, equipment design, output, etc., and has different needs for flexible operation. Thus, each set of flexibility solutions for a specific plant should be customized and designed for each unit, which means there is no 'one-size-fits-all' solution.

The first step to develop each solution set is to systematically assess the design and identify areas that are prone to accelerated damages (fatigue, creep-fatigue, copper dusting) as a result of more frequent cycling operations.



TYPICAL SOLUTIONS FOR FLEXIBLE BOILER OPERATIONS

- Reinforcement of the stator end winding support
- Reinforcement of the stator wedge system
- Reinforcement of the rotor rewinding system (minimized copper dusting modification, redesign of end turn structure, etc.)
- Upgrade modification and reinforcement of the rotor wedge
- Generator auxiliary system modifications through operational simulation
- System upgrade with Doosan's digital solutions in order to ensure better monitoring and pre-warning during all courses of operations

CUSTOMER BENEFITS

- Faster startup and shutdown
- Wider ramp rate
- Minimization of lifetime impact on critical component through flexible operations
- Technical supports to ensure proper cycling operations and respond to any issue during operations





Plant Assessment

Doosan's Plant Assessment & Engineering Team consists of experienced OEM design engineers who specialize in the main components of power plants, including boilers, turbines, generators and other parts. We respond rapidly to clients' requests and suggest the best integrated solutions for total repair, replacement and upgrade solutions. Our advanced OEM power plant technologies enable us to cover both OEM and non-OEM products.

Doosan has participated in many projects to assess, evaluate and offer technical consulting to provide paid or non-paid supports for improvement plans at a wide range of power plants. Our references include the uprating of Eraring (4 x 660MW) in Australia, the 100% coal-to-biomass conversion of Yeongdong (1 x 125MW) in Korea, the upgrade of Morupule A (4 x 30MW) in Botswana, the rehabilitation of Bandel (1 x 210MW) in India, and the NOx reduction at Castel-Peak (4 x 677MW) in Hong Kong. In particular, the Boryeong plant in Korea was able to simultaneously uprate its power by 10%, increase efficiency by 3.4%, extend its life by 20 years and reduce NOx emissions by 25%.

OUR KEY SOLUTIONS INCLUDE

UPGRADES

- Total plant assessment
- Boiler performance assessment
- AQCS performance assessment
- Turbine performance assessment
- Generator performance assessment
- Plant BOP assessment & re-engineering
- EC&I assessment & re-engineering

3.4 %+

Efficiency improvement
at Boryeong
(39.6% → 43%)

100 %+

Biomass combustion
at Youngdong
(Coal → Biomass)

80 %+

Availability improvement
at Morupule
(0% → 80%)

75 %+

NOx reduction
at Castel-Peak
(BOFA + SCR)



PROJECT STORIES



EXPERIENCE LIST

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

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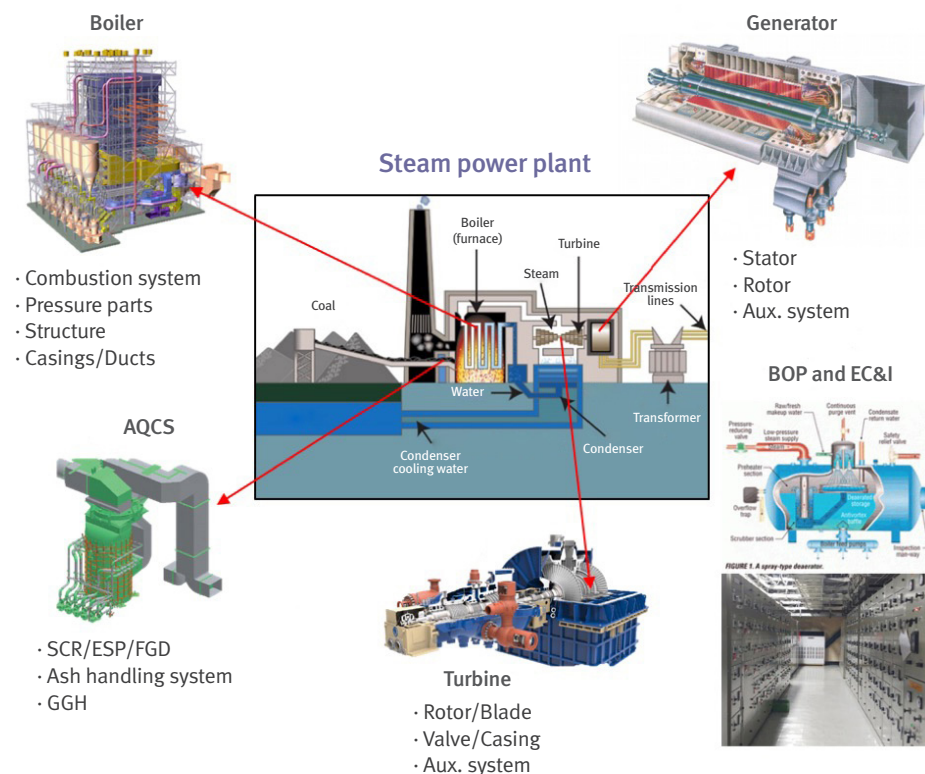
PRODUCTS & SOLUTIONS



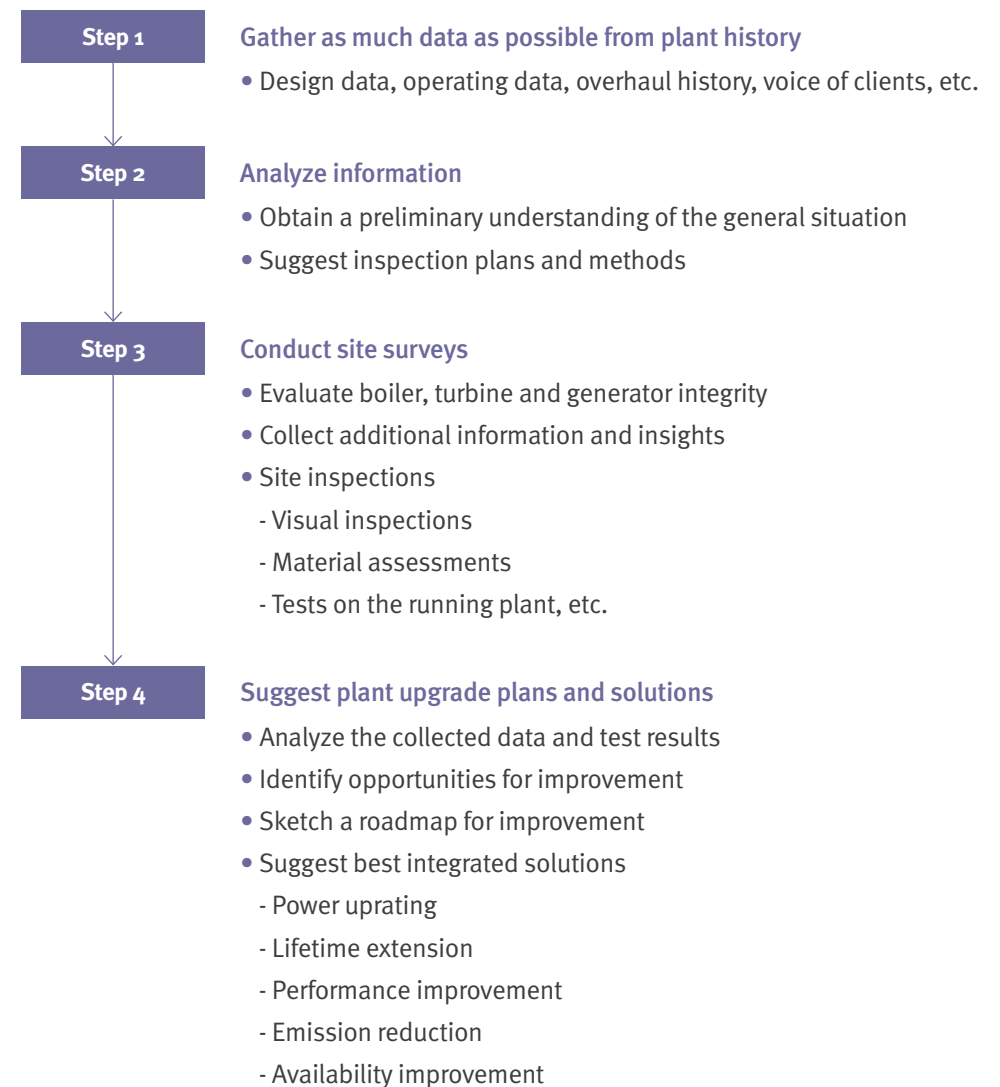
Total Plant Assessment

Doosan's outstanding plant assessment and engineering capabilities enable us to provide customized power plant renovation and modernization solutions, thereby creating values for customers. Both major components, such as boiler, turbine and generator, and various balance of plant (BOP) systems need to be understood, checked and evaluated in depth, in order to ensure that there are no imbalances in the plant and thus achieve successful completion of the upgrade. Doosan offers optimized upgrade solutions across the whole plant system for OEM and non-OEM plants.

PLANT ASSESSMENT AREAS



Steps of plant assessment and engineering services are as follows:



Boiler Performance Assessment

Boilers operate at high temperatures over long periods of time, and therefore require boiler assessment and engineering services to develop mid- and long-term planning to prolong their lifespans. Doosan's experts use advanced measurement equipment, based on experiences in the boiler retrofit, to provide precise diagnosis and residual life assessment services for old power plants.

We provide boiler performance assessment services for both OEM and non-OEM boilers (Type: PC, oil, down shot, CFB, lignite, oxy-fuel; Application: industrial, power, co-generation; Fuel: coal, HFO, gas, biomass, co-firing). Evaluations of boiler performance (performance design, furnace design, water circulation, metal temperature, flow analysis, etc.) and design of equipment (pressure parts, combustion, draft systems, structure, etc.) can identify where performance is degrading, and thus enable us to suggest customized improvement solutions.

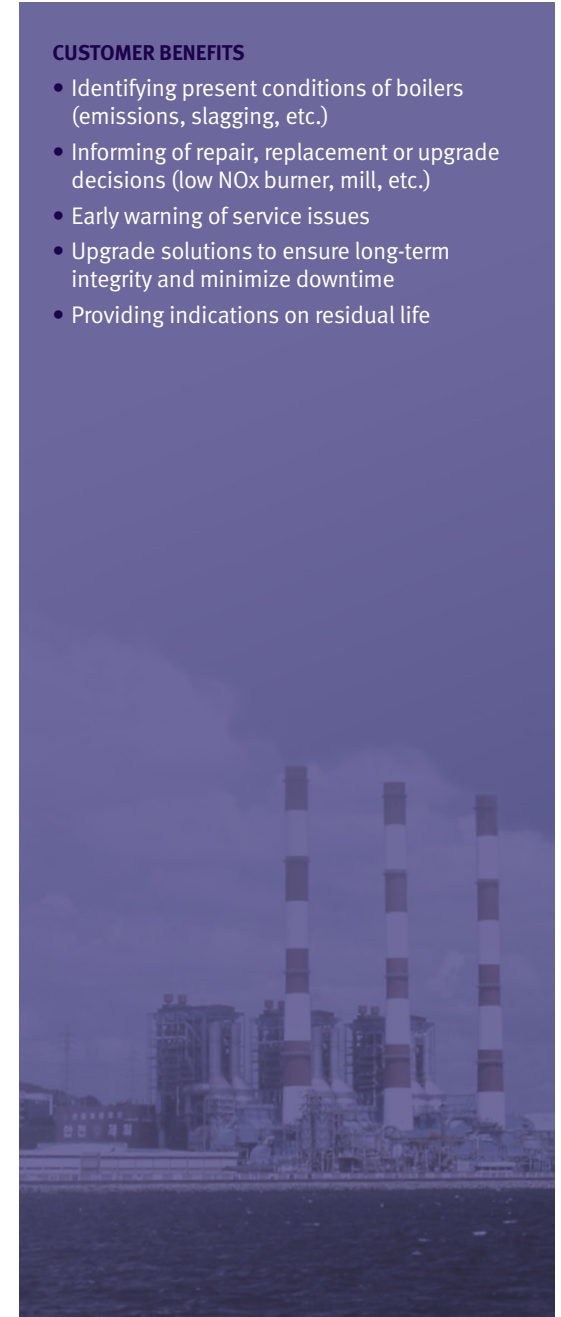


Boiler Assessment Engineering

- Visual inspection of weakness areas
 - Headers/Stub tubes
 - Welds attachment
 - Piping/Hanger support
 - Boiler leaks
- Material assessment
 - Replication/Hardness test
 - NDE (UT, RT, MT)
- Engineering assessment
 - Design margin review
 - Creep assessment
 - Fatigue assessment
 - Creep-fatigue assessment
- Conception engineering
 - Boiler performance
 - Heating surface analysis
 - Metal temperature
 - Dynamic, stress analysis
- Combustion emissions
- Fuel flexibility
- Draft system

CUSTOMER BENEFITS

- Identifying present conditions of boilers (emissions, slagging, etc.)
- Informing of repair, replacement or upgrade decisions (low NOx burner, mill, etc.)
- Early warning of service issues
- Upgrade solutions to ensure long-term integrity and minimize downtime
- Providing indications on residual life



AQCS Performance Assessment

Doosan specializes in air quality control systems (AQCS) for the utility, municipality and industrial sectors. Our proven technologies coupled with AQCS inspection and assessment services enable us to suggest customized solutions for flue gas cleaning, thus helping customers to achieve sustainable reductions in emissions. Our substantial proprietary product portfolio allows us to select the most advantageous process for each type of application, thereby maximizing the benefits for our clients.

Our expertise and advanced engineering skills cover every aspect of plant engineering, maintenance and modernization. Following an in-depth assessment of the existing AQCS, we provide information on the causes of deterioration and how to prevent further deterioration, in order to extend the lifetime of a plant. Our assessment programs include test schedules, replacement strategies and upgrade solutions such as the use of new technologies.

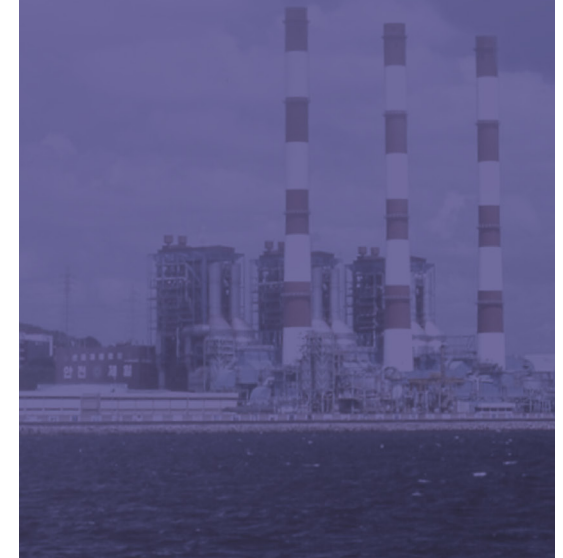


AQCS Assessment Engineering

- SCR
 - Visual inspection (reactor, catalyst, ammonia injection grid) and catalyst sampling
 - Maintenance of expansion joints and catalyst seals
 - Catalyst activity testing/check on NOx removal efficiency
 - Measuring catalyst pressure drop
 - Determination of main deactivation causes
- ESP
 - Ash line check for clogged and cleaning (for finding foreign materials)
 - Quick inspection of high voltage areas and arcing (for finding leaks and moisture)
 - Check on precipitator plates deformation
- FGD
 - Absorber operations
 - Inlet (gas distribution, humidification)
 - Spray (gas/liquid contact)
 - Mist eliminator (liquid/gas separation)
 - Reaction tank (oxidation, dissolution, crystallization)
 - Insulation resistance and polarization index test
 - Limestone supply system (silo, ball mill)
 - Gypsum dewatering system

CUSTOMER BENEFITS

- Identifying present conditions and troubles of the AQCS (emission level, efficiency, etc.)
- Technical solutions provided for repair, replacement or upgrade decisions (upgrade advance system such as NL GGH and Wet ESP)
- Upgrade solutions to ensure long-term integrity and minimize downtime (De-NOx, De-SOx and De-Dust)



Turbine Performance Assessment

Doosan provides plant assessment and engineering services for OEM and non-OEM thermal, combined and nuclear steam turbines. We undertake an analytical evaluation of the steam turbine through destructive testing, non-destructive testing and material deterioration. We then inform the customer of the causes of degradation in performance and offer customized solutions.

In particular, we provide the best integrated solutions through a performance analysis of the turbine cycle (condensate/feedwater system) and the turbine itself. In addition, thanks to precise 3-D scanning measurements, we can review reused assemblies that have been assembled with unmodified parts, and thus minimize risks. These solutions are expected to improve power plant reliability and availability, and also increase output and efficiency.



Turbine Assessment Engineering

- Condition assessment
 - Visual inspection for weakness
 - Blade, bucket, rotor, turning/ring gear, bearing, nozzle diaphragm, packing, casing, valve
 - Rubbing, SPE/deposit/leakage/flow path damage
 - 3D scanning measurement
- Material assessment
 - Replication/Hardness test
 - NDE (UT, RT, MT)
 - Bore/Disk inspection
- Engineering assessment
 - Creep assessment
 - Fatigue assessment
 - Creep-fatigue assessment
- Conception engineering
 - Turbine heat balance analysis
 - Steam path audit
 - Analysis on performance loss between design and current performance
 - Calculation of heat rate loss and power loss of each stage in steam path through in-house software
 - Rotor/Blade stress analysis

CUSTOMER BENEFITS

- Identifying present conditions and troubles of steam turbines
- Informing of repair, replacement or upgrade decisions (steam path upgrade)
- Early warning of service issues
- Upgrade solutions to ensure long-term integrity and minimize downtime
- Providing indications on residual life



Generator Performance Assessment

Doosan provides generator inspection and assessment services for all types of fossil fuel and nuclear generators. We have experience of working with nearly all types of equipment and can offer complete and accurate testing services. We fully inspect and test all equipment parts, and this generator testing service will enable us to generate accurate reports and make in-depth recommendations to keep equipment working properly and at maximum efficiency.

Our generator assessment services include tests on generators, exciters, and other related equipment. This enables customers to extend the lifetime of their generators, increase efficiency and power output and improve the reliability and availability of their power plants.



Generator Assessment Engineering

- Visual inspection
 - Identification of discoloration, cracking, signs of movement or other problems on the rotor body, winding, retaining rings and fans couplings
 - Borescope inspection of stator and rotor winding and blocking (as accessible), stator core step laminations and fingerplates
 - Insulation resistance of RTDs
- Stator insulation tests
 - Insulation resistance and polarization index test
 - High potential test
 - Partial discharge test
 - End winding bump test
 - Electromagnetic core imperfection detection (EL-CID) test
- Rotor insulation tests
 - Insulation resistance and polarization index test
 - High potential test
 - Recurrent surge oscilloscope (RSO) test
- Generator aux. system
 - Operation mechanism test
 - Stator water cooling system
 - Hydrogen seal oil system
 - Exciter inspection insulation resistance tests

CUSTOMER BENEFITS

- Identifying present conditions and troubles of generators
- Informing of repair, replacement or upgrade decisions (rewinding)
- Early warning of service issues
- Upgrade solutions to ensure long-term integrity
- Providing indications on residual life

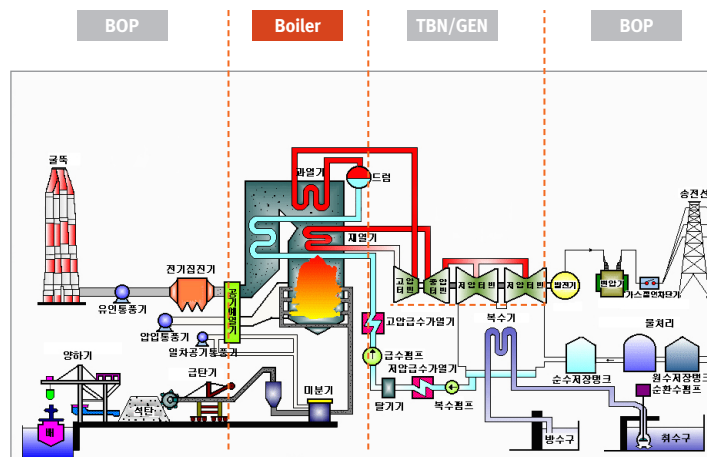


Plant BOP Assessment & Re-engineering

Doosan offers balance of plant (BOP) assessment and re-engineering services across the utility, municipality and industrial sectors for thermal, combined and nuclear plants, in order to achieve efficient power plant operations while also improving plant reliability and availability. We have extensive experiences in BOP assessment, and our expertise covers every aspect of plant engineering, maintenance and modernization, backed by our advanced engineering skills in assessing existing BOP.

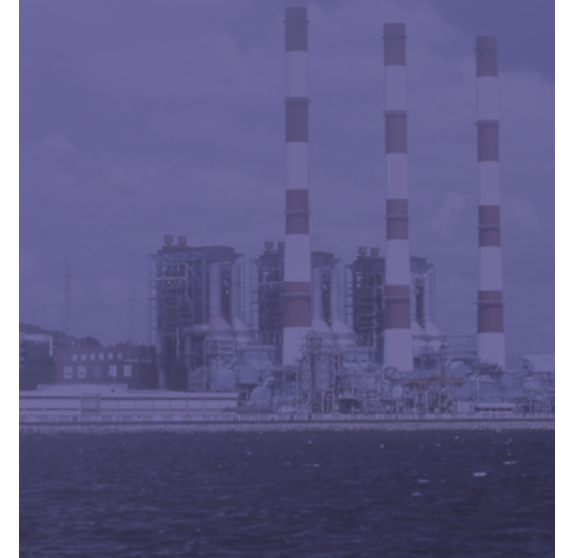
BOP Assessment Areas

- Main, reheat/extraction, and aux. steam system
- Condensate and feedwater system
- Circulating water system
- Closed cooling water system
- Fuel supply system
- Water supply and distribution system
- Water treatment system
- Waste water treatment system
- Chemical feed system
- Coal handling system
- HVAC system
- Fire-fighting system
- Compressed air supplying/distribution system
- Other individual package components



CUSTOMER BENEFITS

- Identifying present conditions and troubles of the BOP
- Analyzing operational limitations of existing BOP
- Informing of up-to-date design and re-engineered process
- Providing repair, replacement or upgrade recommendations (instrument, pump, etc.)
- Early warning of service issues
- Ensuring long-term integrity of supplied BOP components
- Thorough, individual trainings for customers



EC&I Assessment & Re-engineering

Doosan undertakes electrical, control & instrument (EC&I) assessment and re-engineering services across the utility, municipality and industrial sectors for EC&I facilities and systems. Doosan has extensive experiences in EC&I assessment, and our expertise covers every aspect of plant engineering, maintenance and modernization, backed by our advanced engineering skills in assessing existing EC&I.

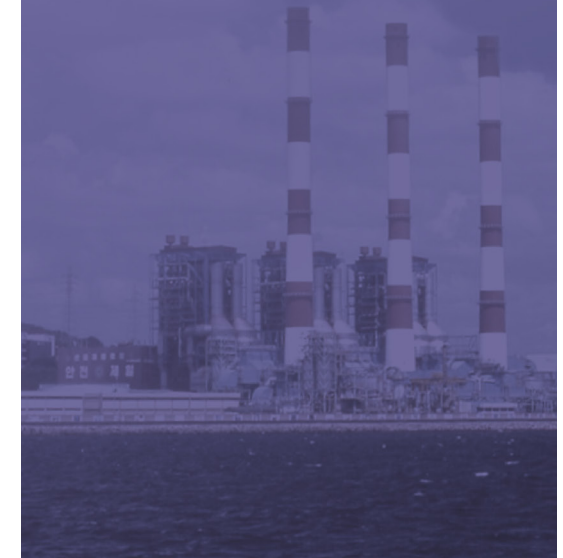
EC&I Assessment Areas

- Electrical control & monitoring system (ECMS)
- MV/LV SWGR & MCC
- Power transformers
- Generator circuit breaker (GCB)
- DC & UPS system
- Distributed control system (DCS)
- Instrumentation
- PLC control system for packaged system
- Cable, raceway system, etc.



CUSTOMER BENEFITS

- Identifying present conditions and troubles of EC&I
- Providing all necessary individual components
- Informing of up-to-date control logic and re-engineered design
- Providing repair, replacement or upgrade recommendations
- Ensuring cost-effective operations
- Suggestion of optimization concepts for EC&I
- Thorough, individual trainings for customers
- Ensuring long-term integrity





Gas Turbines

Doosan's production facilities offer the unique ability to bring together a comprehensive list of services and skills to meet our customers' needs. In addition, we use state-of-the-art technologies and integrate them into our advanced repair techniques, creating results that often exceed standard OEM specifications. Based on its extensive gas turbine technologies and experiences, Doosan is developing its own large gas turbine model which is expected to be commercialized within a few years.

Our gas turbine services provide customized services to satisfy customers' needs through accurate diagnoses and continuous investment in technologies, in our efforts to make gas turbines more reliable and efficient.

OUR KEY SOLUTIONS INCLUDE

OUTAGES/O&M

Hot parts repair and reconditioning
GT workshop services
GT field services
GT long-term services



Non-OEM GT solutions
for hot parts repair and
reconditioning



Experienced
field service
professionals



On-time delivery



State-of-the-art
facilities



PROJECT STORIES



EXPERIENCE LIST



WORKSHOP & FACILITIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



OUTAGES/O&M

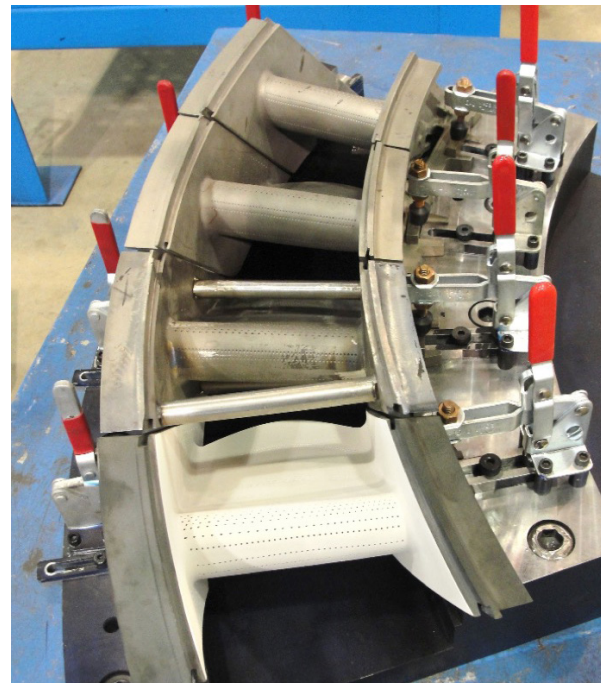
Hot Parts Repair and Reconditioning

Hot parts endure frequent startups and shutdowns across a range of operating conditions which causes damage through thermal fatigue, corrosion, erosion and fouling. This has a direct impact on the efficiency and reliability of gas turbines (GT). It is therefore critical to make sure that hot parts are maintained regularly and thoroughly by experts. Doosan offers one-stop solutions for GT services to provide top quality, reliable hot parts repair and reconditioning, as well as on-site repairs and replacement by highly skilled and experienced technicians. This ensures more reliable solutions and enables our customers to handle unexpected and urgent situations.

Doosan's advanced and reliable heat-resistant coating technologies, supported by the expertise at our Engineering Center, provide customers with optimized maintenance programs which can significantly reduce their operating expenditures (OPEX).

Our hot parts solutions include:

- Hot section repair and reconditioning services which include vane and blade
- On-site repair and replacement duties
- Providing advisory and consulting services for maintenance programs



CUSTOMER BENEFITS

- Reliable one-stop solution which includes hot parts supply and on-site replacement service
- Highly durable and resistant coating technologies for blades and vanes
- Cost reduction by extending maintenance interval

OUTAGES/O&M

GT Workshop Services

Our new world-class repair facilities offer comprehensive and technically-advanced gas turbine component repair and turbomachinery overhaul solutions which include complete refurbishments, coatings, welding, modifications and upgrades of industrial gas turbine rotating and stationary equipment.

Doosan offers a wide range of reliable, customized GT services backed by our extensive GT experiences and technologies as well as ongoing technology development activities at our R&D Centers.

Our gas turbine workshop services include:

- GT component repair and recoating (hot section) against corrosion, erosion and fouling with latest technologies and tools
- GT compressor diaphragm repair (cold section)
- GT complete rotor service with cutting edge equipment for balancing and machining
- Life assessment and extension of rotors
- Heavy mechanical services



Doosan Turbomachinery Services, Inc. in the U.S.

CUSTOMER BENEFITS

- The most comprehensive and advanced overhaul solutions with warranties
- Quick response and engineered solutions for returning to reliable normal operations
- Full support for site services by qualified experts
- Global presence of workshop service support (U.S., Asia, NEMA)



WORKSHOP & FACILITIES

[Total Plant](#)
[Boilers](#)
[AQCS](#)
[Steam Turbines](#)
[Generators](#)
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[Gas Turbines](#)
[AM Services](#)
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[SERVICES](#)
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[PRODUCTS & SOLUTIONS](#)


OUTAGES/O&M

GT Field Services

Doosan's outstanding field engineers and technical personnel specialize in inspection, overhaul and turbine maintenance services for all sizes of GT frames, and they create values by utilizing quality craftsmanship, exceptional services and on-time delivery. Our highly-trained millwrights and engineers, with top-end technical support from our Engineering Center, offer a wide range of skills and expertise, backed by years of experience, to ensure that our customers' rotating equipment maintains its optimum performance.

Our field specialists provide a full range of tailored services for gas turbines including inspections, removals, replacements, trouble-shooting, fault-finding, on-site repairs and re-commissioning.

Our gas turbine field services include:

- Trouble-shooting of unplanned outages and chronic sufferings
- Turbine blade/bucket removal
- Compressor blade tip grinding at site
- Exhaust and inlet weld repair and upgrade
- Siemens and Westinghouse belly band field replacement
- 7FA rotor blend, polish and peen



Doosan Turbomachinery Services, Inc. in the U.S.

CUSTOMER BENEFITS

- A large team of experienced and qualified field engineers and technical personnel
- Quick response and engineered solutions for returning to reliable normal operations
- Global presence of field service support (U.S., Europe, Asia, NEMA)

OUTAGES/O&M

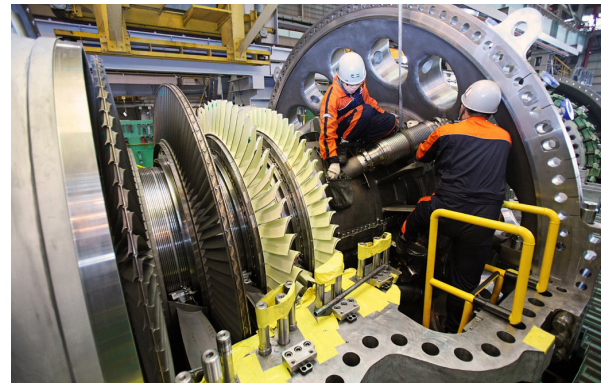
GT Long-term Services

Doosan provides GT long-term services to enhance availability and operational flexibility.

By applying new technologies and using a remote monitoring system, Doosan's long-term services offer better risk management, improved performance and financial stability, in order to make customers' properties more competitive.

Power plants to which our GT LTS solutions are being offered include:

- Yeongwol Combined Cycle Power Plant (Mar. 2014 – Sep. 2021)
- Sejong Combined Cycle Power Plant (Nov. 2013 – Nov. 2023)
- Hanam Combined Cycle Power Plant (Sep. 2012 – Jun. 2031)
- Yangju Combined Cycle Power Plant (Jul. 2012 – Dec. 2030)
- Seoul Combined Cycle Power Plant (Aug. 2019 – Jul. 2029)



LTS SCOPE

- Planned maintenance with hot parts management
- Unplanned maintenance
- Hot parts reconditioning
- Trouble-shooting by engineering experts and OEM technical advisors
- Remote monitoring service (RMS) to spot prognostic issues
- Enhancement programs which increase output and efficiency through precision inspection
- One set of hot part spares stocked as an option

CUSTOMER BENEFITS

- OEM-based RMS, offering optimized operational excellence
- Minimization of losses through immediate responses in case of forced outage



AM Services

Asset management consultants are trusted advisors, and providers of innovative technology and engineering solutions. Our experts work in partnership with customers across the energy and industrial sectors to help solve their most complex challenges. We provide strategic recommendations and technical engineering support in order to optimize asset performance and mitigate commercial and operational risks. This enables customers to safely manage the entire life-cycle of their assets.

Managing the performance and maintenance of assets in an efficient way is more important than ever. With the energy industry in transition, our customers face the challenge of ensuring flexible operations against a backdrop of changing energy policies, stricter emissions targets and an unprecedented level of decentralization. For many asset owners, the answers lie in unlocking untapped value through efficient asset management.

US\$ **240** million

Potential loss in earnings avoided through TAR optimization

87%

Compression in outage scope through pragmatic integrity management strategies

£ **400** k+

Savings by optimizing component installations



Asset management services to help customers reduce their CO₂ emissions by supporting the conversion of 500MWe units from coal-firing to biomass pragmatic integrity management strategies

OUR KEY SOLUTIONS INCLUDE

ASSET MANAGEMENT STRATEGY

It is important that customers have the right information at the right time when they make crucial investment and operational decisions. We have accumulated over 100 years of engineering knowledge and industry insight, enabling us to optimize strategies for your most critical assets.

ASSET PERFORMANCE MANAGEMENT

Improving equipment efficiency is only one aspect of asset performance. Our experts therefore deliver engineering solutions that ensure operational and maintenance optimization, thus enhancing the overall performance of our customers' assets.

ASSET INTEGRITY MANAGEMENT

Our specialists develop and deploy multi-disciplinary office- and field-based preventative maintenance and inspection solutions, helping customers to maximize asset availability and reliability while also ensuring complete confidence in their operations.

TESTING & EQUIPMENT QUALIFICATION

For over 30 years we have provided specialist testing and qualification services by combining the expertise of our engineers with our purpose-built testing facilities. We help our customers to minimize risk while meeting their business requirements by conforming to the standards of multiple industries.

CRITICAL COMPONENT REPLACEMENT

Based on our global supply chain and design and manufacturing expertise, we offer integrated supply, installation and upgrade solutions to meet our customers' business requirements. Customers can be certain that their equipment will comply with all associated regulations for the safe and reliable operation of their assets.



PROJECT STORIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS



Asset Management Strategy

It is important that customers have the right information at the right time when they make crucial investment and operational decisions. We provide strategic and technical advisory supports that transform technical and commercial challenges into intelligent insights and strategic recommendations. Working closely with our customers, we help them to improve their competitive edge, minimize risks and ensure a strong return on their investments. Our expertise can be called upon at any stage during the development of the business case, and at any time during an asset's life-cycle.

Our customers rely on our specialists to transform technical insights into smart solutions that reduce risk and improve their ability to make strategic decisions. We understand the importance of managing the life-cycle of your assets effectively, which is why we help you to select the right technology and maintenance programs for your projects. Our insights help to future-proof your project's development, and allow you to make important CAPEX and OPEX investment decisions with certainty.

Combining over 100 years of engineering knowledge with industry insights to optimize a strategy for your most critical assets

- Impartial advice offered by experienced multi-disciplined engineers
- Smart solutions that improve business and operational performance
- Single point of contact for business and operational recommendations
- Global operational experiences in multiple and diverse industry sectors
- Visibility of relevant policy and standards impacting operations



OUR KEY SOLUTIONS INCLUDE:

Strategic

- Market evaluation scenario planning
- Asset due diligence review
- Through-life management strategy

Economic

- Cost benefit analysis
- CAPEX and OPEX evaluation
- Financial payback assessment

Technical

- Feasibility studies
- Operational performance assessment
- Health and safety audits
- Environmental evaluation

Commercial

- Supply chain analysis
- Procurement audit
- Regulatory compliance assessment



Asset Performance Management

An optimized performance management strategy helps our customers to identify areas in which they can add value to their operations, reduce the risks associated with unplanned downtime and assess the financial investments required to improve asset performance. Our approach is firstly to understand the operating environment, and the associated constraints faced by our customers. We then develop and execute projects in partnership with our customers to improve operations and future-proof asset performance.

Our customers can rely on our services throughout the life-cycle of an asset, from initial project feasibility to trouble-shooting and operational excellence. Our asset performance management experts take a holistic, system-based view of the plant, ensuring that any upgrades and modifications complement and improve existing operations and business objectives. Customers can be certain that their assets will be available for operations, and they will be ready to meet the demands of today's energy market.

Delivering engineering solutions with operational and maintenance optimization to enhance the performance of our customers' assets

- Long-term strategic partner with technical expertise in managing all aspects of plant maintenance and lifetime extension
- Smart solutions that improve business and operational performance
- Testing and inspection solutions to lower minimum stable generation without oil support from 33% to 25% load
- Asset performance management projects to make improvement on NOx emissions of 12-18% pre to post outage



OUR KEY SOLUTIONS INCLUDE

Asset Modification and Upgrades

- Equipment specification
- Plant performance assessment
- Plant improvement project engineering
- Feasibility studies

Performance Monitoring

- Modeling and optimization
- Scenario planning
- Root-cause analysis
- Operational performance assessment
- Environmental evaluation

Commissioning Consultancy

- Site-based trouble-shooting
- Operational and performance investigations
- System baseline and optimization testing
- Commissioning & Testing procedure development and review
- Operator training

Health and Data Analytics

- Remote monitoring for diagnostics
- Prognostics and recommendations
- Bespoke software development
- Data review and categorization

Asset Integrity Management

Doosan has supported customers across the industry to develop and deploy maintenance and inspection programs that can be used throughout the life of an asset. We combine our engineers' expertise in ageing plant with a variety of inspection and testing services to generate solutions which identify and assess our clients' most critical equipment and its health. We then determine the best management program to ensure the safe and continued operation of an asset.

Asset integrity, safety and reliability are major concerns for our customers worldwide. Many of today's assets are operating beyond their intended design lives, and even outside of their original design purpose. Our technical knowledge and engineering expertise help to deliver data-driven insights for customers. Using the latest digital technologies and processes, our engineers deliver smart solutions that ensure the efficient operation of assets, and predict failures before they occur.

Multi-disciplinary office and field-based solutions to maximize your asset availability and reliability with through-life operational assurance

- Optioneering assessments to help customers realize their target of achieving 92.5% plant availability by 2042
- Smart and prescriptive solutions 50% to enable the reduction in expected downtime of an operational plant
- 10-day reduction in TAR outage window by replacing radiography with phased array
- Vibration and fatigue failure investigation services to improve productivity by 60%



OUR KEY SOLUTIONS INCLUDE

Non-Destructive Testing (NDT)

- Phased array
- CHIME
- Time of flight diffraction (TOFD)
- Remote visual inspection (RVI)
- Foreign object search and retrieval (FOSAR)

Metallurgy and Welding

- Materials selection and design
- Fabrication and technique qualification
- In situ metallurgical inspection
- Remaining life assessment
- Failure and root cause analysis

Structural Integrity

- Fitness for service assessments
- Creep and fatigue assessments
- Pressure part design and analysis
- Root cause analysis
- Pipe stress analysis

Noise and Vibration Consultancy

- Piping and structural vibration analysis
- Field-based trouble-shooting
- Dynamic simulation analysis
- Anti-vibration support design and damper selection
- Monitoring systems for permanent and temporary hazardous areas
- Pipe vibration meter (PVM)

Testing & Equipment Qualification

As a well-established global, Doosan has unrivalled knowledge of component design and functionality. For over 125 years, we have supported customers by providing design, manufacturing, installation and maintenance support for their critical components. We upgrade the design of components in order to improve output and performance, and focus on manufacturing highly-engineered equipment which complements the specifications of the original design. This provides customers with the assurance that their equipment will not only operate safely and reliably, but will also comply with all associated regulations.

Our expertise and experience enable our consultants to deliver valuable insights to public and private sector customers worldwide. We have collaborated on a range of government projects, and supported the development of industry-recognized standards and regulations. You can confidently rely on our experts to advise on the most appropriate testing and qualification services, ensuring that your products are delivered promptly to market and comply with all industry standards.

Specialist testing and qualification services, minimizing risk through conformance to multi-industry standards to meet your business requirements

- 30+ years of experiences in providing testing and equipment qualification services
- Adaptable 20,000ft facility to meet bespoke testing requirements
- 13-off above and below-ground blast chambers, capable of pressure testing up to 40,000 psi
- Independently certified radiography chamber for the inspection of test specimens in situ
- UKAS-accredited material testing laboratory and fracture toughness measurement capability



OUR KEY SOLUTIONS INCLUDE

Structural and Performance Assessment

- Prototype TRL acceleration
- Component certification to meet international standards
- Life extension validation
- Finite element model validation
- Unexpected event simulation
- Client specific acceptance qualification

Mechanical Loading

- 20 meganewton tension
- 30 compression
- 6 meganewton meters bending
- + or - 8 meganewton-meters fatigue
- 40,000 psi pressure
- - 80 to + 600 degrees C environmental
- Torsion per client requirement
- Friction and impact testing

Material and Investigative Laboratory Services

- Metallurgy and welding consultancy
- Route cause analysis
- Expert witness evaluation
- Failure incident investigation
- Impact and hardness testing
- Weld procedure qualification and development
- Small scale mechanical testing

Critical Component Replacement

As a well-established global, Doosan has unrivalled knowledge of component design and functionality. For over 125 years, we have supported customers by providing design, manufacturing, installation and maintenance support for their critical components. Our expertise in engineering and procurement helps customers to minimize downtime and safeguard the availability and reliability of their assets, which in turn gives owners and operators the confidence that their assets are ready and available for operations.

We provide complete turn-key solutions so that our customers receive high quality replacement parts for their projects. Our specialists are trusted partners and work closely with customers to understand their requirements regarding component replacement, the timescales involved and the budget available for investment. We supply and install components which comply with all applicable engineering codes and standards, and also complement your existing equipment. This ensures that our customers have readily-available, quality-engineered parts to optimize their overall performance.

Design and manufacture expertise leveraging our global supply chain to support integrated supply, installation and upgrade solutions that meet our customers' needs

- Global OEM heritage
- Complete turnkey solution for component replacement and aftercare support
- In-house manufacturing capability
- Innovative in-house engineering and manufacturing upgrades and design alterations
- In-depth knowledge of global codes and standards relevant to critical components
- Centrally managed global supply chain network



OUR KEY SOLUTIONS INCLUDE

Critical Components for Energy Industry

- OEM and non-OEM pressure parts
- Commodity spares
- Pressure parts
- Marine critical components

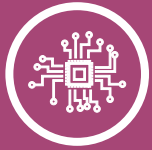
Critical Component Management

- Supply chain and procurement of component inventory
- Pre-approved supply chain network
- Logistics management

After Service Support

- Component reverse engineering
- Component optimization and alterations
- Installation and engineering support





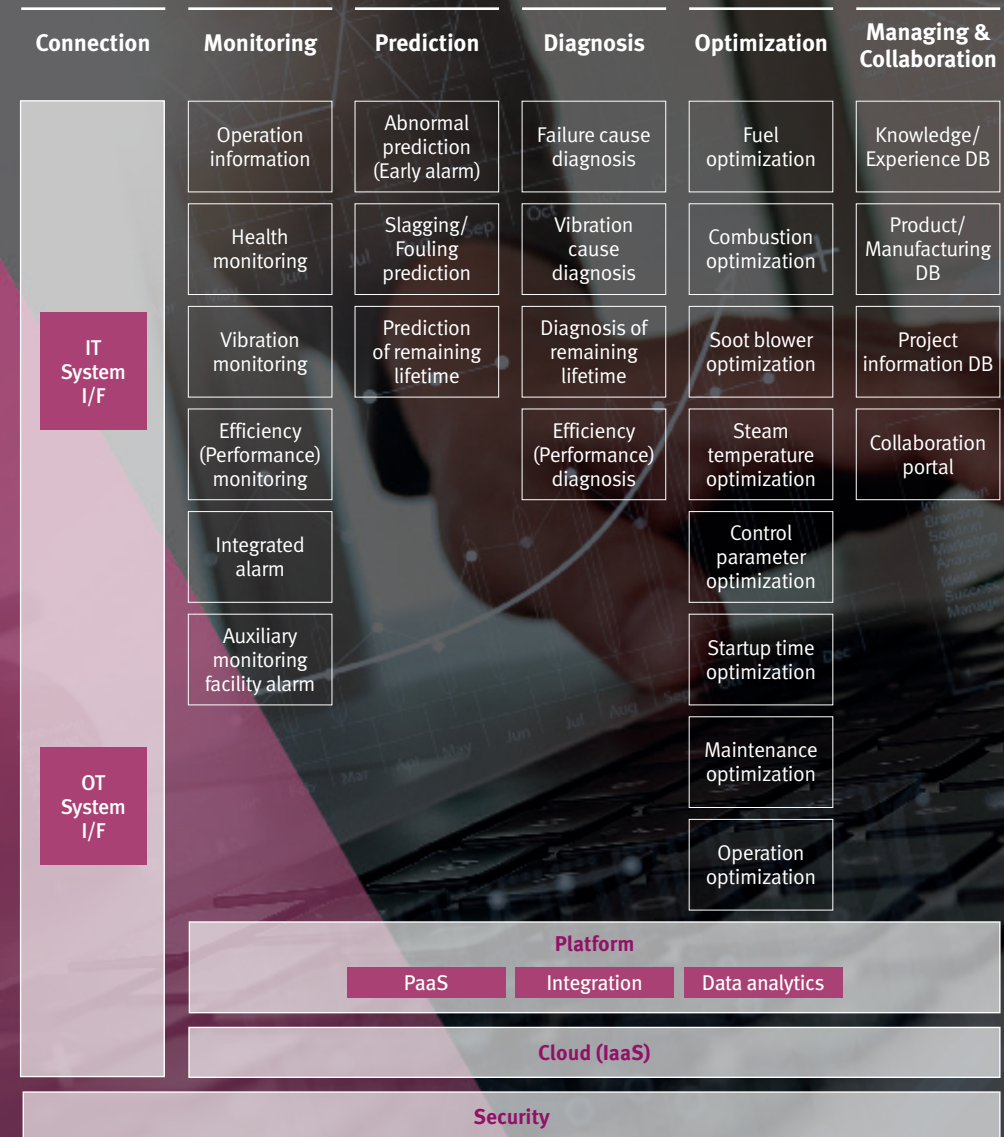
Digital Solutions

Doosan is a plant service company that manufactures, installs, commissions and delivers the best solutions for the power generation industry by combining complete power plant expertise with the latest IT technology. Our customers want to improve efficiency of power plants, meet environmental regulations, run flexibly according to system conditions, and avoid unexpected shutdowns. Doosan's plant digitalization can help them to achieve all these targets.

There have been a number of solutions offered before in power plants, but they have not always been successful. After the adoption of solutions, maintenance is actually more important. In addition, stand-alone solutions tended to be introduced for a specific purpose in the past, which means that there is a lack of connectivity with other solutions, and too many solutions cause difficulties in management. Some of them also face personnel issues, being neglected or not being managed properly if the person in charge changes duties.

Our digital solutions have been developed based on the SAP 'Leonardo' platform, and we manage them in a comprehensive manner.

- Our solution is available in an on-premises environment installed on-site or in the cloud depending on the customer's situation.
- Doosan offers various solutions ranging from distributed control system (DCS) or plant IT system and connection to monitoring, prediction, diagnosis and optimization. We also provide such management support solutions as database and collaboration portals.



PROJECT STORIES



EXPERIENCE LIST

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

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SERVICES

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PRODUCTS & SOLUTIONS



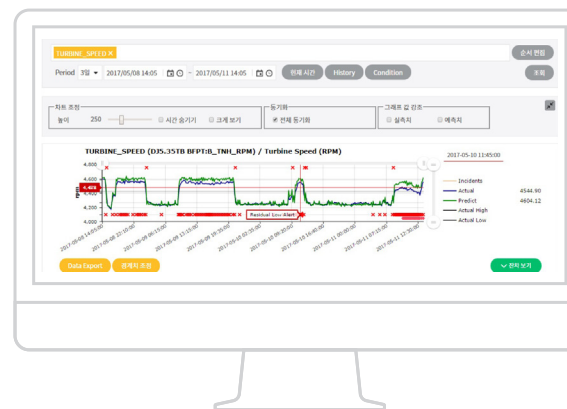
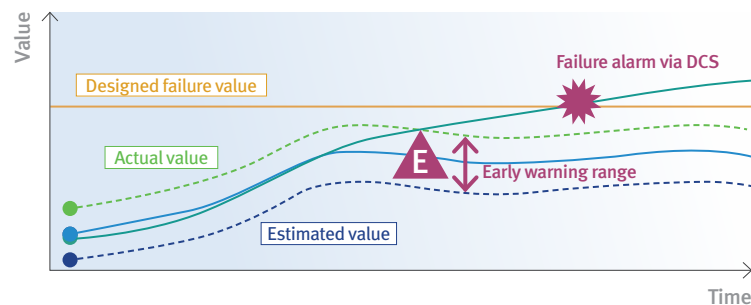
PreVision™ – Early Warning Solutions

What would you do if you knew critical equipment failure in advance? It is far better to prevent an accident than react after it happens. PreVision™ is an AI-based digital solution that learns normal operating patterns, detects the early warning signs of problems, diagnoses the causes, and enables preventative measures to be taken.

PreVision™ detects failures early and alerts before any actual failure occurs, with market-leading accuracy levels, by using differentiated machine learning algorithms that are based on ensemble learning. False alarms can be also minimized.

It reduces engineering efforts thanks to its automatic learning and automatic threshold adjustment. It can be used across a wide range of components and in many types of plant, especially for thermal, combined cycle and wind power plants. In thermal power plants, we have already installed PreVision™ in 12 units in Korea, ranging from 250 to 1,000MW. In addition, the web-based application can be monitored and operated via a web browser regardless of network location, and it is easy to use even without software skills thanks to its diagnosis logic in design.

EXAMPLE OF PREDICTION ALGORITHMS



CUSTOMER BENEFITS

- 80% of the trips of a power plant were tripped within 10 minutes after DCS alarm occurred – adopting an early alarm system has become a necessity for it detects abnormal patterns before DCS alarm
- Minimizing unplanned downtime by preventing trips to trips through action during operations
- Enabling current state-based maintenance and maintenance planning

Combustion Optimization Solutions

Doosan's combustion optimization solution aims to mitigate customer concerns regarding boiler operations and its efficiency. This includes making sure that reheat spray is not being used excessively, and that there is minimal or zero temperature difference between the left and right sides of the furnace due to a combustion imbalance. Doosan also checks that the plant meets increasingly stringent NOx emissions environmental regulations. As a boiler OEM, we provide combustion optimization solution which can solve these problems.

Combustion Optimizer

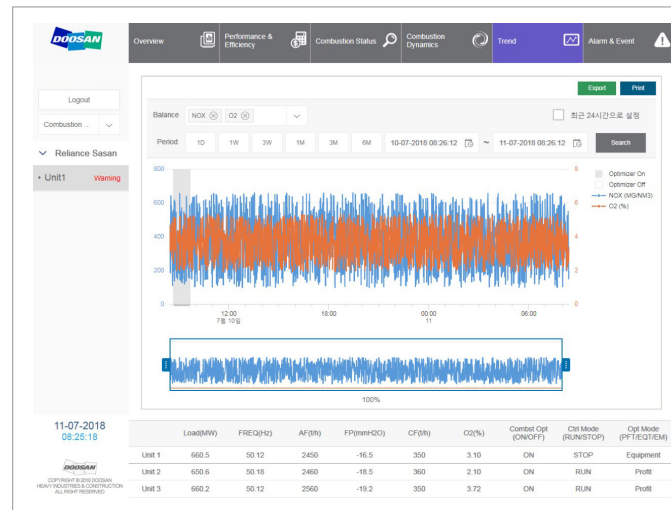
- Key parameters defined through CFD analysis and operation data are used for self-learning to build boiler model by neural network
- NN model simulates scenarios to determine optimal values for SA/OFA flow and OFA yaw

Automatic Adjustments

- Based on optimal values from combustion optimizer, SA/ OFA dampers and OFA yaw are being automatically adjusted
- Adjustments help balancing heat transfer and reducing RH spray/NOx/dry gas loss

Real-time Combustion Monitoring

- Display balancing/emission/efficiency status of a boiler on a real-time basis to determine overall combustion status
- Show adjusted damper positions and achieved efficiency improvement



CUSTOMER BENEFITS

- Heat transfer balancing: Decrease R/H spray to improve cycle efficiency and its imbalance
- Flue gas flow/temperature optimization: Further bring O₂ level down for better heat rate
- NOx minimization: Decrease ammonia consumption by reducing thermal NOx

Boiler Tube Management Solutions

Doosan provides boiler tube Management solutions (BTMS) which reduce outage hours and optimize maintenance by converting forced outages into planned ones. We monitor and predict changes in the remaining life of each tube in erosion-prone areas by calculating erosion rates and assessing changes in operating conditions. In areas not prone to erosion, the erosion risk of the zone is monitored and predicted. Alerts for tube changes or erosion risks can be set up for 200-250 days prior to the required outage.

Life Prediction of Boiler Tubes

- Predict erosion rate for each tube based on erosion prediction model with real-time operation data

Monitoring of 2nd Pass Boiler Tube Life

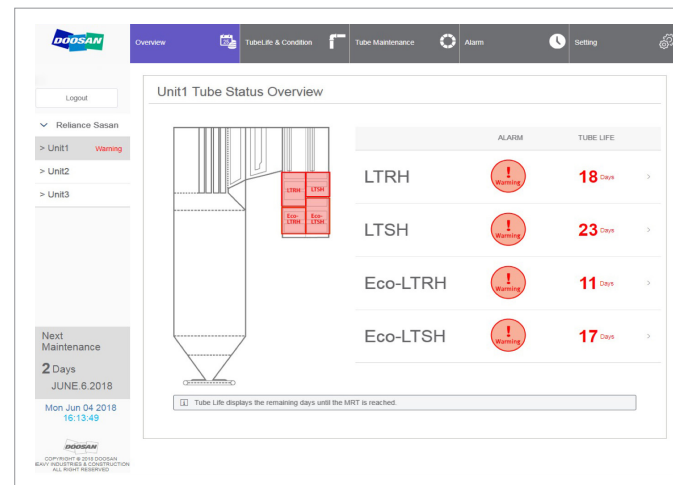
- Display residual life for each tube in erosion prone area and alert on tubes to be replaced before overhaul

O&M Guide and Maintenance Management

- Summarize tubes to be replaced before overhaul and manage tube maintenance history

Consultation Services

- Parts supply and repair, Tube metal coating, Installation of baffles and shield

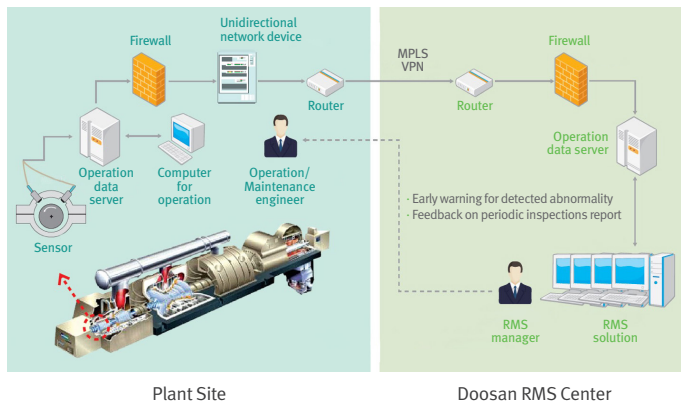


CUSTOMER BENEFITS

- What: Specify which tubes require replacement before overhaul
- When: Predict when tubes go under minimum required thickness and need to be replaced
- Why: Identify which operational factors are attributable to changes in lives
- How: Help clients make decisions on optimal plans for outage and tube replacements

Remote Monitoring Services

Doosan's remote monitoring services (RMS) help customers operate their power plants more efficiently by monitoring the operational information of a plant in real time using information and communication technology (ICT). This means that plants can be monitored from any location, at any time, and it gives customers early warning and diagnosis results in the event of any abnormality.



- Doosan operates the RMS Center to monitor, analyze and diagnose driving information by receiving real-time operational information of main plant operation from power generation plants
- Doosan's AI-based early warning & diagnostic solution, PreVision™¹⁾, detects the early signs of anomalies during operations and rapidly informs the plant of the diagnostic analysis results
- The RMS Center runs an ongoing operations and support system to ensure stable operations and improved performance at a power plant. Our expert in-depth analysis identifies the root causes of problems and proposes counter-measures
- Data analysis and power generation equipment experts at the Doosan back office analyze data from on/offline operations, and report on their diagnoses and evaluations. They also suggest potential areas for improvement, including equipment abnormalities and decreases in performance or efficiency
- Doosan's rotating vibration diagnosis solution, Dooves-RMS®²⁾, analyzes vibration data from the rotating body, diagnoses the causes of any increase of vibrations, and proposes counter-measures
- Doosan develops customized RMS solutions that reflect customer needs and provide on-time services

¹⁾ PreVision™: Doosan's in-house developed early warning/diagnosis solution which includes 12 TPP and 4 CCPP reference

²⁾ Dooves-RMS®: Doosan's in-house developed rotating vibration diagnostics solution in conjunction with vibration problem solving DB and clustering technology during installation

CUSTOMER BENEFITS

- Increase in capacity utilization rate through early warning
- Increased capacity charge income through diagnosis services
- Increased performance margins due to improved performance
- Shortened maintenance time and reduced maintenance costs through predictive maintenance which enhances reliability of power generation facilities and corporate image as well



SOLUTION STORIES

Total Plant

Boilers

AQCS

Steam Turbines

Generators

Plant Assessment

Gas Turbines

AM Services

Digital Solutions



SERVICES

KPI

PRODUCTS & SOLUTIONS

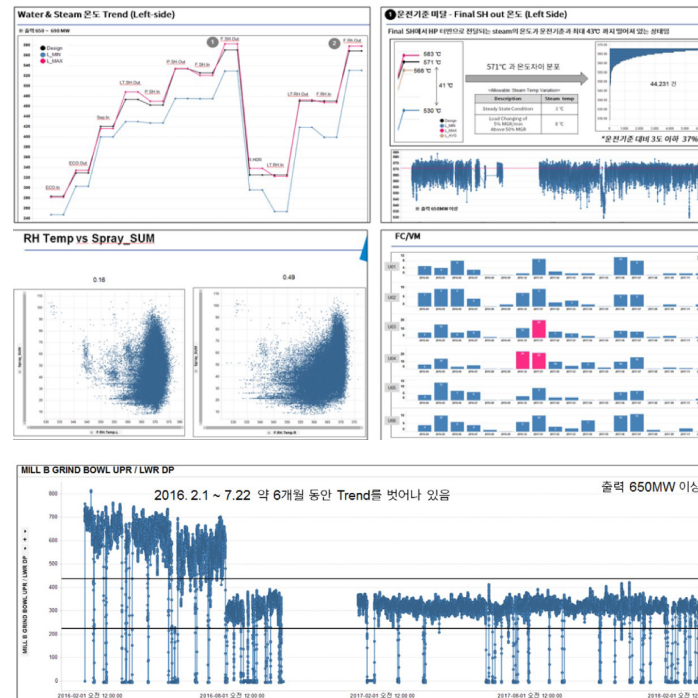


Big Data Driven Diagnosis Services

Doosan finds value in the big data generated at a plant. Our analytic experts identify hidden meanings of the big data to diagnose the condition of the plant, and provide services to counter the problems. In addition, Doosan works in partnership with main device design experts to ensure that the plant continues to operate at maximum efficiency.

We diagnose problems of a plant by using long-term operational data to assess the health of equipment and any factors causing a deterioration in efficiency.

- Visualizing long-term operational trends and diagnosing results driven from a macro point of view
- Analyzing operational results compared to design standards to check for abnormalities of the device and decreases in efficiency, based on which Doosan's design experts can propose such counter-measures as device replacement and changing operation modes
- Analyzing the step-by-step temperature distribution of critical water and steam in a boiler, and using long-term trends to check tube integrity and degradations in efficiency
- Data-driven analysis identifies outliers in data and recommends influence factors by using a model which looks for similarities in abnormal trends. Using these results, Doosan's experts can infer the cause of the phenomenon and establish a solution



CUSTOMER BENEFITS

- Quickly identifying long-term cumulative effects by using long-term big data
- Identifying and improving factors that can affect plant operations which enables customers to improve efficiency and prevent major equipment failures in advance

Coal Supply Management Solutions

Doosan offers coal supply management solutions to build a system which enables to maintain uniform coal quality in an effort to support stable operations at the power plant. These solutions also help to ensure a stable inventory of coal.

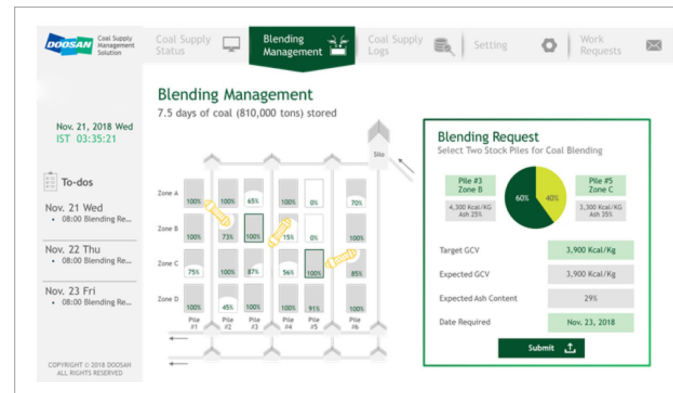
Optimal decision support for calculating coal mixture ratio

- Real-time update of 'As-received' analysis information/ Coal information for each stock pile
- Established CHP operation plan through the linkage of the HMI server for CSM

Work request, monitoring and communication platform for effective collaboration among relevant departments

Optimize for CSM-related collaboration tasks

- 'As-received', 'As-fired' coal industry analysis request
- Sharing short-term combustion plan
- Coal supply status



CUSTOMER BENEFITS

- Up to 0.25p improvement to power plant efficiency
 - Minimizing dry gas loss
 - Reducing unburned carbon
 - Reducing SH/RH spray usage
- Up to 10% NOx reduction and 1% CO₂ reduction
 - Minimizing thermal NOx and CO₂ emissions through optimum supply of O₂ according to coal type
- This solution is particularly effective when used in combination with Doosan's combustion optimization solution

Dooves (Doosan Vibration Expert System)

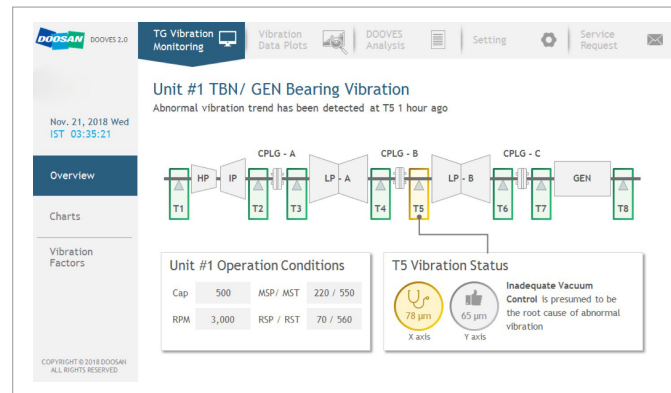
Dooves more rapidly identifies the causes of vibrations in the rotating machinery of a power plant, and suggests appropriate actions to optimize the maintenance of the machinery to improve the availability of the power plant.

Continuous monitoring and analysis of vibration signals to ensure early detection of abnormal conditions

- Analyzing operation and vibration data obtained in real-time through data analysis-based algorithm, and providing users with information to check if the rotating machinery is normal or not

Analysis of abnormal vibration signals to identify causes and provide measures

- Probabilistically identifying possible causes of abnormal vibration signal through case-based diagnosis algorithm
- Providing users with guidance on appropriate measures based on past vibration cases



CUSTOMER BENEFITS

- Increasing availability of a power plant
 - Quickly diagnosing and responding to rotating machinery vibration issues to increase availability of a power plant
- Reducing maintenance costs
 - Enabling preventive maintenance through early detection of abnormal signals

Localized Global Services

As a leading supplier & services provider for power plants, Doosan has established global networks with local partners and branches to offer localized global services.

We are proactively interacting with customers around the world to identify their needs and to deliver what they want at the right time. Through standardized services procedures and reliable supply chains around the world, Doosan is providing prompt and high quality services to customers.

