# BIOMASS - WOOD
## Gasification / Cogeneration

# ARMAGH
## *United Kingdom*

*Gasification is transferring the combustible matters in organic waste or biomass into gas and pure char by burning the fuel via a restricted flow of oxygen. The technology has some clear advantages; with a minor loss in total energy it allows biomass in small-scaled engines and co-generation units – which with conventional technologies is not possible. The state of art of gasification is in rapid development, and in Armagh in Northern Ireland, the City Council has initiated an implementation of a gasification plant, where the gas is utilised in a small-scale co-generation unit.*

# THE CITY

Armagh city is located in the southern part of Northern Ireland The historic cathedral city is referred to as the spiritual capital of Ireland. The city has many tourist attractions including a planetarium and observatory. A heritage centre has been developed at the Palace Stables and the history of Armagh is depicted at St. Patrick's Trian. Navan Fort which was stronghold of the Kings of Ulster from 7000 BC, is located three kilometres from the city. Visitors can explore the archaeology and mythology of the site at the Navan Centre.

**Climatic Data:**
Annual degree days (basis 15.5 °C): 2,440
Annual mean temperature: 8.5 °C


# CONTEXT

A joint project was set up between the renewable energy company B9 Energy Biomass Ltd, Armagh City and District Council and the Blackwater Valley Museum in Benburb, for a wood fuelled, combined heat and power unit. The installation implemented in the museum is providing heat for space heating and domestic hot water at the museum and electricity for around 400 dwellings. The aim was to provide alternative farm income and promote economic development and rural employment opportunities in the field of renewable energy. The installation is the first of its kind in Northern Ireland and the project was initiated by B9 Energy. Like wind, water and solar power, wood is being actively promoted by the government as a renewable resource that can help reduce pollution. In order to achieve a larger amount of renewable energy in the UK, the British Government has initiated a market enablement strategy to stimulate the development of these energy sources. As a part of this strategy, the Government has introduced in Northern Ireland the Non-Fossil Fuel Obligation (NFFO). This seeks to demonstrate those electricity-producing technologies that are closest to becoming commercially competitive and which once established will become viable without further special support. Similar obligations have been introduced in Wales, Scotland and England.

# EXPERIENCE OF ARMAGH

## The fuel


The wood fuel for the gasification plant will be supplied from a mixture of wood from existing forests and coppiced willow from local farmers. There is a significant potential for willow coppice in Northern Ireland. However, to begin with, until grants are in place to encourage farmers to grow willow, the unit will use surplus sawmill wood chips. The wood chips are delivered by lorry to the museum twice a week.

B9 Energy Biomass Ltd. is developing fuel resources from both forestry and energy crops (for example willow). The company has carried out forest residue harvesting trials and developed integrated supply strategies winning a contract with the Department of Agriculture for Northern Ireland to secure a 15 year supply of forest residues from the counties Tyrone, Fermanagh and Londonderry. Energy Crops in the form of short rotation coppice (SRC) willow have been researched in Northern Ireland since the 1970s. This research is now at a stage where energy crops could be integrated into local farming practices.

Agricultural land in Northern Ireland covers about 1,000,000 hectares. It is estimated that around 70,000 hectares could be successfully dedicated to arable coppice in the counties Fermanagh and Tyrone without the loss of farm income. Studies in the UK show that sustainable yields in the excess of 12 oven dry[1] tons per hectare per year can be expected. The gross calorific value of the oven dry wood chips is around 5.4 kWh/kg. According to the ETSU (the British Energy Agency) study "Renewable Energy Resources in Northern Ireland", the potential accessible resource of electricity generated from coppice energy crops grown on 70,000 hectares is 170 GWh/year. This is equivalent to a 54 MW power station.

From an environmental point of view the use of willow coppice as an energy source is attractive. Apart from the saved $CO_2$-emssions, the emissions of $SO_2$ and $NO_x$ are considerably lower than the emissions associated when burning fossil fuels.

## Local and environmental benefits

Using land for energy crops like willow has great potential for improving the environment and stabilising and diversifying rural incomes. In addition, willow plantations returns trees to the countryside creating new habitat with a diversity of flora and fauna.

Renewable energy contracts are for 15 years providing a stable market for willow and the opportunity to index link part of the farm income. Nearly 80% of the growing work is carried out from December to March, which allows farmers to diversify into a winter crop. Over the 15 years of electricity contract approximately 1.4 million €[2] will be spent locally on fuel and labour.

## The wood fuelled CHP unit

The wood fuelled CHP unit is designed and manufactured in Northern Ireland. The plant is the worlds first down draft gasification unit for combined heat and power to operate on a continuous feed system with zero liquid waste produced. Swedish technology, which has

[1] Defined as containing approximately 5% water – chemical bound in the wood.
[2] Exchange rate: One € is here defined as 0.705 Pound.

used wood to power vehicles since the Second World War, was redesigned as a stationary power plant. The wood is transported to the museum with lorries twice a week. The first step is to dry the wood. This is done by means of waste heat from the co-generation unit. The wood chips are dried from approximately 50% water content to 10 - 15%. This is done due to technical demands from the down draft gasification process.

In the gasifier, the wood chips are heated in a restricted airflow, which converts them into a combustible gas and clean char. The gas consists of Hydrogen, Carbon monoxide and Methane as combustible gasses as well as non-combustible gases like Carbon dioxide and Nitrogen.

The gas is cleaned, cooled, mixed with air and fed into the engine. 5 - 10% of the fuel is diesel, which is supplied as the ignition source is the compression ignition.

The co-generation unit has a nominal output on 200 $kW_e$ and 400 $kW_t$, respectively. The electricity is produced at a voltage of 415 V. This is transformed to 11 kV and carried away on the NIE grid.

The engine exhausts contain a considerable amount of heat, which is recovered by diverting it through heat a exchanger. Heat from the engine jacket is also recovered. This energy is partly used for drying the wood chips and partly for the heating of the museum. The size of the go-generation unit is not as such matched to the museum's heat demand but it is dictated by the electricity supply contract of 200 $kW_e$, which as a consequence generates 400 $kW_t$ of heat after drying the feed to the unit. This is approximately the requirement of the museum. There is a back up oil boiler for the museum when the CHP-unit is out for maintenance or on very cold winter days. Surplus heat can not be supplied to other buildings as there is no connection or requirement for one.

The plant is capable of 24 hours per day, unmanned operation for a period of 6 days after which the residual charcoal is removed and the wood chips store replenished. The life expectancy of the plant should be similar to that for a conventional steam electricity plant. The over all energy efficiency is 70%.

The capital cost has been 280.000 €. The project was financed by loans and received a grant of 190,000 € from the EC INTERREG programme. The simple pay back period is forseen to be round 7 years.

The expected yearly production of heat and electricity is 1300 MWh and 2600 MWh respectively. If it is assumed, that this amount of energy was to be produced with oil instead, the following saved emission to the atmosphere can be calculated:

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|---|---|---|
| Saved $CO_2$-emissions | 1,700 | ton |
| Saved $NO_x$-emissions | 12 | ton |
| Saved $SO_2$-emissions | 0.2 | ton |

The local Electricity Company purchases all the electricity produced. The museum has a separate connection and contract for purchasing its electricity. The price for the electricity is the same for buy and sale, 0.11 € per kWh. The generator connected to the engine is (like a wind turbine) an asynchronous generator, and the quality of the produced electricity is regulated in compliance with the G59 standard, which has limits for over/under voltage, over/under frequency, loss of mains, vector shifts, reverse power, earth faults etc.

# EVALUATION AND PERSPECTIVES

The project has successfully demonstrated the technical potential for small-scale wood gasification for co-generation purposes. The commercial demonstration project at Blackwater Valley has the potential to raise further orders for this Northern Ireland Company. It was officially commissioned in November 1999. The Blackwater Valley Museum, already an attraction as water driven linen mill, makes use of the free heat from the co-generation unit to expand its tourist resources.

The knowledge gained through the work with the wood fuelled CHP plant in Armagh has given the renewable energy company confidence to manufacture, sell and operate small-scale wood-fuelled CHP units.

The combination of exploiting local resources for clean energy production, local commitment and use of local labour and improvement of the environment, both due to the saved emissions and transplanting of new trees, are all factors that improve the general living quality in an area.

Linen processing is the central attraction in the museum. This installation is located beside river Blackwater that is used as a renewable energy resource as well. The scheme is run of river operating with a 75 kW Francis turbine. The installation is on average producing 55 kW that is exported to the grid. A voluntary, city based community group commissioned this small-scale hydropower plant. 50% of the investment costs were granted by the European Regional Development Fund.

The future plans for this technology are further major expansion in the generating capacity in the UK and the Republic of Ireland. B9 Energy Biomass is also working on other European contracts for the supply of equipment into other markets.

## FOR FURTHER INFORMATION

Debra Jenkins
B9 Energy Biomass Ltd.
Unit 22 – Northern Road Industrial Estate
Northern Ireland BT48 0LD
Phone: +44 28 7127 1520
Fax: +44 28 7130 8090
E-mail: d.jenkins@b9energy.co.uk Web: www.b9energy.co.uk

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