Warwickshire Biomass Market

Estimates of Wood Fuel Supply and Demand for Thermal Energy

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Information sources

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Acknowledgement

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1 INTRODUCTION

This report estimates the size of the Warwickshire Wood Fuel Biomass market both in terms of the supply of fuel and demand for heating. Four sources of wood fuel are considered: woodland management, tree management, recovered wood from the waste stream and energy crops.

Although the fuel could be used in both thermal and combined heat and power applications only the former, which is most mature market, has been considered. Additionally, the report focuses on non-domestic applications, defined as 15 kW boilers and upwards.

Lastly it is important to note that the volume estimate represent potential fuel sources and not sources that are currently and instantly available.

2 SUPPLY FORECASTS

Biomass wood fuel can come from number of sources within the county:

- Woodland management
- Individual tree management (arboreal activity)
- Recovery of wood fuel from the waste stream – solid recovered fuel (SRF)
- Cultivation of energy crops - for example short rotation coppice (SRC)

Additionally wood fuel could be imported into the county. This is likely to be in the form of wood pellets because of their energy concentration and lower unit transport costs. Imports may be required to satisfy early demand but would not support a sustainable fuel market in the long term.

2.1 Size of Warwickshire woodland

The National Inventory of Woodland and Trees [1] has the following statistics for Warwickshire[2]:

- 11,500 ha of woodland
- 3.5 - 4.7% land cover
- 25% of woodland is under the stewardship of a small group of owners
- 8000 ha is managed by rural hub members
- 4300 ha of woodland is concentrated in wood larger than 0.1ha
- Wood is mainly broadleaved
- Average woodland size is 2.2ha (just under regional average)
- 1.4 million live non-woodland trees
- Nowhere in Warwickshire is more than 2.5km from a woodland
- Many woods are located on small farms

2.2 Wood fuel from woodland management

If we assume that a third of the 11500ha of Warwickshire woodland could be put under active management there would be approximately 4000 ha of woodland available for fuel.

Sustainable extraction rates are roughly 6-8 m^3 per ha per year. A mid point of 7m^3 or 7 green tonnes per ha per year will be assumed.

[1] Forestry Commission 2002.

[2] Additional information from Ewan Calcott, Forestry Commission and Andy Grundy, Heartlands Trust.

After drying each hectare would yield approximately 4 dry tonnes year for broad leaf woodland[3]. The 4000 ha of woodland under management would therefore yield 16000 dry tonnes per year.

We used the following rates to calculate calorific value and boiler capacity:

1. Calorific value of 3.35 MWh per tonne of dry wood chip[4]
2. Boiler efficiency 85%[5]
3. Boiler sizing factor 2654[6]

This gives an annual potential heat output of woodland derived fuel of:

16000x3.35x0.85 = 45560 MWh per year

This fuel could support a total installed boiler capacity of:

45560/2654 = 17 MW

Summary:

- Estimate 11500ha with 4000 ha under management
- Yields 16000 dry tonnes per year
- Potential heat energy of 45600 MWh per year
- Supporting 17 MW of boiler capacity

2.3 Wood fuel from tree management

Tree management covers work on individual trees or groups of trees. This arboreal activity is usually undertaken by tree surgeons. At present waste material arising from this activity is composted or stored.

In order to derive the potential biomass fuel available the Forestry Commission's estimate of non woodland trees has been convert into an equivalent area of woodland and then the procedure used in the previous section applied to derive tonnage, calorific value and boiler capacity.

The Forestry Commission estimated in 2002 that there were 1.4m trees outside of woodlands in Warwickshire[7]. There were a further estimated 38000 dead trees in the county. This can be converted into a equivalent size of woodland using a forest tree density of 480 trees per acre [8] or 200 trees per ha giving an equivalent woodland area of 7000 ha.

If we assume that only one quarter of trees could be managed and assuming a yield of 7 green tonnes per ha per year gives a total yield of:

7000 x 0.25 x 7 = 12250 green tonnes per year

[3] Using a dry to green wood weight ratio of 2.6, source Laughton (2006), p25
[4] Source for 30% moisture content, Andrew Russel of Mercia Energy.
[5] Andrew Russel of Mercia Energy advices that although efficiencies of 90% are achievable in ideal conditions a more pragmatic figure of 85% should be used.
[6] See APPENDIX A – BOILER SIZING
[7] Forestry Commission (2002).
[8] http://www.coloradotrees.org/benefits.htm quoting Raile, G.K. and Leatherberry, E.C., 1988, Illinois forest resource, Resour. Bull. NC-105, USDA Forest Service, North Central Forest Experiment Station, St. Paul, MN, 113 p.

This is the estimate for the quantity of wood arising from tree management.

Halving the green tonnage to derive dry tonnage gives 6125 dry tonnes per year.

Using the rates in the previous section to convert to calorific value and boiler capacity gives an estimate potential heat output from fuel derived from arboreal activity of:

6125x3.35x0.85 = 17440 MWh per year

which could support a total boiler capacity of :

17440/2654 = 6.6 MW

Summary:

- Warwickshire in 2002 had an estimated 1.4 million live trees and 38000 dead trees outside of woodlands.
- This is equivalent to an additional 7000 ha of woodland cover.
- 6100 dry tonnes per year of wood could be recovered.
- Potential heat energy of 17400 MWh per year.
- Supporting 6.6 MW of boiler capacity.

2.4 Estimate of wood in the waste stream

2.4.1 Introduction and approach

No data for wood in the waste stream of Warwickshire was available so figures have been imputed from national data. This national data was obtained from a report by WRAP, Review of Wood Waste Arising and Management in the UK [9] and then proportioned to derive county data on the basis of the ratio of municipal waste for the county against national municipal waste figures.

The margin of error could be significant but should provide some indication of solid recovered fuel available from the waste stream.

There are particular issues in considering the use of wood from the waste stream for fuel:

1) From a sustainability perspective the first choice should be to reuse the wood further up the value chain
2) The wood may be contaminated with metal and plastic and require a further processing step to remove the contaminants

2.4.2 National data

Significant volumes of waste wood are created within the UK. WRAP,[10] identifies 4 main sources of wood waste:

- the municipal waste stream
- furniture
- industrial and commercial waste stream

[9] WRAP (2005)
[10] ibid

- construction and demolition waste stream

The same document quantifies wood waste creation in the UK in million tonnes per year as follows :

Table 1: National estimate of wood in waste stream, mt/yr

	England	Wales	Scotland	NI	Total
MSW	0.9	0.04	0.03	0.09	1.1
Furniture[11]	0.03	0.02	0.02	0.01	0.4
Industry and commerce[12]	3.9	0.2	0.3	0.1	4.5
Construction and demolition	4.1	0.2	0.3	0.04	4.7
Total					10.3

Although the data in the report is from a number of sources, the sources usually refer to years 2003/04. 1.4 mt of the industrial and commercial waste is in the form of packaging.

WRAP provides some information on the final destination of the wood waste which accounts for 10% of the material identified above.

Table 2: National use of waste wood

Final Use	Quantity Mt /yr
Panel board	1.0
Horticultural surfaces	0.1
Animal bedding	0.09
Heat Energy (small scale boilers)	0.2
Heat Energy(MSW incineration)	0.06
Electricity generation (power stations)	no data
Heat Energy (panel board manufacture)	no data
Total	1.5 + ???

Based on this destination data it may be safe to make an assumption that a third of the waste could be available for combustion. Although the priority should always be to reuse and recycle.

2.4.3 Warwickshire data

Scaling factors to derive an estimate for Warwickshire's wood waste were based on data for the municipal waste stream. Warwickshire produces just under 0.3mt of municipal waste per year[13] which represents 1.2% of England's total of 25.5mt[14] . Applying this 1.2% scaling factor to the WRAP wood waste data gives these estimates for wood in Warwickshire's waste stream;

[11] This figure has been extrapolated from the UK total, based on the ratio between country and UK totals for items where country totals are available.
[12] As above
[13] WCC (2005)
[14] DEFRA (2006)

Table 3: Warwickshire waste wood estimate

Source	Warwickshire Estimate(kt/yr)
MSW	10.8
Furniture	0.4
Industry and commerce	46.8
Construction and demolition	49.2
Total	107.2

If we assume one third of the wood could be diverted to combustion this leads to an estimate of 33 kilo tonnes of fuel from waste wood per year generated within the county. Assuming that this solid recovered fuel has the same calorific value as wood chip allows the calculations used in the previous section to be applied giving,

a potential annual heat output from waste wood fuel of:

33000x3.35x0.85 = 93968 MWh per year

supporting a total boiler capacity of:

93968/2654 = 35 MW

2.4.4 Summary

- Wood in Warwickshire's waste stream is estimated at 107 kt per year
- With 33 kt per year available for combustion
- Potential heat energy of 94000 MWh per year
- Supporting 35 MW of boiler capacity

2.5 Biomass crops

Although a first step may be to use fuel from managed woodland there is also the potential for farmers in Warwickshire to grow biomass crops.

The Biomass Task Force Report[15] offers a target of 1million ha of land in the UK that could be put into use for growing non food crops. Proportioning this figure down for Warwickshire based on land area[16] gives a potential figure of 8000 ha which could used to grow energy crops.

The Forestry Commission's yield model[17] offer an approximate average figure of 8 dry tonnes per ha per year for SRC Willow. This rate gives an illustrative potential tonnage of:

8 x 8000 = 64000 dry tonnes per yr for the county

[15] DEFRA (2005), Biomass Task Force Report.
[16] Warwickshire is approximately 0.8% of the land area of the UK
[17] FCR (2003), Biomass Yield Model

Applying the same calculations as above to derive potential heat energy and boiler capacity gives a potential annual heat output of:

64000x3.35x0.85 = 182240 MWh per year

supporting a total boiler capacity of:

207360/2654 = 69 MW

Summary

- Estimated dry tonnage of biomass crops for Warwickshire 64000 t per year
- Potential heat energy of 182200 MWh per year
- Supporting 69 MW of boiler capacity

2.6 Summary of Supply Potential

This table summarises the potential biomass supply in Warwickshire from the 4 sources analysed above.

Table 4. Summary of Warwickshire Biomass Potential

	Potential Quantity of Source Biomass	Potential Yield in dry kt /yr	Thermal value GWh /yr	Boiler capacity MW
Woodland management Woodland 0.1 ha and over	11500 ha, 4000 ha managed	16	45.6	17
Arboreal activity on non woodland trees	1.4 million trees, 7000 ha woodland equivalent	6.1	17.4	7
Wood in waste stream	107 kt per year	33	94.0	35
Energy crops	8000 ha	64	182.2	69
TOTAL		119	339.2	128

If fuel is valued at a conservative 2pp KWh (£20 per MWh, £20000 per GWh) this would value the fuel supply market at approximately £6.8 m per year.

3 DEMAND FORECAST

3.1 Potential Size of the Market in Warwickshire

The Warwickshire Climate Change Strategy[18] reports 2450 GWh of gas sales to 4000 industrial

[18] WCC(2005). Climate Change Strategy Baseline Data.

and commercial clients in 2003. Assuming half of the gas is used for space heating and using the boiler capacity factor of 2654 derived in APPENDIX A – BOILER SIZING gives:

1225 GWh / 2654 = 460 MW of heating capacity required.

This figure then needs to be further reduced, as not all sites will be suitable for a biomass installation. However as the development of wood pellet fuel supply increases more urban sites may become suitable for biomass boilers. We will assume that half of the sites will be suitable for biomass leading to figures for heat demand of 612 GWh per year and boiler capacity of 230 MW respectively.

The potential market can be valued by taking an average project cost of £600 per kW giving a total market value of £138 m.

Summary:

- Potential thermal energy demand from biomass of 612 GWh per year
- Potential required boiler capacity 230 MW
- Biomass boiler market £138 m

3.2 Current boiler market in Warwickshire

This table below gives the current boiler market for Warwickshire. This includes projects that are known to the Warwickshire Biomass Steering Group and may exclude some commercially confidential projects. Some CHP schemes are also included.

Table 5: Current Warwickshire Biomass Projects

Wood Fuel Boiler Projects	Quantity	Total Rating kW
Projects operational or on order	5	610
Projects in progress – at least a feasibility study completed	19	3950 thermal + 6900 power
Known opportunities	23	

This small portfolio illustrates that difference between the market potential identified above and the current biomass boiler capacity in the county. It is estimated that only 0.1% of the market potential has currently been realised with a further 1% of the potential under review.

4 CONCLUSION

A rough estimate of the potential wood biomass fuel supply in Warwickshire suggests that approximately 339 GWh per year or 128 MW of thermal boiler capacity could be supported. The fuel market is valued at £6.8m per year.

An equally rough estimate of the requirement for commercial thermal energy that could be met with biomass is 610 GWh per year or 230 MW of boiler capacity. This represents a market valued at £138m.

Currently the known projects in the county account for less than 1% of the potential supply or demand.

Projects that have been realised are less than 0.1 % this potential.

5 REFERENCES

The following documents are referenced:

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WRAP, 2005. *Review of Wood Waste Arising and Management*. Online document WOO0041Final_summary_report.79f20229.pdf at http://www.wrap.org.uk/document.rm?id=3559

APPENDIX A – BOILER SIZING

In order to provide an estimate of the capacity of boilers that could be supported on a county wide basis from the supply/demand estimates a rule of thumb is required to convert heating demand into boiler capacity. This is termed the "boiler size ratio".

The size of boiler required to deliver a particular heating demand varies according to the pattern of demand of the installation. A number of public domain case studies were reviewed and the boiler size ratio calculated from the continuous hourly output and the maximum capacity rating (MCR) quoted for the boiler.

		Annual thermal reqt	Continuous hourly output	MCR quoted for boiler	Boiler size ratio
		MWh/yr	kW	kW	
RSPB Dearne Valley		175	20.5	100	4.9
Callow Place, Sheffield		2100	245.8	500	2.0
Cirencester Organic Farm Shop		31.25	3.7	25	6.8
Worcester CC		1150	134.6	700	5.2
Kingsbury Water Park		150	17.6	80	4.6
Oakley Wood Crematorium		170	19.9	60	3.0
The Museum, Warwick		250	29.3	60	2.1
St Johns Museum, Warwick		275	32.2	60	1.9
Moreton Hall		550	64.4	220	3.4
Tannery Court		580	67.9	150	2.2
Bedworth Civic Hall		715	83.7	150	1.8
Arden Hall		736	86.1	150	1.7
			Average size ratio		3.3

The average boiler size ratio from this sample was 3.3

To convert annual heat potential or requirement into boiler capacity (ie energy to power) the following calculation will be applied:

3.3 x annual thermal energy / (365 x 24)
= annual thermal en ergy / 2654

The data for this table was provided by Econergy Ltd and the Biomass feasibility studies for Warwickshire's public buildings funded by Energy West Midlands.