25 MW Straw-Fired, High Efficiency Power Plant

1. Aim

The aim of the proposed project has been to design, construct, own and operate a new electricity generation capacity based on renewable energy sources, in this case on straw, with the possibility of adding wood chips, with a sound technological and economical basis. The owner, EHN, expects this project to promote the implementation of its future strategies and plans in its fields of activity. Bio-energy crops are already being investigated at demonstration scale as a fuel alternative, also.

From the point of view of technological development, the aim has been to demonstrate the innovative technical solutions, high efficiency steam boiler with high steam temperature for wood and straw firing with new superheater construction, to solve slagging and corrosion problems up to now related to combustion of straw. The successful demonstration has created (and will create) new project and job opportunities by offering a viable solution to exploit difficult biomass fuels which currently are treated mostly as waste.

2. Introduction

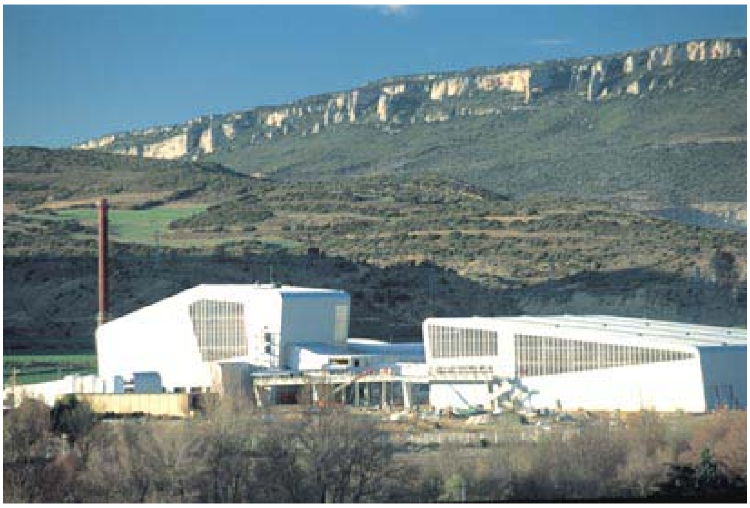

Photo 1: View of the Sangüesa Power Plant with straw barn on the right, and boiler building on the left

The power plant is an electricity generation facility based on renewable energy, which supplies a net amount of 25 MW of electricity to the grid. An additional power production of about 2.5 MW of electricity is generated for consumption in the own operation systems of the plant, and heat production is nowadays released at the condensing system, which is cooled by a water intake from an irrigation channel of the Irati river.

The plant operation availability is expected to be 8.000 hours/year, which leads to an annual electricity production of 200 GWh. The plant is located at the Industrial Area of Rocaforte, near the locality of Sangüesa, in the region of Navarra, Spain.

The **technology** is based on an innovative biomass boiler, together with a conventional steam circuit and steam turbine process. The core technology is located in the boiler, which includes novel hanging platen superheaters for the steam, specifically designed with special materials and shapes for minimizing corrosion on their surface. It also includes a vibrating hydro grate made of two different sections, and an innovative feeding system design, including safety devices for fire prevention. The whole boiler and feeding system is an improved design of the technological partner, the Danish company FLS miljø.

As **fuel**, the plant is initially designed for using only straw 100%, and also mixtures of wood chips and straw up to 50% (in heat values). At the moment, only the investments in facilities and logistics for straw have been carried out, but enough space is available for the construction of an additional barn and feeding systems for wood chips. Annual fuel consumption of the plant is 160 000 tons/year of straw, mainly of wheat, barley and corn, all of which is collected all around the region. Logistics for fuel collection in the fields, handling, transport and storage include long-term contracts with farmers and service companies in order to provide the whole annual supply.

The plant first connection to the grid was achieved on 25th June 2002. After several operation tests the plant has reached full load operation, and results are completely successful.

3. Technical description

Boiler

The straw and wood fired boiler is an improved FLS miljø design. It includes a vibrating hydro grate specially defined for handling the specific quality of the straw to be burnt. The grate is made in two sections that enable the use of straw or a mixture of wood and straw as fuel, having low ash melting temperature and difficult sintering or slagging properties.

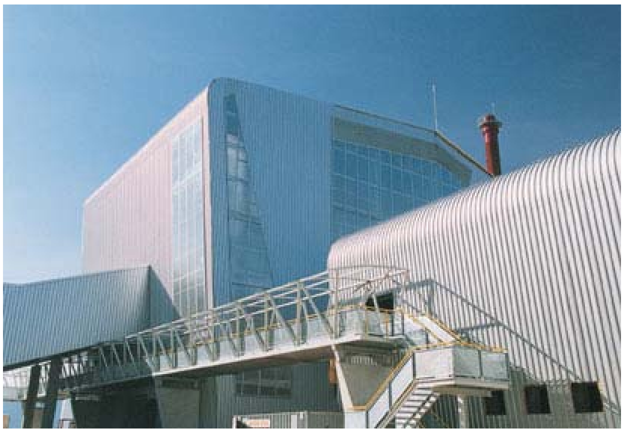

Photo 2: Boiler, turbine and offices buildings

The straw is fed to the boiler through four mechanical feed openings. The transportation of the burning mass and the ash through the grate is made by the ash removal system, which periodically vibrates, during a few seconds every 5 minutes. The cycle of vibration and the intervals are adjusted during the commissioning of the boiler depending on the quality of the straw. The grate itself is made as a boiler panel wall, including perforations for input of the combustion air. This type of grate has very low maintenance costs and high reliability.

Ash that falls down from the grate is then transported to a container, and the fly ash is collected in the bag filter. The remaining particle content in the flue gases is less than 50 mg/Nm^3. From the bag filter ash hoppers, the ash is conveyed to a fly ash container. Both the bottom and fly ashes are being reused as organic fertilisers.

The hot flue gases are led to the hanging platen superheaters inside the boiler and then to the second pass, where the feed water economizer and combustion air preheaters are located. Economizer and air pre-heating are used to cool the flue gases down to approximately 130ºC before releasing them through the stack into the atmosphere.

Superheaters

The new straw fired hanging platen superheaters increase the steam temperature up to 540ºC directly with the straw combustion gases inside the boiler. Due to the rapid high temperature corrosion caused by the alkaline contents of the straw ash, the superheaters have been carefully designed, using resistant materials, an exact design (including the appropriate additional surface area for heat exchange), and completely eliminating the use of natural gas or other fuels for superheating the steam. A research project with the Public University of Navarra is also undergoing, aiming at analysing new materials for these superheaters.

Steam cycle
The power plant process is designed for high electrical efficiency. This is accomplished by using the condensate and feed water pre-heating, “internal co-generation”. The high pressure and temperature steam (100 bar, 540ºC) is fed from the boiler to the extraction-condensing steam turbine. Steam is extracted from the steam turbine for pre-heating in four uncontrolled extractions. The exhaust steam from the turbine is condensed in a condenser using river water as cooling medium. From the condenser the condensate is returned through the pre-heating stages to the feed water tank and further to the boiler for steam generation.

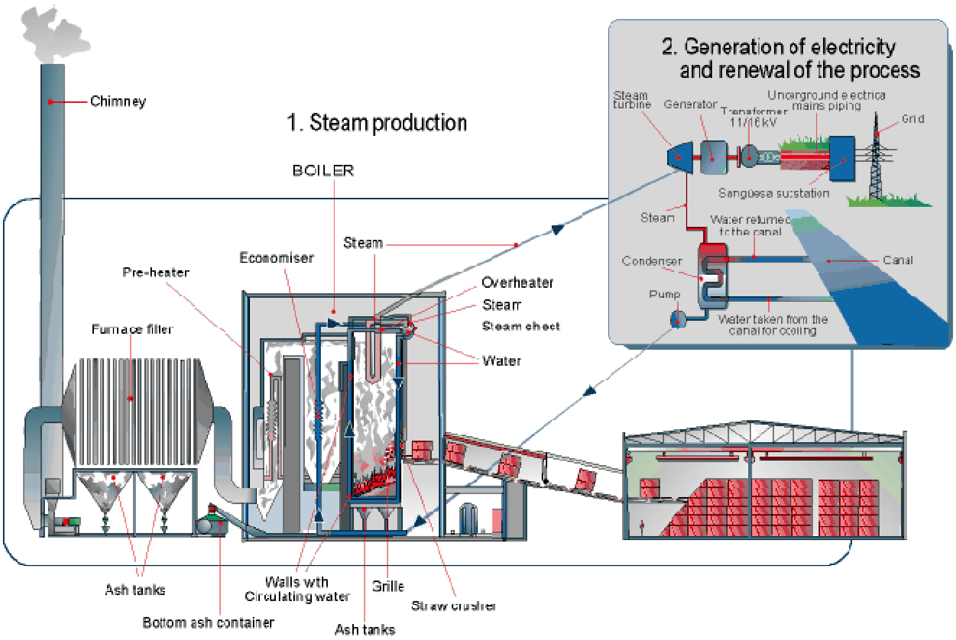

Figure 1: Process diagram

Turbine - Generator
The steam turbine is of extraction-condensing type. It has a capacity of 30 MW at the terminals of the alternator. With an auxiliary power consumption of nearly 2.5 MW, the average net electrical output is 25 MW. The alternator output voltage is 10 kV. The plant is connected to the 66 kV grid through a block transformer. Separate auxiliary transformers are used to feed the auxiliary power for plant’s own power consumption.

4. Performance of the plant

Before starting the plant operation, straw collection and storage in the field started in summer 2000. Campaigns of years 2001 and 2002 were used to fine tuning the logistics activities and increasing the amount of stored straw. The plant first connection to the grid was achieved on 25th June 2002, which meant the start of the commissioning and monitoring phase. Since then, several tests and adjustments have been made, including the gradual power increase until full load was reached at the beginning of 2003. In July 2003 the plant is still adjusting its production parameters, and full commercial operation will start after summer.

During the first whole year of operation at testing level (from June 2002 to May 2003), the plant has consumed an amount equivalent to 99 124 tons of straw with 11% of moisture, and the corresponding electricity supplied at the utility substation has been 118.94 GWh. The efficiency will be improved to 200 GWh/a with 160 000 tons of straw once commercial operation will be reached.

The proposed renewable energy project has a clearly positive impact on the **environment** in the region, as it replaces electricity which would otherwise be produced with fossil fuels, and it does not add the current emissions of straw combustion, because the straw is often burned on the fields. On the contrary, because of the controlled combustion and flue gas cleaning, the CO and particle emissions from the power plant are clearly lower. It is calculated that with the biomass fired power plant of 25 MW, some 210 000 tons/year of CO_2 and 4 600 tons of SO_2-emission are avoided in comparison to power production with coal.

5. Economic Performance

The **operational cost** consists of the fuel supply costs and the operation & maintenance costs of the plant. Cost of straw supply is around 36 €/t, including every logistic activity until fuel reaches the plant. As the annual consumption is 160 000 tons, fuel supply costs are around 5 760 000 €/year. On the other hand, the ordinary O&M costs are estimated around 12 €/MWh, plus other financial, amortization, spare parts and extraordinary costs. The expected **incomes** of the plant will depend on the rate for electricity supply to the grid by biomass means, which is annually revised. As an average, the utility purchases the electricity at a rate of 65 €/MWh, so that the annual electricity sales will be around 13 million €.

As **financial sources**, the European Commission has contributed with 3 million €, and the Spanish "Instituto para la Diversificación y Ahorro de la Energía" (IDAE) has financed another 2.4 million €, plus a share of 10% of the total investment. Taking these contributions into account, as well as the previous performance data, the payback period is estimated to be around 15 years.

Concerning **job creation**, the continuous operation of the power plant creates 24 new permanent jobs at the power plant and approximately 80 jobs more in gathering, processing and transport of the fuel, and other various activities. Also, during the construction period there was an average of 200 people working on site during 18 months.

6. Project Identifiers

Project:	**BM/12/97**
Owner:	**EHN (Corporación Energía Hidroeléctrica de Navarra, S.A)** Yanguas y Miranda, 1 – 5º E-31002 Pamplona SPAIN Tel: +34 948 22 94 22 Fax: +34 948 22 29 70 www.ehn.es
Contractors:	**FLS MILJØ A/S, POWERTECHNICS CONSULTING ENGINEERS OY, IDAE (Instituto para la Diversificación y Ahorro de la Energía)**
Technology:	**FLS (boiler and straw handling)** **Alstom-ABB (turbine & power generator group)** **Abengoa (manager of the plant engineering and construction)**
Total Cost:	**51 000 000 €**
EC Support:	**3 000 000 €**