

July 23, 2001

Phone: +45 79 23 33 33

Fax: +45 75 56 44 77

Our ref.: LHS

Report no.: 01-300a

Project no.: 20300

Page 1 of 7

Verified:

Approved:

Biomass Utilisation

Brief overview of the experience of Tech-wise and Consulting Services provided by Tech-wise

1. Tech-wise's Biomass Experience

1.1 Tech-wise

Tech-wise is a consulting engineering company with approx. 200 employees. We are a subsidiary of the ELSAM utility group, which operates about 5000 MW_e of power plants of which the majority are Combined Heat and Power (CHP) plants. We have engineered power plants from 2 to 600 MW_e, fired mainly with coal, oil and natural gas. During the last decade, biomass and waste have been added to our portfolio of projects. Approx. 25% of our annual turnover comes from international activities and this share is expected to increase in the future.

1.2 Background and R&D Experience with Biomass

Tech-wise's involvement in utilisation of biomass for power production has been going on for more than a decade and has its background in political decisions made by the Danish Government aiming at achieving a substantial reduction of the national CO₂ emission. As a result, the Danish power utilities are obliged to utilise large quantities of biomass for power production.

In order to find the optimum way to fulfil this obligation, a large and still ongoing R&D programme was initiated by ELSAM, and Tech-wise has been actively engaged in all the R&D activities. The R&D activities include investigations of availability and quality of biomass, development of conversion technologies (CFB technology, grate firing technology, co-firing with coal, gasification, pyrolysis) as well as R&D on specific issues such as logistics, corrosion, slagging, emissions, residual products, etc.

Several of these projects have been partially funded by the EU and carried out in cooperation with research institutions, utilities and suppliers all over Europe.

1.3 Experience in Biomass Feedstock and Biomass Characterisation

Tech-wise has built up comprehensive knowledge of biofuels ranging from growing, harvesting, transporting, handling, storing and treating biomass before utilisation in the power plant. Since many biofuels are waste products from a number of industrial processes, these types are also recorded in our files.

In addition to the comprehensive capability available within Tech-wise we also work together with independent institutes and companies specialised in foresting or farming for the investigation of the fuel sources to be supplied. We have references in this field from a number of projects all over Europe.

As the chemical composition of the fuel has great influence on the combustion process, the risk of slagging and corrosion and further on the residual products and the emissions - much attention must be paid to this area. Through a large number of samples analysed at our own laboratory facilities, Tech-wise has recorded a comprehensive database within this area.

A thorough estimate of the biomass resources available to a project is of utmost importance in order to ensure that the power plant can be supplied with sufficient fuel at any time at a feasible price. Experience shows that developing new biomass fuel markets for large consumers such as new biomass-fired power plants needs careful and detailed investigations in order to succeed.

For this task Tech-wise cooperates with various research institutes active in the forestry and agricultural business. As an example the Danish Forest and Landscape Research Institute and Tech-wise have worked together and developed a thorough methodology on how to estimate wood-fuel resources and not least on the costs of producing this wood depending on, e.g., the forest site conditions, ownership of the forest, etc.

Tech-wise has worked extensively on the logistic side including intermediate and long-term storage of wood, transportation of wood and handling of wood delivered to plant site.

Tech-wise has carried out similar resource studies for other biomass fuels such as surplus straw from Danish fields and energy crops such as willow.

1.4 Project Experience

Tech-wise has been involved in the engineering of biomass plants in Denmark as well as abroad. Our involvement in biomass mainly covers plants using straw and wood chips as fuel and with a power output from 2 to 40 MW_e. The plant options include:

- Biomass firing (2 - 40 MW_e), both as straw only as well as mixed straw and wood-firing;
- Combined biomass and coal-firing in CFB boilers;
- Co-firing (10 -20% by heat input) of straw in large utility boilers (150 MW_e).

Some of our references are:

- Rudkøbing CHP Plant (straw);
- Måbjerg CHP Plant (straw, wood, municipal waste, natural gas);
- Grenå CHP Plant (straw, coal, agricultural wastes);
- Ensted Power Plant (straw, wood);
- Ostroleka CHP Plant, Poland (wood);
- Midkraft Co-firing Power Plant, 150 MWe (straw);
- Midkraft Co-firing Power Plant, 400 MWe (straw);
- Thetford Chicken Litter Power Plant (chicken litter);
- EHN, Spain 25MWe (straw, wood);
- Biomasse Italia 80 MWe (wood);
- Alliant Energy, USA 650 MWe (switchgrass);

Additional project experience with biomass technology is available for Denmark, Spain, England, Italy and Poland. For studies and feasibility studies we can also refer to the Czech Republic.

From the plants in operation - especially the plants operated by Elsam - we have achieved comprehensive knowledge of operation and maintenance of biomass plants.

2. Tech-wise's Services related to Biomass

2.1 General Remarks

The consultancy services which we are able to provide cover a complete range of services from feasibility and environmental studies to commissioning and operation, and Tech-wise is capable of handling all phases of a total project. However, to provide as much value to the project as possible, the extent of services has to be defined according to the specific project and the owner's/developer's organisation and experience. A situation frequently encountered is a project owner/developer having contracted with a local engineering company with limited specific knowledge of biomass and design of biomass plants. In such cases our engineering services related to

fuel analysis and characterisation, fuel handling, firing systems and boiler plants are considered very valuable to the project. By joining forces with the owner's staff and/or a local engineering company it is ensured that a strong combination of local knowledge and the practical capabilities of Tech-wise A/S on specific issues related to biomass plants is made available to the project.

In cases where Tech-wise is not acting as an owner's engineer handling the complete plant engineering, we can provide selected services in accordance with the project needs. Below, some examples of selected services from Tech-wise in relation to biomass projects are briefly outlined. Although the descriptions specifically relate to biomass, the services described could be provided for many other types of power plants, waste to energy plants and cogeneration plants.

The examples are as follows:

- Feasibility studies;
- Third-party assessment of feasibility studies;
- Basic plant description;
- Call for tender specification;
- Evaluation of tenders;
- Fuel contract specification;
- Project coordination after signing of contract;
- Commissioning;
- Operation and maintenance.

In the following, we have commented on each of the above examples.

2.2 Feasibility Studies or Third-party Assessment of Feasibility Study

In principle, the most optimal situation occurs when Tech-wise is involved in the very early stages of the project and prepares or contributes to the feasibility study. In many cases the initial investigations or feasibility studies have been prepared by others, however, a third-party assessment of the feasibility of the project is often requested by the owner or by financing institutions. Such an assessment must uncover potential technical risks and the impact of these risks on plant economy. The extent of a third party assessment will vary from case to case but typically, the following issues are dealt with:

- Availability, logistics and pricing of suggested fuels;
- Physical/chemical properties of fuels in relation to the technology suggested;
- Assessment of plant technology and plant design with emphasis on issues with large impact on plant economy such as plant cost, efficiency, availability, O&M;
- Assessment of environmental issues.

2.3 Basic Plant Description

These services may include the whole plant but the following task descriptions are concentrated on boiler and biomass handling equipment. The objective is to ensure that all relevant experience is included in the tender specifications for potential suppliers.

Tech-wise can review the proposed thermal cycle and design parameters and suggest alternative thermal design parameters.

The proposed biomass handling concepts can be described, including design data and requirements for storage concept.

Based on Tech-wise's experience with operating biomass firing plants and purchase of fuels, we find that exact definition and description of the fuels planned to be utilised in the biomass plant are very important in order to leave the turn-key supplier with sufficient information to perform a proper design and provide the right plant equipment, thereby avoiding disputes between owner and contractor at a later stage in the project. Tech-wise can analyse fuels and specify the fuel characteristics necessary for the turn-key tenderers and ensure that the fuel specifications are coordinated with the requirements for monitoring quality in the fuel reception facilities.

The requirements for firing and boiler systems can be described, including emission reducing measures and ash handling equipment.

The staff requirements for the plant can be described.

2.4 Call for Tenders Specification

This service comprises either the complete preparation of a call for tenders specification or a review of an existing call for tenders prepared by others.

In case a call for tenders specification is already available, it should be reviewed to ensure that all relevant experience is included in a functional specification. It should be ensured that the specifications do not impose unnecessary and expensive limitations on the potential suppliers. Such limitations can have serious impact on plant budget. Systems and plant components to receive special attention are:

- Fuel handling and storage systems;
- Fuel specification;
- Boiler specification and firing systems;
- Flue gas precipitation/flue gas cleaning;
- Ash handling.

2.5 Evaluation of Tender

Tech-wise can perform the complete technical and economic tender evaluation, alternatively contribute with evaluation of specific plant parts or evaluation of how suppliers have addressed specific problems.

Due to the many potential technical problems related to the equipment and systems listed below, Tech-wise should as a minimum be involved in the technical evaluation with regard to:

- Fuel handling systems;
- Boiler design;
- Boiler auxiliaries;
- Flue gas cleaning;
- Ash handling.

2.6 Fuel Contract Specification

By utilising our experience in procurement of biomass fuels, Tech-wise can assist in the preparation of draft fuel contracts for negotiation with suppliers of straw and wood, and we can assist in such negotiations. The draft fuel contract, which we provide, will include specification of quality requirements, fuel quality control on receipt as well as reject criteria for the fuels.

2.7 Services during Engineering, Manufacturing and Erection

After a turn-key contractor has been appointed, Tech-wise can assist the owner's organisation either as an overall project coordinator or as a supplement to the owner's project organisation. Examples of such supplementary services in this phase could be conducting design reviews to ensure that the turn-key supplier fulfils the contractual obligations, especially for issues related to fuel handling, boiler design, boiler auxiliaries, flue gas cleaning and ash handling.

2.8 Commissioning

Commissioning

Tech-wise considers commissioning and staff training to be extremely important for the success of a plant, and according to our experience, biomass plants need special consideration in this phase. A typical service of Tech-wise is to provide an experienced engineer for the planning and supervision of the plant commissioning and to assist in the training of the future staff. In this way, the project benefits from lessons learned in other projects and, in addition, the requirement for an increased staff level in the

beginning of the operating period can be overcome by the temporary employment of an experienced engineer.

2.9 Operation and Maintenance

"Operation and Maintenance Services" is a joint business area for the Elsam Group. The business area is led by Tech-wise and is targeted owners and suppliers of power plants and energy producing units in Denmark and abroad.

The services we offer are based on the theoretical and practical know-how of the Elsam Group gained from more than 50 years of experience within engineering, procurement, construction, operation and maintenance of the following plant types:

- Large coal or gas-fired power stations;
- A large number of local gas, biomass or waste-fired combined heat and power plants fully or partly owned. Total capacity approx. 1,000 MW;
- Wind turbines and wind farms.

We can offer to assume operation and maintenance responsibility, in whole or in part, of the operation for a set period, but we can also offer assistance on a consultancy basis, issues such as defining an efficient O&M organisation, initial operation, various interim solutions such as ad-hoc repair assistance, training/supplementary training of operation and maintenance personnel on site or at Danish power plants.

At present, the Elsam Group has personnel seconded to Poland, Taiwan and Denmark in connection with erection and commissioning activities and has previously had personnel seconded to Saudi Arabia, Egypt, Zimbabwe and Botswana and has assisted with replacement of a gas turbine in the Gorm field.