RASLRES

Using Biomass for Process Steam Boilers

Technical Report under the RASLRES project

June 2011

Northern Periphery Programme 2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

WDC
WESTERN DEVELOPMENT COMMISSION
COIMISIUN FORBARTHA AN IARTHAIR

What is Biomass?

Biomass is the biodegradable fraction of products, wastes and residues of biological origin from agriculture (including vegetable and animal substances), forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction from industrial and municipal wastes.

Biomass includes a broad variety of raw materials such as wood, agricultural crops, by-products of wood processing, agricultural and forestry industry products, manure and the organic fraction of waste streams.

Forestry and wood-based industries provide a wider range of different fuels including logs, bark, chips, sawdust and pellets. Biodegradable waste covers the organic fraction of municipal solid waste, wood waste, refuse derived fuels, sewage sludge, etc. Agriculture can provide dedicated energy crops as well as by-products in the form of animal manure and straw. Land can be used for growing conventional crops such as rape, wheat, maize etc. for energy purposes, or for cultivating new types of crops such as willow, miscanthus and others.

A report by:

Paddy Donovan, Fred Tottenham, Tom Bruton and Steve Luker

Introduction

Many industrial facilities in the agri-food sector are currently using heavy fuel oil (HFO) or other fossil fuel for process steam generation. Typical examples are milk processing plants which require steam for drying milk powder, animal feed plants which need steam for conditioning of feed pellets or mushroom farms which require steam for sterilisation of their sheds.

Due to the high cost of HFO, the introduction of carbon taxes and a general trend towards green manufacturing, many of these plants are considering solid biomass boilers for their process steam.

The RASLES project has facilitated two manufacturing plants in considering biomass boilers for process steam. The purpose of this short report is to share the lessons of the RASLRES experience with others considering this option. RASLRES provided expertise to a milk processing plant and an animal feed plant.

This is a short review for information purposes and anyone considering a biomass steam boiler should seek professional advice and gain a more thorough understanding of the technology and specific implications at their site.

Combined Heat and Power?

The coupling of a steam boiler with a steam turbine would facilitate the production of electricity alongside process steam in a combined heat and power (CHP) plant. This is only commercially worth considering at present for sites with a large year-round steam requirement (>5 MW thermal). There are technologies being commercialised which may facilitate sites with a lower steam demand to employ CHP, and policy supports may provide further stimulus[1].

There are several further reasons why CHP is often challenging at these sites including:

- Poor efficiency of steam turbines at small scale (<5MWe)
- High capital and maintenance cost of CHP at small scale
- Higher overall project capital expenditure
- Larger energy and biomass supply requirement if CHP included
- Substantial regulatory challenges in securing grid connection and electricity payments

[1] Please refer to *Biomass CHP Market Potential in the Western Region: An Assessment* and is available for download at www.wdc.ie

Boiler Technology

A number of important commercial and technical considerations will drive the decision behind what kind of boiler to use.

Broadly speaking, there are two types of solid fuel boiler: fire-tube and water-tube. The simpler and less expensive boiler type is the fire-tube (Figure 1). This type is generally used for boiler capacities of up to 30 MWth and and for saturated steam applications < 30 bar. The vast majority of process steam users in Ireland would be more suited to employ the simpler fire-tube technology. The fire-tube boilers are also simpler to clean and maintain. They are usually employed with a moving grate boiler which has a good degree of flexibility in biomass particle size.

The water-tube boiler is used for higher pressure applications and has a higher efficiency than the fire-tube boiler. Larger boilers, particulary for CHP and power generation would typically use a water-tube boiler. The fluidised bed boilers used to burn peat in the midlands power stations are water-tube boilers. They require a very uniform fuel specification and particle size.

Figure 1: Fire-tube boiler heat exchanger at University College Dublin

The biomass fuel characteristics play a major role in boiler technology selection. Parameters of particular importance are the moisture content, particle size, the ash melting temperature and the presence of corrosive elements such as chlorine or sulphur.

Boilers are very much configured for a particular combustion temperature and air-fuel ratio. Large variations in moisture content will have a disruptive influence on boiler performance. Biomass boilers cannot readily switch from, for example wood chip to wood pellets without a shutdown and reconfiguration of boiler controls and fuel supply. Where an industrial user requires a constant steam temperature and pressure, careful attention must be paid to the fuel moisture content.

If the moisture content is too low for a given boiler design, combustion temperatures will increase and potentially cause problems with both flue emissions and ash-melting behaviour. Wood ash typically melts only above 1300 C, but other herbaceous fuels have ash-melting temperatures of ~ 1100 C. At excessive combustion temperatures, ash particles will condense on boiler tubes, heat exchangers and other boiler components and lead to corrosion or other irreparable damage to boiler parts.

Modulation (the capacity to vary the boiler output) is a key concern for biomass steam boilers. Generally biomass boilers will only modulate to 40% of their capacity. A typical oil burner will modulate to 20%, and with the installation of multiple burners, oil boilers can modulate to very low output. Biomass boilers respond much less rapidly to variations in load. From start-up they can take several hours to get up to the required temperature and pressure. Steam is much more difficult to store than hot water. The boiler will have some in-built thermal storage and the use of steam accumulators provides some flexibility, but the key barrier at many sites is that a biomass steam boiler should be designed for a consistently required base-load.

Case Study 1

The milk processing plant has a high peak load of 21 MW, but a very seasonal operation pattern (Figure 2). CHP is not attractive here, however a biomass steam boiler of 7MW capacity has been recommended for this site which would supply 44% of the required steam, with the remainder of steam supplied by existing HFO boilers. The existing HFO boiler capacity is slightly oversized at 26 MW. A fire-tube boiler with a moving grate bed was the recommended biomass technology choice here.

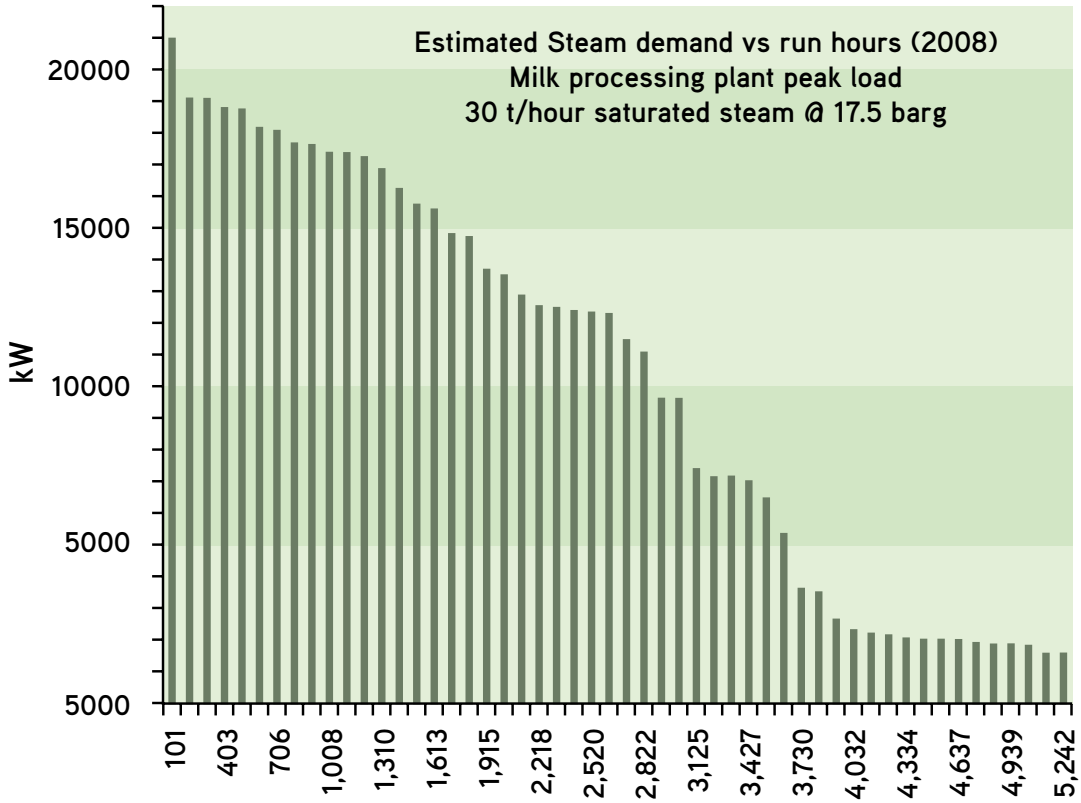


Figure 2: Estimated Steam Demand Milk Processing Plant

Case Study 2

The animal feed plant has a seasonal operation, but a relatively consistent load profile. The peak load is for 850 kg/hour of saturated steam at 8 barg (~650 kW see Figure 3). There is a much smaller load required for longer periods for miscellaneous process steam. The load is currently supplied by a very old light fuel oil (LFO) boiler.

The load profile here facilitates an almost complete switch from LFO to biomass. 96% of the steam requirement would be covered by a 650kW biomass boiler. A small oil boiler, or built-in oil burner in the biomass steam boiler would be required to meet the smaller steam loads which would not be met efficiently by the biomass boiler.

A straight-forward moving grate boiler with fire-tube heat exchangers can be used. The range of suppliers of biomass steam boiler equipment is limited below 1MW thermal as economies of scale are diminished below this level – a 650 kW boiler costs almost the same as a 1MW boiler.

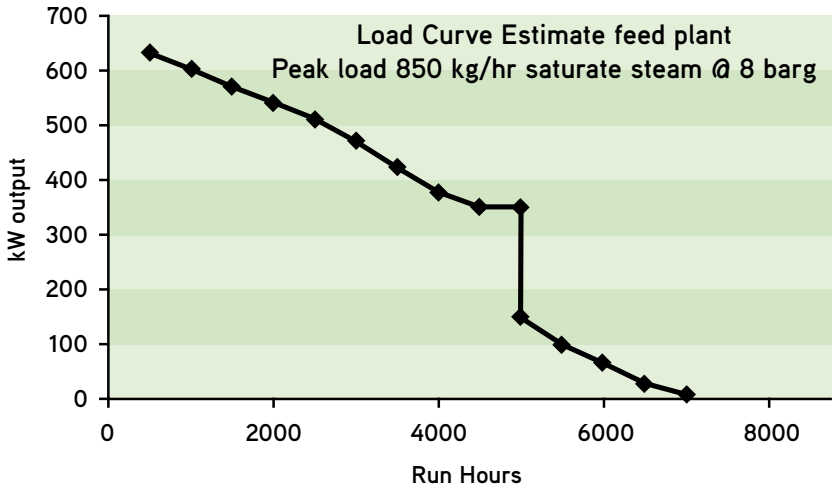
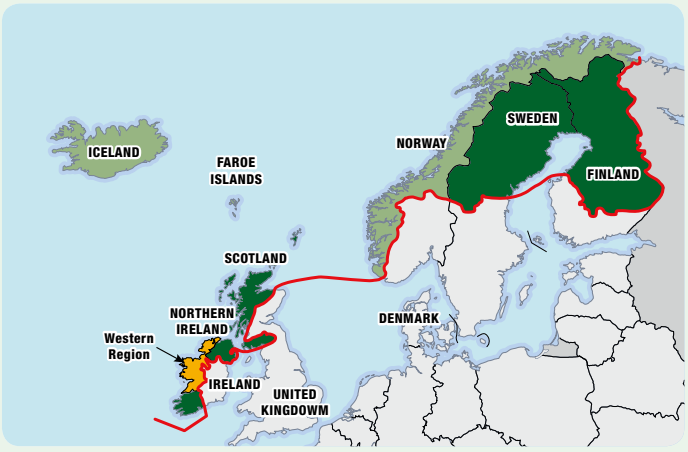


Figure 3: Estimated Steam Demand Animal Feed Pelleting

Key Learnings

- There are a number of manufacturers already using biomass for process steam successfully in Ireland
- Biomass is a viable option for the many package steam boilers currently fired on HFO or other fossil fuels at manufacturing sites around Ireland
- Biomass steam plant is more expensive and complex to install than traditional package fossil fuel steam boilers
- Many sites do not have sufficient load to justify CHP
- The most common and cost-effective technology is a fire-tube boiler with moving grate, suitable for applications of up to 30 MWth
- There is a limited range of providers below 1 MWth capacity
- Many existing boilers are oversized and a lot of work is required to define accurate steam loads



What is RASLRES?

RASLRES (*Regional Approaches to Stimulating Renewable Energy Solutions*) is an EU bioenergy project led by the WDC and funded under the Northern Periphery Programme of INTERREG IVB. The total project budget is €2.8 million over three years. Commencing in September 2009, RASLRES aims to increase the uptake of locally produced bioenergy solutions through the development and implementation of market development models. The project focus is on pilot actions in regard to wood energy, energy crops and marine biomass fuels.

RASLRES is an international partnership which includes:

- Western Development Commission – Ireland
- Action Renewables – Northern Ireland, UK
- Environmental Research Institute, North Highland College – Scotland
- Municipality of Norsjö – Sweden

In the Western Region RASLRES supports the growth of the wood energy sector by delivering practical services to market players and by informing policy development. During 2010 and 2011 RASLRES delivered a range of actions with a focus on selected pilot projects. The project aims to:

- build sustainable local loops of wood fuel supply and demand via new (or existing) wood fueled boilers
- offer best practice approaches to support industry development
- help build critical mass and scale in the wood energy sector of the region
- support investment plans and help secure project finance

RASLRES adopts a full supply chain approach - looking at the energy chain from supply (i.e. fuel producers / processors) to demand (i.e. energy users). The services to the wood energy sector include:

- provision of a range of impartial technical and business advisory support services to selected clients progressing wood energy projects in the region
- generation of market information and intelligence to support the sector e.g. resource forecasting from private sector forestry, assessment of energy crop potential, technical and business case studies
- accessing of international expertise and facilitation of networking with EU markets

RASLRES

For further information contact:

Western Development Commission
Dillon House, Ballaghaderreen, Co. Roscommon.

Tel: +353 (0)94 986 1441 Email: info@wdc.ie

www.wdc.ie

www.raslres.eu

Northern Periphery Programme
2007–2013

Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

WDC
Western Development Commission
Coimisiún Forbartha an Iarthair

NORSJÖ kommun

eri environmental research institute

Action Renewables
the future of energy, today