Services for biomass plants
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## SERVICES FOR BIOMASS PLANTS

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Do you consider investing in a biomass plant, for instance a district heating boiler, a combined heat and power plant or a pellet mill, the possibilities of making mistakes are numerous. A thorough feasibility study helps you through the complexity of options and reveals the worst pitfalls.

Many questions are to be answered in the initial considerations about investment in a biomass plant. Which type of biomass is to be chosen, straw, chip, wood pellets or something different? Is the plant to be based on combustion or gasification? Is it to be both electricity and heat-producing or only heat? How big is the plant to be?

Therefore, it is important to examine all the essential alternatives and which ones that are profitable. It is even more important to consult independent experts who in advance do not have any preferences for a certain solution.

**Funnel model**
We offer to carry out a feasibility study which helps you to make the right choices and to reduce your risks. Typically, we work on a funnel model where initially we set up a wide range of alternatives. As we clarify the conditions with you, for instance fuel supply, fuel prices, technical preferences, energy demands, space requirements and plant size, we can become more specific on your alternatives.

In this process, we make a matrix of alternatives and criteria. In this phase, we have a close dialogue with you so we avoid wasting the time by exploring possible solutions or conditions which are not relevant for you.

The study results in a thorough illustration of selected alternative solutions based on the criteria which are most important. It might for instance be economic conditions such as price of heat, investment and profitability. Or it might also be conditions where choice of fuel, risk, sustainability in the supply or local conditions such as employment and sales of the products of the soil are included.

Together with you, we select the level of details, depending on which type of decisions that are to be made on basis of the study.

**Detailed risk assessment**
After discussion in the board, we offer to go into details with the conditions which you find most important. It might for instance be sensitivity (and risk) fluctuations in gas, oil and coal prices or energy taxes. It might also be flexibility to use other biofuels than the chosen fuel in the plant or a critical assessment of the operational stability of the chosen technology, energy efficiency, lifetime and environmental impact.

When the construction of the plant approaches, we also offer to carry through more detailed feasibility studies and to assist the building contractor in the tender procedure, building and delivery phase.

**Comprehensive contractor consulting services**
We offer to plan a construction sequence with project management, price calculation and planning of call for tenders which fulfils the demands on supply companies. After this, we can prepare operational functionality requirements, invitation of tenders, evaluation of tenders and construction process management. Furthermore, we are specialised in assistance at start-up, delivery, impartial acceptance tests and hand-over for operation.

Further information
Morten Tony Hansen: mth@force.dk
Danish companies are very active regarding development of new technology for combustion and gasification of biomass. From small scale in the form of wood stoves and up to power plant size, new combustion technology, equipment for flue gas cleaning, grates, burners and gasifiers are developed and marketed.

When the new equipment is to come into the market, it is important – and often completely necessary – to be able to present independent documentation showing that the efficiency, emission or availability of the plant can be met in practice.

Independent and adapted measurements
Our measurement technicians arrange in cooperation with our biomass experts a test and measuring programme that is adapted to the specific requirement on the exact type of technology. In most cases, an independent registration of the energy balance (fuel consumption, electricity production, heat production and losses) is the most important. Furthermore, our measurements also cover emissions to air, amounts and composition of ash, waste water and registration of the availability of the plant.

We also include other tests according to requirement, for instance to show the quality of materials, weldings, fuel, water, plant meters etc. The documentation can be used as basis of marketing of the technology. In other cases, it can highlight a need for further development as the registrations point out critical conditions that have to be improved.

Involve the expertise
Our technicians do not only contribute with reports but also with experience, inspiration and guidance which you can use directly in the development work. Thus, we become a participant in the product development itself.

Tests, experiments and documentation are often co-financed by the company which owns the technology and a research and development programme such as The Energy Technology Development and Demonstration Programme (EUDP) or framework programmes from the EC. Our role in the project is either partner or supplier of technical services.

Further information
Morten Tony Hansen: mth@force.dk
When biomass is to be delivered in large amounts, questions to the source of supply will typically arise. What is the origin of the biomass, can we continuously count on a sustainable supply in future, is the quality in order and what about the price?

Beyond our involvement in the plants that convert the biomass, we are also often involved in assessments on the supply side.

The technical properties of the fuels affect directly the operation of the plants and the supply of biomass in large amounts brings up several questions which large-scale purchasers have to consider such as:

- How much biomass can be offered from this source of supply?
- How does the resource develop over time?
- Correlation between the resource exploitation and the price of the fuel?
- Is the production sustainable in the long term?
- Which criteria are used to assess sustainability in the supply chain?
- Documentation of sustainability?
- Is competing sale of the biomass present – for instance for food purposes or for industry or energy purposes in other countries?

**Independent assessment of the resource basis**
The fundamental assessment of production potentials in forestry and agriculture is made by universities and others with special expertise within the area. From here we can take over to analyse and assess the resource basis, from the local supply to a specific heating plant or to the national energy planning. Based on the important questions above, we deliver an independent assessment of availability, prices and sustainability.

**Supply and consumption**
Trade with biofuels takes place in the field between the production in for instance forestry, plantations or agriculture and the conversion in for instance power plants. The two parties do not always understand each other. The forest owner does not understand why roots and stumps are not allowed in his wood chip delivery. And the energy plant does not understand why it can be difficult to deliver ten times more fuel in January than in July.

In this border area it is useful to involve an external “translator” who understands both sides and who can explain why quality, price formation and supply look the way they do.

Our assistance covers from telephone consultancy through support in connection with selection of possible suppliers/purchasers of a specific biomass fuel to support with preparation of the technical clauses in commercial contracts with biomass.

**Environmental and life cycle assessments (LCA)**
Furthermore, we offer more detailed environmental assessments e.g. for a specific use of a concrete kind of biomass. Our LCA experts use acknowledged, standardised methods and well-reputed databases to make models for illustration of the environmental impact of products and services.

Further information
Morten Tony Hansen: mth@force.dk
MARKET SURVEY

The market for solid biofuels develops rapidly both nationally and internationally. Knowledge and details are necessary for companies which act in the market, either as purchaser of fuel or as supplier of everything from wood pellets through wood logs to coconut shells.

We assist with surveys of the market for solid biofuels both nationally and internationally. We have developed methods based on for instance technology, geography, needs, historic development, framework conditions etc. which make it possible for us to deliver market reports which are updated and independently deliver exactly the overview and details needed for decision-making.

Pellets@tlas – an overview of the wood pellet market
We were a part of the Pellets@tlas project (www.pelletsatlas.info) where we have collected, prepared and disseminated information about the wood pellet market, prices and the market development in most of the European countries. And supplemented with knowledge from our other international networks in IEA Bioenergy and others, you get access to the newest market information about fuels and technology from all over the world.

Supports the investment decision
The customers of market studies on biomass are typically manufacturers or distributors of very large amounts of wood pellets who are interested in coming into the European market.

During the years, we have delivered market reports to 10-20 of the present large players in the global wood pellet market. The tasks are initiated with a geographic partitioning – which countries are the most interesting – and are finalised with a market report which supports the customer’s decision on for instance investment in a wood pellet mill.

Knowledge about the market
As a supplier of e.g. wood pellets, a thorough knowledge of the market is necessary, including:

- The development in the consumption
- Prognosis of the future consumption
- The price, both the price until now, the present price and the expectations to the price in future
- Quality requirements to the fuel
- Requirements to sustainability and other requirements regarding the origin of the fuel
- Political framework conditions (subsidies, taxes ...) for both biofuels and competing fossil fuels
- Knowledge of the market players (power stations, district heating stations, industry and large biofuel importers).

Pellet Market Data

Screen image from www.pelletsatlas.info.
The combustion process in a biomass furnace is affected by various factors from the composition and heating value of the fuel to the interaction between furnace temperature and combustion zones. By use of CFD to design your furnace, you can get an accurate overview of the processes in the furnace.

CFD (computational fluid dynamics) is computational calculations which give us an exact knowledge of combustion zones and processes. Based on this knowledge we can identify the optimum design of the furnace in relation to the flow in the furnace and in the boiler passes.

Among other things, the design will take the following into account:
- Temperature distribution
- Air injection rate and direction
- Formation of corrosive and polluting gases.

**Injection of primary and secondary air**

It is possible to control the combustion zone and thus reach an effective combustion through correct injection of primary and secondary air. Thus, an even temperature distribution and an even load on the furnace walls are ensured as well as an optimal utilisation of the boiler tubes which gives the most efficient energy transfer.

The composition of the fuel decides the need of air. Based on data for your specific furnace, our CFD model and calculations, we offer consultancy on the ideal injection of primary and secondary air.

Our experience with air injection and CFD analyses shows that it is often better with few but correctly placed nozzles, which can better control the flow in the furnace. CFD provides a better and more accurate knowledge of the recirculation zones than traditional model tests. Thus we ensure that the recirculation zones are optimally exploited in relation to burnout of particles.

Examples of problem areas in a furnace in a biomass plant before design optimisation and rebuilding.
The advantage of using CFD calculations for optimisation of the boiler passes is that a very precise insight into the flow and processes of the plant is given.

The visualisation provides an accurate overview of the temperature changes, velocities and heat transfer. Altogether precise and necessary data for use in the design phase and optimisation of boiler passes.

**Optimisation of the flow**

The following areas are analysed by use of CFD:

- Flow distribution
- Temperature distribution
- Recirculation zones
- Corrosive gasses.

The flow in the boiler passes is optimised by changing the duct by means of smaller geometric modifications which adjust velocity, temperatures and flow. An even temperature profile through the boiler passes is important in relation to heat transfer and energy exploitation.

CFD can also be applied to calculate the residence time of the flue gas and thus optimise the boiler passes. In this way a burnout of CO and TCO is ensured which gives the best utilisation of the fuel.

**Reduction of corrosion risk**

Based on the very detailed results which are achieved it has turned out to be possible to include CFD as a tool to reduce the risk of corrosion in boilers and especially in superheaters.

Compared with the metal temperature and the risk of coating formation, the concentration of corrosive gases at different places in the boiler can be used to identify areas with a high risk of corrosion. By changing flow or combustion conditions in the boiler, it is possible to adjust or reduce this risk.
With the increased focus on the environment, emissions from the industry have become increasingly regulated. Therefore, it is important that the flue gas cleaning of the plant operates optimally. We can help you to design and optimise your flue gas cleaning plant.

We perform examinations of flow conditions and optimisation of flue gas cleaning plants for the purpose of finding the best possible performance. Furthermore, we can offer cost-effective solutions in the design phase of the plant, extend the lifetime and thus improve the economic results. Our focus is to ensure that the flue gas cleaning plant fulfils your demands.

Types of flue gas cleaning plants
There are several different types of flue gas cleaning plants and depending on your needs, we find the flue gas technology which is most suitable.

We use computer calculations - computational fluid dynamics (CFD) - to design new and optimise working flue gas cleaning plants.

**NOₓ reduction in the hot flue gas**
The NOₓ emission can be reduced by injecting ammonia or urea in the hot flue gas directly in the boiler. By means of CFD modelling of the temperature field in the boiler, we can determine the optimum position of SNCR (selective non-catalytic reduction).

We can also use CFD to model the mixture of ammonia/urea with flue gas and thus optimise the ammonia/urea injection system of the plant.

**NOₓ reduction by use of catalyst**
Another way to clean the flue gas is to inject ammonia in the cooled flue gas and use a catalyst. This method is called SCR (selective catalytic reduction). In this case, CFD modelling is used for determination of flow field, design of guide vanes and static mixers, mixture of ammonia and urea as well as determination of pressure loss.

This optimises the flow field at ammonia or urea injection as well as at catalyst inlet. Documentation of mixture, flow field, dust precipitation as well as determination of pressure loss is verified with physical scale modelling.

**Dust reduction with electrostatic field and filter bags**
CFD is used for determination of flow field as well as design of guide vanes in the inlet and outlet of the unit for reduction of dust to ensure an even flow and to reduce the pressure loss in the system. For an Electrostatic Precipitator (ESP), a design optimised with CFD will give an optimum efficiency. For a filter bag, a CFD optimised design will help to ensure optimum efficiency and minimise the risk of wear, break and fire on the bags.

Further information
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An example of a flow-optimised DeNOₓ plant. The lines with the green-yellowish colours show where ammonia is injected. The illustration shows a good and even velocity distribution from this point to the catalyst.
STABLE ENERGY PRODUCTION WITH GRATEVISION®

We have developed a technology which helps to ensure a more stable energy production. GrateVision® consists of a vision system and a regulating concept that both together and separately can improve the operation in a biomass fired incineration plant.

Illustration of installed GrateVision®.

The GrateVision® technology is based on digital NIR cameras and an innovative regulating concept, which are integrated with the existing monitoring system of the plant.

Increased profit and improved operation

The picture analysis software of GrateVision® sends data to the monitoring system which makes it possible to control the supply of waste, primary air and grate speed optimising the combustion in the plant.

The advanced online picture analysis contributes to increase the profit of the plant and ensure a stable operation. At the same time it gives your operators an updated overview of the distribution and development of the combustion.

Installation and maintenance

The GrateVision® system is flexible and can both be installed in new plants and be retrofitted in existing plants. The camera is installed directly through the panel wall of the boiler (Ø 11 mm).

GrateVision® has an advanced cooling and flush system which reduces the slag before the camera and thus the need of maintenance. The system can be installed alone or together with our regulation concept.

Advantages of GrateVision®

- Increased production and better operational reliability in grate-fired boiler plants
- Increased overview for the operators and automatic operation improve the efficiency of the combustion
- Stable combustion reduces emissions and thus the risk of exceeding emission limits.

Further information

Jesper Cramer: jcr@force.dk
Our regulating concept reduces significantly the fluctuations in the energy production. It means that the efficiency of the boiler becomes more stable which makes it possible to produce more energy.

The regulating concept, which among other things is developed in co-operation with Babcock & Wilcox Vølund and DONG Energy Power, is built on new information about the combustion process.

The information is obtained online from estimates of the thickness distribution of the waste layer on the grate and information about the incineration.

**Increased performance and robustness**

The model-based regulation compensates for variations in the combustion process. The special regulating structure makes quick compensations possible at the same time as it keeps the slowly generating balance of the plant in the fuel layer and the extent of the combustion.

Thus, the regulating concept increases the performance and robustness of the plant at the same time as the need of manual intervention is reduced. It is possible to implement the concept in existing control systems.

**Possibilities and free scope**

The improved furnace control concept gives a better possibility of:

- Avoiding overloading of boiler, and perhaps refractory lining and grate
- Ensuring burning out
- Avoiding exceeding emission limits
- Keeping a stable energy production when the calorific value of the fuel varies.

Altogether, this gives a better free scope for:

- Exploiting the whole load area of the boiler in favour of production of electricity and heat on market conditions
- Increasing the load area of the boiler if the components of the plant are dimensioned for this.

**Improvements at Reno-Nord and Haderslev Waste and Energy Plants**

The advanced measuring techniques and regulating methods have reduced the variations in the generation of steam at Reno-Nord line 4 from 6.9% (@95% confidence) to 4.3% (@95% confidence). This corresponds to a reduction of the fluctuations of 38% (peak performance is up to 50% reduction).

A corresponding improvement was obtained at Haderslev Power Station supporting that the regulating concept is generic and applicable at smaller plants with old furnace technology too.

Further information
Jesper Cramer: jcr@force.dk
SIMULATOR-BASED TRAINING OF OPERATORS

Our PC-based combustion simulators provide an understanding of the entire process of a bio-

mass fired plant and how variations in fuel specification are influencing the combustion.

Training with simulators makes it easier for the operators to obtain an overview of all the processes in the plant, to understand and analyse the operating situation and if necessary, to intervene to ensure optimum operation and prevent faults and avoid accidents.

Moreover, the participants are trained in rare and extreme situations without endangering lives, equipment, the environment or finances.

Our simulator for a biomass-fired CHP-plant consists of:

- A realistic silo, fuel feeding and pusher feed model
- A general dynamic combustion model
- A steam boiler model illustrating the dependence of steam production from the combustion process
- A steam turbine and power generator model
- Models of steam condensers, heat accumulator, pumps, etc. for heat supply to a district heating system
- Process management and control
- A reporting system from trainee PC’s to trainer server-PC.

Development and adjustment of simulators
The training simulator can be adjusted to exactly your plant. If you have any ideas and needs for other simulators, please let us know. It is important for us to adjust the simulator based on a dialogue with the plants.

We have developed simulators for CHP biomass-fired plants, CHP Waste-to-Energy, industrial steam boilers, straw or chip-fired district heat boilers, gas-fired boilers and gas engine plants as well as gasification plants.

Further information
Jesper Cramer: jcr@force.dk
Inspection of Pressure Equipment

With focus on the safety of the pressure equipment and on the conditions around the installation site we take care that you as a user can confidently operate the pressure equipment.

Before placing new biomass plants on the market, they are among others subject to the regulations of conformity assessment in accordance with the Pressure Equipment Directive “PED”, implemented by the statutory order No. 694/2013*) – previously No. 743/1999 - of the Danish Working Environment Authority.

PED applies to the design, manufacture and conformity assessment of pressure equipment and assemblies with a maximum allowable pressure “PS” of above 0.5 bar. Pressure equipment covers pressure vessels, boilers, piping systems, plants (assemblies), valves, safety valves, etc.

Before putting such plants into service for the first time, they have to undergo initial inspection as well as afterwards they periodically have to be inspected and examined by an accredited 3rd party inspection body in accordance with the Statutory Order for application (use) of pressure equipment No. 100/2007. The requirements of periodical inspections and examinations as well apply to plants already in operation.

Any modification or essential repairs on plants in operation are to be performed in accordance with the Statutory Order for integration, modification and repair of pressure equipment No. 99/2007. This covers among others verification by an accredited 3rd party testing body.

Inspections and safety

As a DANAK accredited inspection and testing body as well as appointed Notified Body, we can participate in the conformity assessment, initial and periodic inspections and examinations as well as any verification necessary on new and existing biomass plants. In this way, we take care that the equipment fulfils the current legal demands and we ensure that the installation is correct. Furthermore, we examine continuously whether the equipment keeps its operational and safety properties. In other words, we contribute to make the plant safer.

If you have any questions regarding the PED, the statutory orders of the Danish Working Environment Authority, EN regulations or other relevant matters, we are pleased to be at your disposal.

* From the 19th of July 2016 the New PED (No. 2014/68/EU) is put into force and implemented by the Statutory Order No. 190/2015.

Further information
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Standards

The European Committee for Standardization – CEN – has prepared a large number of standards which are based on the essential safety requirements of the PED.

The 6 largest harmonised standards within this area are:

- EN 12952 water tube boilers (pressure parts and assemblies)
- EN 12953 flue boilers (pressure parts and assemblies)
- EN 13445 unfired pressure vessels (pressure parts)
- EN 13480 metallic industrial piping (pressure parts)
- EN 764-7 safety systems for unfired pressure vessels (assemblies)
- EN 378 refrigerating systems.
Technical water is an important element in the operation of plants both as boiler and cooling water, as energy carrier and in flue gas cleaning. Also, it is very important that the transport of the heat to the consumers takes place in the most environmental and cost-effective way.

**WATER TREATMENT**

An appropriate water quality in the technical systems contributes to optimise the operation and the lifetime of the plant. Our experts are ready to advise you on the optimum water treatment in your plant.

During the years, we have worked with energy producing (steam boilers etc.) as well as energy carrying plants (district heating systems, cooling systems etc.). Furthermore, we have experience with many other types of technical water.

**Minimises interruptions of operation**

The production of technical water is of great importance for the operation of the plant. The main purpose of the water treatment is to provide a water quality which minimises the interruptions of operation (coating, corrosion etc.) in the plant. We offer consultancy on the optimum choice of water treatment based on economic and operational considerations. At existing plants, our consultancy is typically based on chemical analyses of technical water (boiler water, feed water, make-up water etc.). The analyses are carried out directly at the plant or in our laboratory which is accredited by DANAK (the Danish Accreditation Fund).

We offer:
- Consultancy about optimum water treatment in a given system
- Measurement directly at the plant (pH, conductivity, oxygen content etc.)
- Analysis of water samples in our laboratory
- Control of water quality in technical systems and evaluation of analysis results
- Training of operating staff on technical water.

If unforeseen situations with leakages or signs of deposits or corrosion arising, we can help with supplemental measurements, analyses, sparring and consultancy to reduce interruptions of operation, repairs or discarding.

**Interpretation**

For us it is important that the results of the analyses are interpreted and can be used by you. Therefore, the analysed values are often assessed in relation to the applicable guidelines as for instance an environmental approval. If exceeding, we advice about operational changes in order to bring the water quality back to a satisfactory level.

Further information

Søren Klinggaard: srk@force.dk
Corrosion in pipes and boilers

Corrosion in biomass plants increases the operating costs significantly and can weaken components and thus increase the risk for the operating staff and others at the plant. We offer closed surveys of the corrosion at your plant to optimise performance and minimise future corrosion.

We advice on high temperature corrosion as well as corrosion on the boiler side in contact with water. With our assistance and consultancy, we can in cooperation take care that the safety remains at a high quality at your plant and contribute to the optimisation of the economy.

Broad-spectred consultancy
In the design phase and during the normal operation, we can offer assistance regarding the optimum selection of materials. During root cause analysis of damage, we use inspections and assessments of the corrosion attack and we will be able to determine which factors that influence the corrosion.

In our consultancy, we use the result of the inspection to advise on how the future operation can be arranged in order to minimise the risk of corrosion.

Besides the mentioned aspects of our consultancy, a number of our other services will also be included, for instance:

- Laboratory analyses of water to be able to assess the aggressiveness of the water
- Metallographic examinations for description of the corrosion attack
- Examinations in Scanning Electron Microscope (SEM) to describe the character of the corrosion attack to clarify the cause of the corrosion in this way
- Energy Dispersive X-rays (EDX) of corrosion products to survey aggressive components in the corrosion products.

Factors which control the corrosion
Corrosion develops when metallic materials are exposed to an aggressive environment (water and flue gas etc.). Boiler systems, cooling systems, district heating systems, flue gas cleaning, waste water systems are typical systems where the corrosion of plant components is a factor which influences the operating economy. In aqueous systems, the corrosion is among other things controlled by pH value, conductivity, oxygen content, temperature and selection of materials. Very often oxygen causes the corrosion and in many technical water systems target is therefore that the oxygen content is lowest possible.

However, certain biomass-based fuels also have a composition which results in a substantial risk of high temperature corrosion (corrosion of superheaters). Therefore it is crucial that the fuel is also characterised with regard to the risk of corrosion before it is fired in a plant.

Further information
Søren Klinggard: srk@force.dk
Corrosion on the flue gas side in biomass plants is unavoidable. But reduction of the corrosion can have environmental as well as economic advantages. With our high temperature (HT) corrosion probe we can assist you to predict which areas that are exposed.

By means of the HT corrosion probe, we can monitor the corrosion in the boiler and pinpoint particularly exposed areas.

The use of the corrosion probe requires a minimum of alterations on the boiler as the probe is designed so that the pressure part of the boiler is not influenced by the installation of the corrosion probe. Therefore, installation and measurement can be made without the need of additional inspection or approvals.

The specifications of the probe
The probe is built up in such a way that 10 ring-shaped coupons can be exposed at the same time. This setup makes it possible to inspect the corrosion on a number of different alloys at the same time as a statistical verification of the results can be obtained. Furthermore, it is possible to inspect the effect at different exposure times. The new probes are air-cooled and can be exposed and retrieved from the plant without any interruptions.

Our HT corrosion probes are among others a part of the following services:
- Testing and measurement of corrosion rate of new materials which may be used in biomass-fired plants, including test at different superheater temperatures
- Testing of general corrosive properties and specific corrosion rates for new and less known biofuels
- Test to find the optimum position of superheaters concerning the least possible corrosion.

Prediction of the corrosion rate
We are developing a quite new concept, Predictive Corrosion Monitoring System, which can predict the corrosion rate of for instance superheaters based on measurement of relevant components in flue gasses. The service concept will focus on support to the owners of biomass plants concerning minimisation of the corrosion in the boiler.

Advantages for the plant owner are:
- Optimisation of the steam temperature and consequently optimisation of the electricity production
- Optimum selection of materials
- Optimum selection of operational parameters
- Longer lifetime of superheaters
- Less risk of emergency stop and repair time.

The HT corrosion probe and Predictive Corrosion Monitoring System can function together or independently.

Further information
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The corrosion probe after exposure in plant.
CONCRETE CONSTRUCTIONS

Biomass plants are aggressive environments for concrete, which can result in deterioration of concrete and corrosion of the reinforcement in the structure. We perform inspection of constructions, survey the critical areas and advice you how to prevent deterioration of your precious concrete structures.

However, if the damage is done we have the tools to determine the extent of the damage as well as the expertise to determine the cause of failure. Additionally, we can help you finding the appropriate remediation method.

Together, with our help and consultancy, we can ensure your constructions are thoroughly inspected, maintained and protected. You can avoid deterioration, which can result in expensive repairs and possibly downtime of production.

Our experience shows that structures close to incinerating cinder piles are suffering from leached salts and alkalis.

Routine water flushing of truck tyres contributes to an increased humidity in the surrounding constructions and dissolved deleterious salts often seep into your concrete structures.

**Inspection is crucial**

Routine inspection of concrete structures in an aggressive environment is of capital importance. You prevent that aggressive environmental impacts and derived damages are registered as early as possible. In this way the deterioration is stopped before the damages progress to an extent where the construction can no longer fulfil its function or spillings pose a hazard for the personnel. If we find damages at a routine inspection, we have the required knowledge and methods of investigation to assess cause and scope.

We have a wide range of equipment at our disposal to perform the inspections and the necessary experience and knowledge for interpretation of the data.

**Corrosion of reinforcement**

We can assess the risk and measure the extent and degree of corrosion on the reinforcement in the concrete. If a reinforced concrete structure is exposed to CO₂ or chlorides and moisture at the same time, the reinforcement will most likely start to corrode. This will also affect the actual concrete, which will spall or crumble.

If the concrete is already cracked, penetration of chlorides and CO₂ will happen faster and damages that are more serious may arise. We develop and produce equipment and probes used for corrosion measurements. Furthermore, we are leading within cathodic protection of concrete constructions, both regarding production of cathodic protection control systems, anodes, design and inspection of existing systems on site.

**Collapse of refractories**

Furnace refractory liners are exposed to an aggressive physical and chemical environment depending on the type of biomass that is burnt. Collapse of refractories results in several direct or indirect economic consequences for the operation. First of all, the refractories must be replaced but in addition to that, expenses for renovation and loss due to shutdown will add to the overall economical consequence.

Additionally, a collapse of furnace refractories may result in damages on the exterior steel construction, which does not tolerate direct heat or chemical exposure. We can conduct inspection of decisive factors during shutdown as well as technical inspection of refractories in connection with damage.

**Further information**

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![Corrosion on foundation due to salts from flue gas cleaning.](image1)

![Corrosion on column at conveyor belt for slag.](image2)
INCREASED RELIABILITY THROUGH NDT

NDT (non-destructive testing) is used both for testing after manufacturing and for maintenance and inspection of existing plants after service exposure.

Manufacturing control
At the production control during new building, rebuilding, renovation etc., welded joints are inspected for production-related defects. Thus it is ensured that the specified quality requirements are fulfilled.

Check of condition after service exposure
At a planned check of condition, possible damages related to the operation are examined so knowledge of these possible damages is obtained at an early stage and the risk of unintended shutdown can be minimised. At detection of early stage and incipient operation-related damages, replacement of components can be planned and completed in sufficient time before breakdown with which operating loss can be minimised resulting in an improved economy.

Custom-fitted NDT solutions
NDT is the common name for the variety of inspection methods, which are used to investigate properties of materials without damaging the material. Specially trained inspectors with many years of experience deliver NDT services which are custom-fitted the conditions in the individual biomass plant.

We document the problems thoroughly so you as a customer minimise the risk of unplanned and expensive shutdowns and breakdowns.

New NDT services with Drone and E mate
Through an effort from a specially trained team consisting of an UAV pilot and a NDT inspector, visual inspection of hard-to-reach places carried out by use of UAV (drone), for instance chimneys, façade of buildings, boiler walls etc. Thickness measurement with E mate gives a quick determination of the material thickness of the pipes. Data measurements are recorded and saved (mapping) and can be visualised in a colour plot which gives a quick overview of the condition of the pipes. Furthermore, mapping is a good tool in connection with the planning of investigations at future maintenance tasks.

Further information
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NDT inspection methods
- Radiographic testing
- Digital Radiography
- Eddy current testing
- Ultrasonic testing
- Ultrasonic thickness measurement
- Magnetic testing
- Penetrant testing
- Hardness testing
- Video endoscopy
- E mate (thickness measurement of pipes)
- Visual testing
EMISSIONS AND RESIDUAL PRODUCTS

EMISSION MEASUREMENTS

Biomass plants are subjected to legislation regarding their emissions. We perform emission measurements to ensure that biomass plants are able to document that they live up to the current legislation. Our measurement work is based on either the legislation or an operational aspect.

The compulsory measurements include performance control, AST (Annual Surveillance Test) and QAL2 (Quality Assessment Level 2). There may also be measurements which are connected to the CO₂ and NOₓ rates.

Operational measurements are typically related to flue gas cleaning, test of fuel types and process optimisation.

Emission reduction
A substantial area in connection with air pollution is a reduction system which reduces the emission of one or several undesirable substances so the limit values are kept.

Even if the plant has a reduction system installed, unfortunately it does not always have the intended effect.

For instance, there may be a wrong dimensioning of the plant, inappropriate operation, lacking inspection and maintenance or modification of process parameters which causes that the basis of the dimensioning for the reduction system is changed.

We perform measurements and analyses in connection with the problems and advice on selection and optimisation of the reduction system.

Guarantee of handover tests
We carry out handover tests for a large number of suppliers of boilers and flue gas cleaning systems. The handover test has to document that the plant can subsequently comply with the emission limit values. A so-called “Performance Test” may also be a possibility where the boiler supplier wants documentation for all the emission parameters. As the emission demands are different all over the world, the “Performance Test” can among other things be used in the suppliers’ sales drives.

Reference Laboratory and DANAK accreditation
We deal with all aspects within emissions to the air. We participate actively in the development of methods and the standardisation work so we together ensure the best results. We are accredited by DANAK (the Danish Accreditation Fund) to carry out air emission measurements and appointed by the Danish Environmental Protection Agency as Reference Laboratory for measurement of emissions to the air.

Further information
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Solid bio fuels like straw, wood chips and wood pellets cause a number of challenges which require profound expertise to overcome. Furthermore, the properties of solid bio fuels may vary more than many fossil fuels. Minimise the problem by making demands for your supplier.

**PROBLEMATIC FUELS**

The special properties of the biomass often cause problems at the conversion plant for instance with corrosion, fouling, slagging, incomplete combustion, emissions, loss caused by residual carbon in the ash or mechanical problems in the transport systems.

**Accredited analyses – know the fuel**

To solve or at least reduce such problems, knowledge of among other things the chemical composition of the fuel, water content, size distribution and ash melting behaviour is required. At our accredited fuel laboratories we analyse your fuel and verify data with analysis reports from previous analyses of corresponding fuel samples.

**Interaction between fuel and plant**

Subsequently, we compare the data of the fuel with the design and operating conditions of your plant. From one plant to another, it differs which fuel quality parameters that are relevant. Even for the same type of plant, it might occur that a fuel can be used without problems at one plant while for instance it causes slagging problems at the other.

The core in our specialised consultancy is on one hand the combination of knowledge about the plant design and operation and on the other hand knowledge about the fuel properties and this is what solves the fuel-related problems at your biomass plant.

Of course, it is especially interesting for new and not so well known fuel types but even for the traditional solid biofuels as for instance wood chips, deviating conditions can occur and cause unexpected operational problems.

**Make demands on quality**

For all of the players in the supply chain it is important to manage the fuel quality. Our consultancy and expertise within the area is therefore directed towards producers and consumers of biomass as well as equipment suppliers.

You ought to make demands to the fuel quality for the specific plant and current operational conditions and these demands ought to be a specification of the fuel that can be included in your sourcing contracts. Also, make sure to specify how the quality should be assured through sampling and analyses of the fuel, locally or at an accredited laboratory.

Further information

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**EMISSIONS AND RESIDUAL PRODUCTS**
At biomass-fired plants, a need for many different analyses, chemical as well as physical, may arise. We offer tailor-made analysis packages according to individual demands.

In a dialogue with our customer, we identify the problem and ensure the optimum solution. With FORCE Technology you only need one supplier.

FORCE Technology is accredited by DANAK (the Danish Accreditation Fund) to analyse a large number of parameters for solid and liquid fuels, residual products, ground water, drinking water, technical water, fresh water, seawater, wastewater, sludge, soil and sediments.

In addition to this, we carry out analyses of many other types of samples at our laboratories in the Danish cities of Brøndby, Holstebro and Vejen. We are specialists in clearing up of “What is this” problems. At the same time, we are also well prepared to solve tasks concerning “What went wrong and why?” due to our many specialists within the areas materials, fuels, corrosion and water treatment.

Analysis of solid biofuels
Whether it is a matter of traditional solid biofuels like wood chips, wood pellets and straw or more alternative kinds of biomass like palm kernel shells or olive pits, we offer a wide range of testing, dependent on the actual problem, such as:

• A comprehensive testing for energy content and content of specific elements for determining the fuel quality of new types of biofuels
• Analysis of moisture content in connection with settlements of received consignment of fuel
• Determination of content of ash and its melting behavior with regard to slagging problems
• Examination of bulk density, content of fines and mechanical durability of fuel pellets.

Analysis of residual products
For produced residual products such as bottom ash, fly ash or the total ash, we offer among others:

• Accredited testing according to the Danish ministerial order concerning reuse of biomass ashes for agricultural purpose
• Accredited testing for content of “un-burned matter”, measured as loss on ignition, total carbon content (TC), total organic and elementary carbon content (TOC) and/or gross calorific value (residual energy)
• Accredited testing for content of acid-soluble metals (cf. Danish Standard DS 259) or the total contents of metals and other elements
• Fast screening analyses for chemical composition and/or content of trace elements (non destructive X-ray methods).

Sampling and testing of waste water and leachates
For wastewater and leachates, we offer accredited sampling, flow proportional, time proportional or random sampling. Furthermore, we carry out accredited testing for a large number of inorganic, organic and microbial analysis parameters.

Further information
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QUALITY ASSURANCE OF AUTOMATICALLY MEASURING SYSTEMS

AMS is the environmental meters of the plant in the chimney. The Danish Environmental Protection Agency’s statutory orders as well as the statutory orders of SKAT (the Danish tax authorities) on NO\textsubscript{2} and SO\textsubscript{2} taxes make demands on quality assurance of AMS measurements and calculations of emissions for payment of taxes.

We can carry out tests which ensure that your AMS measures correct values and thus correct tax payment. Correct tax payment is of great importance for the economy of the plant and therefore it is necessary that the AMS in the chimney measures correctly. The increased taxes on NO\textsubscript{2} means it is extremely important that especially flow AMS but also NO\textsubscript{2} AMS are calibrated. An indication error of a few percentages on for instance a flow AMS may result in large amounts for your plant.

In consultation with you we can perform tests which ensure that your AMS measures correct values. We have thorough knowledge of the newest standards, statutory orders etc. and we can at any time ensure that we deliver that piece of work which comes up to your needs. The scope of parallel measurements is big and therefore we optimise the work in a close dialogue with you so it is carried through as cheap as possible.

**QAL2 and AST parallel measurements**
AMS meters must fulfil the demands in the Danish Standard DS/EN 15267-3 or corresponding standards and they must pass a quality assurance in accordance with the principles in EN 14181. An AMS meter has to be calibrated by comprehensive parallel measurements (QAL2) carried out during one day. After this, AMS meters have to be checked with accredited parallel measurements according to reference methods (AST) every third year.

The AMS and O\textsubscript{2} meter have to go through a yearly control and a yearly service check, a so-called performance test without linearization. The AMS and O\textsubscript{2} meter are inspected and adjusted with calibration gases according to the supplier’s instructions.

In connection with both QAL2 and AST, a performance test has to be carried out, among other things to ensure that the AMS is in good condition, that the sample system is dense and the measurement capability is maintained. In those cases where for instance an AMS does not pass the measurement capability test or the calibration function looks “unusual”, we will always enter into a dialogue with you to clarify what the reason is and if possible, repair the error immediately.

**Optimum AMS position**
At a new installation of AMS and at existing plants, a homogeneity test for gas AMS has to be carried out and a pre-inspection of flow AMS ought to be carried out. Both tests are intended to examine whether the measuring place is suitable for an AMS position and thus can deliver reliable measuring results.

**Complementary environmental measurements**
The standard conditions make demands for yearly performance control measurements for the emission of particles and for plants larger than 5 MW, also NO\textsubscript{2} (however, only every second year if the emission is smaller than 60 % of the threshold limit values).

The performance control measurements can be combined with the control of the AMS meters every third year and can be supplemented with parallel measurements of the AMS parameters the other years as an extra control of correct tax payment.

Further information
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CALIBRATION AND TEST OF MEASURING EQUIPMENT

Like other companies, biomass plants are subject to regulations which require measurement and registration of a large number of parameters. FORCE Technology calibrates and tests most of the equipment types which are used for measurements at biomass plants. Thus you can be confident to comply with the regulations.

We ensure that you keep demands and regulations
FORCE Technology’s services within calibration ensure that the plant keeps the demands and the legislation in relation to measurement and registration. First of all, the demands on the biomass plants imply that registrations of expended fuels have to be made – both of biofuels and used fossil back-up fuels (oil or gas), if any.

Furthermore, measurement of the heat production has to be made. If you are subject to the Quota Directive, measurements of productions on the individual section plants as well as of lost energy to water, if any, will often be needed.

A co-operation with FORCE Technology guarantees you compliance with regulations and legislation because we:

- Have expert knowledge within the area
- Are accredited by DANAK (the Danish Accreditation Fund)
- Are a national metrology institute for force, pressure, volume, density, gas flow and flow of other liquids than water
- Have a large staff of specialists within calibration and test of measuring equipment.

Consultancy on measuring technique
Based on our competences within measuring technique, we assist with consultancy on measuring techniques within many different areas. We carry out assessments of meters and metering systems as well as determination of measurement uncertainty. We can also determine method and interval for control of your measuring equipment and assist you in preparation of procedures for operation and maintenance of meters and metering systems.

Calibration and verification of equipment
We calibrate and verify most types of equipment which are used directly or indirectly for measurements at your plant. It includes among other things weighbridges, crane weights and mobile weighing systems, energy meters and metering systems, pressure and temperature sensors, oil meters and gas meters as well as water meters. We carry out calibration and verification of equipment on site and at our laboratories.

Furthermore, we calibrate equipment within force (transducers, load cells, dynamometers, jacks etc.) and equipment within torque (wrench, screwdrivers, transducers etc.), and we also offer verification, calibration of scales and weights and sale of weights.

Further information
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Calibration is carried out by means of weight in the grab.
Auditing is a structured process for assessing compliance and implementation of management system standards and customer requirements in a management system. Furthermore, it is an excellent tool for identification of opportunities for improvement within established management systems.

**Internal audits**
You may benefit from having an impartial authorised body conduct the internal audits:

- To manage limited personnel resources
- To receive professional sparring in relation to the management system
- By having audits performed in areas where your resources are inadequate or no auditors, who are not involved in the audited area, i.e. internal audit of your QHSE organisation, are available
- By getting an outside view of your company and its management system.

Our consultants hold extensive experience in conducting internal audits, and their focus is pragmatic and value adding. Our consultants look at the different aspects of the management system from your perspective as well as from the perspective of their own extensive experience.

We supply objectively assessed facts as input to your management decisions.

**Management systems**
We help you to build up and develop your management systems. Our consultants add value as sparring partners and instructors within quality – ISO 9001, environment – ISO 14001 or occupational health and safety – OH-SAS 18001.

We offer a number of training courses within management systems, both planned training and training specifically adjusted to the individual needs. The training includes introduction, system build-up and further development of management systems within quality, environment and occupational health and safety.

**Hire a system manager**
If you need a system manager to control and strengthen the daily work in your organisation, you can hire a quality, environmental or occupational health and safety manager or a lean responsible from our company.

**Further information**
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Specific services
Besides the mentioned services we readily help you with:

- Audits of the methods and procedures for documenting NOx emissions and verification of such amounts
- Audits of procedures, methods and accounts of GHG emissions and climate account etc.
- Review of metering systems and connected procedures for operation and maintenance, including calibrations and uncertainty budgets
- Risk assessments.
In connection with new establishment or substantial changes, for instance increased capacity, biomass plants with an input effect larger than 1 MW have to be environmentally approved. We offer consultancy within environmental approval to ensure that your plant meets the criteria.

The environmental approval includes requirements to the operation of the plant as well as conditions regarding air emissions, waste water, noise etc. and is issued by the environmental authorities based on a comprehensive application from the company.

It is important that before your application for an environmental approval, you have thought of the drawing up of the conditions. It is your possibility of making proposals for and having influence on the control which will take place at the plant.

In this way, you can minimise the risk of having control conditions which make your workdays difficult and give you many demands for documentation in connection with for instance the environmental management system.

However, you cannot get influence on all conditions. Some conditions are fixed through different regulations while for other conditions, for instance control of air cleaning equipment, it is possible to get substantial influence if “good suggestions” are presented by you. If for instance you control some parameters in another connection and you think these may have influence on the ambient environment, you ought to consider whether these can form part of the conditions. Once a condition is notified, it might often be difficult to change it.

The conditions in the environmental approval mean that among other things, measurements of emissions to the air have to be carried out. These measurements can be as manual random tests or in the form of establishment of an AMS system (automatically measuring systems). When establishing an AMS system, normally a number of demands in the environmental approval for maintenance, service and control measurements are made.

Further information
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TECHNOLOGICAL DEVELOPMENT

We have several decades’ experience of developing technologies for biomass combustion. In close co-operation with our customers, our goal is that the technology fulfils all the involved parties’ demands and expectations.

We can assist you at every stage in the process of development from idea to a market ready product. We have experience of being a part of bilateral co-operations and of being one of several partners in project consortiums which are often co-financed by public funds from national or international bodies.

We can help you to:

- Formulate ideas and goals
- Make the necessary applications
- Control projects
- Carry out calculations or simulations
- Prepare design and construction
- Plan and complete test programmes
- Be in charge of proof-of-concept and commercialisation.

The rules of co-operation

We understand the importance of intellectual property rights (IPR). Therefore, it is important for us that an agreement about IPR and future commercial conditions is made as early as possible in the process of development.

Thereby, we have the possibility to meet problems/challenges before they arise. It saves you for problems later in the progress and ensures a more effective development.

The agreement will reflect the involved parties’ background knowledge, how large an effort the parties have made in the development and the economic financing of the activities. As a GTS institute (GTS Advanced Technology Group), we can give exclusive rights under certain circumstances.

Further information
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TECHNOLOGY ASSESSMENT

Introduction of new technology requires a thorough technical understanding. It may sound trivial but in reality decisions are often made that later turn out to work badly, be too expensive or perform worse than expected.

When it comes to biomass technology, there is a lot of experience to rely on. Most types of plants have been in operation in large numbers for many years. Nevertheless, unrealistic expectations occur for instance regarding electrical efficiency or number of operational hours because they are taken out of context.

Among other things, we have seen examples where the nominal efficiency of a plant has been confused with the expected average annual efficiency and where values from technical calculations or the supplier’s marketing brochures have been used for feasibility calculations instead of factual figures experienced in real plant operation. The difference can be substantial and it appears directly at the bottom line. Furthermore, we observe that upper calorific value is sometimes used in calculations instead of lower calorific value.

Independent assessment of new technologies
For new and untested technologies, unrealistic expectations are often based on ignorance in the sense that decision makers in the absence of operational experience from full scale plants base their decision on optimistic research results or experimental data from small pilot plants. This especially applies to technologies for production of liquid fuels from biomass.

In such contexts involvement of independent technical expertise can make the difference between bad investments of millions or a successful conversion. You can draw on our professional competence both in connection with general tasks as for example national energy planning or environmental legislation and in connection with tasks where you are intend to sign a contract regarding delivery of equipment.

Broad technical expertise
Our expertise within biomass for energy purposes covers quite broadly and behind this we have an organisation which covers a very large field of varied expertise – from corrosion through water to fuel analysis and environmental assessments. Therefore, you get a qualified and independent assessment of biomass technology which makes it possible to compare alternative solutions or scenarios and qualifies your decision on investment in new plants.

Co-operation with the authorities
We serve as technical consultants for the authorities who have the responsibility to examine possible development scenarios for new technology, such as biomass-based solutions for generation of electricity and heat or for production of liquid biofuels. Our role might for instance be to provide reliable and independent data for the ability and economy of the given technical solutions.

We are also involved when the authorities are to implement legislation and put forward new environmental thresholds for technical plants for instance in the form of emission limits, definition of approved fuels or framework conditions in the form of BAT notes (Best Available Technology). Our role here is correspondingly to assess what in fact is possible and economically viable.

Further information
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Danish Test Centre for Bioenergy offers services targeted companies within bioenergy, who for instance deliver biofuels, feeders, boilers or other plant components, control systems, flue gas cleaning, stock facilities and district heating meters. Furthermore, we offer services for owners of energy plants, universities and technical schools.

Danish Test Centre for Bioenergy is a co-operation between FORCE Technology and Halsnæs Supply. The test facilities are situated at Halsnæs Supply’s heating plant that in co-operation with FORCE Technology are specially prepared for tests.

Besides the function as a test facility, the plant delivers district heating to citizens in the city of Frederiksværk and the immediate neighbourhood. Halsnæs Supply produces the district heating of CO₂-neutral biomass from wood chips, wood pellets and bio-oil.

**Facilities**
The facilities at Danish Test Centre for Bioenergy include:

- 2 wood chip fired boilers, each of 10 MW
- 1 wood pellet fired boiler of 10 MW
- 2 bio-oil fired boilers of 7 MW and 10 MW
- 2 flue gas condensers/scrubber plants
- 3 multi cyclones for removal of particles
- 1 filter bag
- District heating pipes with a diameter from 16 to 450 mm
- Wood chip stock and wood pellet stock
- Mixer funnel
- Automatic feeding cranes
- Workshop with welding unit, lathe etc.

**Special facilities for testing**
The boilers for wood chips and wood pellets are equipped with far more measuring ports and better possibilities of influencing and adjusting the process than common plants.

There is a possibility of testing new fuels and fuel mix. Experiments not only with amounts of combustion air but also with flow profiles, mixtures and vortex formations are possible. Air amounts and other data are collected and processed in the automatic system for control, regulation and monitoring (SRO system).

Further information
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Examples of tests
There are plenty of possibilities of testing the whole process from fuel to district heating:

- Test of fuel types, for instance fast-growing willow tree, garden/park waste, all types of pellets or mixed fuels. Experiments with pre-treatment of fuels or testing of additives are also possible.
- Test of grate combustion strategies, including control of primary and secondary air and the influence on ignition point and place as well as burn-out and tendency of flying glows.
- Test of monitoring technology, for instance camera surveillance of the combustion and new computational algorithms for control, regulation and monitoring.
- Test of flue gas processing system – new design of filter, scrubber and cyclones, for instance in relation to a better cleaning efficiency or less consumption of electricity.
- Test of emission measuring equipment for measurement of for instance NOx, CO particles, corrosive flue gases etc.
- Test of district heating meters – sensitivity towards variations in operation and water quality.