Guide

Performance Optimization for Diesel Power Plants

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Save energy, save money and save the environment

A more efficient power plant yields better economics and improves the environment.

When you optimise your diesel power plant, it runs more efficiently, which means you can save significant amounts of fuel and corresponding costs. But beyond the financial benefits, optimising your plant can also improve the local environment, which can create a better relationship with the community.

At the same time, the plant will see fewer unforeseen incidents such as forced outages, which makes operation smoother and more predictable, easing the workday for everyone at the plant.

Here is what plant optimization can help you achieve:

- Lower fuel costs
- Higher availability
- Reduced emissions and effluents
- Satisfied power consumers
- Better financial results

Discover hands-on tips for optimization

This guide unfolds the most valuable benefits of diesel power plant optimization and comes with tangible, practical advice for how your plant can start down the optimization path.

You will learn:

- How to improve heat rate
- How to optimise plant availability
- How to reduce emissions
- How to extend the lifetime of your plant

Whether you are a plant owner, a plant manager, an engineer or operational technician, understanding how to holistically optimise your diesel power plant can make you more effective in your job and help produce better results for your organization.

Read on to learn more about diesel power plant optimization.

Improve the heat rate of your plant

A lower heat rate indicates better efficiency in terms of getting more energy output for lesser energy input.

The heat rate shows how much energy the plant uses to generate a certain amount of power. Better efficiency also reduces environmental impact and improves profitability all at once.

There are three ways to achieve a better heat rate:

1. Reducing specific fuel oil consumption
2. Reducing plant own consumption
3. Waste heat recovery

1 Reducing specific fuel oil consumption

Reducing specific fuel oil consumption

This starts with creating good conditions for the engine, the core of the diesel power plant.

The engine needs to 'breathe' and to be cooled effectively. Fouled or defective air and exhaust gas passageways will starve the engine of air and cause poor combustion, which leads to higher fuel consumption and higher emissions.

By undertaking regular checks and cleaning of engine parts, you can ensure the engine is running efficiently.

Look for:

- Fouled charge air intake filters
- Fouled, worn or defective turbochargers
- Fouled charge air and radiator coolers
- Fouled exhaust gas boiler or misaligned dampers

Worn, defective or maladjusted mechanical components can also lead to poor combustion and higher fuel consumption.

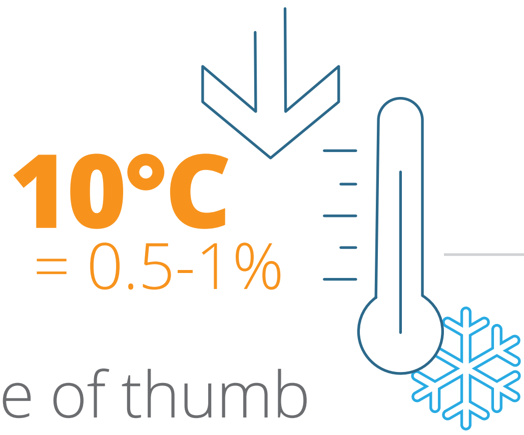
Look for:

- Defective fuel injection equipment – make sure nozzles and pumps perform correctly
- Defective or leaking intake or exhaust valves in the cylinder
- Worn or broken piston rings
- All this contributes to getting the best out of the engine itself

What's the best way to identify these problems?

Keeping a thorough overview of the engine condition is the easiest way to identify fouled or defective components. At BWSC, we suggest conducting regular engine performance assessments to keep track of changes over time. This includes making trend curves and comparing them to the commissioning figures, so you can see if something is going in the wrong direction.

This helps you predict the need for cleaning and maintenance, minimizing unplanned incidents and downtime. It also helps keep fuel consumption as low as possible.



Rule of thumb

For every 10°C decrease in charge air temperature, SFOC goes down by approximately 1.5 g/kWh. Decreasing charge air temperature through these defouling initiatives could save up to 0.5-1% in fuel consumption, translating into considerable cost savings.

Run the most efficient generating units first

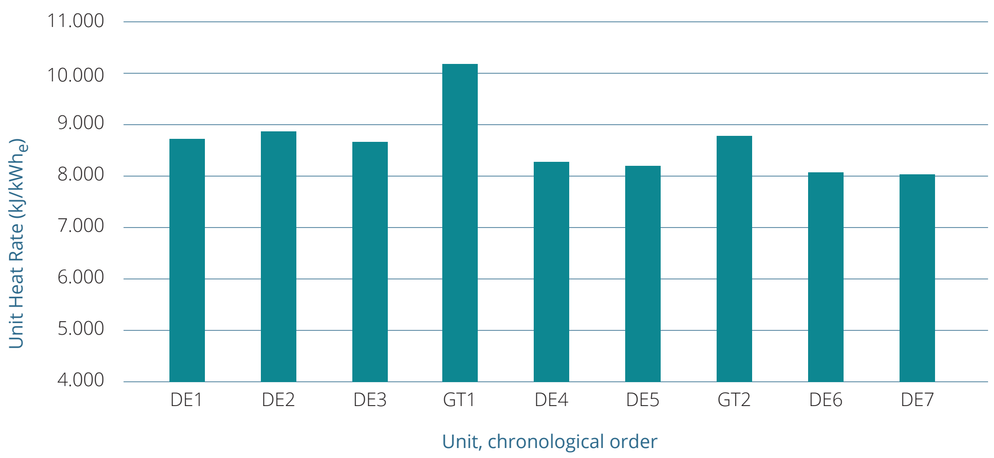
Determining the heat rate of your generating units enables you to dispatch the most economical units first according to load demand and minimize use of less efficient units.

Conducting a heat rate survey will map your units and make it possible to rank the units for most optimal dispatch to address demand fluctuation, typically starting with the best units first and old engines last.

The optimal ranking should also include these factors:

- Fuel type (cost) – more expensive fuel will affect the ranking. When a unit operates on a more expensive fuel it would rank in the higher end. Unit size (part load characteristics) – it might not be economically wise to force bigger units into part load operation even they have a lower heat rate than the smaller unit.
- Maintenance cycle (where in the cycle is a particular unit) – you would not want to force a unit into premature scheduled outage.
- Other considerations (for example, lube oil consumption).

GENERATING UNIT HEAT RATE SURVEY

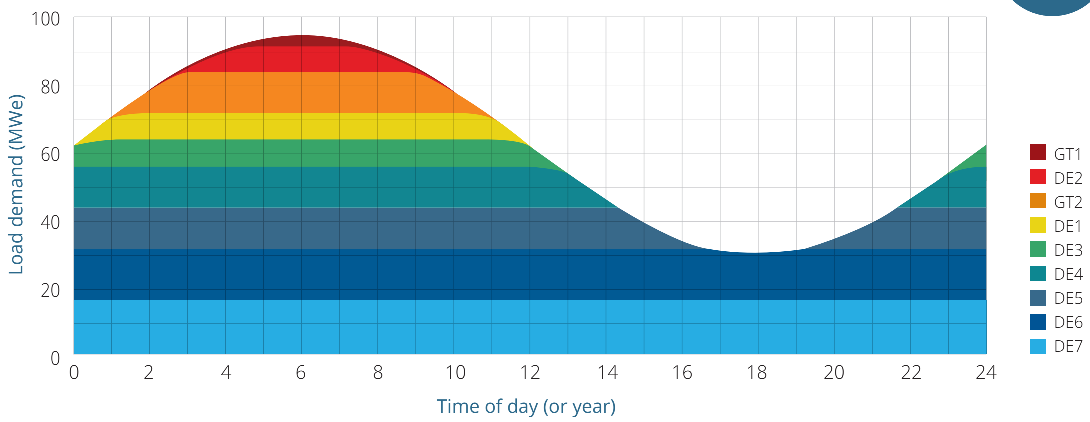


Weighted avg. heat rate:

8,623

kJ/kWh$_e$

DISPATCH DISTRIBUTION (EXAMPLE)



↓4%

Avg. dispatch heat rate:

8,299

kJ/kWh$_e$

2 Reducing plant own consumption

Look for oversized pumps – unnecessary auxiliary consumption

Often plants are equipped with oversized pumps to ensure sufficient flow at all times. But this translates into unnecessary costs as pumps require excessive amounts of energy – and often they are producing more than adequate flow to do the job.

It all starts with EPC contractors who are under pressure to avoid installing too small auxiliary equipment, so they specify pumps that more than cover the flow needed in the plant. When OEM suppliers come into the picture, they add a design margin to cover manufacturing tolerance.

49%
above baseline

Oversizing example

Cooling water pump

A certain flow and calculated pressure (head) are needed for a cooling pump. Due to uncertainties, the EPC contractor adds 5% flow and 15% head margins. Then the OEM supplier adds a further 3% flow and 3% head to the design margins.

That adds up to 8% flow and 18% head. But in reality, as extra flow also generates pressure loss, the head margin would be more than 38%. That results in a pump power demand specification of more than 49% over baseline.

Making small adjustments around the plant can add up to considerable savings

Plant own consumption is the power used to run the power plant itself, including facilities such as administration buildings, workshops, warehouses, etc. It accounts for 2-3% of the production and is often overlooked when it comes to cost-saving initiatives.

Here are 7 ways to reduce energy

1 Avoid oversizing

At specification, limit adding safety margins to ensure that the actual operation is close to BEP (Best Efficiency Point).

2 Impeller trimming

If a pump is oversized, trimming the impeller is a more cost-effective and energy-efficient way of reducing the pressure and flow than using throttling.

3 Variable frequency drives

Reduce energy use of oversized pumps or when there are differing duty requirements at different times by varying the motor speed to achieve the actual head and flow demand, rather than running. the pump at full capacity.

4 Parallel pumping systems

When maximum conditions are a lot higher than standard operating demands, install a smaller, second pump to relieve the larger pump from operating far below its capacity and away from its BEP.

5 Limit pipework pressure loss

Reduce pressure loss by minimising bends, optimising pipe diameter/ length and installing low-pressure drop valves.

6 Eliminate unnecessary use

Implement control systems to shut down pumps when not required.

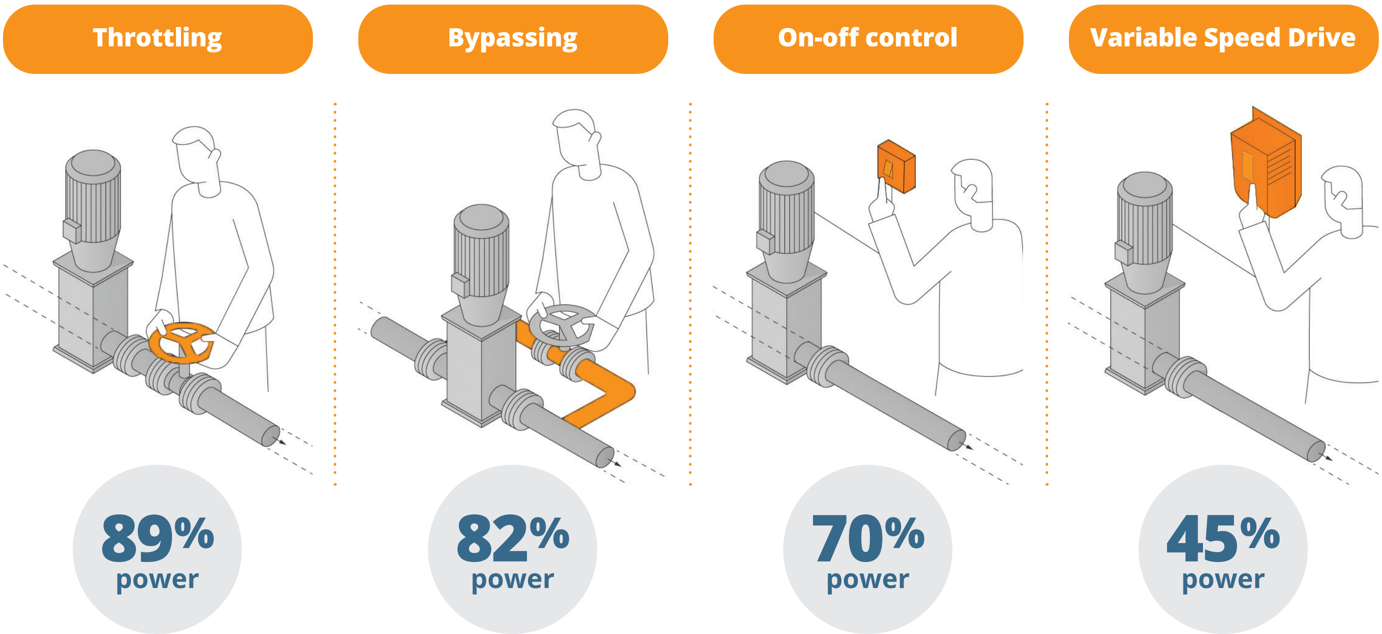
7 Maintenance

E.g. replace worn wear rings to reduce leakage inefficiencies.

How to match pump capacity with demand

Pumps and fans are typically designed to run consistently at full load. However, often only part load is necessary, which means pump energy is wasted.

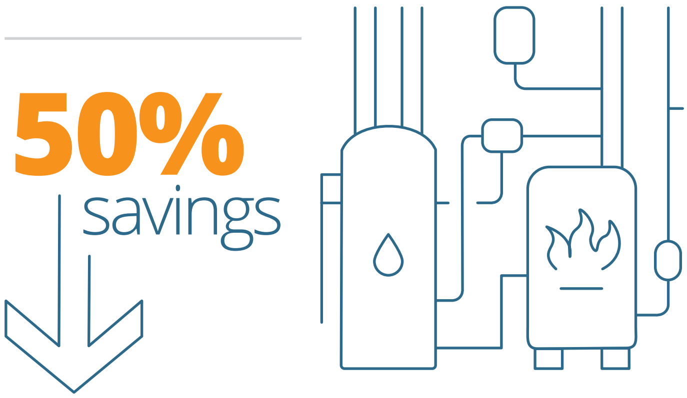
There are various ways to regulate pump flow to save energy:



Variable Speed Drives (VSDs) ensure the pump is delivering only the necessary flow. Installing VSDs on pumps and fans helps avoid unnecessary energy consumption.

Consider installing VSDs on large units such as:

- Cooling water pumps
- Seawater pumps
- Radiator fans
- Engine hall ventilation fans



By using only the amount of energy required to do the job, variable speed drives can save up to 50% energy.

Business case

Variable speed drives pay back in 2-3 years

A diesel plant in the tropics comprises four-stroke engines (~ 100 MW net out) and radiator coolers with 8 fans per engine unit and using on/off control. The assumed operation profile is 7,500 hours per year at 90% load on average.

The design ambient temperature is 37°C but average temperature is < 30°C , meaning that some fans are often switched on/off.

However, if all fans are operated at reduced speed by variable speed drives, the overall power consumption is reduced due to the lower air velocities/pressure drop and the full utilization of cooler banks.

Plant example

50 kW per engine unit

50 kW × 6 units × 7,500 hrs × 0.2 kg fuel/kWh × 400 USD/ton HFO

Estimated payback time:

2-3 years

Estimated installation cost:

USD 350,000 – 400,000

Estimated savings:

USD 350,000 – 400,000

Other low hanging fruits for reducing plant own consumption

- **Keep radiator coolers clean**
  For example, by installing semi-automatic cleaning devices. This increases heat transfer capacity and fans can save energy
- **Review control concepts**
  For example, demand-based capacity control, for potential improvements and savings
- **Eliminate pressurised air leaks**
  To avoid unnecessary compressor power consumption
- **Optimise A/C distribution system**
  For example, check pipe insulation and buildings insulation
- **Install timers on A/C in offices**
  To save energy at night and on weekends
- **Switch to LED light sources**
  Compared to HP sodium vapour lamps, LED lights use 80% less power and last 10 times longer
- **Install motion sensors on lighting**
  To ensure lights are only used when needed
- **Replace oil-fired boiler with solar water heaters**
  For stand-by heating
- **Install solar PV panels**
  To cover some of the auxiliary consumption

Start with a complete plant survey

To identify which of these initiatives could be the most beneficial for your plant, we recommend starting with a thorough plant assessment. (See details on page 24.)

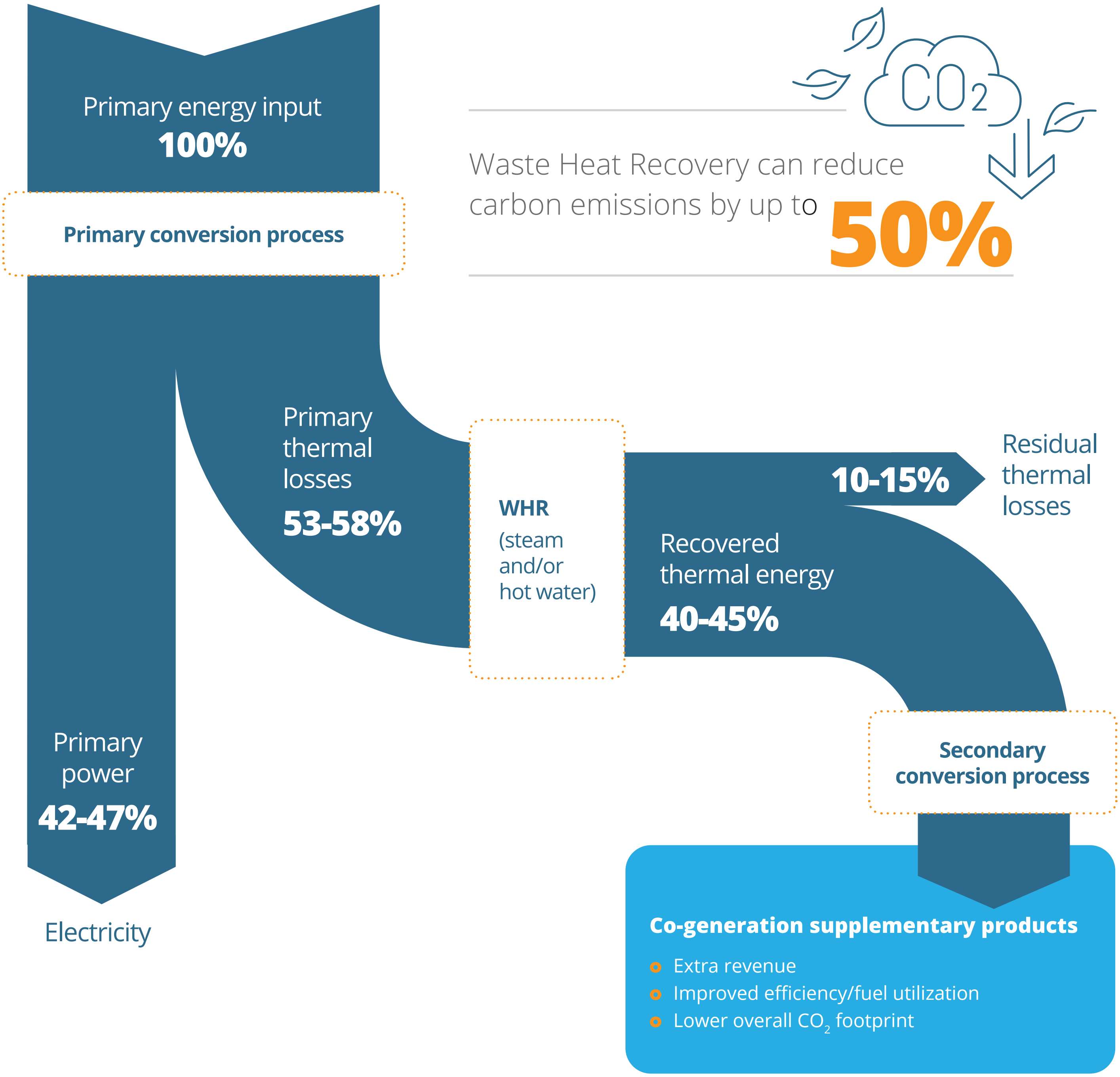
3 Waste heat recovery

Another opportunity to harvest energy, save fuel and lessen the environmental impact is through waste heat recovery (WHR), utilizing the excess heat from the generation process.

With a traditional diesel generator, only 45% of the fuel goes into electricity production. The rest is wasted in the form of cooling water and hot exhaust gas.

Recovering this waste heat makes it possible to produce electricity, heat and even cooling.

Waste heat recovery and co-generation

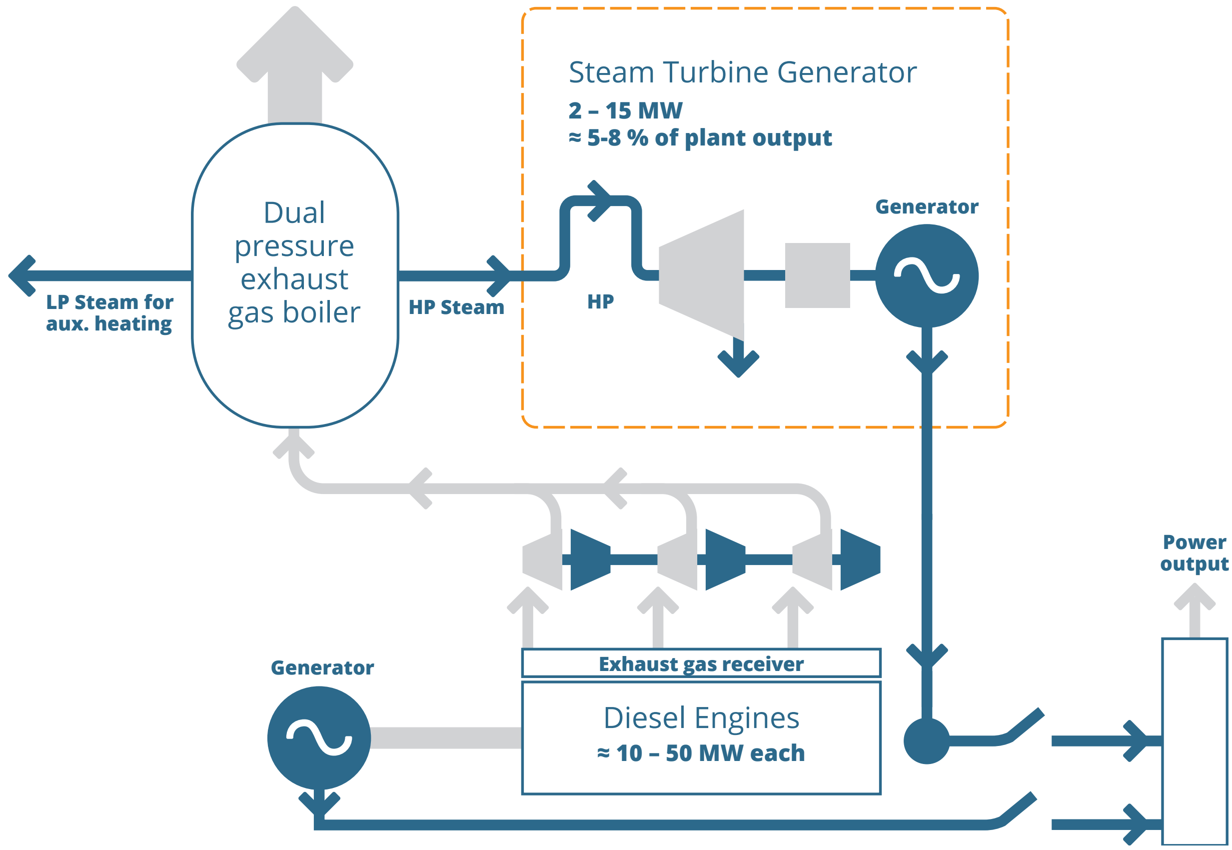


Co-generation technologies

For decades, the Nordic countries have been refining co-generation processes, and today there are several well-proven co-generation technologies available:

- WHR steam boilers & turbine generator (high efficiency combined
  cycle concept)
- Industrial/District Heating (Combined Heat & Power concept)
- Industrial/District Cooling (Combined Cool & Power concept)
- Tri-generation (CHP + CCP concept)
- Desalination or distillation of sea water into fresh water (Co-generation)

EXAMPLE OF CO-GENERATION/COMBINED CYCLE CONCEPT



Top 3

benefits of co-generation

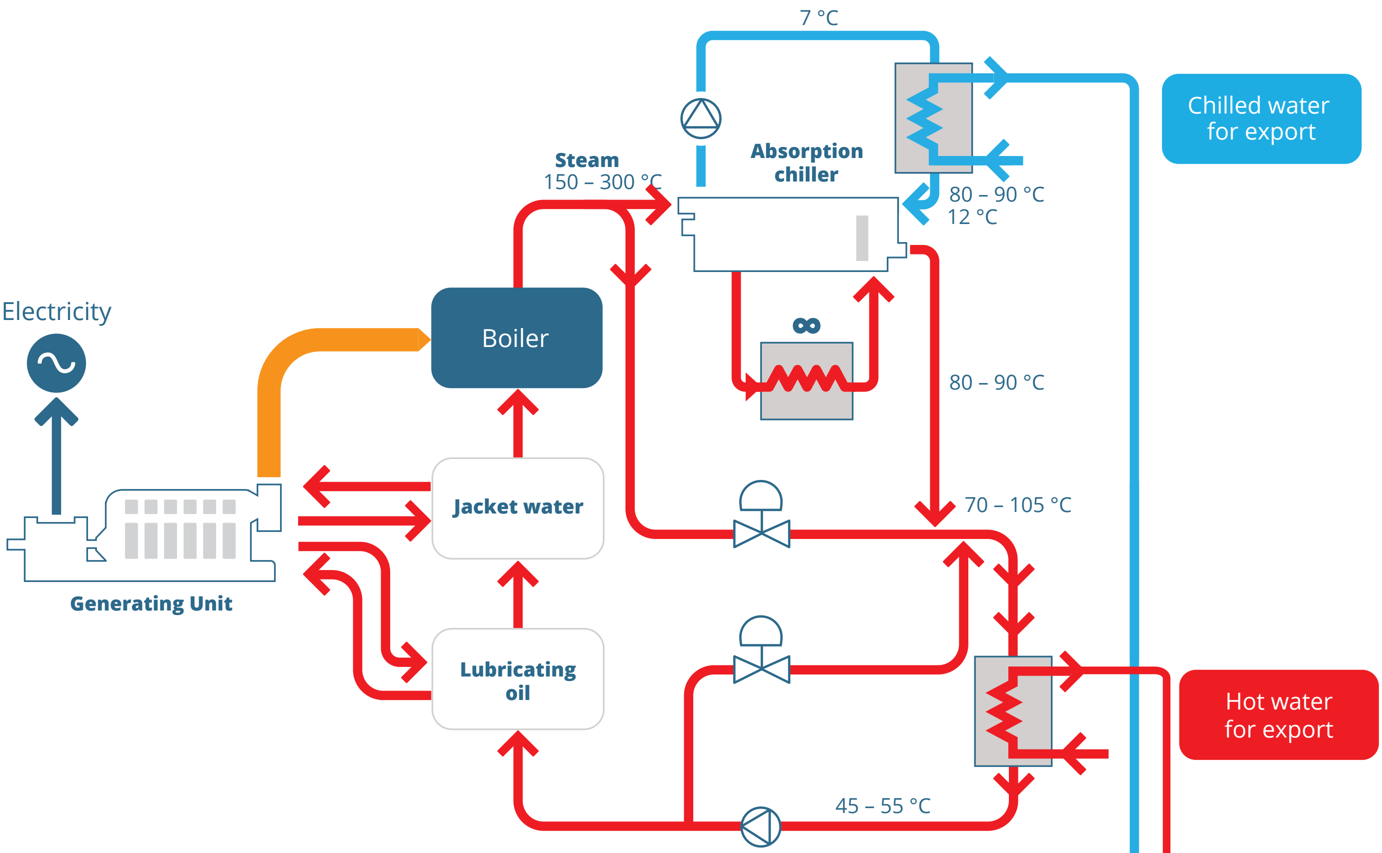
- Lesser environmental impact
- Reduced fuel costs and potential additional income from sale of extra power, heat or chilled water
- Deferred installation of new generation capacity, since a great part of electrical power produced is used for air conditioning – and if A/C is produced from waste heat, the peak power production will diminish.

Tri-generation concept: electricity, heat and cooling

Tri-generation is the simultaneous generation of electricity by using exhaust gas and HT cooling water to generate hot water, steam or chilled water.

This concept allows utilities to produce heat and chilled water for A/C from otherwise wasted heat and sell it to nearby facilities that require heating and/or cooling.

EXAMPLE OF TRI-GENERATION CONCEPT



Potential off-takers

- Cold stores
- Office complexes
- Shopping malls
- Hotels
- Airports
- Hospitals
- Refineries
- Destilleries
- Breweries
- Residential complexes

How to ...

How to...

Improve plant availability

Small adjustments can make a difference and the savings add up
Plant availability is the number of hours a generating unit is capable of providing power, whether or not it is actually in service and regardles of the load.

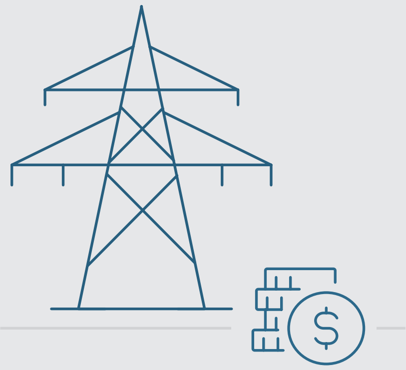
Factors that influence plant availability

- Optimised maintenance planning and preparation
- Quality control programs for the maintenance work
- Relevant strategic/safety spare parts available
- Circulating/swing parts available (to limit downtime for overhaul)
- Delivery of correct spare parts in due time – additional savings from avoiding last minute air freight
- Correct fuel oil, lube oil and water monitoring and treatment
- Close monitoring and trending of the unit performance to schedule proactive maintenance
- Well-trained and motivated plant management and staff

Ensuring the most fuel-efficient units are available can deliver significant cost savings.

$$AF = \frac{AH}{PH} \times 100\ [\%]$$

AF: Availability Factor
AH: Available Hours
PH: Period Hours



Savings per year

$1,150,000

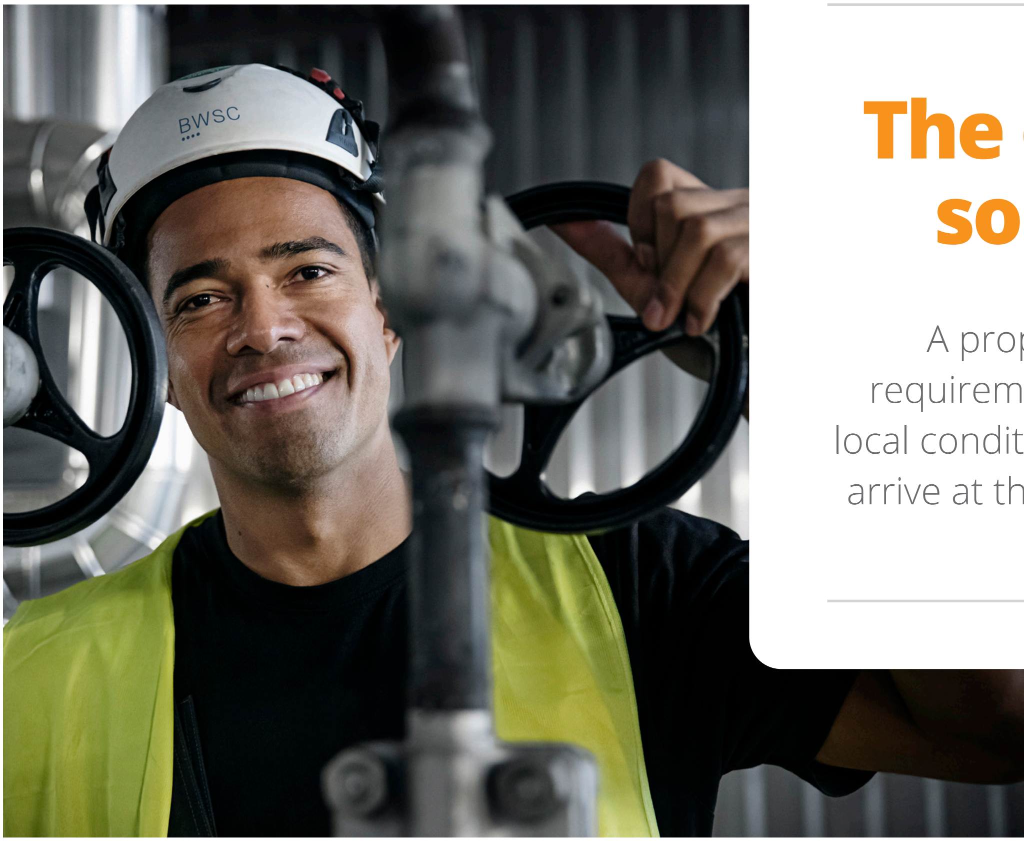
Business case

Improving availability saves money

By improving availability by just 3%, a typical diesel power plant (100MW) can save approximately USD 1,150,000 per year when substituting less efficient or more costly units:

- 100 MW Diesel Plant
- SFOC diesel engine on HFO: 200 g/kWh
- SFOC open cycle combustion turbine on gas oil: 250 g/kWh
- Price HFO: 400 USD/ton
- Price Gas Oil: 550 USD/ton

Availability: from 7,800 to 8,000 hours per year (200 hours ~ 3%)
Savings: USD 1,150,000 per year



The optimal solution

A proper analysis of requirements, options and local conditions is necessary to arrive at the optimal solution.

How to...

Reduce emissions

A well-maintained diesel power plant minimises its environmental impact.

Environmental legislation may make it necessary to give your power plant an environmental upgrade. But beyond enabling compliance, an environmental upgrade extends the lifetime of your plant, deferring CAPEX expenditure.

With a reasonable heavy fuel oil (HFO) quality, maximum 2% Sulphur and less than 0.05% ash, most diesel plants can comply with current IFC and World Bank regulated emission of NOx, SOx and particulate matter (PM). However, this may not be enough.

Reducing emissions is usually a complex affair involving many considerations and local conditions.

First, consider whether the plant can switch to or be retrofitted to use a cleaner fuel, such as low- sulphur HFO, DO or ULSFO or gas. It may be OPEX-costly but should as a minimum serve as a reference for other options.

Secondly, look at secondary abatement options, such as:

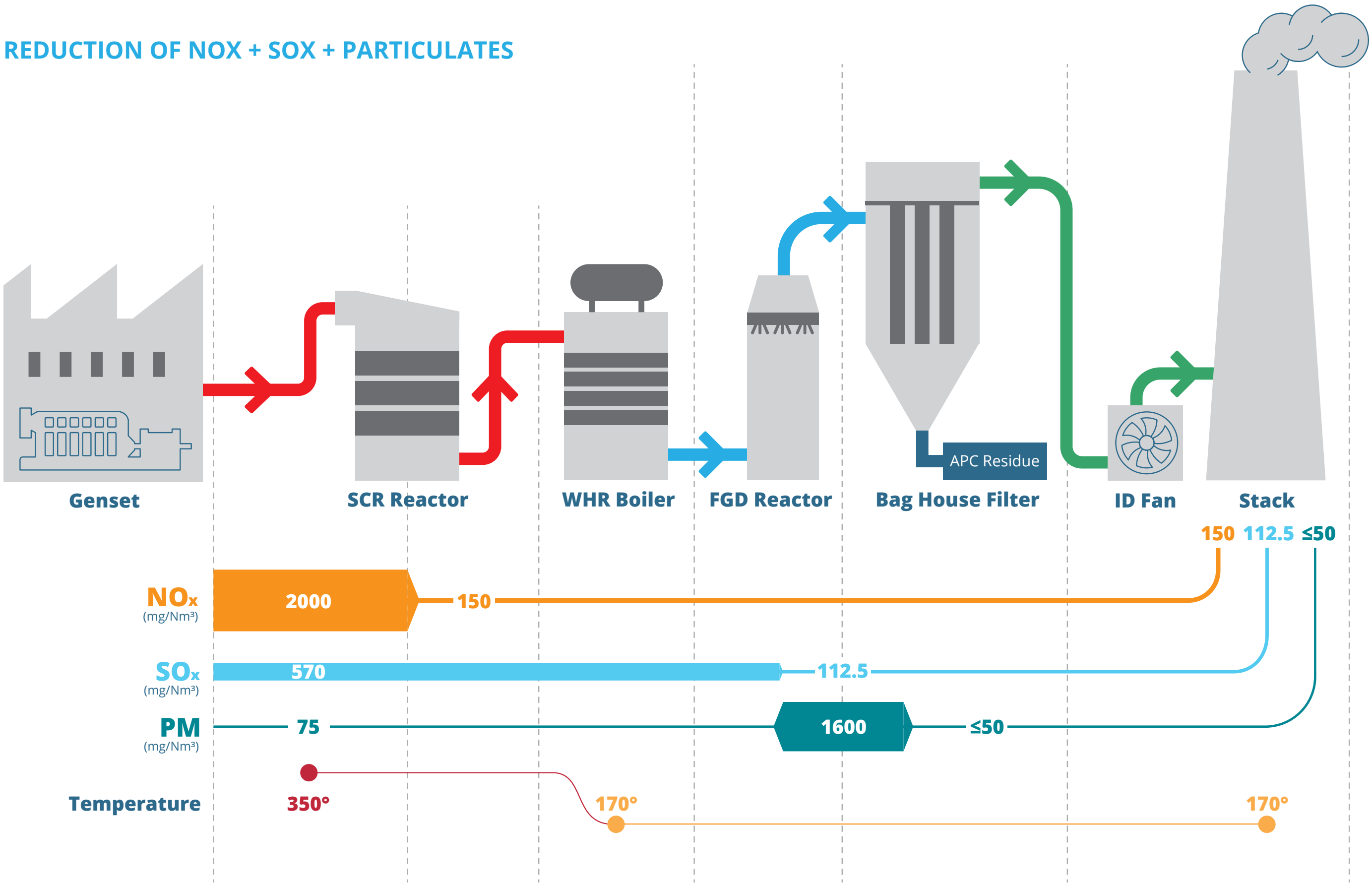
- SCR with urea or aqueous ammonia solution as reagent for NOx reduction – This technology is fairly well proven on diesel engines, although a bit more complicated for low-speed two-stroke engines than for medium-speed four-stroke engines. The process leaves no residuals to handle.
- Various forms of dry, semi-dry or wet scrubbing techniques for SOx reduction – There are many alternatives and several reactants to choose between. Some of these processes can potentially also reduce PM. Local availability of potential reactants, residual disposal and expected remaining service life are important factors to consider.
- ESP (Electrostatic Precipitator) for PM reduction – If not already addressed in combination with SOx reduction above.

Other potential environmental upgrades to consider

Other upgrades could be considered to lessen your environmental impact and make the plant a better neighbour to the surrounding community:

- Ensure proper handling, treatment or disposal of waste oil and sludge and other hazardous waste
- Monitor and potentially improve wastewater collection and treatment system
- Survey noise and investigate if major noise sources can be reduced – there may be low- hanging fruits that can be addressed with reasonable means to the satisfaction of employees and neighbours
- Perform regular environmental surveys to follow up on environmental compliance and identify and address potential problems before they develop further
- Set up a system to record and deal with potential external as well as internal complaints or concerns

REDUCTION OF NOX + SOX + PARTICULATES



How to...

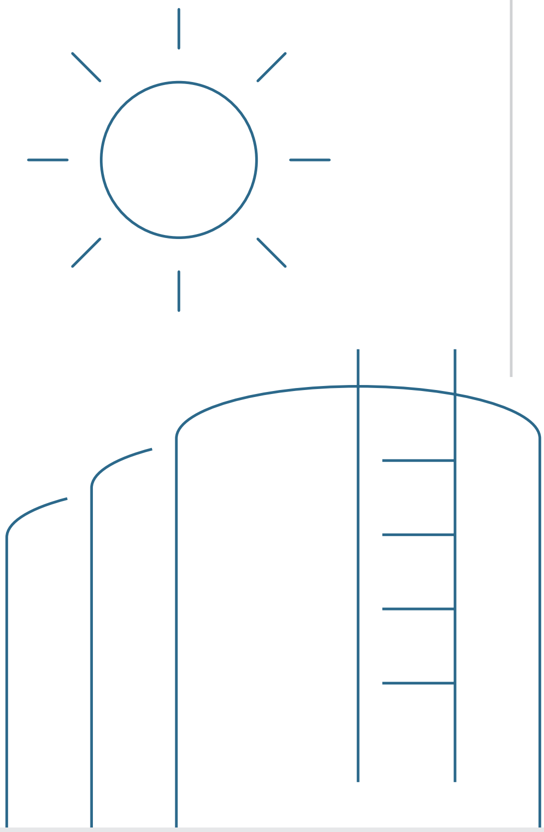
Extend the lifetime of your plant

Prime movers and other major equipment, when well-maintained, can often last longer than initially specified and expected.

However, to extend the lifetime of the entire plant beyond the specified term, some components and equipment must be upgraded, rejuvenated or replaced.

For example, when:

- Equipment becomes obsolete
- Spare parts or support are no longer available on the market
- New equipment and solutions come with significantly better performance Legislation dictates upgrades, e.g. new environmental laws



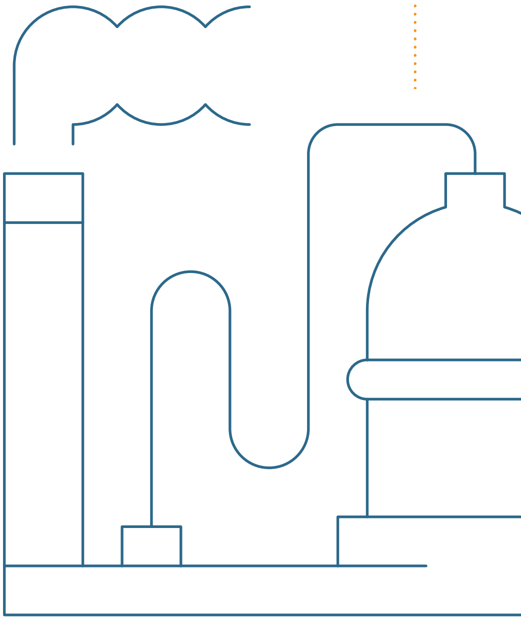
At BWSC, we undertake re-engineering, supply, installation, and commissioning of a range of equipment and systems:

- Plant control systems – DCS, upgrading of software and hardware
- Obsolete electrical equipment, HV, MV, LV and DC
- Generator AVR/excitation systems Turbochargers
- Cooling water systems, radiator coolers etc. Conversion to alternative fuels e.g., Ultra-Low Sulphur
- Oil purifiers
- Oily water and sludge treatment plants

AVR/EXCITATION SYSTEM

OLD

NEW



TURBOCHARGER

OLD

NEW

Plant condition surveys and assessments

Steps in a plant survey and reporting process:

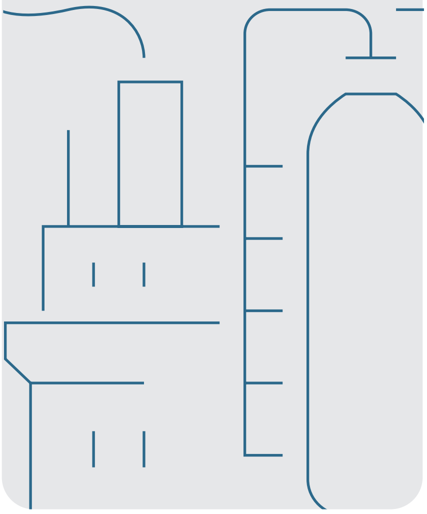
Onsite inspection

Data analysis & benchmark

Documented findings

Cost/benefit analysis

Recommendations



Plant assessments reveal potential optimizations and savings

As part of the long-term strategy for a power plant, it pays to make a thorough technical assessment to determine the current asset condition and benchmark against industry standards. This can help estimate the remaining lifespan of equipment for budgeting and planning purposes and provide a detailed review of Operation & Maintenance procedures.

A plant assessment can reveal potential optimisations leading to:

- Improved overall plant performance: availability, reliability, output
- Better fuel economy and energy savings
- Lifetime extension of equipment
- Replacement of obsolete equipment
- Reduction of emissions and effluents
- Reduced cylinder lube oil consumption

General plant performance assessment Potential optimizations, lifetime assessment, operation and maintenance procedures	**Plant efficiency survey** Fuel economy, availability, reliability, output, own consumption
Electrical/automation survey Safety, lifetime assessment, obsolescence	**Environmental assessment** Emissions, effluents, renewable readiness audit
Asset/equipment inspection Equipment performance, trouble-shooting, lifetime assessment	**Damage assessment** Emergency response, root cause analysis, repair cost estimates, insurance claims support

BWSC can help

We have specialists within all disciplines – Mechanical, Electrical, Process and Instrumentation & Control – covering all aspects of diesel and steam power plants. Through our tailored plant assessments and surveys, we can help identify fouled or defective components, visualise performance to enable predictive maintenance and we can help prioritise your heat-generation units. We can also help identify where variable speed drives could add most value and we can assist with waste heat recovery.


BWSC

Why work with us?

We have decades of experience and expertise in design, construction, operation, maintenance, repairing, upgrading and managing power plants, and we cooperate with leading partners and suppliers within the industry enabling us to respond to all of our clients' technical needs. Our services are carried out by qualified supervisors, specialists and flying squads working in shifts around the clock. And we won't stop until the job is done and your plant is armed with the knowledge it needs to move into a more cost-efficient, environmentally friendly future.

Get in touch

To arrange a plant assessment, get in touch with BWSC today.

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We support "The Global Goals for Sustainable Development"

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About BWSC

Headquartered near Copenhagen, Denmark, BWSC provides specialized consultancy, engineering, installation, operation and maintenance services at power plants and green energy facilities worldwide.

Forty years of experience with energy infrastructure, a diverse staff of seasoned experts, full technology independence and our big-picture approach make us uniquely able to help customers define their ambitions and reach them through expert design and continuous improvement of their facilities.

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