POWERING THE FUTURE

CONSULTANCY ON FLEXIBLE, EFFICIENT AND RELIABLE THERMAL POWER PLANTS

WWW.RAMBOLL.COM/POWER
Ramboll has more than 45 years of experience in the planning, design and implementation of energy solutions.

Our energy team provides expertise on the full spectrum of technologies and all parts of the value chain from production through to transmission and distribution.

Our special competencies lie within thermal power, wind energy, waste-to-energy and district energy. Within these four areas, we provide a one-stop shop of services based on know-how and experience gained from a large number of projects, unmatched by other consultancies.
WHAT WE CAN DO FOR YOU

Modern energy systems face increasingly complex challenges. Global power demand is rising as societies develop, whilst we must also reduce climate change impacts. Growth in wind, solar and other renewable generation, along with the development of higher efficiency and flexible fossil fuel plants are increasingly seen as the key to delivering these reliable lower carbon solutions.

Sustainable solutions
The projects that we carry out for our clients typically provide the overall societal benefits of securing the supply of energy, reducing climate impact, improving energy efficiency and countering resource scarcity.

We assist our clients in all project phases, ranging from planning and engineering design, to long-term operation and maintenance.

Special energy competency areas
Besides thermal power, we offer world leading competencies within offshore wind, waste-to-energy and district energy.

More than 65% of the world’s offshore wind turbines rise from foundations engineered by Ramboll, and we have provided expert services to onshore wind farms with a nominal output of +60,000 MW in more than 60 countries.

We have worked on waste-to-energy projects in 45 countries, providing consulting services for 145 new units and retrofits.

We have provided consulting services to more than 200 district heating and cooling systems worldwide, ranging from small village schemes to city-wide transmission networks.

Thermal power services
Ramboll offers a ‘one-stop shop’ of services based on a multidisciplinary approach to power generation.

Our unique strength stems from the acquisition in 2011 of DONG Energy’s in-house thermal engineering team, responsible for the project development and implementation stages of world leading high efficiency power plant projects right through to operations and maintenance support, failure investigation and power plant rehabilitation and upgrades.

Unlike many other consultants we are able to bring expert plant operational insight into new power project developments. Our power group has continued to strengthen with strategic recruitment of staff with extensive international power generation engineering consulting experience.

Thermal power experience
On behalf of our clients, we have designed and constructed more than 90 major power plants, including some of the most energy-efficient plants in the world, and are instrumental in the ongoing conversion from fossil fuels to biomass.

For our clients, working with Ramboll means that they will benefit from our long-term experience and know-how, and together we can transform complex challenges into solutions that are future proof, energy efficient, cost effective and practical.

INDEPENDENT ADVICE
• Owner’s Engineer
• Lender’s Engineer
• Project and programme manager
• Environmental advisor

LARGE RESOURCES
• Group 13,000 staff
• Energy 1,500 staff
• Power experts >240 staff

FULL SCOPE SUPPORT
• Feasibility & costing
• Specification, tendering & contracting
• Construction
• Commissioning
• O&M
• Life extension & upgrade
• Decommissioning & redevelopment

KEY EXPERTISE
• High efficiency power plants
• Biomass and bioconversions
• Cogeneration (CHP)

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KEY EXPERTISE
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• Cogeneration (CHP)
Ramboll has pioneered the development of innovative power plants with worldwide highest efficiencies and have particular expertise in:
- High efficiency power plants
- Biomass and bioconversions
- Cogeneration (CHP)

The Ramboll mind-set is to set and achieve the highest standards for health and safety throughout all stages of a project and subsequent plant operation.

**Project development**
The project development stage is of vital importance. It is at this time when key decisions are made on a project; this is the time to optimise to ensure the site selection, fuel type, technology and subsequent contracting methods considered are best aligned with the overall project objectives. If not addressed fully at the outset, subsequent optimisation and changes in later stages of a project can have significant cost and programme implications.

**O&M support**
Ramboll has strong competencies within operation and maintenance, which enables our clients to make their operations more efficient and hence optimise the operating economy of their plant. Ramboll can assist with trouble-shooting on the entire power plant, from the inlet of the fuel through the delivery of power, steam and heating as well as the handling of residual products and flue gas.

**Life extension**
Lifetime extension of existing power plants can present an efficient way of meeting power generation needs whilst keeping investments at a manageable level. Ramboll’s highly experienced experts identify how to extend the lifetime of power plants and seek out all possible improvements leading to increased plant efficiency, flexibility and availability and reduction of operational costs.

**Full project lifecycle services**
We provide a comprehensive range of project lifecycle services ranging from strategic level to highly expert engineering specialisms.

Where projects involve wider infrastructure such as LNG facilities, ports etc. Ramboll is also able to deliver and integrate a complete range of project services.
The long-term prospects for the floating production sector are promising. In order to meet the world’s energy demands, the industry will have to move into deeper waters and harsher environments, where FPSOs continue to be the best answer.

Ramboll’s project portfolio counts a long line of FPSO projects, most recently the Petrojarl 1 and Teekay Foinaven (Teekay), and Goliat (ENI Norge).

OFFSHORE PLATFORMS

Ramboll operates within all areas of offshore platforms: From studies and design to modifications, lifetime extensions, complete or partial revamps, tie-ins, maintenance, and process improvements. We design platforms both for the oil/gas and wind energy sector. Recent projects include Substation for Westermost Rough Offshore Wind Farm (DONG Energy), and Tie-in project Trym – Harald (Maersk Oil).

“RAMBOLL FULLY UNDERSTOOD THE SUCCESS CRITERIA OF THE PROJECT AND WORKED PROACTIVELY TO ACHIEVE THE GOALS”

LEIF HØGH SØRENSEN, DONG ENERGY
Common fuels include manufactured wood pellets, grown crops, recovered residues, straw and various wastes.

**Global leading experience**
Ramboll has delivered biomass plants of all types and is a global leader in this area.

As well as developing multiple new biomass power and CHP plants, Ramboll staff pioneered the conversion of coal plants to biomass firing - at a time when there was no experience in the contracting supply chain.

Our experience of coal to biomass conversion is unparalleled. Our references are famous world-wide, and we continue to take a leading role globally.

**Services**
Ramboll offers all engineering services with respect to the planning, design, tendering, construction and operational phases for new build or upgraded power or CHP plants, fuelled by all types of biomass.

**Optimising combustion**
Biomass combustion can lead to fouling and corrosion of boiler heating surfaces as well as placing new demands on flue gas treatment systems and the disposal of the ash. Ramboll’s expertise can help our clients to optimise the fuels and power generation systems that are critical for good efficiency and availability.

**Delivering fire safety**
Fuel system changes require consideration of fire safety (ATEX) and other health and safety issues.

Ramboll provides advice, risk management support and design solutions for all challenges arising.

**Storage facilities**
The main challenges in storage facilities stem from fire and explosion hazards.

Ramboll is internationally recognised as the leading expert in the area of biomass related fire safety. We have invented and have a patent pending on a fire fighting concept which is highly suited for large wood pellets inventories.

**Designing innovative solutions**
Ramboll has designed highly automated bio fuelled power plants comprising automated straw reception and transport systems that only require man-power during receipt of straw.

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Biomass

Sustainable biomass offers a renewable low carbon alternative to fossil fuels for thermal power and heat generation.

01. Manufactured wood pellets are globally traded and used for power and heat generation

02. Straw handling at a biomass CHP plant.
03. AVEDORE UNIT 2, DENMARK
575 MW
New biomass fuel storage silos. The fire detection and response system specifications were developed by Ramboll.

04. Avedore Unit 2 is one of the world’s most efficient multi-fuel power plants and has undergone 100% biomass conversion. Ramboll supplied development, design and expert engineering support to the Owner (DONG Energy) from concept to operation, covering all aspects from fuel handling & storage, to combustion & turbines, CHP systems, emission controls and residue management. Similar services are provided for the conversion of Unit 1.
LYNEMOUTH, UK
420 MW full biomass conversion. Having supported the Owner at the development stage, Ramboll was appointed to provide support for the implementation of the project. In total the project comprises nine engineering packages, including an import terminal, site fuel handling and storage as well as the power plant conversion (Image: John Dalrymple).

ASNÆS, DENMARK
Full biomass conversion of existing units and development of a 180 MW dedicated biomass fired power plant integrated into the existing power plant site.

STUDSTRUP UNIT 3, DENMARK
Full biomass conversion. Supplies 350 MW electricity and heat to the surrounding district heating system. Ramboll supported the plant’s owner in all project phases from analysis through to commissioning.

GLADSTONE DOCK, LIVERPOOL, UK
Wood pellet import terminal with 100,000 tonne storage capacity. The plant is rail connected for fuel distribution. Ramboll was expert adviser to the construction contractor (Image: Drax).
“RAMBOLL DEMONSTRATED A STRONG AND DETAILED UNDERSTANDING OF THE SUBJECT MATTER AND A GOOD APPRECIATION OF THE ENVIRONMENT WE ARE OPERATING IN.”

EDF ENERGY PLC
**HIGH-EFFICIENCY POWER PLANTS**

**Ramboll offers expertise in:**
- Ultra super critical plants
- Combined cycle and open cycle gas turbine plants
- Integrated solar thermal
- Multi-fuel applications
- Carbon capture and storage
- Advanced technologies such as gasification and oxyfuel

**Efficient coal utilisation**
The Nordjylland 3 Ultra Super Critical (USC) Power Plant, engineered by Ramboll, indeed holds the world record for most efficient coal utilisation, with an efficiency of over 47%. Ramboll achieved this through extensive insight and optimisation of the steam cycle and overall plant design.

**Plant flexibility**
Equally important for modern thermal plants is to operate highly flexibly, with a need to rapidly balance energy demands resulting from an increase in intermittent renewable energy sources. Ramboll has successfully engineered plant modifications which enable faster start-up times and greater cyclic operation.

**USC plants**
Ramboll has designed and realised some of the most efficient and fuel flexible thermal power plants in the world, applying the most advanced USC steam parameters and steam cycles. The plants are typically designed for coal, heavy fuel oil and/or natural gas.

**Combined cycle plants**
Our knowledge of Combined Cycle Gas Turbine (CCGT) plant concepts is extensive. Ramboll has realised some of the most efficient and flexible CCGT power plants in the world to date.

We can handle both relatively standardised CCGT projects and highly advanced CCGT projects involving customisation to fit specific requirements such as process steam supply for an industry, district heating supply or integration of a CCGT into an industrial process plant.

Our specialists have a combined working experience of realising more than 25,000 MW of CCGT plant capacities worldwide.

**Multi-fuel applications**
Our ability to develop innovative power generation projects is ably demonstrated by our role in engineering and implementing the Avedøre Unit 2 project which incorporates within an optimised thermal cycle:
- USC multi-fuel fired boiler
- Straw boiler
- Gas fired turbines in feed water cycle
- Energy storage heat accumulators

**Avedøre 2 - Multi Fuel Concept**

- Straw (Bales) → Straw boiler 105 MWth
- Natural gas → Main boiler (USC) 800 MWth, 580°C/600°C, 300 bar
- Heavy fuel oil → Steam turbine
- Wood pellets → Steam turbine
- Natural gas → 2 gas turbines 2×35 MWel
- Electrical power
- Heat accumulator
- District heating

**Efficient coal utilisation**

**Combined cycle plants**

**Multi-fuel applications**

**Avedøre 2 - Multi Fuel Concept**
HIGH-EFFICIENCY POWER PLANT REFERENCES

MONGSTAD CCGT CHP PLANT, NORWAY
280 MWe + 350 MWth heat. Refinery integrated high efficiency CHP plant supplying high pressure steam and power. Ramboll staff acted as EPC Manager for the Owner during the plant development and construction.

ENECOGEN, ROTTERDAM, NL
870 MW high efficiency gas CCGT. Ramboll’s Owner’s Engineer services included engineering design review, HAZOP, witness of testing, and review of O&M.

SALALAH II, OMAN
440 MW dual fuel CCGT natural gas/fuel oil. Ramboll was appointed to monitor construction and commissioning and to provide project co-ordination services.

KAPCO, PAKISTAN
Muzaffargarh 660 MW coal fired power plant. Ramboll was appointed to deliver the plant feasibility study, ESIA and EPC Contractor tender evaluation.

ENECOGEN, ROTTERDAM, NL
870 MW high efficiency gas CCGT. Ramboll’s Owner’s Engineer services included engineering design review, HAZOP, witness of testing, and review of O&M.
“RAMBOLL GOES THAT EXTRA MILE IN ANSWERING ADDITIONAL QUERIES NOT NECESSARILY COVERED BY THE SCOPE.”

ANDY WOODWARD, RWE
With power-only generation, low value energy is lost, but with CHP most of it is captured for use.

CHP can offer the advantage of reliable energy supply as well as lower-carbon or renewable power and heat.

CHP systems also offer the possibility of district scale cooling systems, and can support the intermittency issues experienced with other renewables through energy storage.

Co-generation – also known as Combined Heat and Power (CHP) generation – increases the efficient use of fuel by supplying heat as well as power.

Services
For both new and retrofit CHP projects Ramboll offers all services necessary for establishing optimised:

• CHP plants
• Energy storage
• Heat accumulators
• District & local heating systems
• District & local cooling systems

Our services range from planning, design and procurement to implementation and O&M support:

• Thermal modelling and optimisation
• Turbine design
• Heat accumulator design
• District heating systems design
• Plant generation and heat distribution system interface optimisations

Experience
Ramboll has been a leading consultancy in the development of both district heating, CHP conversion and new plant construction projects for more than 40 years.

Our vast experience with energy production facilities based on a variety of fuels combined with our experience of district heating transmission systems help us maximise the benefits for both investors and consumers.

KEY COMPETENCIES:
Energy system planning:
• Strategic studies
• Options appraisal
• Systems design
• Demand & supply capacity mapping
• Resource efficiency
• Carbon reduction

POWER PLANTS:
• Fuel handling
• Boiler design
• Process control
• Emissions control systems
• O&M
• Turbine design
• Heat exchangers & pumps
• Energy storage & heat accumulators

DISTRICT HEATING & COOLING:
• Transmission lines
• Distribution systems
• Auxiliary equipment
• End user connections

01 and 02. Gladsaxe, Denmark
Natural gas fired district heating peak load facility. Ramboll was lead consultant.

03. CHP accumulator tanks
Ramboll designed large-scale heat accumulators allowing the Avedøre CHP plant to decouple heat and power production to optimise demand economics, and support a system with high wind power generation.
The system provides renewable, low carbon heat to consumers linked to one of the world’s largest integrated district heating systems.
SPECIAL COMPETENCIES

Ramboll is unique amongst independent international power generation consultants, possessing highly expert competencies covering every aspect of power generation facilities and being able to offer clients a truly comprehensive range of specialist services.

Alongside our project lifecycle services we provide specialist services at a detailed design and Front-End Engineering Design (FEED) level including a complete range of services to support plant operation, maintenance and lifetime extension.

Using 3D scans, Ramboll provides designers with hundreds of thousands of coordinates in retrofit projects to optimise design and co-ordination.

Ramboll has developed an Online Process Optimisation system to enable plant operators to continuously identify areas impacting upon plant performance with remote specialist support on hand to assess significant performance deviations.

Using 3D scans, Ramboll provides designers with hundreds of thousands of coordinates in retrofit projects to optimise design and co-ordination.

With solid flow distribution modelling Ramboll can advise on detailed design modifications.

EXPERT COMPETENCIES

- Project Management
- Boiler, combustion and fuel logistics
- Turbine, process, balance of plant and cooling systems
- Power piping
- Environmental and emissions control
- Electrical power systems
- Instrumentation and control
- Civil engineering
- Site supervision
- QHSE & inspection services

SPECIALIST SERVICES

- Risk and process safety
- Boiler CFD modelling
- Creep damage and low cycle fatigue calculations
- Performance modelling and online process optimisation
- Root cause analysis
- Fire safety & ATEX
- Noise control engineering
- Vibration analysis and vibration protection
- Combustion and emissions performance optimisation
- Condition monitoring
- 3D modelling and laser scanning
- CE marking
CREEP & FATIGUE CALCULATIONS
For many years, Ramboll specialists have been leading the way in refining fatigue and creep calculations in order to establish knowledge on the remaining lifetime of power plants. We have developed the unique software called Lifetex to perform exact calculations.

CFD BOILER MODELLING
Using our in-house CFD modelling expertise, Ramboll can assess the performance of new and existing boilers as well as develop designs and specifications for fuel and plant modifications.
FURTHER REFERENCES

SANDVIK, VÄXJÖ, SWEDEN
40MWe + 60MWth biomass CHP plant. Fuels include wood chips, bark, saw dust and branches and roots.

Ramboll was the Owner’s Engineer for the design and construction phase of a new biomass fired unit with technical responsibility for the boiler, turbine, flue gas cleaning and balance of plant. Our role commenced with the procurement of the major components, and then included monitoring of manufacturing, erection and commissioning as well as supervision of initial commercial operation and guarantee tests.

GAS-TO-POWER PROJECT, MOROCCO
LNG import terminal including storage and maritime jetty, 2400 MW CCGT and connecting gas pipelines.

Ramboll is the Technical Adviser to ONEE, working alongside legal and commercial advisers, with the responsibility to develop the project involving the definition of the institutional structuring of the project, preparation of feasibility studies and tender documents, evaluation of the offers, negotiation and contracting leading to the appointment of the company (ies) who will finance, construct and operate the Gas-to-Power project.

HERNING, DENMARK
97MWe 180MWth multi-fuel CHP plant. This plant has been progressively adapted over more than two decades and now combines high efficiency with the capacity for flexible firing of a full range of fossil and biomass fuels, including wood pellets, wood chips, oil, coal and natural gas.

Ramboll was the Owner’s Engineer for all project phases from project analysis, design and planning to commissioning. Our technical input was provided across all parts of the plant from fuel delivery, storage and handling, to boiler and controls modifications, fire strategy and emissions control systems.
ORION, DHAKA AND KHULNA, BANGLADESH
2 x 630 MW high efficiency coal.

Large increases in power demand in developing countries result in the need for high efficiency solutions to permit development whilst limiting impacts.

Ramboll was chosen as the Owner’s Engineer to ensure technical coherence and an optimised plant design comprising the highest possible overall efficiency of the plants.

Phases include input from pre-FEED and FEED to tendering and eventual construction and commissioning.

KILPILAHTI POWER PLANT, FINLAND
The project involves the re-planting of thermal facilities at the largest refinery in the Nordic region. Ramboll was appointed as the Lender’s Technical Adviser (LTA) covering technical, commercial and environmental aspects up to financial close. We continue as LTA during the construction and operational phases of the project.

PUŁAWY, POLAND
400 MW CCGT. A turn-key EPC project where Ramboll was appointed to provide Owner’s Engineer technical support during procurement through to construction and commissioning stages. Services included review of tender specification, tender evaluation and Owner’s Engineer services during project implementation.

SAUDI ARABIA, RABEC
1200 MW heavy-oil fired power plant. Ramboll executed root cause analysis (RCA) following tube failures and boiler CFD analysis to help select appropriate mitigation. Ramboll acted as independent adviser to the client.

GUELPH, ONTARIO, CANADA
2 x 20MW new biomass CHP plus 1 x 7MW expansion. Ramboll was appointed by the project developer to provide engineering support to determine the facilities’ requirements, options and preliminary engineering design and cost for all three projects, including all mechanical and electrical services for the identified projects.
Ramboll is a leading engineering, design and consultancy company founded in Denmark in 1945. The company employs 13,000 globally and has especially strong representation in the Nordics, UK, North America, Continental Europe, Middle East and Asia-Pacific.

With more than 300 offices in 35 countries, Ramboll combines local experience with a global knowledgebase constantly striving to achieve inspiring and exacting solutions that make a genuine difference to our clients, the end-users, and society at large. Ramboll works across the markets: Buildings, Transport, Planning & Urban Design, Water, Environment & Health, Energy, Oil & Gas and Management Consulting.