

BIOMASS

Pilot Installation

FRANKFURT AM MAIN

Germany

By the year 2010, 12% of the gross inland energy consumption of the European Union is to be covered by renewable sources of energy. To meet this goal, intensified use needs to be made of biomass, both for heating purposes and for power generation. Timber and forestry residues are available in ample quantities, but the required investment costs are a barrier to the broad-based use of this energy source. The German city of Frankfurt am Main, a member of Energie-Cités, is currently in the process of converting its school hostel in the rural area of Wegscheide to 100% energy supply from renewable sources.

THE CITY

The city of Frankfurt am Main (population about 650,000) was founded on the banks of the River Main in the eighth century on the site of an old Roman settlement. Already famous for its markets in the Middle Ages, Frankfurt has now become a financial and commercial centre (largest stock exchange in Germany, headquarters of the European Central Bank). Venerable buildings (the Römerberg, cathedral, gothic churches, the house where Goethe was born) contrast with the skyscrapers of the financial institutions. The chemical sector is the dominant industry in Frankfurt.

Climatic data:

Heating degree days (18°):	3,269
Mean annual temperature:	10.7°C



CONTEXT

As a founding member of the Climate Alliance of European Cities, the city of Frankfurt am Main has committed itself to reduce CO₂ emissions by 50% by the year 2010 to protect the world's climate. The city laid the foundations for its present energy policy by the adoption in the city parliament of the 'Climate Offensive 1991'. This policy resolution focuses on reducing the consumption of electricity and heat, promoting decentral combined heat and power production (CHP) and utilizing renewable energy sources.

Since 1990, solar collectors have been installed with a total area of some 3000 m². The German Renewable Energy Act (Erneuerbare Energien Gesetz) has triggered an intensive expansion of photovoltaics since the year 2000. An investor company has installed large photovoltaic installations on three schools totalling 80 kW_p. The city made the roof areas available free of charge. The Mainova AG company has installed a 30 kW_p facility under a public participation scheme on top of a football stadium. The central organic composting plant uses organic wastes collected by the city of Frankfurt to produce biogas, converting this into power and heat in a 440 kW_{el} small-scale CHP unit. However, the most comprehensive scheme has been implemented outside of the city, namely in the school hostel in Wegscheide.

EXPERIENCE IN FRANKFURT AM MAIN

Initial situation and approach

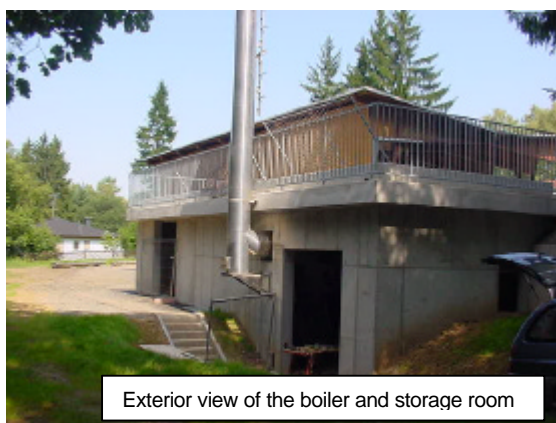
Near Bad Orb, in the densely forested Spessart uplands, the foundation 'Stiftung Frankfurter Schullandheim Wegscheide' runs the largest school hostel in Germany, which receives up to 650 children in the summer.



Numerous measures to modernize energy and water supply and wastewater disposal were necessary in the period from 1995 to 2000. When carrying out structural modernization work, the foundation has always been at pains to implement ecological criteria of sustainable production and consumption and to combine these with the promotion of environmental education in the hostel.

The initial focus was placed upon energy conservation measures. This included improving the thermal performance of several residential and dormitory buildings through low-emissivity glazing and cellulose insulation. To provide hot water heating for a seminar building with a separate heating boiler, a 50 m² solar installation was erected on a nearby south-facing building, this work involving apprentices of the heating system trade. The buildings were equipped with thermostatic valves, numerous high-efficiency lamps and water-saving fittings. Instead of a costly connection to the relatively distant municipal sewage plant, the hostel built its own biological sewage treatment facility with plant-based purification.

The key element of the energy plan for the site is now the wood-chip-fired heating system. Most buildings, including the kitchen, were previously supplied with hot water for space heating and hot water for domestic purposes by means of two heating boilers through two heat networks. Annual heating oil consumption exceeded 180,000 l.



Technology

The two older oil-fired boilers that supplied most of the buildings with space heat and hot water were shut down. In their place, a new wood-chip-fired boiler with a capacity of 800 kW was installed. The two existing local heat networks were connected with about 250 m of new heat piping, thus supplying a heated floor space of some 7000 m². Steam supply in the kitchen building continues to be provided by firing heating oil, but the hot water is heated using renewable energy in the wood chip facility.

The wood chip facility has no peak-load boiler fired with heating oil because, due to low occupancy of the buildings in winter and temperature setback, there is no particularly elevated peak load in the winter season. Future wood chip demand will be about 2500 m³ annually. In accordance with grant requirements, more than 50% of this will come from forestry residues – the rest can come from uncontaminated sawmill wastes.

The boiler room is adjoined by the wood chip storage room with a capacity of 150m³. The stock suffices for about 14 days. It is filled from the top by a truck with a 40 m³ container. A distribution system spreads the fuel across the length of the storage room, from where it is conveyed to the boiler room. The wood chips are conveyed to the metering screw in the furnace chamber by means of a chain trough conveyor.



Cost-effectiveness

The initial investment costs of the wood chip facility (incl. storage, boiler, conveyance etc.) amount to approx. € 450,000 (VAT included). This includes the costs for the heat piping, which amount to € 75,000, and for interconnection with the existing local heat networks, which amount to approx. € 80,000. The German regional state of Hesse supports the investment with a grant of approx. € 125,000. After deducting the grant support, the capital costs amount to approx. € 25,000 per year, the fuel costs approx. 30,000 €/year and the operating costs 8000 €/year – this results in total costs of 63,000 €/year or approx. 3 cent/kWh.

Modernization of the oil-fired heating systems, in contrast, would have involved total costs of 3.5 cent/kWh (heating oil) + 0.6 cent/kWh (capital and operating costs). If we deduct the costs of the avoided modernization of the oil-fired heating systems from the initial investment costs, we arrive at extra costs of the initial investment amounting to approx. € 275,000. To this are contrasted annual fuel cost savings amounting to € 35,000, so that the initial investment pays back in about 8 years.

Although special features make comparisons difficult, it can be said that, at specific costs of 580 €/kW (450 €/kW without local heating network) the Wegscheide facility is among the most cost-effective facilities receiving grant support in the German regional state of Hesse. These facilities range from 400 to 2500 €/kW. At 30 €/MWh, the wood chip facility in Wegscheide has a very low ratio of initial investment to annual heat production.

Problems and solutions

As this is the first wood-fired heating system of this size undertaken by the city of Frankfurt, all participants often had to break new ground. Overall planning consequently took several years. The Frankfurt energy department (Energierreferat) carried out the first surveys and statistical evaluations of energy consumption in 1996/97. The overall concept was drafted in 1997. As no contract energy management company willing to take on financing and operation was found, financing was assured by the city of Frankfurt and the foundation. In April 2000, the government of Hesse provided an assurance of grant support for the facility. However, after tenders had been requested, it became apparent that system interconnection would necessitate extra costs. The government of Hesse raised its grant commitment in February 2001. Work on the wood chip facility commenced in February 2001, and the first wood was fired in August 2001. The official opening ceremony took place in November in the presence of the Environment Minister of the German regional state of Hesse.

Educational concept

Environmental learning in Wegscheide combines the presentation of environmental content with the hostel itself as a concrete place of learning. In all matters concerning food supply, energy supply and waste disposal, the hostel is a microcosm in which many things can be discovered. At the same time, there is a great array of practical things that can serve as

learning objects. The forest, water and sun can be experienced directly, e.g. by making small solar collectors. It is a declared aim of the modernization of the buildings and of the energy supply system that it is to have an exemplary function and should support the environmental education concept. Here schoolchildren learn that one hectare of forest sequesters 10 tonnes of CO₂ a year.



Emissions inventory and reduction costs

The wood chip facility prevents emissions of about 600 tonnes CO₂ annually. In full-cost terms, savings figure approx. 2 cent/kWh. This cost-effectiveness results in negative CO₂ reduction costs of approx. 60 €/t CO₂.

EVALUATION AND OUTLOOK

Today, the wood chip facility already achieves a roughly 80% renewable energy supply of the school hostel in Wegscheide. The goal is to achieve 100% over the medium term. It is therefore currently being examined to what extent the electricity supply of the hostel can also be placed upon a renewable basis, by means of using a small-scale combined heat and power (CHP) unit fired with rape oil or by purchasing 'green electricity'. A photovoltaic installation – financed by parent shares – can complement the demonstration of renewable energy technologies at the hostel. The priority goal is at first to save electricity with the aim of compensating for the extra costs of green electricity supply.

Together with partners, the city of Frankfurt organized in 2001 a congress on 'Renewable energy for Frankfurt and Europe'. In addition to exploring ways to tap local markets, this meeting also established contacts to eastern European countries. A plan was developed for doubling by the year 2010 the share of renewable energy sources in Frankfurt, with the support of all important local actors. Efforts include the construction of a 7 MW_{el} wood-fired power plant by an industrial operator, but also the propagation of heating systems using wood pellets. In addition, the supply-side market for solar installations shall be expanded substantially through joint efforts with craft enterprises.

FOR FURTHER INFORMATION

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