South Devon Woodfuel Study

Final Report
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Executive Summary

1. Introduction

With the second highest area of woodland across the English regions, the South West has excellent potential for woodfuel production and has already established a significant woodfuel supply infrastructure, which in early 2011 provided fuel to around 482 installations in the region totalling 56MW. With Devon having the largest proportion of this capacity of all South West counties, there now exists a significant opportunity to further expand the woodfuel sector by stimulating local demand and by facilitating a more localised assessment of the woodfuel resource.

To explore the opportunities available in South Devon, Energy Action Devon commissioned the Centre for Sustainable Energy and Crops for Energy to undertake a study looking at the supply and use of woodfuel in the South Devon Coastal Local Action Group area. The main aim of this study was to assess supply and demand of woody biomass in the area with a view to developing a woodfuel hub or depot to source, process and supply woodfuel to a range of markets across the domestic, business, public and community sectors. This report presents the findings of the study, which was funded by the South Devon Coastal Local Action Group.

2. Woodfuel supply

The study found that existing woodfuel supply chains in Devon and the South West are relatively advanced with several supply depots and suppliers distributed across the region. Currently forestry-derived supplies are therefore reasonably abundant, with a proportion of existing feedstocks in and around the study area likely to be drawn into woodfuel production through the stimulus of new woodfuel demand regardless of any new supply-side initiatives.

The main woodfuel technical resource annual arisings in the study area (in oven-dry tonnes) has been estimated as being 7,622 tonnes from woodland management and over 50,000 tonnes from mixed waste wood arisings, although only a small proportion of waste wood is likely to be developed into woodfuel as it will comprise mixed clean and contaminated sources and currently goes to non-fuel end uses. The theoretical energy crop resource was identified as 479,955 and 329,280 tonnes from miscanthus or SRC respectively, although again only a small proportion is likely to be developed due to barriers around competing land use and land-owner engagement.

Other sources of woodfuel that could be exploited include major road verges, hedgerows, field boundaries on minor roads, railway verges and coastal area, although there are specific challenges in accessing these resources. Another option for increasing biomass supply would be to plant trees or energy crops on restored landfill sites. This is becoming common practice amongst waste services companies.

Woodfuel from energy crops has lower quality but can be produced more cheaply than other sources as long as good land is used and best practice is adhered to. Small plantings of energy crops produce sufficient fuel for small – large buildings. A farm may require only 2 ha of SRC whilst a secondary school would require 10 ha.

3. Woodfuel demand

The study identified that Devon has a high proportion of woodfuel heating installations compared to elsewhere in the South West and the UK, which will facilitate further expansion of the sector and benefit the development of a woodfuel hub in terms of feedstock supply chains and the woodfuel market. The South Devon study area is likely to see woodfuel heating projects coming forward that are generally smaller in size than the South West and UK averages as a relatively high proportion of installations will take place in off-gas domestic properties and farms. There will therefore be a need for logs and pellets as well as woodchips.

A number of biomass energy support mechanisms have helped to stimulate the sector over the last decade. The recent launch of Phase 1 of the Renewable Heat Incentive scheme is set to significantly boost the uptake of woodfuel installations over the next few years; this is particularly true if domestic installations become eligible during Phase 2 in 2013.

A useful tool to help identify heat loads within a local community is the National Heat Map[1], developed by CSE and launched by the Department of Energy and Climate Change in March 2012. A preliminary analysis of the South Devon area shows there are relatively few areas of high heat density where district heating schemes may hold potential.

Heat demand from larger new development sites represents an opportunity for woodfuel through requirements to achieve challenging emission targets from tightening Building Regulations and local policies on sustainable construction. The most likely applications include non-residential single buildings/sites such as schools, public buildings, large estate properties and factories, and district heating networks which supply multiple buildings including both residential and non-residential uses;

4. Woodfuel hub options for South Devon

A sensible approach in identifying potential sites for a new South Devon woodfuel hub would be to first consider sites which already host some form of woodfuel-related activity or have existing facilities which may be easily adapted to woodfuel processing. Key criteria for a hub includes ensuring there is sufficient space to incorporate suitable layouts for a woodfuel storage barn, outside woodfuel/bi-product storage and processing areas with hard standing, space for a site office, parking and unloading/loading, and equipment storage. The site should also have good transport links and be located with due regard to the feedstock resources in the local area i.e. located within a good capture radius of known wood arisings. The site selection process should also pay due regard to matching feedstock types with woodfuel products and the associated quality assurance and standards.

Another key requirement for establishing a new site will be to ensure that there is sufficient woodfuel demand in the area to make the project financially viable. Viability may also be improved if there exists an opportunity to operate a woodfuel heat facility on the site to supply low carbon heat to nearby buildings, and/or to supply on-site wood drying processes.

It is likely that a woodfuel hub in the study area would operate at a relatively small scale. In order to increase the likelihood of maximising feedstock capture across the study area, a number of woodfuel hubs would need to be set up with a good geographical spread. Conversely it might be more cost effective to site a single hub near the source of greatest production. However, the woodfuel market in the hub locality will again be an additional factor to consider.

The ownership and operational arrangements of a woodfuel hub also need to be considered. In particular, community groups pursuing a new woodfuel initiative may wish to identify the most suitable organisational legal structure under which to operate. In any case, high priority should be given to early consultation with stakeholders to ensure that the community is kept informed and that their views are considered;

The Torr Quarry Industrial Estate north of Kingsbridge is an example of a potential hub site worthy of further investigation. Although on-site heat loads are thought to be relatively small, the site has been flagged as having sufficient space and good accessibility to act as a woodfuel hub.

[1] http://ceo.decc.gov.uk/nationalheatmap/

5. Recommendations

a) Woodfuel hub – next steps

- Using this report as a reference, a dialogue should be started with stakeholders in the area to draw on local knowledge and help identify further candidate sites for a woodfuel hub;
- For each potential site, local heat markets should be identified and the potential for localised woodfuel demand established. The financial benefits of the Renewable Heat Incentive scheme should be demonstrated and publicised to the local community to attract potential customers;
- Economic viability and operational requirements of the hub should then be examined in more detail;
- Stakeholders should then be consulted to help reach a consensus on the option to take forward;
- Options should then be explored for project partners and/or a community group legal entity and a business model developed.

b) Encouraging woodfuel supply and demand in South Devon

- Woodfuel technologies should be publicised and demonstrated to communities across the study area along with the financial benefits of the Renewable Heat Incentive scheme. Areas on which to focus include off-gas communities, developers, planners and architects;
- Farmers should be encouraged to look at the potential for growing and using energy crops for heating their own farm businesses. Similarly woodland owners should be approached and made fully aware of the benefits of woodfuel production for own use or to sell on;
- Further investigations on district heating opportunities should be undertaken using the National Heat Map to examine specific sites and by on-the-ground surveys. Additionally, the woodfuel resources identified in this study can be assessed spatially in relation to identified heat loads to look at opportunities for woodfuel heating plant. Similarly the potential for wood-fired district heating schemes within larger scale new development as identified through South Hams Council adopted site allocations should be assessed in relation to complimentary existing heat loads and local woodfuel supplies;
- An interactive map of contractors could be produced showing woodfuel infrastructure across the local area[2] – this could enable new entrants to use the services of these local contractors rather than buying new chippers/log processors;
- Stakeholders such as South Hams Council, Devon CC, Highways Agency, National Trust etc should be engaged about the potential for acquiring woodfuel from roadside verges, coastal areas etc;
- Devon County Council Estates Team could be approached to look into the possibility of growing small parcels of energy crops on County Farms in order to self supply and provide fuel for local authority buildings;
- Waste management companies and waste authorities could be approached to explore the potential to establish energy crops on reclaimed landfill sites, and to assess how clean wood waste could be diverted for use as fuel;
- Opportunities for growing energy crops (particularly SRC willow) in riparian zones should be explored to gain the multiple benefits of reduction in N pollution, reduction of soil erosion and soil stabilisation, and flood reduction etc;
- Funding opportunities should be explored to invest in energy crop infrastructure. SRC requires planting and harvesting machinery whilst miscanthus requires densification machinery e.g. pelleting facilities.

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[2] A regional supplier search and map facility is currently available at www.southwestwoodshed.co.uk

1 Introduction

1.1 Background

With a notable increase over the last few years in the use of woodfuel as a sustainable energy resource, more people are starting to realise that they have a valuable asset on their hands. This is particularly true now that the Government has launched the Renewable Heat Incentive (RHI), which pays a guaranteed income related to the amount of heat energy produced and thus in most cases significantly improves the economic viability of renewable heating systems. DECC's UK Renewable Energy Roadmap (2011) suggests that this incentive could deliver up to an additional 24,000 biomass heat installations by 2020. Such initiatives are a result of the Government's commitment to source 15% of the total UK energy demand in 2020 from renewable energy, with renewable heat possibly contributing some 12% towards total UK heat use.[3]

With the second highest area of woodland across the English regions, the South West has excellent potential for woodfuel production and has already established a significant woodfuel supply infrastructure, which in early 2011 provided fuel to around 482 installations in the region totalling 56MW[4]. With Devon having the largest proportion of this capacity of all South West counties, there now exists a significant opportunity to further expand the woodfuel sector by stimulating local demand and by facilitating a more localised assessment of the woodfuel resource.

To explore the opportunities available in South Devon, Energy Action Devon has commissioned the Centre for Sustainable Energy and Crops for Energy[5] to undertake a study looking at the supply and use of woodfuel in the South Devon Coastal Local Action Group area (shown in Figure 1). This report presents the findings of the study, which was funded by the South Devon Coastal Local Action Group.

1.2 Study objectives

The main aim of the study has been to look at matching supply and demand of woody biomass in the area with a view to developing a woodfuel hub or depot to source, process and supply woodfuel to a range of markets across the domestic, business, public and community sectors. Specifically, the study objectives comprise the following elements:

1. **Woodfuel supply**: assessing the woodfuel resource in the study area to include arboricultural and sawmill arisings, waste timber, woodland/farm management residues and energy crops;

2. **Woodfuel demand**: assessing the potential demand for woodfuel in and around the study area by considering potential end users such as new housing developments and existing heat demand;

3. **Woodfuel hub options**: identify opportunities to match woodfuel supply and demand, including a potential site (or sites) to establish a woodfuel hub (and the key criteria for its development and operation) that could accept and process various types of woody feedstock into quality assured woodfuel for a range of end users.

[3] UK Renewable Energy Strategy (2009)
[4] Renewable Energy Progress Report: South West 2011 Annual Survey; RegenSW; March 2011
[5] www.crops4energy.co.uk

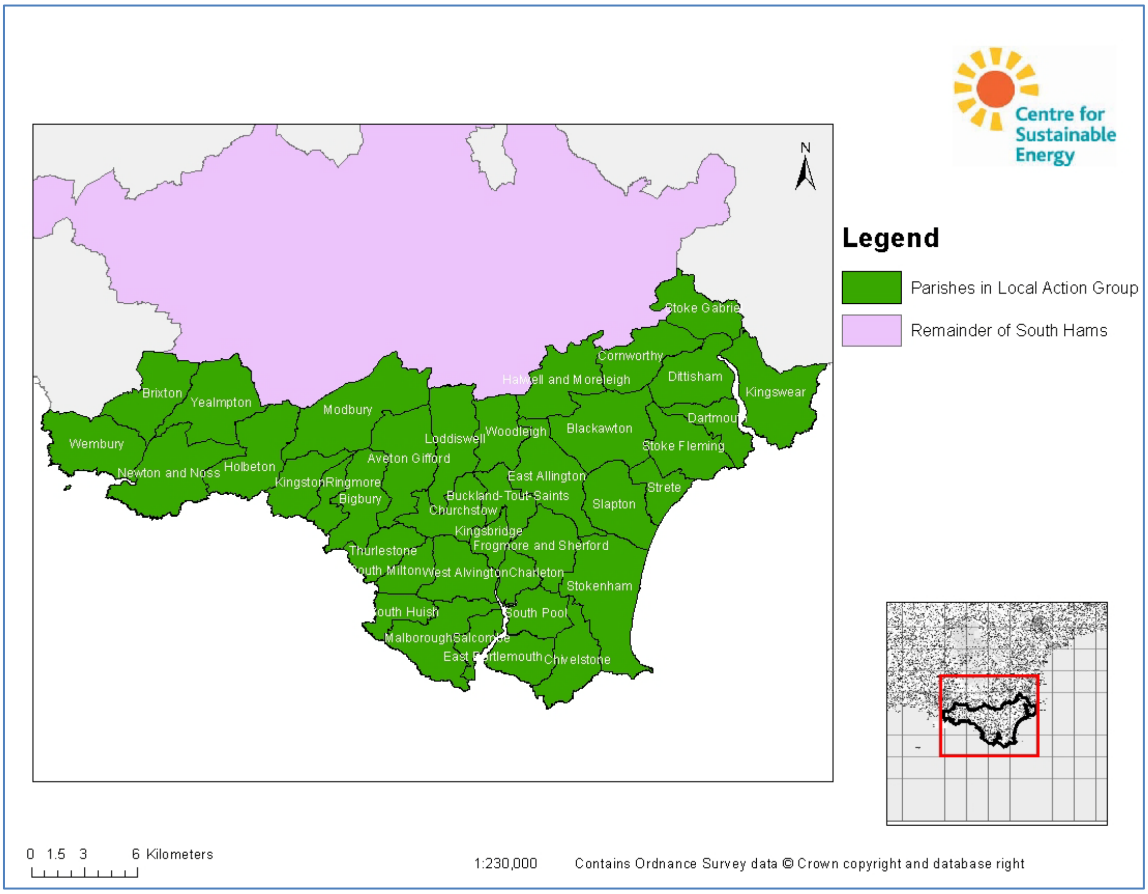

Figure 1: Map of study area (defined by the South Devon Coastal Local Action Group)

2 Woodfuel supply

2.1 Types of feedstock

The types of woodfuel considered in this study draw on a variety of feedstocks that come in various forms and from various sources. Three broad categories are included:

1. Forestry and tree management – which considers 'green' or virgin wood residues which may be available from woodland/forest management or from the arboricultural management of parks or street trees;
2. Energy crops – such as miscanthus and Short Rotation Coppice (SRC); and lastly
3. Waste wood arisings – consisting of clean, untreated material and that which is contaminated with paint, preservative, fixings and other foreign materials.

Whilst clean waste wood can potentially be sourced directly from saw mills, carpenters, joineries etc, a large proportion of this resource will be mixed with contaminated material in mainstream commercial and municipal solid waste streams. Due to pollution and air quality concerns contaminated waste wood is generally not suitable to be used in small or medium scale boiler installations due to the lack of suitable exhaust gas clean-up equipment; these clean-up systems are costly and tend to be viable on large scale plant only. Additionally, the RHI imposes certain eligibility criteria on the sustainability of solid biomass sources and air quality impacts of biomass plant. The focus of this element of the resource assessment was therefore placed on clean untreated wood waste as this resource is considered to be more relevant to the study area.

2.2 Forestry and tree management

2.2.1 Woodland resource

The technically available resource from sustainable management of woodland can be assessed by calculating the total area of woodland in the study area and using assumptions about the yield that can potentially be obtained. Two Forestry Commission datasets have been used for this analysis. The National Inventory of Woodland and Trees[6] (NIWT) is produced by using satellite images to identify and classify areas of woodland[7]. It classifies areas of woodland into the following categories:

- Broadleaved
- Coniferous
- Coppice
- Coppice with standards
- Mixed
- Shrub
- Young trees
- Felled
- Ground prepared for planting

The Forestry Commission has recently updated this dataset with the National Forest Inventory (NFI)[8]. This dataset adds some additional areas to the NIWT but does not classify them into woodland types. As the NIWT dataset provides more information about the woodland type, this has been used as the main dataset, with additional information being obtained from the NFI. Felled areas, shrub and young trees are excluded because they will not provide woodfuel. They have been mentioned here because they are in the NIWT, and because felled areas may be replanted in the future, while young trees will mature over time into a viable resource. Figure 2 shows areas of woodland as mapped for the study area. Larger resolution maps are included in Appendix 2.

[6] http://www.forestry.gov.uk/forestry/HCOU-54PG9U, data available from http://www.forestry.gov.uk/datadownload
[7] This means that there are occasional errors where patches in photographs have been erroneously identified.
[8] More information available from www.forestry.gov.uk/forestry/infd-8eyjwf

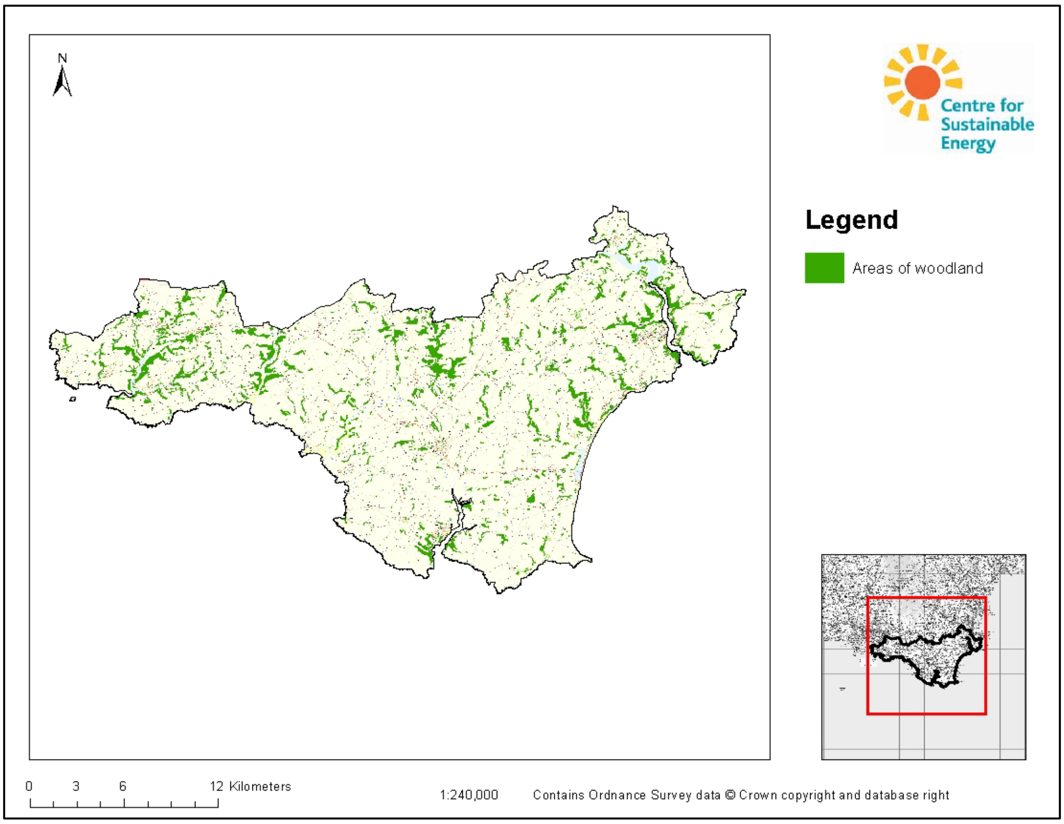

Figure 2: Areas of woodland in the study area

Using the GIS data behind the above maps, the technically available resource by woodland category is shown in Table 1 below. This estimates the annual tonnage of wood and its delivered heat potential – this has been assessed by using assumptions about the sustainable yield that can be obtained, heating plant efficiency and the energy content of wood. It is likely however that a significant proportion of this resource is already being utilised for the woodfuel requirements of domestic log stoves and open fires (see Section 2.7.1).

Type	Area (hectares)	Estimated yield (oven-dry tonnes/yr)	Delivered heat potential [MWh/yr]
Broadleaved	2,182	4,364	19,553
Coniferous	311	622	2,787
Felled	25	50	224
Mixed	108	216	968
Shrub	53	106	475
Young trees	172	344	1,541
Woodland (not specified)	1,210	2,420	10,843
Total	**4,061**	**8,122**	**36,391**
Total excl. felled, shrub and young trees	**3,811**	**7,622**	**34,150**

Table 1: Woodland area and yields in study area by category

Assumptions:

- As the large majority of woodland is of the broadleaved type, a yield factor of 2 oven-dry tonnes per hectare per year is used with an energy content of 5,150 kWh/tonne (source: www.biomassenergycentre.org.uk). Average heating system efficiency = 87%;
- 7,622 oven-dry tonnes would be approximately equivalent to 9,528 tonnes of air dried logs (at 20% MC) or 10,888 tonnes of wood chip at 35% MC.

As woodfuel is often transported some distance from source to end-user, the same analysis was undertaken for an area with a radius of 40km outside of the study area and the results are shown in Figure 3 and Table 2 below. Note - these figures are additional to those in Table 1 i.e. they exclude the resource in the study area.

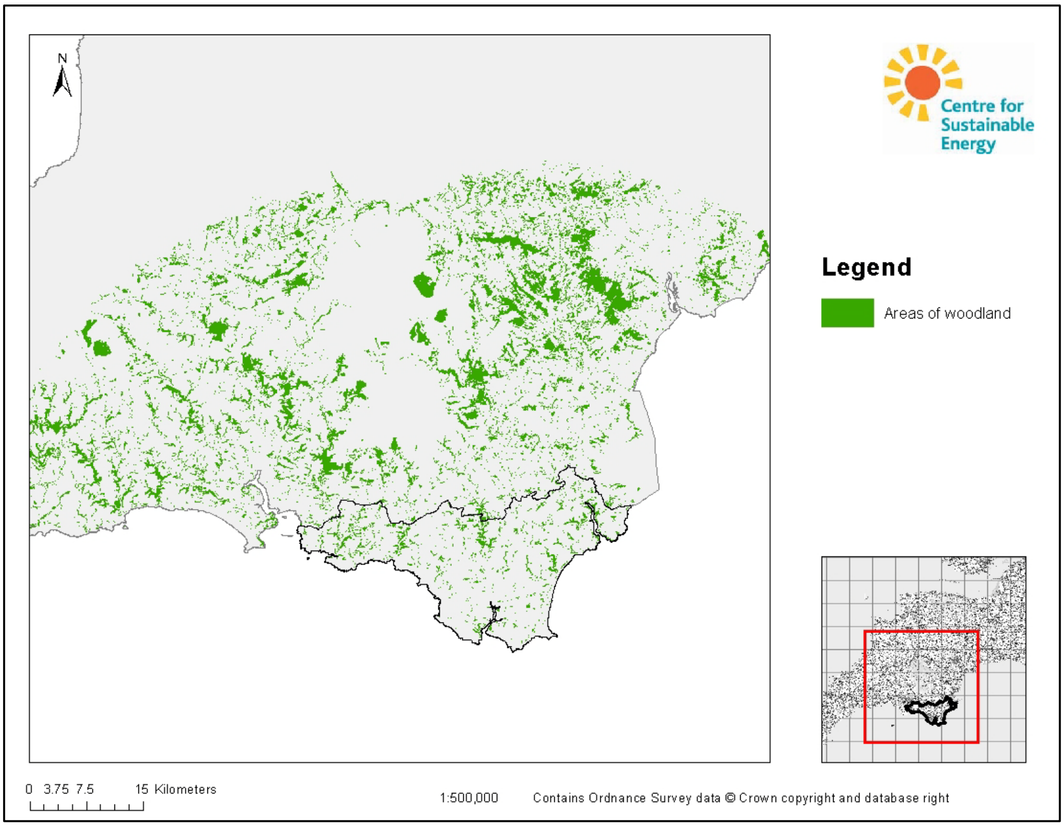

Figure 3: Areas of woodland in 40km radius from study area

Type	Area (hectares)	Estimated yield (tonnes/yr)[a]	Delivered heat potential [MWh/yr][b]
Broadleaved	19,448	38,896	174,274
Coniferous	9,705	19,410	86,967
Coppice	44	88	394
Felled	1,642	3,284	14,714
Mixed	4,720	9,440	42,296
Shrub	256	512	2,294
Young trees	1,822	3,644	16,327
Woodland (not specified)	10,074	20,148	90,273
Total	**47,711**	**95,422**	**427,538**
Total excl. felled, shrub and young trees	**43,991**	**87,982**	**394,203**

Table 2: Woodland area and yields within 40km radius of study area (excluding resource in study area)

Assumptions:

- As the large majority of woodland is of the broadleaved type, a yield factor of 2 oven-dry tonnes per hectare per year is used with an energy content of 5,150 kWh/tonne (source: www.biomassenergycentre.org.uk). Average heating system efficiency = 87%;
- 87,982 oven-dry tonnes would be approximately equivalent to 109,980 tonnes of air dried logs (at 20% MC) or 125,683 tonnes of wood chip at 35% MC.

2.2.2 Arboricultural arisings

Around ten arboricultural businesses were identified in the area, with only two responding to calls and emails. The quantities are outlined in the table below and at present all arisings have an end use, although both contractors currently dispose of the majority of this at places that will accept the arisings for no fee. It seems that unless a local woodfuel hub was more convenient than their current disposal routes, the businesses would need some financial incentive to change their practices.

Company name	Location	Annual quantity of wood produced	Existing selling/disposal practice
H2 Environmental	Kingsbridge	20 tonnes, mostly green waste	Recycled into compost
Broadleaf Tree Surgery	Plymouth	50 tonnes chip; 10 tonnes logs	Chips given to garden centre; logs used amongst family/friends

Table 3: Responses from arboricultural contractor survey

2.3 Energy crops

The two main energy crops considered here are Short Rotation Coppice (SRC) e.g. willow and miscanthus.
Both energy crops have pros and cons. Miscanthus cultivation uses existing machinery, typically produces higher yields, is harvested annually and the fuel product is relatively dry when cut. However, it is more expensive to establish (around £2,500 per hectare). SRC willow is easier and cheaper to establish (£2,000 per hectare), is better for biodiversity and suitable for a wider range of boilers. However, it requires specialist machinery, is harvested every three years, and produces a wetter fuel (50-60% moisture) that needs to dry before it can be used. Both crops have similar lead in times with around 4 years until they produce commercial harvests. Miscanthus will reach its peak yield in year 5 and SRC will achieve its peak yield in the second rotation which is harvested in year 7.

Recently the Forestry Commission engaged in a national trial of fast growing exotic and native trees managed as short rotation forestry (SRF). One of these trials has been planted on the Dartington Estate. SRF involves growing single stemmed trees which are harvested after 8-15 years. Felled plantations are then restocked with new saplings. Broadleaved coppice offers another alternative involving growing native trees and harvesting after 15-20 years. After each tree is cut down to ground level it will produce many shoots.

2.3.1 Mapped resource

The total technical potential resource for energy crops is often assessed by looking at the total amount of suitable agricultural land within the study area. A broad assumption is that energy crops can be grown on agricultural land of grades 1-3 (arable land) but with constraints applied to exclude areas of agricultural land where energy crops are unlikely to be grown such as certain types of permanent pasture and moorland, public rights of way, woodland, historic parks and gardens and for miscanthus, exposed areas with high average wind speeds. Resource assessments should also bear in mind that for a given land area miscanthus has a higher yield tonnage than SRC; this is typically 15 odt/hectare (oven-dried tonnes) for the former and 10 odt/hectare for the latter. Exotic trees such as *Eucalyptus nitens* grown as SRF can achieve similar yields to miscanthus (12-15 odt/ha/yr)[9]. Native trees grown as SRF or broadleaved coppice have much lower yields (2-7 odt/ha/yr)[10].

Using the above assumptions, the technical energy crops resource for the study area was mapped and the results are shown in Figure 4 and Table 4 below. Larger resolution maps are included in Appendix 3.

[9] A Review of the Potential Impacts of Short Rotation Forestry. February 2006. P D Hardcastle, LTS. www.forestry.gov.uk/pdf/SRFFinalreport27Feb.pdf/$FILE/SRFFinalreport27Feb.pdf .
[10] Establishment and management of broadleaved coppiced plantations for energy. www.biomassenergycentre.org.uk/pls/portal/docs/PAGE/RESOURCES/REF_LIB_RES/PUBLICATIONS/GUIDANCE/BROADLEAVED%20COPPICE%20GUIDE%20REVISION%20020309.PDF

Clearly this is a very 'broad brush' theoretical assessment intended to illustrate the potential and many other factors not considered here will influence whether energy crops will be viable for a particular area. These include issues such as economic viability, end-use of energy crops, land ownership, existing farming activities, potential biodiversity impacts, protected landscapes and the presence of water-stressed areas.

In reality only a very small proportion of this technical resource would be developed. However, with the Common Agricultural Policy (CAP) currently under revision for the period 2014-2020, there is a suggestion that new measures will include a 7% ecological focus area on each farm holding. This aims to take out several million hectares of arable land out of production. The European Biomass Association (AEBIOM) and the UK National Farmers Union are lobbying for perennial energy crops to be eligible for planting within this 7% area and their argument is based on the fact that SRC, miscanthus and SRF are multifunctional crops that help to improve water quality, enhance biodiversity, prevent erosion and mitigate climate change compared to traditional annual crops.

If we assume that this measure is adopted and that 50% of farmers in the study area choose to grow miscanthus or SRC on 7% of their land then annual yields would be in the order of 16,800 tonnes/yr for miscanthus or 11,525 tonnes/yr for SRC. Taking the SRC yield, for example, would equate to around 59,354 MWh/yr, which is the equivalent of supplying the annual heat demands of around 3,142 typical homes.[11]

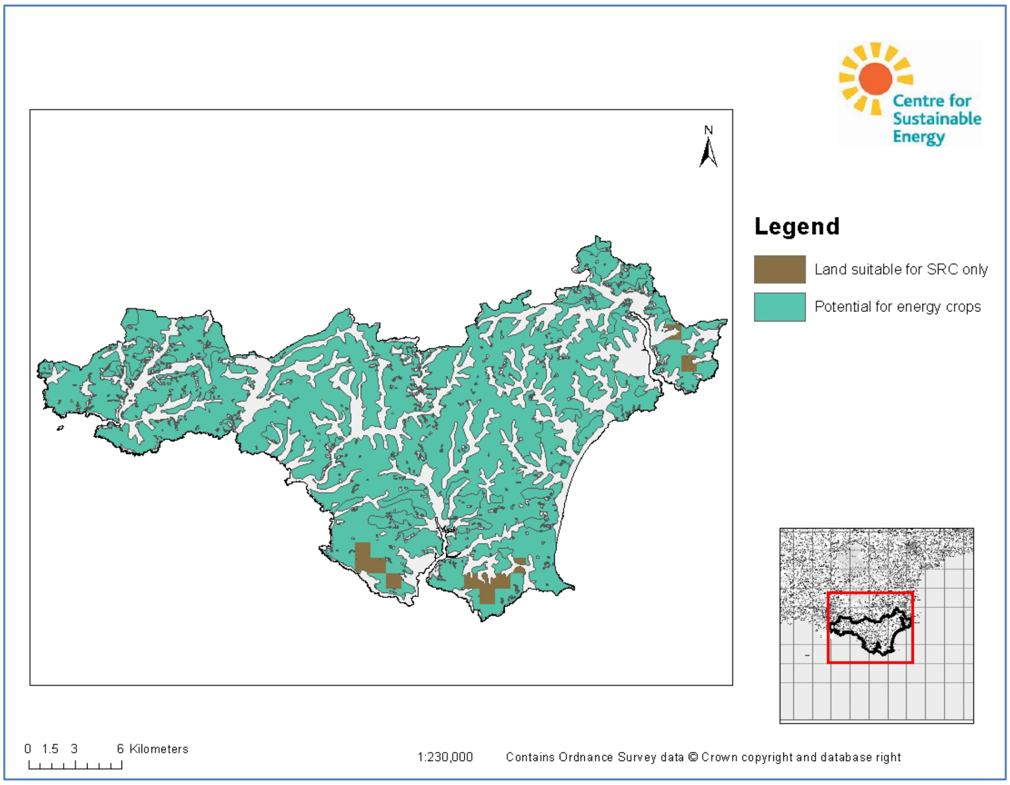

Figure 4: Energy crop technical resource in study area

[11] Assumes a boiler efficiency of 90% and annual heat demand of 17,000 kWh/yr

	Miscanthus			SRC		
Agricultural Land Classification	**Area (hectares)**	**Estimated yield (dry tonnes/yr)**	**Delivered heat potential [MWh/yr]**	**Area (hectares)**	**Estimated yield (dry tonnes/yr)**	**Delivered heat potential [MWh/yr]**
Grade 1	0	0	0	0	0	0
Grade 2	31,997	479,955	2,471,768	32,928	329,280	1,695,792
Grade 3						

Table 4: Technical energy crop resource in study area in terms of area available, yield and potential delivered heat

Assumptions:

- Assumed yields of 15 and 10 dry tonnes/hectare per year for miscanthus and SRC respectively. Figures assume total suitable area is planted out with either miscanthus or SRC
- Total area for miscanthus excludes locations having an average annual wind speed of >7m/s, i.e. exposed areas where miscanthus is assumed to be unsuitable

2.3.2 Devon Miscanthus and Woodfuels Opportunities Statement

A 2007 study by CSE entitled '*Devon Miscanthus and Woodfuels Opportunities Statement*'[12] considered the geographical potential for, and constraints on, the cultivation of miscanthus and SRC willow in the county of Devon, along with the opportunities for using arisings from existing woodlands as an energy source. A key output from this work included the identification of areas of Devon within which priority might be given to coupling local production and consumption of heating fuels derived from energy crops. The analysis considered three factors: level of domestic demand for heat within Devon wards; access and lack of access to mains gas supply within Devon census output areas; and risk of fuel poverty as given by the Fuel Poverty Indicator, again on a census output area basis.

It can be seen from the figures below that three 'Priority Areas' were identified (3, 6 and 16) within the South Devon study area. Table 5 shows the estimated resource specific to each area.

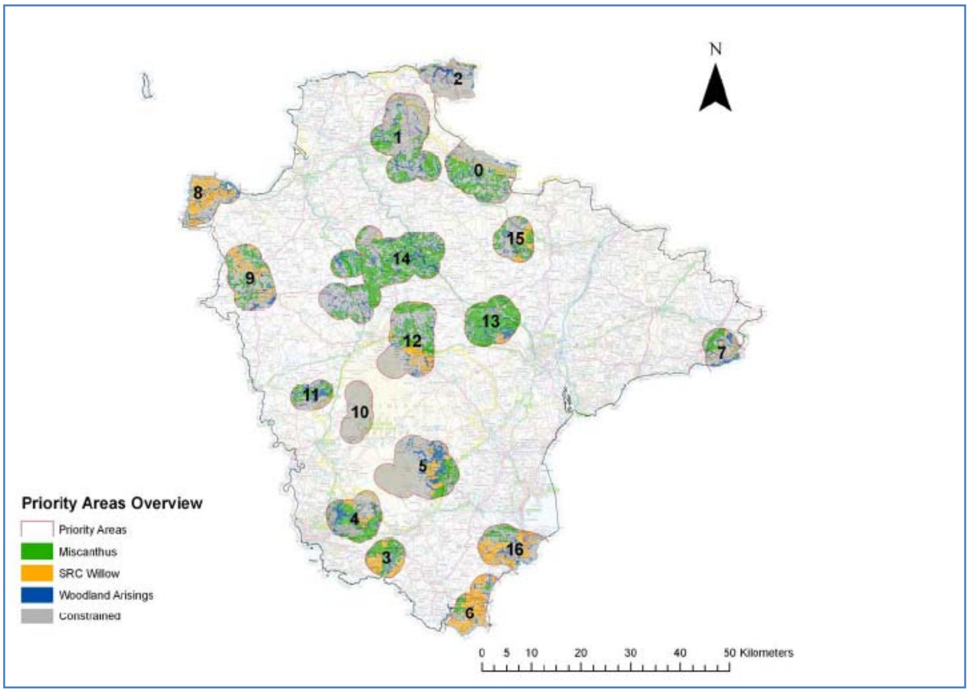

Figure 5: Priority Areas across Devon (Fig 30 from Devon Miscanthus and Woodfuels Opportunities Statement)

[12] www.cse.org.uk/downloads/file/Devon%20Biomass%20and%20Woodfuels%20Statement%20(low%20res%20images).pdf

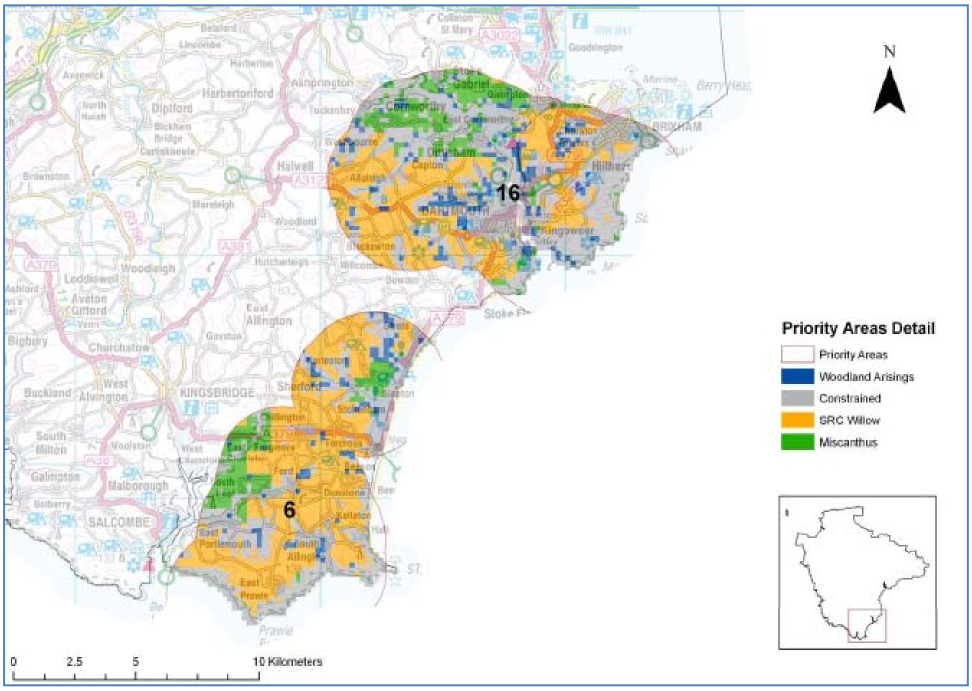

Figure 6: Priority Areas detail (6 and 16) in study area (Fig 35 from Devon Miscanthus and Woodfuels Opportunities Statement)

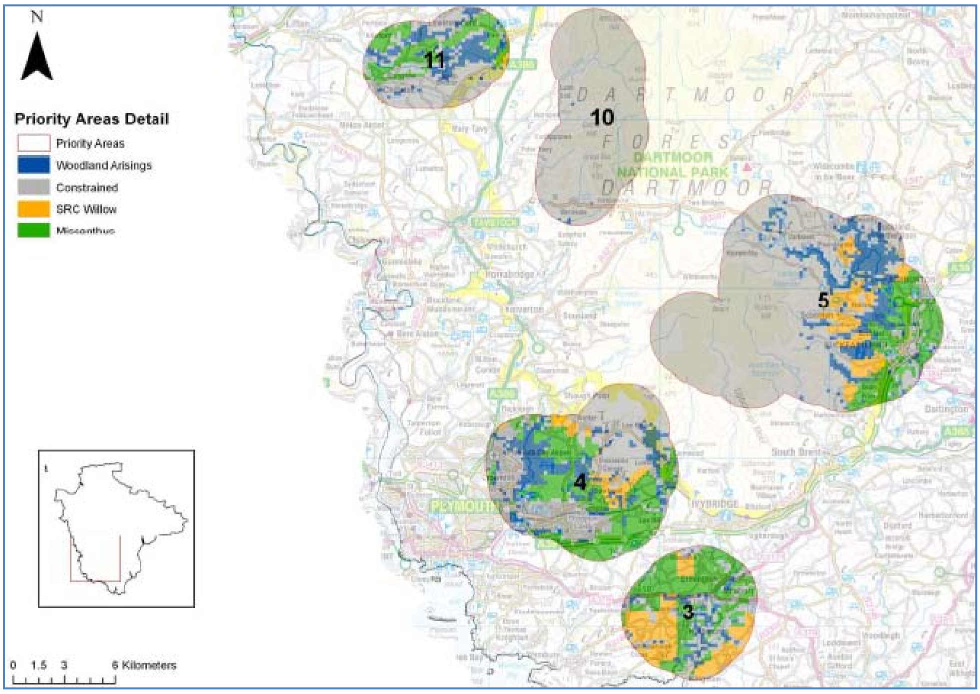

Figure 7: Priority Areas detail (3) in study area (Fig 33 from Devon Miscanthus and Woodfuels Opportunities Statement)

Priority Area	Yields (dry tonnes per year and GWh heat per year)						
	Woodland arisings		SRC Willow		Miscanthus		Total
	tonnes	GWh heat	tonnes	GWh heat	tonnes	GWh heat	GWh heat
3	888	4.9	11,528	53.8	37,369	178.0	236.7
6	720	4.0	30,384	141.8	13,562	64.6	210.3
16	1,456	8.0	23,680	110.5	18,912	90.1	208.6
Total	**3,064**	**16.9**	**65,592**	**306.1**	**69,843**	**332.7**	**655.6**

Table 5: Potential yields from energy crops in priority areas (extract from Table 16 of Devon Miscanthus and Woodfuels Opportunities Statement) . Note – assumptions regarding the resource assessments for this study in some cases differ from those taken in this report e.g. in estimating yields a preference was assumed for miscanthus due to its higher yields.

2.3.3 Landscape character

DEFRA have evaluated the suitability of English regions to incorporate energy crops into different landscape types. The South Devon study area falls under Joint Character Areas (JCA) No. 151.

DEFRA's 'Opportunities and optimum sitings for energy crops within the study area' states[13]:

> *"South Devon is a dissected coastal plateau landscape where steep wooded valleys separate rounded hills. Much of the area is included in the South Devon Area of Outstanding Natural Beauty.*
>
> *Both SRC and Miscanthus could potentially be accommodated on floodplain pasture in wider valleys, which would bring a new character to these areas. Avoid valley sides with small-scale field patterns, as the scale of planting could disrupt. The coastal strip will be particularly sensitive to alteration of landscape character through planting."*

Table 6 below indicates the effects (beneficial, adverse or neutral of planting energy crops in this area.

Generic landscape characteristics	Key landscape characteristics	Potential effects from growing energy crops
Topography	Rounded hills separated by steep, intricate wooded valleys. Diverse and complex coastline with ria estuaries cutting through coastal plateau.	Neutral - undulating landscape may provide opportunities for planting on lower slopes. Impractical on steep slopes.
Woodland	Steep slopes of upper valleys and rias are heavily wooded, woodland often extending to water's edge. Wider valleys e.g. Dart have willow and alder.	SRC would be beneficial in wide valleys, especially where plantations could link with existing willows and woodland. Should avoid introducing large scale plantings of miscanthus where not be in keeping with wooded character scale and pattern.
Boundary features	Generally irregular field patterns, with larger fields on higher, flatter land and a more intact, smaller field pattern on valley sides. Network of Devon banks giving a sense of enclosure, though many removed in previous decades by intensive farming.	Potentially adverse/neutral - whilst appropriate in larger fields, energy crops would bring some enclosure and hence alter character. In areas of intact smaller fields, plantations could obscure the pattern of hedges.
Agriculture	Mixed farming characterises area. Floodplain pasture on wider valleys.	Potentially adverse/neutral - where it would cause loss of floodplain pastures
Settlement and development	Villages sited in sheltered valley locations; towns at ria heads or mouths.	Being taller SRC may have an adverse effect – planting should be avoided close to settlements where it would obstruct views and alter character

[13] Opportunities and optimum sitings for energy crops within the South Devon study area. Joint Character Areas – 151 South Devon www.naturalengland.org.uk/ourwork/farming/funding/ecs/sitings/areas/151.aspx

	A roads connect major settlements, with sunken lanes linking farms and hamlets. China clay extraction in Bovey valley.	of their landscape setting. Some areas are only accessible for harvesting via narrow lanes.
Semi-natural habitats	Large expanses of saltmarsh and mudflats extending far inland. Patches of heathland present at northern edge where merges with pastoral Dartmoor fringe.	Energy crops may have an adverse effect where plantations would affect heathland that is vulnerable to change, or saltmarsh.
Historic features	Rich in archaeological remains including prehistoric field systems, drovers' tracks and ridgeways, burial mounds, earthworks and Iron Age hillforts.	Avoid these and other known archaeological sites and their settings, and respect historic landscape character
Rivers and coasts	Rivers rising on Dartmoor cut through the plateau, with narrow rias at the coast.	Avoid changing the character of river valleys by introducing more enclosure on valley bottoms.
Views and inter-visibility	Fine & extensive views at coastline, often looking along coast & deep inland along rias. Also from roads and settlements on higher ground looking across the plateau & to Dartmoor. Hedgerows and undulating land provide enclosure and limit intervisibility at a local level.	Energy crops may have an adverse effect where they restrict coastal and inland views Energy crops would be more suitable and less conspicuous in sheltered valleys.

Table 6: Key landscape characteristics of the South Devon JCA 151 and the potential effects of growing energy crops.

Within South Devon's protected landscapes (e.g. South Devon AONB), short-rotation forestry or broadleaved coppice is potentially a better way of integrating future energy cropping into landscape conservation. Managed in a mosaic on a 17-to-25 year cycle such woodlands can comprise native species (ash, alder, and willow) as well as being multi-functional: areas for access, sport and conservation.

2.3.4 Energy Crops Scheme

This scheme is administered by Natural England and will run until September 2013. It provides 50% grants towards the cost of establishing SRC (willow, poplar and other native broadleaved trees) and miscanthus. The minimum project size is 3 hectares with a minimum field size of 0.5 hectare. Eligible costs include: plant material and planting, cultivations (ploughing, sub soiling, power harrowing), spraying and sprays, rabbit fencing, and topping at the end of the establishment year.

In the South Devon AONB, an Environmental Impact Assessment will be required for both SRC (EIA (Forestry) (England and Wales) Regulations 1999) and miscanthus (EIA (Agriculture) (England) (No. 2) Regulations 2006). In both cases the threshold level is 2 hectares.

2.4 Waste wood arisings

2.4.1 Sawmills and joineries

One principal sawmill identified in the South Hams area, Barton Sawmill, was found to produce around 50 tonnes of waste wood annually; the mill itself currently produces and sells chips and logs. Approximately ten carpenters/joineries were contacted with only the two shown in the table below responding with any significant quantities of waste wood. One business currently gives away its wood to a local pellet/briquette maker, while the other gives it away to be composted; both give their wood away for free.

Company name	Location	Annual quantity of wood produced	Existing selling/disposal practice
Barton Sawmill	Totnes	50 tonnes (65% softwood)	Produces and sells chips and logs
Nigel J Crouch	Kingsbridge	12 tonnes	Sent to local pellet/briquette maker
Rendle & Elliot	Dartmouth	12 tonnes shavings/sawdust	Given away for compost

Table 7: Responses from sawmills and joineries

2.4.2 Municipal and commercial waste

By far the largest handler of waste wood in the region is Wood-Yew-Waste of Plymouth. Devon County Council waste management and private waste contractor Greencrop Waste both give all of their waste wood to Wood-Yew-Waste, who process around 50,000 tonnes annually. Around 80% of this is used for local panelboard manufacture (Norbord), 15% for animal bedding and the remaining 5% is sold as woodfuel. Details are shown in the table below.

Company name	Location	Annual quantity of wood processed	Existing selling/disposal practice
Devon County Council waste	Exeter	17,322 tonnes – not all clean	Given to Wood-Yew-Waste
Wood-Yew-Waste	Plymouth	50,000 tonnes	80% used for Norbord;15% animal bedding; 5% fuel
Greencrop waste	South Hams	300 tonnes	Given to Wood-Yew-Waste

Table 8: Responses from waste wood contractors

2.4.3 Other sources of biomass

There are potentially other sources of woodfuel that are almost certainly going to waste. It might be possible to exploit woodchip arisings produced from habitat management and conservation work on coastal areas, management of trees and woody shrubs on the banks of major highways and alongside railway lines as well hedgerow management by landowners. The potential resource and ease of removal is discussed in the table below.

One local arboricultural contractor that has worked in many of these testing environments is Jon Kay Trees[14] based in Chudleigh. It would be worth engaging with this contractor to see if they would be prepared to look at ways in which more of the potential wood fuel could be removed from challenging sites.

[14] www.jonkaytrees.co.uk

Woodfuel location	Responsibility	Contact	Management method	Quantity	Ease of extraction
Major highways	Devon County Council	0845 1551004	Chainsaw, brushcutters, and wood chippers. A great deal of material is chipped back into the verges.	Could be significant. Might be possible to plant trees with future harvesting in mind.	Most verges are gentle slopes so should be possible. Would need engagement from contractors. Would probably increase costs.
Field boundaries on minor roads	Landowners	n/a	Flail mounted on tractors. Should be done in Jan-Feb but often isn't.	Could be significant.	Difficult to capture wood with standard machinery. Cutting every 2-3 years would be better for wildlife and produce better quality wood chip.
Railway verges	Network Rail	08457 114141	Employ an arboriculturalist who decides which trees are planted. Larger trees tend to be planted further away from the tracks.	Not that many train lines in study area. Likely to be low.	May be difficult and dangerous to remove wood.
Coastal areas	National Trust	Simon Hill 01548 562344	Flail mounted on mini digger or tractor. Use brushcutters on steepest slopes. Not many contractors are interested in the work due to the dangerous slopes.	Mainly gorse. 40 miles of coastline so high potential but limited by terrain.	Many of the coastal areas are too steep or have poor access. Probably too dangerous to remove.

Table 9: Other potential sources of woodfuel

Hedgerow management

There is an estimated 53,000 km or 33,000 miles of hedgerows in Devon[15]. If managed sustainably this could provide a significant woodfuel resource to landowners. In south Devon the hedgerows are of three main types: beech hedges; windswept hedges with gorse and elm dominated hedges.

A recent report, produced for the Devon Hedge Group looked at the economics of using hedgerow logs as woodfuel[16]. The study focused on a 90 m hedgerow aged around 15 years old. The hedge consisted of willow, ash, hazel, oak, blackthorn and rowan. Activities included laying, extraction, stacking of cord wood, burning of brash, moving cords to barn storage and cutting and splitting. The total labour involved was 68 man hours with a total cost of £808 and the woodfuel yield was 2.815 tonnes of air dry logs (20% MC). Including all expenses the cost of woodfuel was £287/tonne or 7.0p/kWh; if the cost of laying the hedge and burning the brash is excluded then the price of woodfuel would be £110/tonne or 2.7p/kWh. The report concluded that it is uneconomic to lay hedges purely for firewood but if the hedge was going to be laid anyway then it would produce a very cost effective source of fuel.

Although, hedges vary considerably in the amount of wood they contain it is possible to extrapolate these results to give an indication of the local resource. In the aforementioned study, a 90 m hedge would produce 2.25 odt. This is equal to 0.025 odt/m. Over 15 years this would give a yield of 0.00167 odt/m/yr. As there is approximately 53,000 km of hedges in Devon, the theoretical resource potential would be 88,510 odt/year. South Devon covers approximately 12% of the land area of Devon so this could mean a theoretical resource in the study area of around 10,620 odt/yr. However, we are a long way from realizing this potential. According to Dr Robert Wolton, the co-chair of the Devon Hedge Group only about 1% of hedgerows in Devon are laid in any one year.

An ongoing EU project called Cordiale[17] is looking further at the potential of sustainable hedgerow management for woodfuel production. The UK partners are North Devon AONB and Tamar valley AONB). A further ten hedges are being investigated for woodfuel production and a report on this activity is currently being drafted. Initial results

15 www.devon.gov.uk/devons-distinctive-hedges-sept-11.pdf
16 The economics of harvesting wood for heating fuel from hedgerows. Case study: Hedge at Locks Park Farm, Hatherleigh. Robert Wolton. October 2010. www.hedgelink.org.uk/importance-hedges-and-hedgerows.htm
17 www.cordialeproject.eu/en/home

suggest that a standard farmhouse with an annual heat requirement of 30 MWh could meet its needs with around 200 m of hedgerow. Over a 15 year rotation, 6 km of hedges would be required, which would allow for only 50% of the hedges to be managed for woodfuel in order to maintain biodiversity. The average farm in Devon is 50 hectares and has around 10 km of hedgerow so based on this many farms could potentially be self-sufficient in heat by managing their hedgerows more sustainably[18].

Another option for increasing biomass supply would be to plant trees or energy crops on restored landfill sites. This is becoming common practice amongst waste services companies. The Waste Recycling Group has planted 100 hectares of miscanthus in Yorkshire whilst several sites managed by other operators in southern counties are earmarked for planting with SRC. The Environment Agency's website suggests that there are several potential sites that could be exploited in this way. It is beyond the scope of this study to look into the feasibility of this.

Name	Location	Last waste received
Molescombe Quarry	Kingsbridge	1994
Winslade Quarry	Kingsbridge	1992
Quarry Farm	East Allington	/
Part Torr Quarry	East Allington	1993
Torr Quarry	East Allington	1992
Rake Farm	Kingsbridge	/
Easton Court Farm	Kingsbridge	1994
Dallacombe Farm	Dartmouth	/
Land near Whympston's Farm	Modbury	1990
Sharkham Point Tip	Brixham	1970
Downton Wood Landfill	Dartmouth	/

Table 10: Active and restored landfill sites in south Devon

2.5 Existing suppliers of woodfuel

Compared to the rest of England, the south west region has a high number of woodfuel heating installations, which in early 2011 totalled 56MW across 482 projects[19], with Devon having the largest proportion of all south west counties. This in turn reflects a reasonably well-established woodfuel supply chain network with a range of guidance and tools available to help those considering woodfuel such as South West Woodshed[20]. Quantifying the woodfuel resource (as currently available from suppliers) in a relatively small area such as South Devon is difficult due to the fact that many suppliers operate over large areas and source their wood from many locations. However, a survey of suppliers with depots in and around the study area has been undertaken and Table 11 below lists the results.

Discussions with a range of fuel suppliers revealed that very little was actually sourced from within the South Hams district. By far the largest supplier in the region, Forest Fuels, reported that 1,000 tonnes of woodchip per year is currently supplied from their Marley Head Sawmill depot in South Brent, which is not far from the Coastal LAG boundary. They reported that an additional 2,000 tonnes of woodchip could easily be supplied from feedstocks provided by woodland and forestry owners in the surrounding area. The site has the capacity to expand to 5,000-6,000 tonnes/yr by renting out additional storage space adjacent to the site. Ecowood Fuels, based in Cullompton, are another large supplier, producing between 500 and 1,000 tonnes of wood pellets annually, generally using wood sourced from regional sawmilling and construction processes. Forever Fuels, who operate a supply depot in Okehampton, are also a large national supplier, although it is understood their pellets are sourced from Holland.

'Gardening Services & Firewood' reportedly sell annually around 200 tonnes of logs, sourced from all over the south-west. Bioshed of Kingsbridge handle 100 tonnes of logs per year though report that 90% of this is sourced from

[18] Dr Robert Wolton, personal communication.
[19] Renewable Energy Progress Report: South West 2011 Annual Survey; RegenSW; March 2011
[20] www.southwestwoodshed.co.uk

outside the region. Devon Biofuels currently produce around 40 tonnes of pellets per year from wood sourced around Newton Abbot, but also produce more from wood sourced further afield. Their production capacity is currently around two tonnes per day if demand requires.

Company name	Location	Product type and approx. annual quantity of wood supplied (if known)
Forest Fuels Ltd	Okehampton (Head Office)	1,000 tonnes woodchip from South Brent depot (Marley Head Sawmill); 2,000 tonnes woodchip from woodlands / forestry in surrounding area.
Ecowood Fuels	Hemyock	500 – 1,000 tonnes pellets (produced from regional sawmilling and construction processes)
Forever Fuels	Okehampton	Pellets – from Holland
Gardening Services & Firewood	Kingsbridge	200 tonnes - logs
Bioshed	Kingsbridge	100 tonnes – logs (90% sourced outside region)
Devon Biofuels	Spreyton	40 tonnes from Newton Abbot area, more from further afield. All made into pellets; ability to produce 2 tonnes/day.
Suppliers taken from the Carbon Trust fuel supplier map:		
South Devon Biomass Company	Occombe Farm, Torquay	Capable of processing around 5,000 tonnes/yr of round wood into woodchip. Received £160 k from round 3 of the Bioenergy Infrastructure Scheme. Supplies chip to Paington Zoo.
Dartmoor woodfuel co-op	PL20 6SG	Chips, logs
Teign Trees and Gardens	PL20 9PH	Logs, chip
Tamar Joinery Company	PL20 7HJ	Chip
CPL Kellybray	PL17 8ER	Logs

Table 11: Responses from existing suppliers of woodfuel

2.6 Woodfuel initiatives

There are a number of initiatives that have already emerged elsewhere in Devon and through European collaboration. It is possible that lessons could be learnt from these projects in order to enable best practice in the South Devon study area.

2.6.1 Devon-based woodfuel initiatives

The Dartmoor Woodfuel Co-operative involves five landowners who grow, harvest and process areas of small woodland in Devon for local wood fuel supply. It is a not for profit organisation and encourages collaboration between local woodland owners and biomass end users to improve woodland management, reduce carbon emissions, raise public awareness of renewable energy and encourage ecotourism in the area. Members include the River Dart Country Park and Brimpts Farm. www.dartmoorwoodfuel.co.uk.

Axewoods is a co-operative set up in East Devon and West Dorset to link owners of undermanaged woodlands with people wanting to provide voluntary work in exchange for a supply of woodfuel. The co-op has work parties every fortnight on the second and final weeks of the month. Membership costs £11/year but members are allowed to gather and remove all small logs on working days and can get discounts on machinery and training. www.axewoods.org.

The Ward Forester Project is aimed at linking woodland owners with a professional forester who can help them manage their woodlands in a cost effective way. The model aims to improve the productivity of small woodlands by encouraging clusters of woodland owners to defer management responsibility to the professional or "ward forester". This helps enable the necessary economies of scale for viable practical management which is very difficult for individual owners to achieve when working on their own.
www.wardforester.co.uk

2.6.2 EU funded woodfuel initiatives

There are various EU-funded initiatives that are looking to encourage landowners to increase woodfuel supply and improve wood fuel supply chains. The Forest Programme involves seven European partners including a SW of England consortium comprising Regen SW, Severn Wye Energy Agency and the University of Exeter. (www.forestprogramme.com).

AFO (Activating private forest owners to increase forest fuel supply) involves six partners including the South Yorkshire region. Both programmes have highly informative websites which include training tools, documents and case studies. The AFO website has downloadable reports of best practice examples of wood fuel supply clusters in Austria and Finland. (www.afo.eu.com)

2.7 The reality of woodfuel availability

The amount of woodfuel from each resource that ultimately reaches the market place will be dictated by a number of factors. As a result the realised woodfuel availability will be much lower than the theoretical potential. The mitigating circumstances limiting this potential are explored below.

2.7.1 Woodland

The Forestry Commission are encouraging woodland owners to bring back their woodlands into management. It is estimated that 60% of Devon's 77,000 hectares of woodland are undermanaged[21]. Even with new grants such as the Woodfuel Woodland Improvement Grant[22] there are many reasons why significant areas of woodland will remain unmanaged. For instance:

- Many small woods are owned by individuals whose principle interest is to enjoy the surroundings, rather than manage the resource;
- Many sites are small in size and remote making felling and extraction difficult and expensive;
- Many sites will be unsuitable due to poor access as a result of rough steep terrain, poor drainage and a lack of road infrastructure.

The Forestry Commission are currently updating the National Forest Inventory and this will be completed in 2014. The most up to date information was produced as part of the National Inventory of Woodland and Trees in 2002. The county report for Devon[23] provides the following information:

- There are a total of 2473 woods over 2 ha in Devon with a mean wood area of 16.8 ha
- There are 6203 woods from 0.1-2 ha with a mean wood area of 0.4 ha
- 19% of the woodland area is below 10 ha and 30% of the woodland is below 20 ha

[21] http://wardforester.co.uk/?page_id=4
[22] http://www.forestry.gov.uk/ewgs-wigwoodfuel
[23] www.forestry.gov.uk/pdf/devon.pdf/$FILE/devon.pdf

- The Forestry Commission owns 14% of woodland in Devon. The remaining 86% is made up as follows:
  - 53.1% Personal
  - 18.8% Business
  - 8.6% Charity
  - 4.8% Local authority/Public bodies
  - 0.6% Other

The survey does not provide specific information for South Devon but it is probably safe to assume that these findings are similar in the study area.

Small woods make up 71% of the total number but only 6% of the woodland area in Devon. The majority of small woods (even those classed as undermanaged) will probably already be utilised for woodfuel. The odd tree will be felled on an ad hoc approach to supply logs mainly for personal use in log stoves and open fires. A recent survey in Dorset suggested that around 15% of domestic properties have a log stove and take up has increased rapidly in recent years[24]. As the South Devon study area is also predominantly rural with many off gas areas it is likely that a similar trend exists. It is likely that this demand is already being serviced by logs produced from smaller woods, from stem wood produced from tree surgery operations and from wood imported from elsewhere in Devon.

The potential woodfuel resource required for such a market is quite significant and can be estimated as follows:

Annual log requirement for an average house	
Stove size	5 kW
Usage	4 hrs/day (for 26 weeks)
Heating produced	3,640 kWh
Calorific value of air dry logs (20% moisture content)	4,000 kWh/tonne
Annual requirement per house	0.91 tonnes of logs
Bulk density of stacked hardwood logs	450 kg/m^3
Volume of stacked logs required	2m^3

Annual log requirement for South Hams district homes	
Population of South Hams	83,500
Average no. occupants in house	2.5
Approx. no. houses	33,400
No. of houses having log stoves	5,010 (15%)
Approx. annual requirement in South Hams	4,559 tonnes (at 20% MC)

Table 12: Estimated domestic market for woodfuel logs in South Hams district

If this is the case then this existing market would already take a significant chunk of the available resource. 4,559 tonnes at 20% MC is 47% of the total available woodland resource estimated in Section 2.2.1.

Many larger woodlands (> 20 ha) and those owned by public bodies and businesses will probably already be under management and providing woodfuel from thinning wood. If we estimate that ultimately 75% of these larger woodlands could be brought back into management then that would give a revised woodfuel resource of 4,035 oven dry tonnes per year or 5,764 tonnes at 30% MC.

2.7.2 Arboricultural arisings

Tree surgery work results in two very different products: stem wood that is suitable for logs and the branches and twiggy ends which are typically chipped on site to reduce the volume. In rural areas stem wood is typically left with

[24] Pete West, Dorset County Council. Personal communication.

the owner of the tree to use as firewood. In urban areas the contractor is more likely to remove the stem wood and process it into logs themselves. In all probability most of the stem wood is already finding its way into local markets for stove logs.

The chipped wood is more of a problem to the contractor. In order to maximise this resource several conveniently located timber stations would need to be set up across the study area. Alternatively, it might be more cost effective to site a single timber station near the source of greatest production. Even then the throughput of woodchip from local contractors is likely to be low. Blaise Nursery, a tree station in Bristol typically processes around 500 tonnes/yr.

2.7.3 Energy crops

The energy crops industry has struggled to get much of a foothold in the SW of England. According to Energy Crops Scheme planting records obtained from Natural England there is currently no miscanthus or SRC planted in the study area. In Devon as a whole there is only 32.07 hectares planted in the north and west of the county. In total there are currently 645 hectares of miscanthus and around 150 ha of SRC in the SW region as a whole. There are numerous reasons for this slow adoption rate such as:

- It is seen as a risky crop by farmers with a 20 year time frame - the average age of farmers is in the late 50's; many think they are too old for such a long term investment;
- This activity ties up land for long periods;
- There are expensive up-front costs to establish the crop;
- There is very poor cash flow in early years – SRC only breaks even after second harvest (Year 7);
- There is a perception that markets don't exist; unfortunately there is a chicken and egg situation – the market will come but only when the crop is grown;
- There is a perception that there is plenty of better quality wood available so there is no point in trying to compete;
- Farmers worry that planting energy crops will affect land values;
- There is a lack of infrastructure – especially machinery for planting and harvesting SRC;
- Once established the crops require very little farmer input and so is off-putting to farmers who still want to farm;
- Energy crops tend to appeal to younger entrepreneurial farmers or city farmers;
- Farmers worry that the crop will affect land drains;
- Farmers worry that the crop will be difficult to get rid of;
- The failure of projects to get planning and companies such as Bical going bust makes farmers sceptical of getting involved;
- There are unfortunately many plantations which are bad adverts for energy crops – poor practice means poor yields.

Despite all of this, experience elsewhere in the country suggests that farmers will grow these crops when contracts are made available. Furthermore, considering the relative local shortage of woodfuel many farmers and land owners would be well placed to grow these crops for their own heating use or to sell to other end users.

A farm using 10,000 litres of oil per year (~100,000 kWh) for heating would require about 27 tonnes of woodfuel per annum. This could be produced by growing just 2 hectares of SRC willows or miscanthus.

A small holding using 4,000 litres of oil (40,000 kWh) for heating would need around 11 tonnes of woodfuel a year. You could produce this from planting around 1 hectare of SRC. You would need to plant a third of a hectare for three years to produce a seamless supply. These examples, along with additional requirements for growing energy crops for third party end users are demonstrated below.

	SRC chip				Miscanthus chip			
	Small holding	Farm	Primary school	S'dary school	Small holding	Farm	Primary school	S'dary school
Amount of oil (litres/year)	4,000	10,000	25,000	50,000	4,000	10,000	25,000	50,000
Heat used (kWh/year)	42,400	106,000	265,000	530,000	42,400	106,000	265,000	530,000
Annual fuel required (tonnes @ 30%)	10.0	25.0	62.5	124.7	/	/	/	/
Annual fuel required (tonnes @ 25%)	/	/	/	/	10.3	25.8	64.4	128.8
Land requirement (ha)	0.8	2.0	5.0	10.0	0.7	1.9	4.6	9.3
Storage space (m^3)	57	143	357	713	103	258	644	1288
No of fillings of a 30 m^3 hopper	2	5	12	24	3	9	21	43

Table 13: Energy crop requirements for example heat loads

Assumptions:

- Efficiency of boilers: oil boiler being replaced =70%; biomass system using SRC = 85%; biomass system using miscanthus = 80%
- Calorific value of SRC = 3,500 kWh/tonne at 30% MC
- Calorific value of miscanthus = 3,600 kWh/tonne at 25% MC
- Yield of SRC is 10.9 oven dry tonnes/ha/yr
- Yield of miscanthus is 13 odt/ha/yr
- 20% yield losses during harvesting, storage and transport

When growers use good quality land and follow best practice guidelines good yields can be achieved which also enable low production costs. Both miscanthus and SRC willow can be produced for under 1p/kWh (see Appendix 4). This compares very favourably with woodchip from an existing farm woodland (1.5 p/kWh) or bought in woodchip (2.5p/kWh). Woodfuel self supply is therefore an excellent way of maximising the savings compared to fossil fuels and the revenue from the RHI (see case studies in Appendix 5). However, in many cases growers choose to plant energy crops on poor land and fail to engage in good practice. The result is a poor yielding, low quality fuel with higher production costs.

Figure 8: SRC being planted with the four row Step Planter (Courtesy Northern Bioenergy)

Even when a high yielding crop is produced there is no guarantee that 100% of the biomass will get to the end user. During harvesting yield can be reduced due to the incorrect height of stem cut by the harvester, machine operator errors such as poor co-ordination between the driver of the harvester and the driver of the adjacent tractor trailer or spillages from overfilled trailers. In addition, with SRC some stems will be missed by the cutting blades due to poor habit in individual plants.

Following harvest there are further losses. Freshly cut wood chip contains around 50% moisture so any heap may heat up and dry matter will be lost through composting and respiration. Some of these losses can be avoided by harvesting

SRC with a billet harvester. When these larger chunks of wood are stored in a heap they have more air spaces and dry quickly without dry matter losses. However, billets need to be reprocessed into granulated fuel or pellets.

Figure 9: Harvesting miscanthus with a forage harvester

Miscanthus straw is typically harvested with a lower moisture content (25-30%) and in bale form will dry well with minimal losses. However, if miscanthus chip is produced then this will be prone to similar heating up and loss of dry matter. Finally, it is inevitable that some material will be lost during transfer operations from the storage area to an intermediate store and then to the end user.

Experience suggests that all these factors might contribute to commercial yields being around 20% lower than those produced in small plot trials. Allowing for these losses a miscanthus crop on typical arable land with a potential yield of 15 odt/ha/yr would have a realised yield of around 12 odt/ha/yr and a an SRC crop with a potential yield of 10 odt/ha/yr would have a realised yield of around 8 odt/ha/yr.

3 Woodfuel demand

As seen above, the demand for woodfuel in the South West has steadily increased over recent years due to the increase in take-up of renewable biomass heating systems, which in turn has been stimulated by a range of national, regional and local initiatives. In particular the launch of the Renewable Heat Incentive (RHI) in November 2011 and the planned expansion of this scheme in 2013, which may include the domestic sector, is expected to drive a step change in woodfuel production and sales. Strategic planning of woodfuel use in a specific area therefore needs to consider the expected demand alongside existing and new supply chains. With this study focusing on medium/small scale woodfuel applications (as opposed to large scale electricity generation from biomass plant), identifying opportunities through heat demand is therefore important; this is considered in the following sections.

3.1 Heat supply opportunities from existing development

Future uptake of woodfuel installations within existing development will depend on many socio-economic factors and it is difficult to predict this for a given area. A useful first step however is to gain some idea of the potential heat loads in a locality and to understand more about what kind of buildings make up that heat load. Residential development is relatively straightforward in that heat loads related to housing type are well established. Non-residential heat loads however are much harder to estimate due to the very wide range of building types and uses within this sector.

A useful tool to help identify heat loads within a local community is the **National Heat Map**[25], developed by CSE and launched by the Department of Energy and Climate Change in March 2012.

3.1.1 About the National Heat Map

The National Heat Map shows heat demand across England at a range of scales from national to local. Behind the heat map is a database of modelled heat demand for every address in the country (and actual heat demand for buildings which have Display Energy Certificates). This enables users to locate and investigate areas of high heat demand which may be suitable for district heating.

The purpose of the map is to support planning and deployment of local low-carbon energy projects in England, by providing publicly accessible high-resolution web-based maps of heat demand by area. The most useful way to visualise heat map data is in the form of a heat demand density layer. This shows heat demand per unit of land area (typically kWh heat / square metre). Areas with high concentrations of heat demand have higher spatial density values. This is intuitively easy to understand when seen on a map - Figure 10 show an example heat density map[26] overlaid on the address points from which it originates. The address points are scaled so that those with higher heat demand are represented by larger points. Heat density (the coloured base-map) is shown from blue to red, with blue areas being low density and red areas high density. Areas in which there are more and/or larger point heat demands close together, have higher heat densities.

[25] http://ceo.decc.gov.uk/nationalheatmap/
[26] This is an example area which is not within South Devon

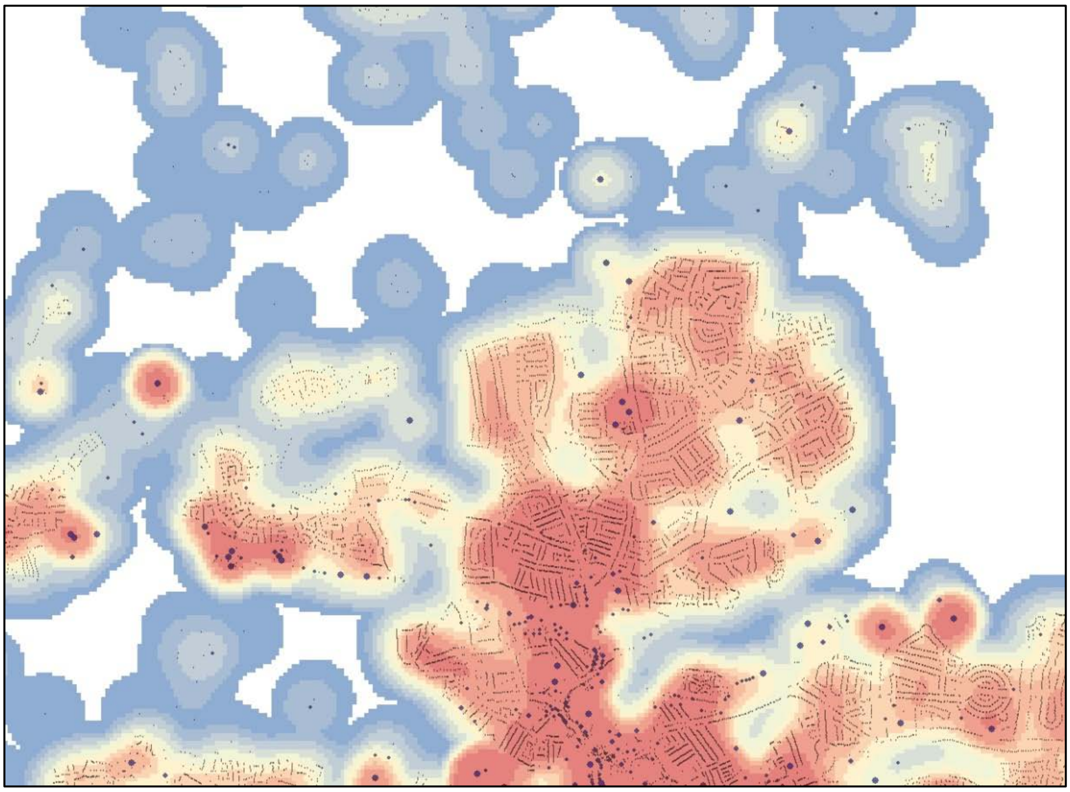

Figure 10: Example of a heat density map

3.1.2 Heat demand across South Devon

In this report different heat density maps are shown as derived from the National Heat Map tool. A point of note when looking at the maps illustrating this section of the analysis is that for a given location, the value for heat density will vary depending on the parameters used for the density calculation. This is because the heat density is calculated using a volume-preserving form of weighted average over a radius around each location on the map. Larger radii are typically used for larger scale, less detailed maps. Conversely, smaller radii are used on smaller scale, more detailed maps. As the level of detail increases, overall heat demand is constrained into smaller areas, so the density values naturally increase. Therefore, the relative heat density of different parts of an area is more important than the absolute figure.

Figure 11 to Figure 13 show all heat demand, residential heat demand and non-residential heat demand across the study area. Overall, as can be seen in Figure 11, the highest heat demand density is concentrated in Kingsbridge and Dartmouth, as would be expected. Larger scale maps for these areas are shown in Figure 14 and Figure 15.

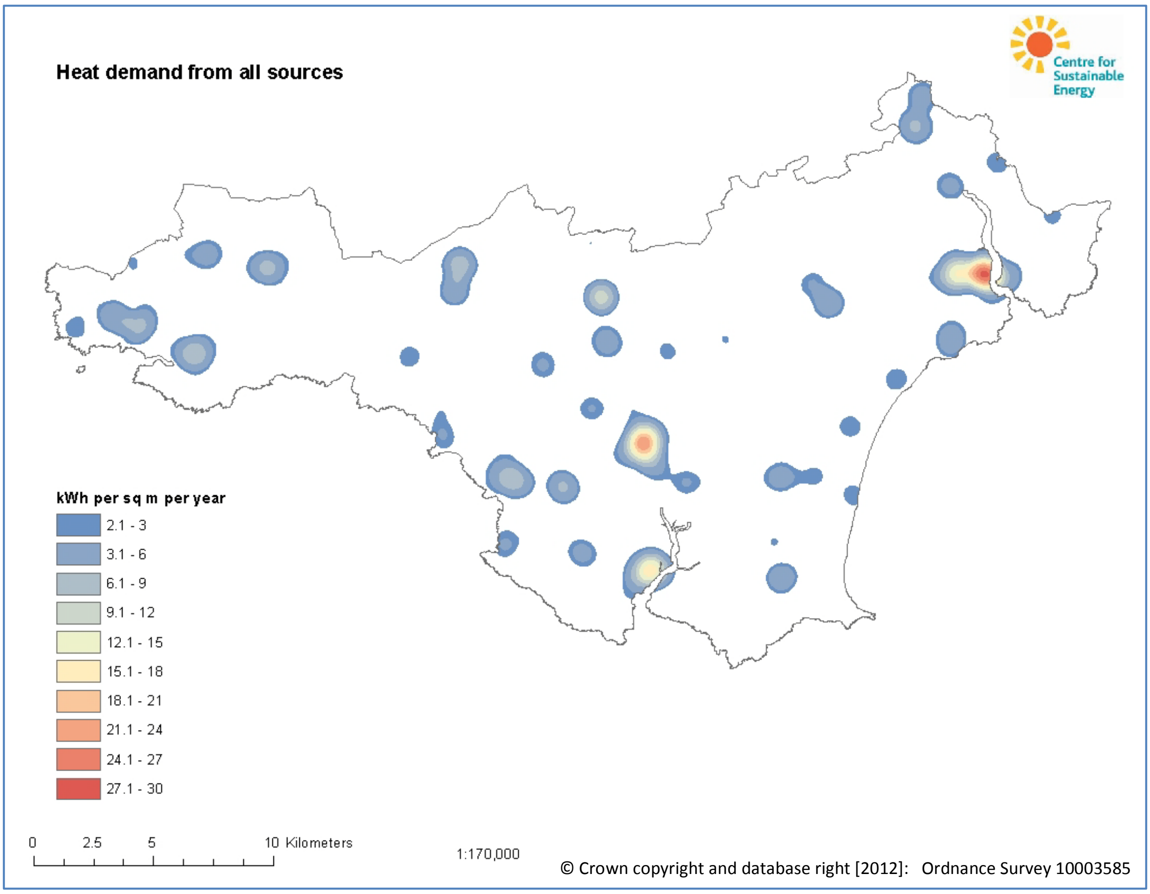

Figure 11: All heat demand

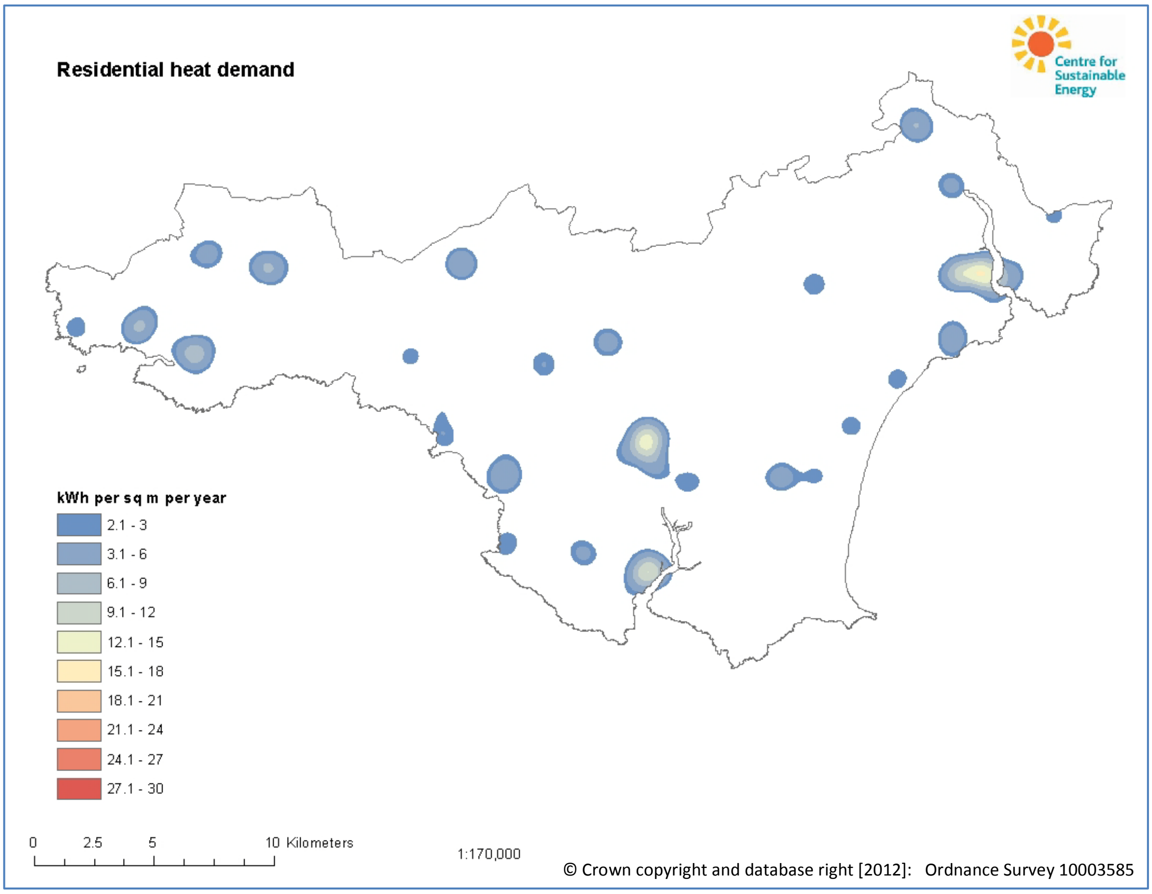

Figure 12: Residential heat demand

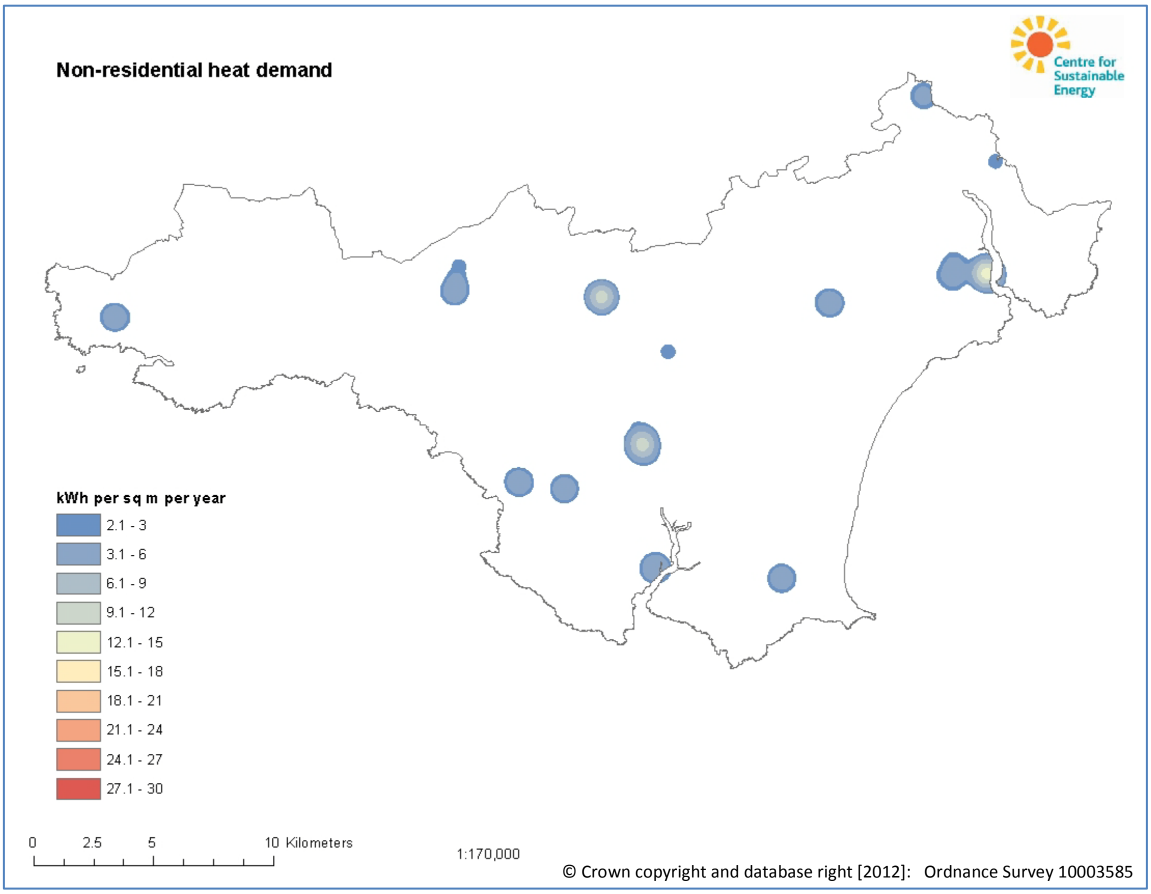

Figure 13: Non--residential heat demand

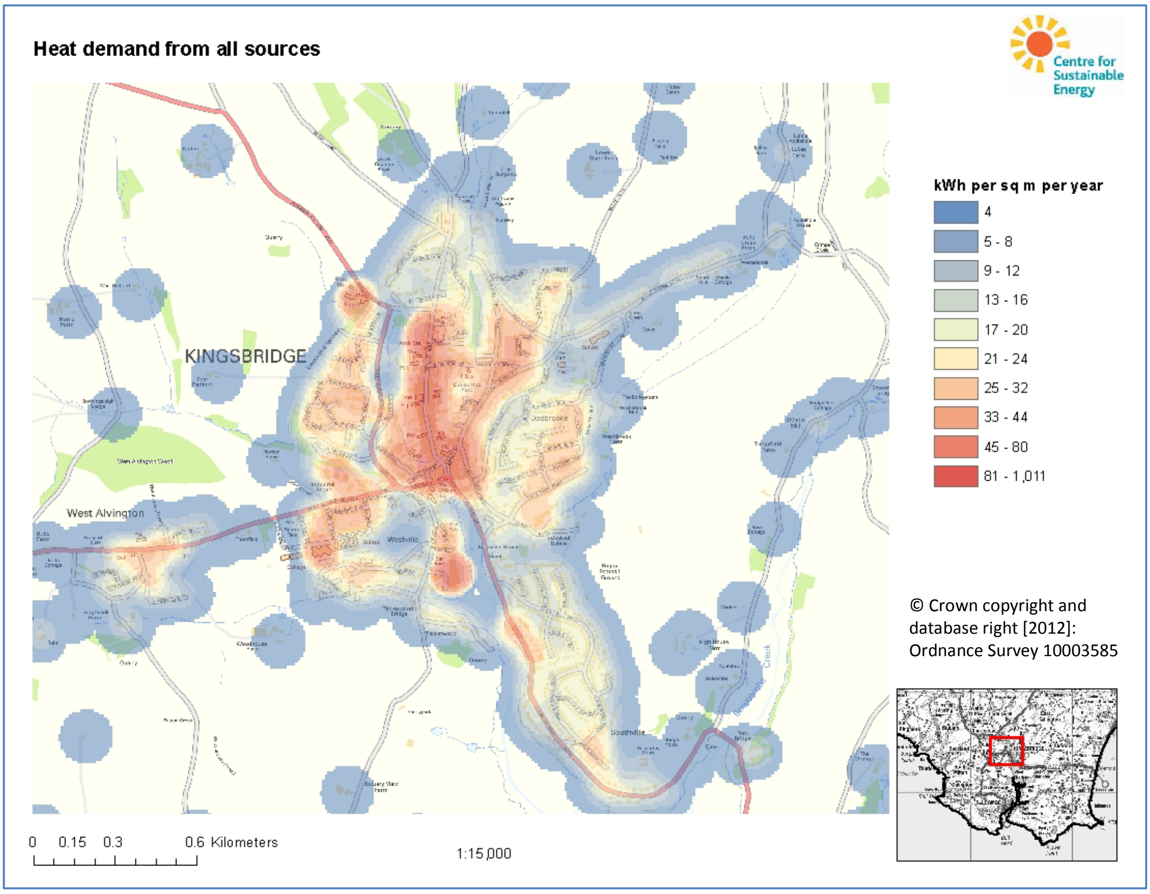

Figure 14: Kingsbridge – heat demand

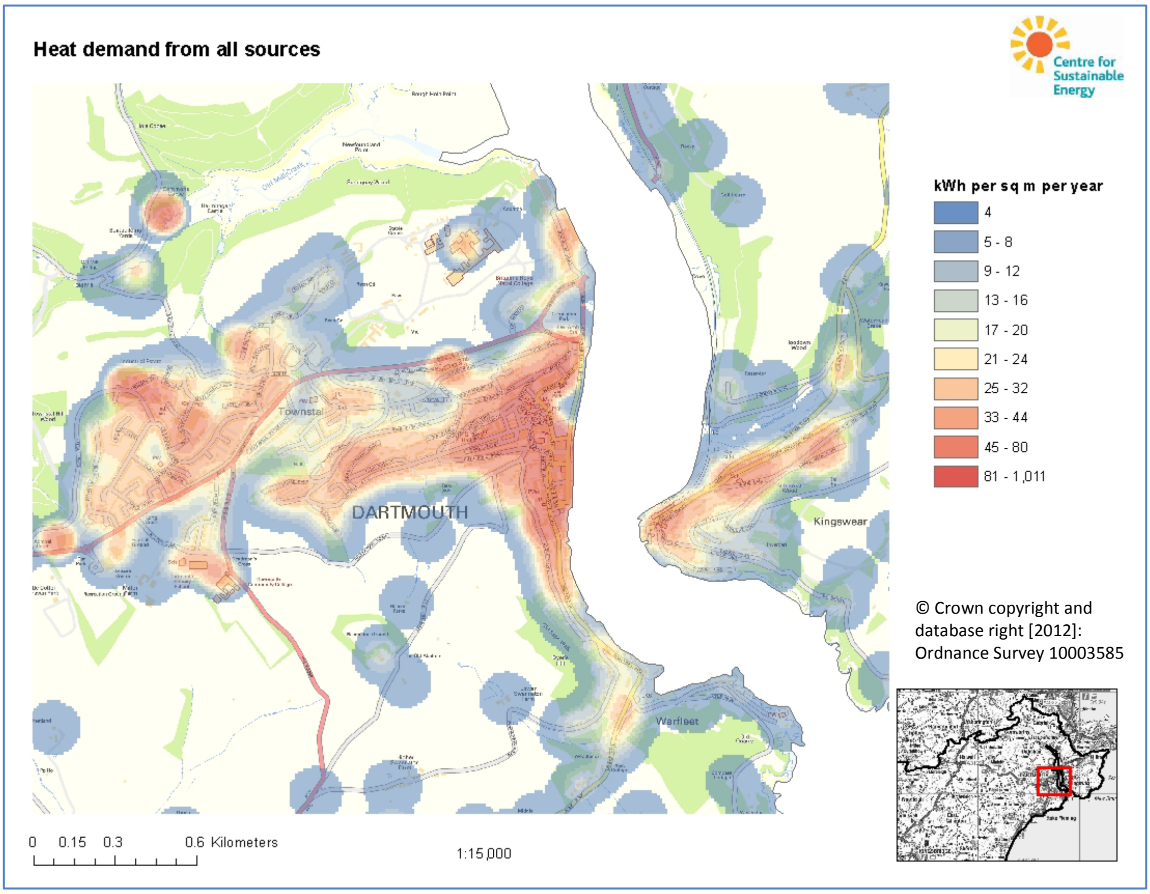

Figure 15: Dartmouth – heat demand

3.1.3 Opportunities for district heating

District heating is the term used to describe the infrastructure for delivering heat and hot water to several buildings, using a central heat source and a network of pipes, which is generally a more efficient way of generating and delivering heat than the use of individual heating systems within buildings. Heat networks can range in scale from a biomass boiler supplying a few homes, to schemes serving entire city centres. They can source their heat from a range of energy plant technologies which may generate heat only, combined heat and power (CHP) or combined cooling, heat and power (CCHP). CHP plants combined with district heating can be an efficient way to provide energy[27], but the relative yields of heat and power are critical factors in economic plant operation. In particular, the proportion of generated heat that can be used (i.e. sold) is vital to consider during the design of CHP plant, hence the importance of establishing the potential for district heating. CHP plants not supplying district heating networks have potential for high energy use buildings, where imported mains electricity can be offset through cheap on-site generation and where there is an on-site use for the associated heat generation.

Looking at the heat maps in Section 3.1.2, there are relatively few areas of high heat density, which would be expected for an area such as this i.e. predominantly made up of smaller towns and villages. Low heat density is one of the main constraints to district heating as the civil works associated with laying longer heat mains to service larger areas is expensive. High heat densities mean shorter pipe runs and therefore lower costs.

It is beyond the scope of this study to undertake detailed analysis of the 'hot spots' within the South Devon study area but further investigations can be undertaken via the National Heat Map to examine specific sites and by on-the-ground surveys. Additionally, the woodfuel resources identified in this study can be assessed spatially in relation to identified heat loads to look at opportunities for woodfuel heating plant. There are also a number of key spatial

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[27] For more information see DECC's CHP Focus website and Site Assessment Tool: http://chp.decc.gov.uk/cms/

factors which influence the viability of opportunities for (and benefits from) wood-fired district heating systems which should be considered; these include:

- **Heat demand density:** as a rule of thumb, at least 55 new dwellings per hectare (dph) are thought necessary for financial viability of a residential only scheme or an average heat demand density of at least 3,000kW per square kilometre;
- **Diversity of existing heat load:** a variety of different building types combined in one district heating system provide a more constant heat load, which allows the system to work more efficiently. For example, if a system incorporates some homes which require heat in the mornings and evenings, some shops and offices which use heat during the day, and a swimming pool in which heat can be stored overnight, then the boilers feeding the system are able to work at a consistent level all the time, which is more efficient than if they are providing widely fluctuating amounts of heat;
- **Redevelopment of existing buildings and infrastructure:** the cost of connection to district heating can be lower if carried out at the same time as other works;
- **Anchor heat loads:** these are high, stable sources of heat demand. For example, a large hotel or hospital consumes a high amount of heat, and the heat used does not vary much during a day. This is a useful load to 'anchor' a district heating system around because it can provide a large proportion of the initial customer base required to justify the initial cost of the investment. Other, smaller sources of heat demand can be added on around this;
- **Energy plant:** adequate space for the heating plant, boiler house, fuel store and delivery access is also necessary;
- **New developments:** district heating schemes are also cheaper in new developments due to more design flexibility and the lower cost of civil works on new sites (see Figure 16 for locations of South Hams adopted Site Allocations). However, adjacent existing development can potentially provide additional heat loads either at the start of a project or during later phases.

CHP/district heating using biomass fuels generally employs combustion or advanced thermal processes such as gasification which may require different types and forms of biomass feedstock depending on the scale and type of technology. To date, biomass CHP has only proved commercially viable at large scale, although biomass district heating is more flexible, often being used for a range of applications including small residential schemes.

Case studies of community-run district heating schemes using woodfuel can be found on the Plan LoCaL website[28].

3.2 Heat supply opportunities from new development

3.2.1 Emission standards

Over the last few years, new development has resulted in increased opportunities for renewable energy through a trajectory of higher standards on carbon emissions as required under Building Regulations and sometimes by local authority policies on sustainable construction. South Hams Development Policy 4, for example, requires larger developments to provide at least 10% of a scheme's energy requirements through on-site renewable energy sources. As Building Regulations evolve up to the Government's proposed 'Zero Carbon' standard for all new housing from 2016, renewables will be increasingly needed to achieve these requirements.

Precisely which renewable technologies will be best suited to which type/scale of development will ultimately be determined by the developer, who will in most cases be seeking a least-cost solution provided by an optimum mix of energy efficiency and renewable energy generation. As we move towards zero carbon standards however, renewable heat technologies such as biomass will be increasingly important to mitigate emissions from heating requirements.

[28] www.planlocal.org.uk/downloads/group/case-studies

This is in spite of the fact that heat loads in new developments are actually decreasing due to higher building fabric energy efficiency standards.

The most likely applications for woodfuel heating installations within new development tend to be the heating of non-residential single buildings/sites such as schools, public buildings and factories, and heat networks which supply multiple buildings including both residential and non-residential uses.

3.2.2 Assessing heat loads

Similarly to existing development, residential new development heat loads are easier to estimate than non-residential new development heat loads. One source of data that can be used to indicate the potential for heat demand in new housing is the Strategic Housing Land Availability Assessment (SHLAA). SHLAA is a technical exercise to assess the amount of land that could be made available for housing development and the amount of housing that this land could yield. All local planning authorities carry out a SHLAA in order to help them identify sites for housing development in Local Development Documents.

Currently, SHLAA datasets are held by each local planning authority, showing all identified locations for housing development, along with an assessment of the feasibility of housing in each location, an estimated potential yield of dwellings and a figure for the density of the site (number of dwellings per hectare).

The SHLAA dataset can be used to model the effects of specifying various building standards, and to look at how minimum energy demand varies accordingly when assumptions about the mix of dwelling types and the baseline energy consumption for each type are made. More complex modelling can then be used to estimate the proportion of carbon savings that is likely to be achieved by renewable energy technologies and which particular types, possibly based on the least-cost technology mix for a certain category of site. Modelled heat demand can also be used to identify new housing sites where district heating would be feasible.

For the purposes of this study however, GIS data on South Hams adopted site allocations in the study area has been provided by South Hams Council. These are indicated in Figure 16 below (small green dots), along with the proposed location of the Sherford development proposal (see below) which is not included in the adopted site allocations list.

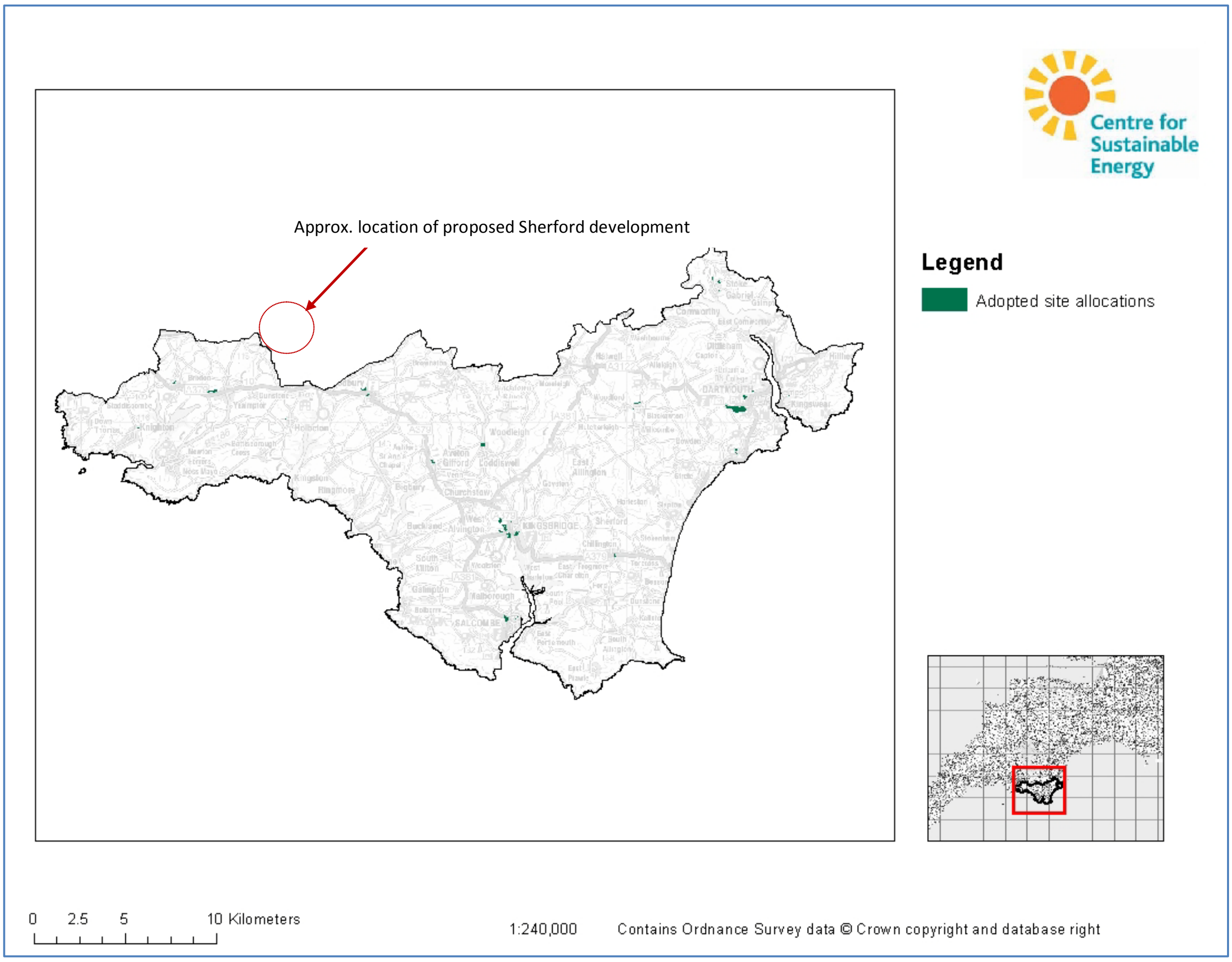

Figure 16: Study area showing locations of South Hams adopted site allocations

Table 14 lists the details of the sites in terms of approximate areas and dwelling numbers. Table 15 then estimates heat loads from broad assumptions on construction standards up to and beyond 2016. The total heat load from this exercise comes to around 12,220 MWh/yr. Assuming 25% of these dwellings were heated at 90% boiler efficiency using woodfuel, around 659 oven-dry tonnes of woodfuel per annum would be required.

Area (hectares)	To 2016 Number of dwellings	To 2016 Employment land (hectares)	Post-2016 Number of dwellings	Post-2016 Employment land (hectares)
27.16	155	2.00	250	2.50
3.97	0	0.00	50	0.00
4.83	0	0.50	0	0.00
4.64	0	0.00	100	1.00
4.16	40	0.00	0	0.00
4.04	100	1.00	0	0.00
2.92	50	0.50	30	0.50
2.98	45	0.00	50	0.00
3.91	0	0.00	150	0.00
2.77	0	0.00	50	0.10
0.81	0	0.50	0	0.00
1.93	0	0.00	10	0.00
2.22	75	5.00	0	0.00
1.97	30	0.00	0	0.00
1.51	50	0.50	0	0.00
1.41	50	0.00	0	0.00
1.05	0	0.00	45	0.10
0.98	0	0.00	30	0.00
0.81	0	0.00	0	0.00
0.71	0	0.00	55	0.10
1.36	0	0.00	20	0.00
0.32	15	0.00	0	0.00
0.31	0	0.00	50	0.50
0.26	0	0.00	0	0.00
0.22	0	0.00	30	0.10
2.28	65	0.50	30	0.50
0.34	10	0.10	0	0.00
2.09	30	0.00	0	0.00
4.99	50	0.00	50	0.50
86.9	**765**	**10.6**	**1,000**	**5.9**

Table 14: Adopted site allocations for study area (totals in bottom row)

No of dwellings	Estimated total heat demands [kWh/yr] – assumes an 'average' dwelling floor area of 79m^2 (mid-terrace)	
	To 2016	Post-2016
765	5,638,815	n/a
1,000	n/a	6,581,000

Table 15: Estimated heat demands from adopted site allocations

Assumptions:

- **Post-2016:** 39 kWh/m^2/yr space heating[29] plus 3,500 kWh/yr hot water[30] for a 3-bed dwelling
- **To 2016:** 49 kWh/m^2/yr space heating[31] plus 3,500 kWh/yr water heating for a 3-bed dwelling

In practice, not all the above sites may be developed and the list does not include other SHLAA sites that are at different stages of the planning process. Falling into the latter category is the proposed development at Sherford, which is discussed below.

Sherford Market Town proposal

The proposed development at Sherford (see Figure 16) will make provision of up to 5,500 new dwellings; up to 67,000m^2 of business and commercial space; up to 16,700m^2 of mixed retail accommodation, community and open space facilities; three primary schools and one secondary school; health care centre; sports centre and community park; and two community wind turbines. A Section 106 requirement has also been tabled in which the applicants

[29] This is the space heating Fabric Energy Efficiency Standard for zero carbon homes (blocks of flats and mid-terrace housing) as proposed by the Zero Carbon Hub. www.zerocarbonhub.org/building.aspx?page=2

[30] General figure for domestic hot water demand – relates to occupancy rather than house type

[31] Assumes an average 25% increase in space heating requirement from the post-2016 standard

must use reasonable endeavours to set up an Energy Services Company (ESCO) to manage the energy delivery to the development. The carbon reduction measures proposed in the site Masterplan[32] includes biomass heating/CHP (neighbourhood/building scale) as well as large scale wind and solar technologies, although the current status of these proposals is not known.

3.2.3 Opportunities for district heating

As mentioned in Section 3.2, district heating holds particular potential for new developments where they can be factored into the masterplanning process at an early stage. A strategic view can be taken of how the development may be phased or how existing buildings may also be served by the network. To help achieve this, heat demands from existing developments and their locations can first be assessed using the National Heat Map described above. Heat demand data from new developments can then be overlaid to consider whether heat loads and potential routes for heat networks can be optimised. Existing developments can improve viability of new development district heating systems by offering 'anchor' loads i.e. buildings offering a sizable and consistent base heat load to the network.

Adopted housing site allocations for South Hams shown in Figure 16 and Table 14 suggest there is limited scope for district heating within the study area. However, the largest site (near Dartmouth) with an allocation of approximately 400 dwellings and 4.5 ha of employment land would be worthy of further investigation.

3.3 Biomass support mechanisms

Over the last decade there have been a number of national and regional schemes that have aimed to stimulate the bioenergy sector. Table 16 below shows the timescales over which each of these operated. The Co-ordinated Woodfuel Initiative, Sustainable Woodlands SW and Bioheat provided support in the SW only. Typically, the SW and Devon have done very well from bioenergy grants and initiatives. This is probably due to Devon having a relatively high woodland cover as well as having many districts situated off the national gas grid. As a result many householders, businesses and organisations have chosen to adopt woodfuel rather than to pay higher prices for heating oil, LPG or electric heating.

<table>
<tr><th colspan="12">Year</th></tr>
<tr><th>2002</th><th>2003</th><th>2004</th><th>2005</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th></tr>
<tr><td colspan="4">Bioenergy Capital Grant Scheme Round 1</td><td>BCGS Round 2</td><td>BCGS Round 3</td><td>BCGS Round 4</td><td>BCGS Round 5</td><td>BCGS Round 6</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Bioenergy Infrastructure Scheme Round 1</td><td></td><td></td><td>BEIS Round 2</td><td></td><td>BEIS Round 3</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Clear Skies</td><td colspan="5">Low Carbon Buildings Programme</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">Co-ordinated Woodfuel Initiative</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="7">Rural Development Programme for England (Sustainable Woodlands South West)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Bioheat / SW Bioenergy Capital Grant Scheme</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Renewable Heat Incentive</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Phase 1</td><td>Phase 2</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Renewable Heat Premium Payment</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Farming & Forestry Improvement Scheme</td></tr>
</table>

Table 16: Bioenergy support mechanisms over the last decade

[32] www.redtreellp.com/downloads/Masterplan%20Book/chapter%204d.pdf

3.3.1 Bioenergy Capital Grants Scheme

Information was obtained from the Department of Energy and Climate Change (DECC) on biomass boiler installations supported by the six rounds of the Bioenergy Capital Grants Scheme[33]. From Round 3 onwards (2007-2010) 210 projects were supported nationally with an installed capacity of 88 MW. 41 projects (including 3 combined heat and power schemes) were supported in the SW of which nine were in Devon.

Table 17 below shows the breakdown of BCGS projects for the UK, the SW and Devon. In virtually all instances, the average project size for both the SW and Devon is much lower than the UK as a whole. The most significant sector in terms of installed capacity for the UK and SW was industry. By contrast none of the nine supported projects in Devon were for industry users.

Along with Gloucestershire, Devon had the most projects in the SW but again the average heat only project size was much smaller than the SW average (203 kW versus 310 kW). The two most common project types in the SW were installations in schools and on farms:

- 9 educational projects totalled 4.1 MW; 21% of projects, 25% of installed capacity
- 12 agricultural projects totalled 2.5 MW; 32% of projects, 22% of capacity

Sector	UK			South West			Devon		
	% of total projects	% of total installed capacity	Avg. project size (kW)	% of total projects	% of total installed capacity	Avg. project size (kW)	% of total projects	% of total installed capacity	Avg. project size (kW)
Agriculture	19	10	264	32	22	211	33	13	79
Charity	12	7	290	8	10	410	22	51	465
Education	12	18	793	21	25	369	22	27	250
Hospitality	8	4	264	3	2	133	11	7	133
Industry	20	41	1096	18	34	569	0	0	0
Local Authority	13	13	532	10	5	158	11	2	30
Other	16	7	245	8	2	94	0	0	0

Table 17: Breakdown of BCGS supported projects in the UK, SW and Devon.

There is a definite bias to educational projects in urban areas. For instance in the west of England (former Avon), education projects make up 66% of the total (20 out of 30 installations and 79% of the installed capacity. Unfortunately, the information provided by DECC does not indicate the boiler technology used (e.g. chip, pellet, logs) by the supported projects. However, it is assumed that larger projects would use wood chip as this is the cheapest fuel source.

3.3.2 Bioheat / SW Bioenergy Capital Grant Scheme

The SW Bioheat programme provided hand holding and feasibility studies for 30 projects across the SW. An underspend of funding from Round 3 of the BCGS provided £3 million of capital grants to help these projects progress. Projects included a 13 MW pellet boiler at Davidstow Creamery in Cornwall, a 750 kW wood chip boiler at the Royal Cornwall Hospital and a 500 kW boiler at Lanoyce Nursery in Cornwall. The Dartington Estate received a great deal of assistance looking at the potential for the site for biomass heating but as yet this has not been followed up with any installation.

Sector	No. of projects	Installed capacity (kW)
Charity	1	400
Commercial	1	160
Education	5	2040
Industry	2	13,500
Local Authority/Health	1	750
Total	**10**	**16,850**

Table 18: Breakdown of projects supported by the SW BCGS

[33] www.decc.gov.uk/en/content/cms/funding/funding_ops/innovation/historic/bio_grants/bio_grants.aspx

3.3.3 Bioenergy Infrastructure Scheme (BEIS)

Devon was particularly successful in achieving funding through the three rounds of this national scheme. Out of 79 projects funded, 13 were from Devon (16%). In terms of the grants awarded Devon projects received £1,022,824 from a total paid out of £6,770,589 (15%). The projects are listed in Table 19. Amongst, the successful projects there was funding for seven chippers and three pelleting facilities. Unfortunately, the project name provided by DECC doesn't always give an indication to the location of the recipient. However, it appears that only one project (South Devon Biomass Depot in Torquay) was inside the study area.

BEIS round	Name of Project	Final Total Grant	Administrative set-up costs for a producer group	Harvesting equipment	Wood chippers	Pelleters	Other pre-use processing equipment (e.g. shredders, dryers etc)	Quality assurance equipment (e.g. for checking moisture content, chip size etc)	Specialised handling equipment	Storage and hard-standing	Training
1	Clinton Devon Estates	£15,564						X		X	
1	Forest Fuels	£69,050	X		X				X	X	
1	Pellets Direct Ltd	£69,652				X				X	
2	Ford Barton Wood Fuels (biedeford)	£157,740			X			X	X	X	X
2	Mid Devon Wood Fuels	£34,397	X				X	X	X	X	X
2	Quality Woodchip Supplies	£28,287			X			X	X	X	
2	Holsworthy Wood Pellet Company	£139,000				X	X	X	X		X
2	Biofuel/Bioenergy manufacture	£157,320				X			X		X
2	Mells Park - Woodchip	£28,590			X				X	X	
2	Everard Partners Woodfuel Supplies	£117,910		X	X			X	X	X	
	Dartmoor Woodfuel Cooperative (PG)	£68,778	X	X				X	X	X	X
3	South Devon Biomass Depot	£60,305	N/A		X		X		X	X	
3	Coombe Woodlands Biomass Project	£76,231	N/A	X	X		X	X	X		

Table 19: Breakdown of projects supported by the Bioenergy Infrastructure Scheme

3.3.4 Co-ordinated Woodfuel Initiative (CWI)

The CWI covered the whole of the SW and provided a telephone advice line, free site visits from experts, and access to capital grants for small – medium scale biomass installations[34]. The county of Devon received a great deal of support from this service. 187 phone queries out of 516 came from Devon (36%) and 28 visits out of 80 were made to Devon customers. In addition 12 of the 24 funded installations were in Devon. Table 20 below indicates the breakdown of calls to the service according to different sectors. Over 50% of the calls were from householders or people living on farms or in estate properties.

Sector	No of calls	% calls	Visits	% of visits
Domestic	213	41	3	11
Farms	77	15	5	18
Estates	36	7	4	14
Community	41	8	9	32
Business	59	11	7	25
Other	90	17	0	0

Table 20: Breakdown of CWI calls

Six visits were conducted in the South Hams area: three to community buildings, one farm, one domestic property and one business. Capital grants were made available to encourage installations within participating protected landscape areas. Table 21 shows how the grants were spread across the various sectors.

Sector	Installations	% of installations
Domestic	5	20
Farms	4	17
Estates	3	13
Community	4	17
Business	7	29
Public	1	4

Table 21: Breakdown of grants awarded through the CWI according to sector.

17 out of the 24 projects were for pellet or log boilers indicating again a preference for these technologies in small scale projects (< 50 kW):

Boiler Technology	No of Installations	Installed capacity (kW)	Average project size (kW)
Wood chip	5.5	440	80
Wood pellet	7.5	299	40
Logs	10	487	49
Multifuel	1	70	70

Table 22: CWI Installations by boiler type (note: one installation used both wood chip and wood pellet)

3.3.5 Rural Development Programme for England (RDPE)

This programme includes a particular initiative called Sustainable Woodland SW which provides forestry businesses with the opportunity to apply for capital investment grants in machinery, equipment, infrastructure, buildings and marketing support[35]. Jez Ralph of the Silvanus Trust who runs the scheme provided some information on the sort of queries that have been received[36]. Many of these queries may not even have reached the application stage, but the following information provides an indication of the type of interest being shown by local forestry businesses.

Since the inception of RDPE there have been 510 enquiries from across the SWof which 166 were in Devon. Of the Devon enquiries, 45 related to woodfuel and nine of these originated from South Hams as follows:

- Firewood producer in Thurlestone interested in a log processor;

[34] www.cse.org.uk/projects/view/1087.58
[35] www.silvanustrust.org.uk/index.php?page=grant-funds-for-forestry-businesses
[36] Email from Jez Ralph, Silvanus Trust received 23/1/12.

- Woodland owner looking at self supply of logs and needing processing equipment;
- Prospective firewood merchant in Totnes interested in a log processor;
- Woodland owner setting up firewood business to provide income from his woodlands;
- Joinery wanting to set up briquette production using saw-dust waste;
- Sawmill wanting to store and dry wood chip;
- Firewood processor in Kingsbridge wanting new processor;
- Estate wanting to start harvesting timber for self-supply and sales of woodfuel;
- Firewood processor wanting winch for timber extraction and hardstanding for conversion.

Of the nine queries, six concern small scale woodfuel production in terms of logs and briquettes. Only three of the queries indicate an interest in woodchip production.

DEFRA are currently processing applications to Round 1 of the Farming and Forestry Improvement Scheme (FFIS). This national funding pot provides grants for a variety of forestry activities including chippers and log processors. Early results suggest that SW farms and forestry businesses produced 490 applications. This equates to around 25% of the total for the English regions. As many as 350 applications may be successful. It is therefore highly likely that there will be more woodfuel infrastructure available in the very near future, although how much of this will be in the South Devon area remains to be seen.

3.3.6 Renewable Heat Incentive

The aim of the RHI is to increase the amount of renewable energy production in the UK by encouraging initially non-domestic users to install renewable energy technologies for heating buildings or for processing activities. The scheme is managed by Ofgem, the energy regulator. A useful summary of the scheme has been produced by Econergy[37]. In order to be eligible for the scheme a project developer has to go through an accreditation process with Ofgem which is completed after the boiler is installed.

Phase 1 of the scheme is underway for non-domestic users e.g. offices, hotels and schools. Quarterly rebates are paid to the project developer based on the capacity of the boiler and its quarterly meter readings. The scheme provides the best return for small boilers under 200 kW. In this case the first 1,314 hours that the boiler works each year (15% capacity) will provide a rebate of 7.9p/kWh. Above this number of hours the rebate is 2p/kWh.

<table>
<tr><th>Tariff name</th><th>Eligible Technology</th><th>Installed capacity (kW)</th><th>Tariff rate (pence/kWh)</th><th>Duration (years)</th><th>Support calculation</th></tr>
<tr><td>Small biomass</td><td rowspan="3">Solid biomass (includes: wood chip, wood pellet, wood logs)</td><td>Up to 199 kW</td><td>Tier 1: 7.9
Tier 2: 2.0</td><td rowspan="3">20</td><td rowspan="2">Metered:
Tier 1 applies annually up to tier break, tier 2 above the tier break.
The tier break is 1,314hr x installed capacity (kW)</td></tr>
<tr><td>Medium Biomass</td><td>200 kW to 999 kW</td><td>Tier 1: 4.9
Tier 2: 2.0</td></tr>
<tr><td>Large Biomass</td><td>1000 kW and above</td><td>1.0</td><td>Metered</td></tr>
</table>

Table 23: RHI tariff levels

It is possible to use heat produced from an eligible system to dry woodfuel. This would work nicely with an SRC willow growing operation. SRC is harvested wet and could be dried to produce a premium grade wood chip. Examples of potential returns for different sized projects under the 200 kW threshold are summarised in Table 24 below.

[37] www.econergy.ltd.uk/docs/files/RHI%20OFGEM%20Guidance%20Summary%2017-11-2011.pdf

It is still very early days yet for the RHI. So far only six projects have received accreditation including four biomass boilers[38]. Three of the four projects are under 70 kW in size. The RHI is currently only available to non domestic biomass installations. Phase 2 of the scheme, which is currently being developed, may potentially be open for domestic properties and is scheduled for launch in during 2013.

Boiler rating	70 kW	150 kW	199 kW
Total annual heat demand to be met from biomass boiler	100,000 kWh	200,000 kWh	320,000 kWh
Number of operating hours	1429	1333	1608
Tier Break	70kW x 1,314hrs = 91,980 kWh	150kW x 1,314hrs = 197,100 kWh	199kW x 1,314hrs = 261,486 kWh
Tier 1 tariff revenue	91,980 kWh x 7.9p = £7,266	197,100kWh x 7.9p = £15,571	261,486 kWh x 7.9p = £20,657
Tier 2 tariff revenue	(100,000 - 91,980) x 2.0p = £160	(200,000 – 197,100) x 2.0p = £58	(320,000 – 261,486) x 2.0p = £1,170
Total annual RHI revenue (Tier 1 + Tier 2)	£7,426	£15,629	£21,827

Table 24: Potential returns from the RHI

3.3.7 Renewable Heat Premium Payment

The RHPP is the forerunner of the RHI for domestic customers. The RHPP runs until 31st March 2012 and provides one off payments of £950 for biomass boilers.

So far over 3,500 vouchers have been issued and over 20% of these have gone to projects in the SW. For biomass boiler installations, the SW has the most domestic installations of all eight English regions and also exceeds uptake in Wales. The 129 biomass projects in the SW are only surpassed by the 180 installations in the whole of Scotland.

We have made a request to DECC to provide information on technology type and size and a breakdown of the statistics according to SW counties and districts. Unfortunately, at the time of writing this information has not been forthcoming. If this information becomes available in due course it will be provided to Energy Action Devon.

3.4 The reality of woodfuel demand

At part of this study we have sought to acquire as much information as possible to indicate the types of end user and projects that are early adopters of biomass heating. An understanding of the local end user demographic is very important when attempting to match supply and demand and considering the feasibility of woodfuel hub projects.

3.4.1 Trends in biomass installations

The most accurate records for woodfuel heating installations in the South West are produced by Regen SW. Figure 17 below shows the increase in biomass installed capacity in the SW as a whole and for the county of Devon since 2005[39].

[38] https://rhi.ofgem.gov.uk/Public/ExternalReports.aspx?id=1
[39] Regen SW Annual Surveys 2005-2011. www.regensw.co.uk/projects/support-for-decision-makers/annual-survey

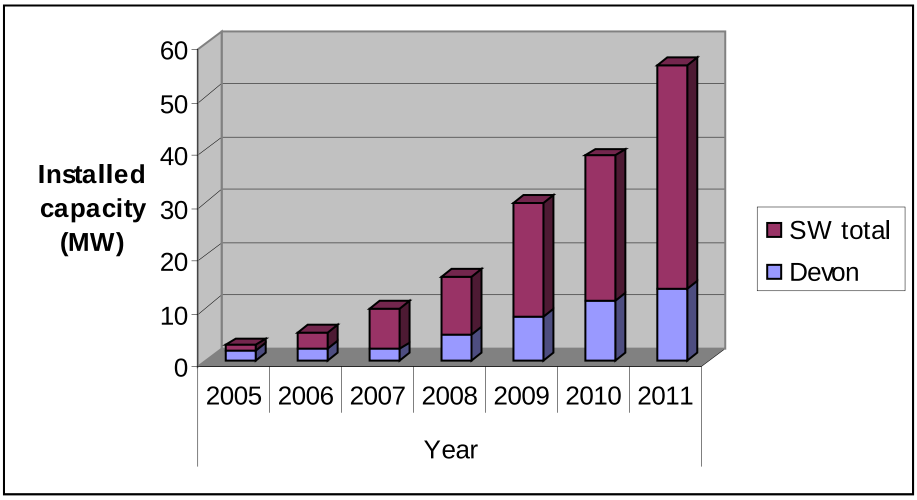

Figure 17: Biomass installed capacity in SW and Devon since 2005

As of March 2011 there were 482 biomass heating projects In the SW with an installed capacity of 56.04 MW. The average installed capacity is 116 kW. Devon has the greatest share of biomass projects with 185, totalling 13.77 MW. However, the average installed capacity in Devon is 74.4 kW which much lower than the regional figure. Devon therefore has 38% of total projects but only 25% of the total installed capacity in the region.

Unfortunately, Regen SW has only produced numerical figures for woodfuel projects since 2010. In 2010/11 the number of projects in the SW increased from 352 to 482, a 37% increase. In Devon the projects rose from 149 to 185 a 24% increase. Also, in 2010, Regen SW began publishing figures for districts within counties. Projects in the South Hams area currently have an installed capacity of 1.75 MW which means that the study area currently has 3% of the total installed biomass capacity of the SW. The 2011 figure saw a 78% increase in capacity over the previous year.

These results would suggest that other counties are beginning to narrow the gap with Devon. Yet certain districts such as South Hams which have previously been slow in adopting biomass technology are also showing an increase in activity.

Table 25 below shows some of the current boilers in the South Hams area that are mapped on the South West Woodshed website[40]. The total capacity of these projects is much lower than the figure provided in the Regen SW annual survey for 2011, hence there must be other projects in the study area that are not listed below. In general woodchip boilers tend to be used in larger projects than log and pellet boilers.

Site	Boiler type	Capacity (kW)	Date installed
Lower Coombe Royal Holiday Cottages	Pellet	25	2007
Sandover Associates	Log	25	2007
Sharpham Trust	Chip	200	2008
Slapton Ley Field Centre	Pellet	100	2008
Underwood Delivery Centre	Log	25	2009
Paington Zoo Crocodile Swamp	Chip	114	2009
Torr Quarry	Chip ?	100 ?	2009 ?
Devon Furniture Forum	?	?	?
Dean Forge	?	?	?
Hatch Court	?	?	?

Table 25: Woodfuel boilers installed in the study area

[40] www.southwestwoodshed.co.uk

3.4.2 Woodfuel demand in South Devon

It is beyond the scope of this project to fully identify and quantify the potential demand from end users in South Devon. However, if previous activity for the whole of Devon is representative of the study area then we are likely to see projects coming forward that are generally smaller in size than the SW and UK averages. This is probably because a great many installations will take place in off-gas domestic properties and farms. Other ideal candidates for the study area include commercial organisations such as hotels, golf courses and holiday lets, local authority buildings (particularly schools), leisure centres and care homes and large estate properties including those owned by charitable organisations.

It is possible that a great deal of the woodfuel demand in the study area will be in the form of logs and pellets. This is likely to be the case because:

- The majority of projects will be at the domestic and farm scale;
- Some end users will be in urban situations where space is a premium;
- Some end users particularly those in the hospitality sector will require quick, simple, non-disruptive and tidy delivery methods.

The need for additional pellet supply could dovetail nicely with the need for additional biomass from energy crops. Miscanthus in particular could be improved as a fuel by densification into a pellet. The bulk density of the fuel would increase by a factor of five and the combustion qualities could be improved by blending with sawdust or the inclusion of additives such as lime. The use of wood chips is likely to be for larger projects typically over 70 kW where space is less of a consideration.

4 Woodfuel hub options

4.1 Review of case studies and business model options

A woodfuel hub or depot is a permanent site of woodfuel production and distribution which often may be part of a larger enterprise such as a sawmill or waste management company seeking to add value to other activities, or it may be a separate business in its own right. A range of factors will determine the operations of the hub, including its location, the feedstock being processed and how much storage space is available. In considering options for South Devon, some examples of existing woodfuel hubs and related initiatives are included below.

4.1.1 Blaise Nursery, Bristol

Bristol City Council (BCC) has created a depot for arboricultural arisings at their Blaise Nursery site in the north of the city. Contractors tip their arisings onto an area of hard standing and the chip is transferred into a mechanical grading facility which has a processing throughput of 15 tonnes per hour. Of this, five tonnes of suitable woodfuel is produced which is stored in an adjacent Dutch barn. Oversized material is then re-chipped whilst fines are composted.

Figure 18: Dutch barn and woodchip grading kit at Blaise Nursery

The Energy Management Unit at BCC suggested that the grading system cost £45k. The construction of a 15m x 10m pole barn cost in the region of £40,000 and enables the chip to dry more effectively and protects it from rain. They also point out that only a proportion of the woodfuel potential from arboricultural arisings across the city will be realised as some tree work will take place too far away to make it cost effective to transport to the depot.

4.1.2 Down Farm

Down farm in Hampshire is a traditional family mixed farm that has operated a green waste recycling operation since 2002, which is in effect a woodfuel hub. Local landscape contractors and tree surgeons can come and tip after each job, along with larger consignments from waste transfer stations and site clearance jobs. The waste is shredded or chipped on site, producing either compost for the farm or woodchip for sale as fuel. Suppliers have to pay a gate fee, but access is automatically controlled and can be 24 hours a day. The work area is concreted and floodlit with turnaround being as little as 3 minutes.

4.1.3 BioRegional TreeStation

The sustainability charity BioRegional developed the model of a 'TreeStation'[41,42] as a place where wood residues are collected, processed into high grade woodfuel and then supplied for use in local biomass installations. A pilot TreeStation was developed in Croydon in partnership with Croydon Council and City Suburban Tree Surgeons

[41] www.BioRegional.com/news-views/publications/TreeStationprojectreportsep01/
[42] www.BioRegional.com/files/.../CroydonWoodchipCaseStudy.pdf

intending to produce 10,000 tonnes of high quality woodchip a year. After eight years of activity the structure and operations of the Croydon TreeStation were reviewed by BioRegional. The site, which has for the last five years been owned and operated independently of BioRegional, processes and sells 3,000-5,000 tonnes of wood residues from arboricultural activities per annum. However, in contrast to the original plan the fuel is low grade and unsuitable for use in small to medium scale biomass boilers and biomass CHP.

The capital cost of the project was £190,700 with funding coming from various grant sources, direct investment from City Suburban and BioRegional, and in-kind contributions from London Borough of Croydon. BioRegional suggest a total figure of around £232,500 for developing a new TreeStation, based on the Croydon site but represents likely maximum costs.

BioRegional state the crucial partnership of themselves, the tree surgeons and Croydon Council, highlighting the importance of a public-private partnership, which is supported by the South-West Wales study below. BioRegional's project planning and fundraising, the council's provision of the site, facilities (e.g. weighbridge) and access to raw materials and City Suburban's investment, skills and experience were all vital to the establishment of the TreeStation. At present the commercial viability of the TreeStation depends on Croydon Council passing on the gate fee of £22/tonne they receive for dropping off material at the yard. It is suggested that the long term commercial success depends on the development of a local, smaller scale biomass heat market.

Initial production rates were very low, though they have steadily increased as staff became more familiar with the equipment and working methods have been refined. Increasing throughput and efficiency has occurred as arboricultural waste has been brought from wider area, reducing disposal costs for other councils and suggesting that only a few TreeStations are needed to serve the whole of London.

4.1.4 Forest Fuels

Forest Fuels[43] is a major woodfuel supplier based in the South West supplying woodchip and pellet nationally through a network of 15 local depots, including one at South Brent in South Devon. They aim to source, dry and process woodfuel as close to the end users as possible. Timber is bought as freshly-felled at the roadside or as delivered to their depots, or alternatively it is bought through landowner partnerships. They also offer Heat Supply Contracts where the customer pays no capital outlay but agrees to buy heat for a defined period.

4.1.5 LC Energy

LC Energy is a relatively new dedicated woodfuel supply company operating with four small depot sites across North London. They operate supply contracts to local customers, mainly of high grade woodfuel. The sites are unmanned "farm based" operations, where material is brought in as roundwood feedstock and processed using mobile chipping equipment, before being distributed to customers. The company is a dedicated wood heat supplier. They are not involved in other operations.

4.1.6 AHS Energy

AHS Energy is a privately owned company involved in biomass supply, currently operating two depot sites in the south of England; one at Aldermaston in North Hampshire and one in Sussex. The main depot at Aldermaston consists of an extensive area of hard standing, clean tarmac, concrete bays, a mobile chipping facility and on-site fixed screening. It processes both roundwood and tree surgery arisings. Processed high grade fuel and low grade woody biomass for use in larger scale operations are distributed from this central hub over a very wide radius (including supply to a hospital at Boston in Lincolnshire). AHS Energy's business model is predicated on the economies of large-scale processing and storage at a single site with efficient low cost distribution through a haulage partner. AHS takes large quantities of wood chip from arboricultural and utility landscape operations from across the North London area. The residues are taken to the depot in Aldermaston for reprocessing and then distributed, mainly to power stations.

[43] www.forestfuels.co.uk

4.1.7 Woodfuel production in South East Wales

A 2011 report entitled '*Developing Woodfuel Production and Use in South East Wales*'[44] by Woodfuel Solutions identified a host of factors that will affect the success of a woodfuel hub. It points to a public-private partnership as the ideal way to establish a hub, arguing that:

- The private sector will be unwilling to invest in infrastructure before there is a clear market for woodchip – this won't help unlock the current "chicken and egg" situation;
- The public sector has traditionally not had the commercial experience and skills to operate long-term successful & profitable (and therefore truly sustainable) businesses;

Successful operation of a woodfuel hub means offering secure woodfuel supply contracts to customers to build the credibility of woodfuel – and taking the commercial risk on these contracts is a crucially important part of that credibility. This risk does not sit well with local authorities.

The report proposes that a local authority invests in the site infrastructure and rents it (on a commercial basis) to a private sector woodfuel business. This is a model which has been used successfully elsewhere, such as a site in South Yorkshire:

> *"Various pieces of equipment were purchased by a public body (chipper, tractor, trailers) and their operation tendered to the private sector. Silvapower Ltd won this tender and has operated the equipment for several years, paying for it on a profit share system. The injection of new, high-quality equipment into the supply chain made a step-change difference to woodfuel in the South Yorkshire area. This model is identical to that proposed above i.e. public sector invests, private sector operates and pays a hire charge, and the market is developed."*

The advantages of this set-up to the local authority reportedly include:

- a good level of return from site rental without the risk of operating contracts;
- establishes hub without having to commit to its operation;
- use of private sector presence, skills and experience in operating business contracts;
- ensures establishment of hub in the right place;
- kick-starts local woodfuel production;
- builds confidence among customers.

Local authority depots are very often provided to a private sector arboricultural or grounds maintenance operator for the duration of their contract with the local authority.

Some further guidance from the report on woodfuel hub operation and management is included below:

Hub operation:
The report suggests that the local authority would run the site and invest in necessary infrastructure, but then rent to a private operator. Long-term leases are advised to give the operator confidence to invest and build stock. Rent could be charged on a site or throughput basis: the latter offers support during slow initial start up. This partnership model may unlock the investment barrier that may exist when a potential woodfuel depot is owned by a third party such as a farmer who could not justify the necessary capital expenditure. Careful site selection, design and layout are needed to minimise environmental issues, such as noise, vehicle movements, dust and the potential of leachates. Guidance should be sought from the Health and Safety Executive, in particular in relation to site drainage.

[44] http://llaisygoedwig.org.uk/wp-content/uploads/2011/08/South-East-Wales-Woodfuel-Supply-Final-Report-July-2011.pdf

Management and staffing requirements:
Permanent staff may not be financially viable in a hub's early stages and so part time staff as and when required may be more suitable. When the hub commences supply, however, it is thought that permanent staff with an engineering and operational background would be required. Training in day to day operation and basic maintenance and repair of onsite equipment is essential, along with procedures ensuring efficient management of stock levels. Specific training in woodfuel handling, processing and adherence to fuel quality standards is thought critical.

4.1.8 North London woodfuel processing hub feasibility

BioRegional's '*North London Woodfuel Processing Hub – A Feasibility Study*'[45] publication in early 2010 investigated the feasibility of a woodfuel processing hub in North London by identifying a number of interested parties and producing an evidence base for informing an investment decision. BioRegional's experience is based on the pilot TreeStation in Croydon, discussed above. Along with a region-wide resource and demand assessment, the report sought to investigate suitable sites, identify potential project partners and develop a business model and establishment plan.

The resource assessment identified approximately 58,000 tonnes per year of woodfuel (predominantly woodlands and arboricultural arisings) and the capacity of the modelled woodfuel hub was 20,000 tonnes per year. Modelling four scenarios – both a new or existing depot with or without a grant – the study concluded that despite needing a high capital investment, operational revenues could ensure the financial viability of a hub.

Through research and stakeholder engagement the project team established that the viability of a new site was in doubt and decided to concentrate on identifying existing sites. The report outlines some key physical characteristics:

- gross area of approximately 2 hectares;
- shape/layout should allow the erection of woodfuel storage barn and external storage for timber, off-cuts and woodchip;
- sufficient space for office, parking, processing, loading/unloading, machinery storage and servicing, re-fuelling and storage of bi-products such as mulch and bark;
- existing hard standing is beneficial;
- suitable shape and size to accommodate a range of vehicle and machinery movements.

The report highlights a range of potential partners with sites who expressed an interest in the project. Two of these are referred to above as case studies identified by BioRegional in earlier reports – LC Energy and AHS Energy - who are already involved in the woodfuel industry and have sites set up with much of the requirements already in place. Other potential partners include large-scale arboricultural contractors, other existing woodfuel suppliers, waste contractors, a county council and an agricultural college.

As part of the report's financial modelling haulage is assumed to represent around 25% of sales cost, and it is highlighted that diversity in boiler sites will require a wide range of delivery vehicles; it is thought impossible for the hub operator to own these and so it will be heavily reliant on contract haulage.

The report projects that when the depot is supplying over 12,000 tonnes per year around 9 full time staff would be required, with 2-3 of these office- based.

Rent has not been included for the existing sites, though for new depots the model assumes £12,000 per year, with an additional £4,800 for rates and £1,200 for water. Regarding capital expenditure, the model assumes around £270,000

[45] www.cchangeproject.org/jsp/uploaded_files/documents/misc/woodfuelhub_feasibilitystudy_BioRegional.pdf

for the new sites as all processing equipment will need to be purchased. For the existing sites it is assumed that most of the machinery is provided by the partner, though screening and loading equipment is costed at £70,000.

4.2 Processing feedstock to woodfuel

Each of the woodfuel resources reviewed in this report has its own characteristics and dealing with them requires an understanding of the handling, storage, drying, processing and utilisation. Appendix 1 provides in depth information on the physical characteristics and the handling, storing, drying, processing and utilisation issues for each fuel source. Many of the wood fuel options with lower up-front costs will require more handling in order to produce a quality end product enabling a boiler to work efficiently and minimise operation and maintenance issues and prolong its lifetime.

4.2.1 Woodfuel specifications

All biomass boilers come with a manufacturer's specification for the woodfuel that should be used to maximise performance. Until recently each country had their own set of standards but now a European wide standard (CEN /TC 335) has been created. There are standards for wood chip, wood pellets, logs and briquettes. The following is simple explanation of the new CEN standards as produced on the Biomass Energy Centre website:[46]

> *CEN/TC 335 allows all relevant properties of the fuel to be described, and includes both normative information that must be provided about the fuel, and informative information that can be included but is not required. As well as the physical and chemical characteristics of the fuel as it is, CEN/TC 335 also provides information on the source of the material.*
>
> *Specifications:*
> *The fuel specifications and classes for all solid biofuels are set out in CEN/TS 14961:2005, which defines certain parameters and property classes.*

The normative and informative specifications for different types of wood fuel are set out below in Table 26:

[46] http://www.biomassenergycentre.org.uk/portal/page?_pageid=77,19836&_dad=portal&_schema=PORTAL

	Chips	Logs	Pellets	Briquettes	Miscanthus straw
Origin					
Dimensions (mm)	Main fraction, fines fraction & coarse fraction	Length & diameter	Diameter & length	Diameter & length	Round bale: diameter & length; Square bale: height, width & length
Moisture content					
Ash content					
Volume (m3 stacked or loose) or weight (kg)					
Mechanical durability					
Amount of fines					
Additives					
Particle density					
Bulk Density (kg/m3)					
Energy density (kWh/kg or kWh/m3 loose or stacked)					
Proportion of split volume (No split = round wood; split = 85% of volume is split; mixed)					
The cut off surface (even and smooth or uneven)					
Mould and decay (> 10% of weight					
Bale density (kg/m3)					
Net calorific value					
Nitrogen content					
Chlorine content					
Sulphur content					
Ash melting behaviour					
Species					
Binding type of bales					
Production method					

Table 26: Normative & informative woodfuel specifications

Key:

	Normative
	Normative/informative
	Informative

4.2.2 Pellet Quality

The standards for wood pellets have been rolled out through the ENplus quality certification agreed by the European Pellet Council in January 2011[47]. There are three grades of pellets recognised:

- Grade ENplus A1 pellets are typically required for domestic boilers and attract a premium price of around £200/tonne. Suitable raw materials for this grade includes stem wood and chemically untreated wood residues.
- Grade ENplus A2 pellets are worth around £150/tonne. A suitable raw material for these pellets includes whole trees without roots, stem wood, logging residues and chemically untreated wood residues.
- EN B pellets are more appropriate for larger commercial and industrial boilers which are more robust and can run on a lower grade of fuel. Suitable raw materials for these pellets include virgin wood, chemically untreated wood residues, chemically untreated used wood but no demolition wood. EN-B does allow minimum levels of glue, grease and other timber production additives used in saw mills so long as concentrations are low and chemical parameters fall within the set limits. They have a significantly lower

[47] www.pelletcouncil.eu/en/pellet-quality-enplus/qa/

price of £100/tonne. Typically pellets derived from energy crops, arboricultural arisings and heathland arisings would fall into this category.

The table below shows the EN specification under each grade for different parameters.

Parameter	EN specification		
	EN Plus– A1	EN Plus– A2	EN-B
Pellet durability (%)	≥ 97.5	≥ 97.5	≥ 96.5
Bulk density (kg/m^3)	≥ 600	≥ 600	≥ 600
% Moisture content	≤ 10	≤ 10	≤ 10
% Sulphur content	≤ 0.05	≤ 0.05	≤ 0.05
% Nitrogen content	≤ 0.3	≤ 0.5	≤ 1.0
% Chlorine content	≤ 0.03	≤ 0.07	≤ 0.10
Net calorific value (MJ/kg)	≥ 16.5	≥ 16.3	≥ 16.0
% Ash content	≤ 0.7	≤ 1.5	≤ 3.0
Ash melting temperature (°C)	≥ 1200	≥ 1100	≥ 1100

Table 27: EN specifications for pellets

4.2.3 Woodfuel limitations

Some typical values for solid biomass fuels[48,49] are detailed in the table below. It is clear from this that energy crops have lower quality than woodchip produced from round wood. Typically, they have higher ash content, lower ash melting point, lower bulk density, lower calorific value and higher contents of nitrogen, chlorine, sulphur and silica.

Parameter	Unit	Coniferous wood	Broad leaf wood	SRC willow	Miscanthus
Ash	w %	0.3	0.3	2.0	4.0
Bulk Density of chip @ 30% MC	kg/m3	225	330	175	100
Net calorific value	MJ/kg d	19.1	18.9	18.4	17.7
Nitrogen	w %	0.1	0.1	0.5	0.7
Chlorine	w %	0.01	0.01	0.03	0.2
Sulphur	w %	<0.02	0.02	0.05	0.2
Silica	mg/kg d	150	150	500	8000
Ash melting point	^{o}C	1426	1340	1283	973

Table 28: Typical properties of woodfuels

Arboricultural arisings would probably have a similar profile to SRC, although this source is likely to have a higher chlorine concentration due to the amount of leaf material mixed in with the chip. In addition this source may have other contaminants such as plastic, metal and soil.

Table 29 below shows how using high ash fuels in a boiler will require more frequent ash disposal. Fuels with a low ash melting point result in clinker, a glass like deposit which builds up in the combustion unit. This restricts air flow which not only leads to less efficient combustion but also prevents the cooling effect of the air flow on the grate leading to rapid erosion. Fuels with low bulk density require more storage space and more frequent deliveries. Fuels with a high content of chlorine or sulphur can lead to the corrosion of boiler walls and tubes. Fuels that are high in

[48] Solid biofuels – Fuel specifications and classes. Part 1 General requirements. British Standard BS EN 14961-1:2010
[49] AEBIOM Woodfuels Handbook

nitrogen are more likely to produce higher emissions of nitrogen oxides (NOx). These will be more closely monitored under Phase 2 of the Renewable Heat Incentive.

Biomass used tonnes/yr	Ash produced tonnes/yr				
	1%	2%	3%	4%	5%
100	1	2	3	4	5
250	2.5	5	7.5	10	12.5
500	5	10	15	20	25
1,000	10	20	30	40	50
1,500	15	30	45	60	75
2,000	20	40	60	80	100

Table 29: The ash produced depending on the amount of biomass used and its ash content

However, none of these issues are insurmountable as long as an appropriate boiler is used. A miscanthus compliant boiler should have some or all of the following features:

- A step grate or tilting grate;
- Stainless steel-lined combustion chamber;
- Sophisticated feed system including an agitator and reversible auger and a rotary chopper to cut oversize material;
- A lambda probe which adjusts the input of fuel as well as the air intake for combustion according to the energy density of the fuel being used;
- An exhaust gas flue recirculation system. This extracts flue gases and recirculates them into the combustion chamber. The gas mix is oxygen poor so this inhibits the burn temperature and thereby reduces clinkering;
- Automatic cleaning;
- Large volume ash bins meaning longer intervals between emptying;
- An alarm which goes off when the ash box is full.

An end user must consider the following before installing a miscanthus system:

- The bulky fuel means that much more storage is required;
- If the fuel is being delivered from a third party there will be much more frequent deliveries;
- Boilers using miscanthus are downgraded in their capacity as it is physically impossible to get enough fuel into the combustion chamber to achieve the rated capacity. Hence a 200 kW boiler can only achieve an output of 150 kW using miscanthus;
- The boiler will require more operations and maintenance as a result of its high ash fuel and its low melting point;
- In the absence of a stainless steel combustion chamber it is possible to reduce the impact of chlorine damage by adding lime to the boiler combustion chamber. Tests by AFBI in Northern Ireland suggest the need for 3.8 kg of lime for each tonne of miscanthus used[50].

4.2.4 Renewable Heat Incentive (RHI) emissions limits

From October 2012 all installations accredited under the RHI must meet emission limits of 30 grams per Gigajoule (g/GJ) for particulates and 150 g/GJ NOx. It should be possible to achieve this with good quality woodchip in more efficient boilers. By contrast, miscanthus is particularly dusty and produces a high level of particulates (around 100

[50] Alistair McCracken, AFBI. Personal communication.

g/GJ)[51] so is likely to miss this target. However, it might be possible to achieve these stringent requirements by using ceramic filters in the flue. It is suggested that ceramic filters can significantly reduce PM10 (particles measuring 10 micrometers or less) and PM2.5 from boiler emissions. However, this would add around 10-15% to the installed costs of the boiler[52].

Both SRC and miscanthus have higher nitrogen contents than typical woodchip and they might fail to meet the grade on this front as well. Currently there is no emissions control technology that is capable of cost effectively reducing NOx emissions from smaller biomass boilers. However, until now there has been no incentive for manufacturers to address NOx emissions so once addressed it should be possible to achieve these limits.

4.3 Options for a South Devon woodfuel hub

4.3.1 Woodfuel hub viability

Drawing on lessons learned from woodfuel hub initiatives elsewhere, a sensible approach in identifying potential sites for a new South Devon woodfuel hub would be to first consider sites which already host some form of woodfuel-related activity or have existing facilities which may be easily adapted to woodfuel processing. Based on the North London study (see Section 4.1.8), key criteria for a hub included having a gross area of approximately 2 hectares (assuming a production capacity of 20,000 tonnes per year) to incorporate a suitable layout comprising a woodfuel storage barn, outside woodfuel/bi-product storage and processing areas with hard standing, space for a site office, parking and unloading/loading, and equipment storage.

Clearly the site should also have good transport links and be located with due regard to the feedstock resources in the local area i.e. located within a good capture radius of known wood arisings. The site selection process should also pay due regard to matching feedstock types with woodfuel products and the associated quality assurance and standards. Another key requirement for establishing a new site will be to ensure that there is sufficient woodfuel demand in the area to make the project financially viable.
Viability may be improved if there exists an opportunity to operate a woodfuel heat facility on the site to supply low carbon heat to nearby buildings, and/or to supply on-site wood drying processes.

The results of the North London study concluded that although high capital investment is needed along with working capital, operational revenues can result in favourable returns. The project modelled four scenarios as follows:

Modelled scenarios	IRR % over 5 years	IRR % over 10 years	Payback period (Not Discounted)	NPV 10%
1. New depot	(10)	10	6 years 2 months	£181,130
2. New depot with grant	(3)	20	5 years 3 months	£348,791
3. Existing depot	5	26	4 years 7 months	£492,310
4. Existing depot with grant	19	38	3 years 9 months	£648,164

Table 30: Viability of scenarios as modelled in 'North London Woodfuel Processing Hub – a feasibility study'[45]

Looking at the resource figures for the South Devon study area, it is unlikely that a woodfuel hub would be viable at the scale considered in North London i.e. 20,000 tonnes per year, but there are examples of sites operating at much smaller scales, such as the Blaise Nursery depot in Bristol (see Section 4.1.1) which typically processes around 500 tonnes/yr. In order to increase the likelihood of maximising feedstock capture across the study area, a number of

[51] Thermal degradation of Miscanthus pellets: kinetics and aerosols characterization. Sophie Dorge, Mejdi Jeguirim and Gwenaëlle Trouvé. WASTE AND BIOMASS VALORIZATION Volume 2, Number 2, 149-155.
[52] www.environmental-protection.org.uk/assets/library/documents/EPUK_RHI_Response_(Final_190410).pdf

woodfuel hubs would need to be set up with a good geographical spread. Conversely it might be more cost effective to site a single hub near the source of greatest production. However, the woodfuel market in the hub locality will again be an additional factor to consider.

The ownership and operational arrangements of a woodfuel hub also need to be considered. In particular, community groups pursuing a new woodfuel initiative may wish to identify the most suitable organisational legal structure under which to operate. Options include Community Interest Companies, Worker Cooperatives, and Industrial & Provident Societies. These are explored further in the Plan LoCaL resource[53]. In any case, high priority should be given to early consultation with stakeholders to ensure that the community is kept informed and that their views are considered.

4.3.2 Example site – Torr Quarry Industrial Estate

To investigate all potential sites across the study area is beyond the scope of this study, but an example of one such site which may warrant further investigation is the Torr Quarry Industrial Estate north of Kingsbridge, which currently hosts the Kingsbridge Recycling Bank, a waste transfer station, vehicle workshop and a number of other businesses. Although on-site heat loads are thought to be relatively small, the site is thought to have sufficient space and good accessibility to act as a woodfuel hub.

Figure 19: Aerial view of Torr Quarry Industrial Estate (courtesy of Bing Maps)

[53] http://www.planlocal.org.uk/downloads/group/exercises/page:5#listTop

5 Summary of findings

5.1 Woodfuel supply

- Existing woodfuel supply chains in Devon and the South West are relatively advanced with several supply depots and suppliers distributed across the region. Currently forestry-derived supplies are therefore reasonably abundant, with a proportion of existing feedstocks in and around the study area likely to be drawn into woodfuel production through the stimulus of new woodfuel demand regardless of any new supply-side initiatives;
- The main woodfuel technical resource annual arisings in the study area (in oven-dry tonnes) has been estimated as being 7,622 tonnes from woodland management, over 50,000 tonnes from waste wood arisings and a potential 479,955 and 329,280 tonnes from miscanthus or SRC respectively;
- A significant proportion of the woodland resource is likely to be already producing woodfuel for domestic use. Additionally, in reality only relatively small proportions of the waste wood and energy crop technical resource are likely to be developed into woodfuel supply chains. For example, the bulk of the waste wood arisings currently go to non-fuel uses and will be mixed with contaminated waste streams, and the development of energy crops faces the barrier of competing land use and land-owner engagement;
- However, to further illustrate the potential, if 25% of the woodland resource and 3.5% of the SRC energy crop resource were brought into production, a total of 13,431 oven-dry tonnes/yr could result. This could deliver around 69,170 MWh/yr, which would be approximately equivalent to the annual heat supply needs of 3,662 typical homes and would result in CO_2 savings of around 14,000 tonnes/yr if displacing heating oil;[54]
- Other sources of biomass that could be exploited include major road verges, hedgerows, field boundaries on minor roads, railway verges and coastal area, although there are specific challenges in accessing these resources. Another option for increasing biomass supply would be to plant trees or energy crops on restored landfill sites. This is becoming common practice amongst waste services companies;
- Woodfuel from energy crops has lower quality but can be produced more cheaply than other sources as long as good land is used and best practice is adhered to. Small plantings of energy crops produce sufficient fuel for small – large buildings. A farm may require only 2 ha of SRC whilst a secondary school would require 10 ha;

5.2 Woodfuel demand

- The 2007 study 'Devon Miscanthus and Woodfuels Opportunities Statement' considered 'Priority Areas' across Devon where levels of domestic demand for heat, lack of access to mains gas supply and risk of fuel poverty may combine to create particular opportunities for woodfuel. Three Priority Areas around Dartmouth, east of Kingsbridge and Yealmpton were identified in the South Devon study area;
- Devon also has a high proportion of woodfuel heating installations compared to elsewhere in the South West and the UK, which will facilitate further expansion of the sector and benefit the development of a woodfuel hub in terms of feedstock supply chains and the woodfuel market;
- The South Devon study area is likely to see woodfuel heating projects coming forward that are generally smaller in size than the South West and UK averages as a relatively high proportion of installations will take place in off-gas domestic properties and farms. There will therefore be a need for logs and pellets as well as woodchips;
- A number of biomass energy support mechanisms have helped to stimulate the sector over the last decade. The recent launch of Phase 1 of the Renewable Heat Incentive scheme is set to significantly boost the uptake of woodfuel installations over the next few years; this is particularly true if domestic installations become eligible during Phase 2 in 2013;
- A useful tool to help identify heat loads within a local community is the National Heat Map[55], developed by CSE and launched by the Department of Energy and Climate Change in March 2012. A preliminary analysis of the

[54] Assumes emission factors of 0.247 $kgCO_2/kWh$ for oil and 0.02 $kgCO_2/kWh$ for woodchip
[55] http://ceo.decc.gov.uk/nationalheatmap/

South Devon area shows there are relatively few areas of high heat density where district heating schemes may hold potential;

- Heat demand from larger new development sites represents an opportunity for woodfuel through requirements to achieve challenging emission targets from tightening Building Regulations and local policies on sustainable construction. The most likely applications include non-residential single buildings/sites such as schools, public buildings, large estate properties and factories, and district heating networks which supply multiple buildings including both residential and non-residential uses;

5.3 Woodfuel hub options for South Devon

- A sensible approach in identifying potential sites for a new South Devon woodfuel hub would be to first consider sites which already host some form of woodfuel-related activity or have existing facilities which may be easily adapted to woodfuel processing. Key criteria for a hub includes ensuring there is sufficient space to incorporate suitable layouts for a woodfuel storage barn, outside woodfuel/bi-product storage and processing areas with hard standing, space for a site office, parking and unloading/loading, and equipment storage. The site should also have good transport links and be located with due regard to the feedstock resources in the local area i.e. located within a good capture radius of known wood arisings. The site selection process should also pay due regard to matching feedstock types with woodfuel products and the associated quality assurance and standards;
- Another key requirement for establishing a new site will be to ensure that there is sufficient woodfuel demand in the area to make the project financially viable. Viability may also be improved if there exists an opportunity to operate a woodfuel heat facility on the site to supply low carbon heat to nearby buildings, and/or to supply on-site wood drying processes;
- It is likely that a woodfuel hub in the study area would operate at a relatively small scale. In order to increase the likelihood of maximising feedstock capture across the study area, a number of woodfuel hubs would need to be set up with a good geographical spread. Conversely it might be more cost effective to site a single hub near the source of greatest production. However, the woodfuel market in the hub locality will again be an additional factor to consider;
- The ownership and operational arrangements of a woodfuel hub also need to be considered. In particular, community groups pursuing a new woodfuel initiative may wish to identify the most suitable organisational legal structure under which to operate. In any case, high priority should be given to early consultation with stakeholders to ensure that the community is kept informed and that their views are considered;
- The Torr Quarry Industrial Estate north of Kingsbridge is an example of a potential hub site worthy of further investigation. Although on-site heat loads are thought to be relatively small, the site has been flagged as having sufficient space and good accessibility to act as a woodfuel hub.

6 Recommendations

a) Woodfuel hub – next steps

- Using this report as a reference, a dialogue should be started with stakeholders in the area to draw on local knowledge and help identify further candidate sites for a woodfuel hub;
- For each potential site, local heat markets should be identified and the potential for localised woodfuel demand established. The financial benefits of the Renewable Heat Incentive scheme should be demonstrated and publicised to the local community to attract potential customers;
- Economic viability and operational requirements of the hub should then be examined in more detail;
- Stakeholders should then be consulted to help reach a consensus on the option to take forward;
- Options should then be explored for project partners and/or a community group legal entity and a business model developed.

b) Encouraging woodfuel supply and demand in South Devon

- Woodfuel technologies should be publicised and demonstrated to communities across the study area along with the financial benefits of the Renewable Heat Incentive scheme. Areas on which to focus include off-gas communities, developers, planners and architects;
- Farmers should be encouraged to look at the potential for growing and using energy crops for heating their own farm businesses. Similarly woodland owners should be approached and made fully aware of the benefits of woodfuel production for own use or to sell on;
- Further investigations on district heating opportunities should be undertaken using the National Heat Map to examine specific sites and by on-the-ground surveys. Additionally, the woodfuel resources identified in this study can be assessed spatially in relation to identified heat loads to look at opportunities for woodfuel heating plant. Similarly the potential for wood-fired district heating schemes within larger scale new development as identified through South Hams Council adopted site allocations should be assessed in relation to complimentary existing heat loads and local woodfuel supplies;
- An interactive map of contractors could be produced showing woodfuel infrastructure across the local area[56] – this could enable new entrants to use the services of these local contractors rather than buying new chippers/log processors;
- Stakeholders such as South Hams Council, Devon CC, Highways Agency, National Trust etc should be engaged about the potential for acquiring woodfuel from roadside verges, coastal areas etc;
- Devon County Council Estates Team could be approached to look into the possibility of growing small parcels of energy crops on County Farms in order to self supply and provide fuel for local authority buildings;
- Waste management companies and waste authorities could be approached to explore the potential to establish energy crops on reclaimed landfill sites, and to assess how clean wood waste could be diverted for use as fuel;
- Opportunities for growing energy crops (particularly SRC willow) in riparian zones should be explored to gain the multiple benefits of reduction in N pollution, reduction of soil erosion and soil stabilisation, and flood reduction etc;
- Funding opportunities should be explored to invest in energy crop infrastructure. SRC requires planting and harvesting machinery whilst miscanthus requires densification machinery e.g. pelleting facilities.

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[56] A regional supplier search and map facility is currently available at www.southwestwoodshed.co.uk

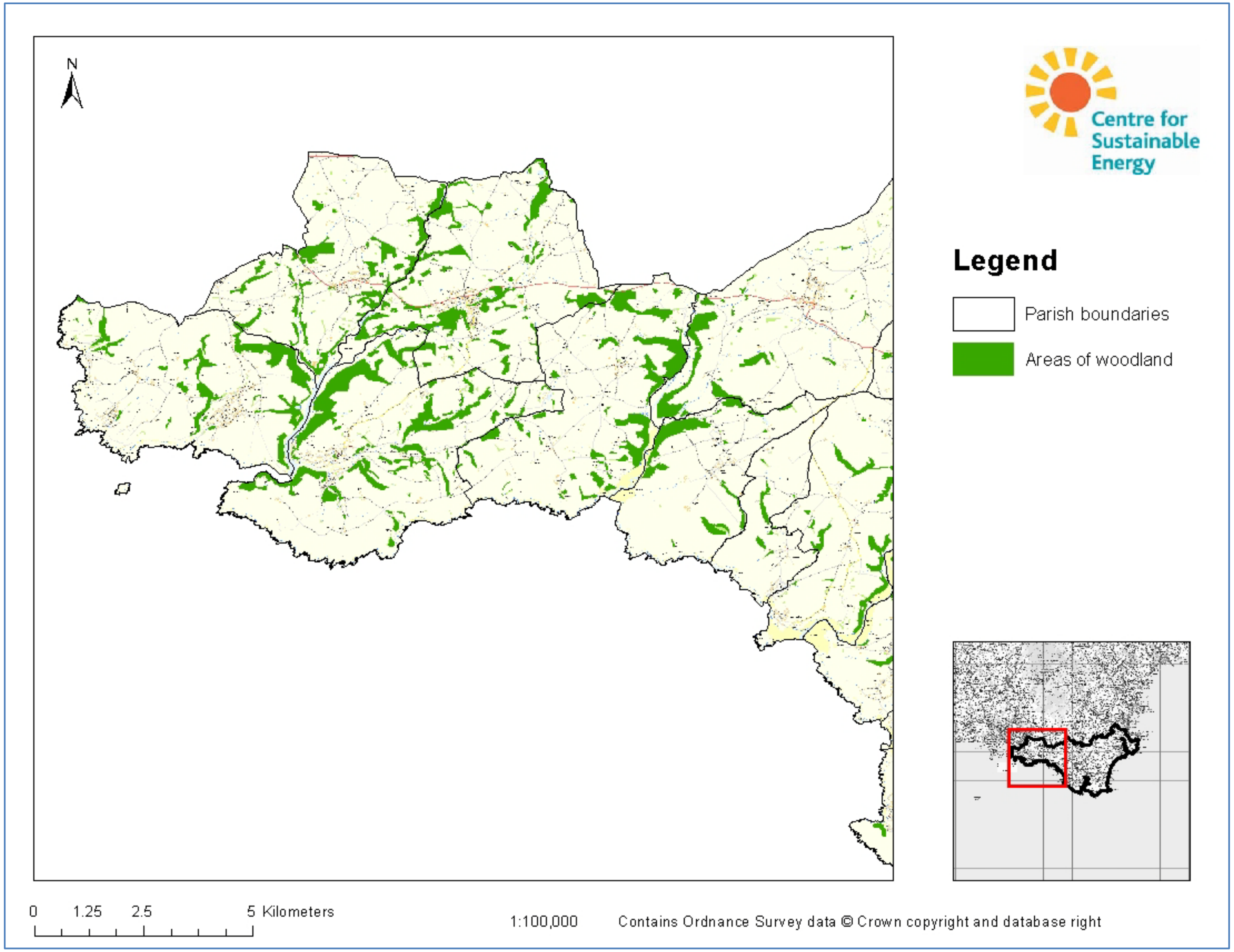
Appendix 1: Woodfuel types and characteristics

	Traditional forestry	Forestry residues	Small woodlands
Physical characteristics	Even-diameter pole-length timber – continuous straight lengths. Few side branches. High wood:bark ratio - often debarked.	Non uniform. Includes leaves, needles, pine cones, twiggy branches. High bark content. Contaminants – soil and stones.	Very mixed quality. All shapes and sizes, not straight, side branched. High wood:bark ratio.
Wood types	Predominantly conifers – soft wood Thinning wood.	Lop and top from forestry – therefore mainly soft woods.	Wide range of species – mainly hardwoods
Handling, Storage, Drying & Processing issues	Tend to have good access – fairly easy extraction. Usually transported as round wood - High bulk density. Typically dried in the round on bearers and then chipped /split with large scale chipper or conveyor splitter when around 35% MC.	Generally dealt with on site – chipped or baled. High volume product – low bulk density (120-150 kgm^3 although this can be increased to around 285 kg m^3 when bundled). Usually high moisture content. Chipped material likely to compost. Bales dry well. Can be difficult to extract – terrain etc. Brash bales need a chipper or tub grinder. Screening would be required if used as chip in conventional boiler.	Tend to be small scale and fragmented. Problematic access – no rides. Often haven't been thinned so more difficult to fell. Labour intensive extraction. Should be dried in the round on bearers and then chipped /split when around 35% MC. Often small scale chipper or hydraulic log splitter – lots of manual handling involved.
End use product	Chips or logs	Chips or pellets	Logs or chips (often for self supply)
End use type	Small - medium scale heating	Large scale heat & CHP; Power stations	Small- medium scale heating
Utilisation issues	No bark, low ash. Bulk density of spruce and fir wood chips is 225 kg/m^3 – need more storage space than hardwoods.	High bark content, high ash, high in chlorine, low bulk density. Would need a forgiving boiler able to tolerate high MC and larger particles. Step grate boilers are more expensive and have a larger footprint. More frequent O&M.	Bulk density of beech wood chips is 325 kg/m^3 - need less storage space than for softwoods. Need to stoke boiler/stove less frequently. Low bark, low ash.
Pros	Established infrastructure. Straightforward operations.	Potentially maximises revenue from a site.	Provide good wildlife habitats.
Cons	Existing markets (i.e. non woodfuel) take most wood.	Needs expensive kit. Low value product. Suitable for larger end users so needs transporting further afield. Removes brush mat which takes nutrients out of the system and makes moving forestry. machinery more difficult.	Low yield. Potentially far away from markets. Management may be low priority - easier to leave alone than manage.

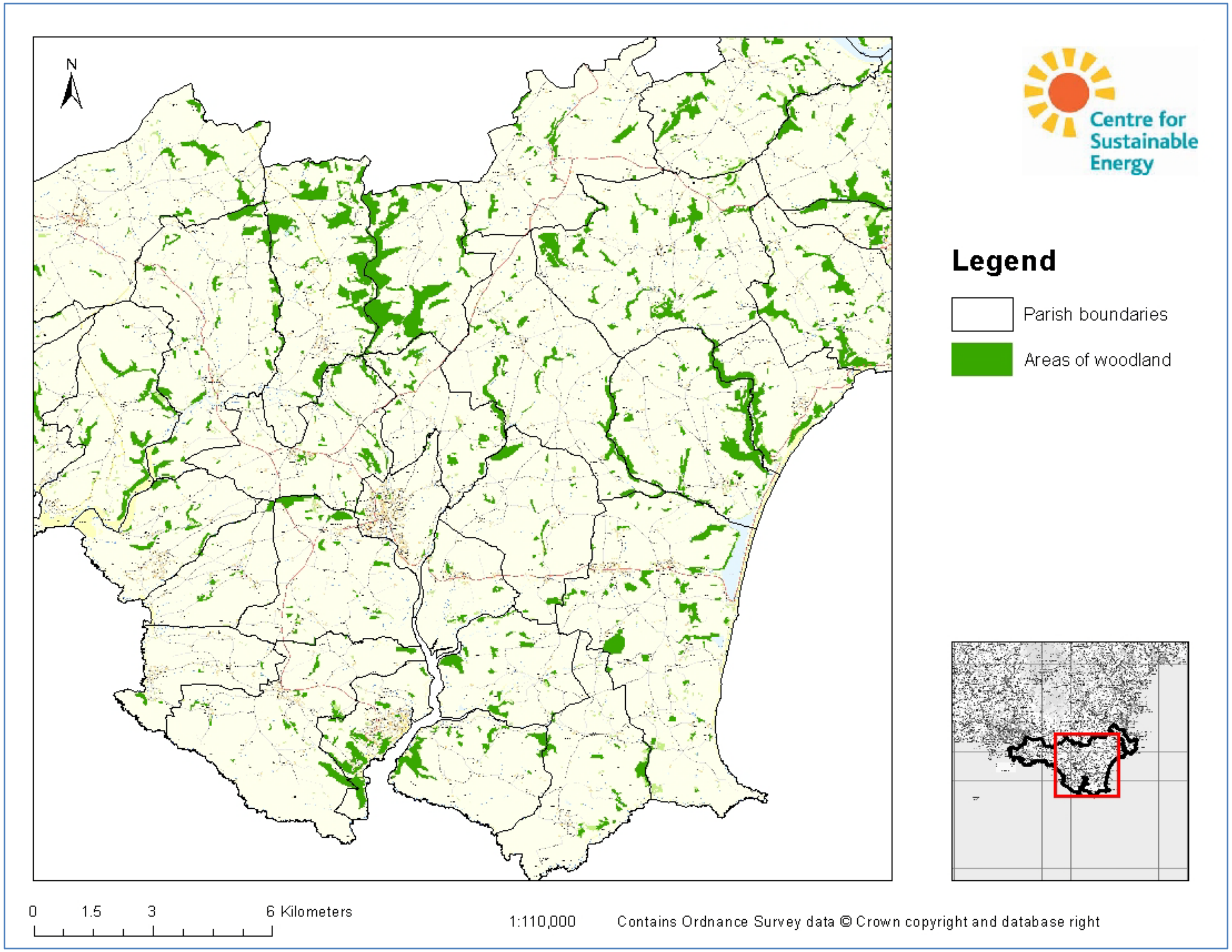
	Arboricultural waste	Energy crops	
		Short rotation coppice	Miscanthus
Physical characteristics	Wide variety of shapes and sizes High moisture content Dead wood and leaves included Contaminants – plastic, metal	High moisture content. Poor quality chip. High bark:wood ratio.	Low moisture content when harvested.
Wood types	Variety of species - predominantly hardwoods	Willow or poplar	Herbaceous – woody grass
Handling, Storage, Drying & Processing issues	Stem wood often left with client or taken to depot and split for logs. Branch wood is chipped to reduce volume usually with disc chippers. Sometimes chipped into verges or turned into mulch. Contractors often need to find a place to dispose of the chip. Low bulk density - transport expensive as most contractors have small tipper trailers. If heaped may compost. Best stored under cover. Poor quality woodfuel chip – will need grading/screening to remove oversized particles.	Often stored outside in peaked windrows Difficult to dry as chip. 5-20% dry matter lost in poorly constructed heaps due to composting. Low bulk density (chip = 175 kg/m^3). Can be dried in grain dryers. Poor quality woodfuel chip – will need grading/screening to remove oversized particles. Can be harvested as billets or sticks. These dry well with negligible loss of dry matter but needs reprocessing - pelletised or granulated.	Stored under cover as bales or chip Bales dry easily. Chip can self heat and compost. If ultimately using as chip, bales would need to be shredded using a large scale chipper or tub grinder. Low bulk density (chip = 100 kg/m^3, bales = 140 kg/m^3). Need to densify product if transporting any distance.
End use product	Chips, logs	Chips, self supply logs, pellets	Chips, bales (self supply only), pellets, briquettes
End use type	Small-medium scale heating; Large scale heat & CHP	Small-medium scale heating; Large scale heat & CHP; Power stations	Small-medium scale heating; Large scale heat & CHP; Power stations
Utilisation issues	High bark content, high ash. Will require step grate boiler and more frequent O&M. Corrosion of the combustion chamber more likely due to high chlorine content – shorter boiler life span.	High bark content, relatively high ash (2%) Probably best with a step grate boiler although underfed boilers possible with dried/screened chip. Higher N content than typical wood chips – unlikely to meet RHI emissions levels without expensive filters.	Bulky nature of miscanthus means that boilers cannot operate at rated capacity – a 200 kW boiler would be downgraded to 150 kW. Relatively high potassium, chlorine , sulphur contents so more likely to corrode walls of combustion chamber. High silica, content. High ash content (2-6%) and low ash melting point so greater likelihood of clinker. Higher N content and particulates than typical wood chips – unlikely to meet RHI emissions levels without expensive filters. Needs miscanthus compliant boiler – step or tilting grate with exhaust gas circulation and stainless steel lined combustion chamber.
Pros	Predominantly urban. Cheap and locally plentiful. Useful resource with few other market options.	Very fast growing. Good for wildlife. Harvested every three years so patchwork effect.	Very fast growing. High yields. Harvested every year with conventional machinery.
Cons	Low value product. Removal from site and delivery to a woodfuel depot is often viewed as a hassle.	Lack of infrastructure to plant and harvest. High MC at harvest and poor storage means that the product is usually poor quality. Often needs additional processing or grading.	Not suitable for many woodfuel boilers. Bulkiness means generally unsuitable for urban projects unless densified. Less biodiverse than SRC.

	Sawmill co-products			Clean waste timber
	Sawdust	Slab wood	Offcuts	
Physical characteristics	Dry Bulky Dusty	Continuous straight lengths Dry High bark:wood ratio.	All shapes and sizes. Dry No bark Bulky	All shapes and sizes. Usually unsorted Wide range pallets to wardrobes, Leylandii to fence posts. Can be contaminated – nails, staples, glue, preservatives, paints
Wood types	Depends on source. Predominantly softwoods.			Pallet wood tends to be softwood.
Handling, Storage, Drying & Processing issues	Relatively small quantities produced. Low bulk density (160 kg/m^3). Difficult/expensive to transport. Usually dry. Potentially explosive material.	Hard to handle -lots of manual handling involved. Often sold in long lengths that need to be cut with a chainsaw for logs. Bulky - Difficult to transport Usually well seasoned.	Typically dumped in skips. Bulky - difficult to transport. Hard to handle - lots of manual handling involved. Usually well seasoned.	Generally dry. Hard to know if some woods are clean. If mixed very labour intensive and expensive to sort. Bulky, awkward - Difficult to transport. Chipping/shredding dry material can lead to shards and dust.
End use product	Pellets, briquettes	Logs, chips	Logs, kindling	Chips, pellets
End use type	Small-medium scale heating.	Small-medium scale heating; Large scale heat & CHP.	Small-medium scale heating.	Small-medium scale heating. Large scale heat & CHP.
Utilisation issues	Low ash, high durability. Excellent bulk density (650 kg/m^3) and high calorific value (4700 kWh/tonne).	Relatively high ash. If used as logs then more frequent stokings required. Take longer to stack.	Good fuel - low ash	The onus is on the end user to prove that the wood they are using is clean and uncontaminated. Very difficult to prove. If the waste is a mix of clean and treated then the boiler would need to be compliant with the Waste Incineration Directive. This is heavily regulated so WID plants tend to be large scale.
Pros	Sawdust makes best quality pellets and briquettes.	Currently low cost product for end user.	High quality logs and kindling	Close to urban markets Usually very cheap
Cons	Low quantities produced mean that it's not worth investing in pelleting/ briquetting equipment - lacks economies of scale.	Requires extra time to stack, stoke and de-ash boiler.	Quantities are often too small to make it worth bothering with. Requires someone to come and take it away.	Low quality product. Always a danger that the wood has come into contact or been mixed contaminated wood.

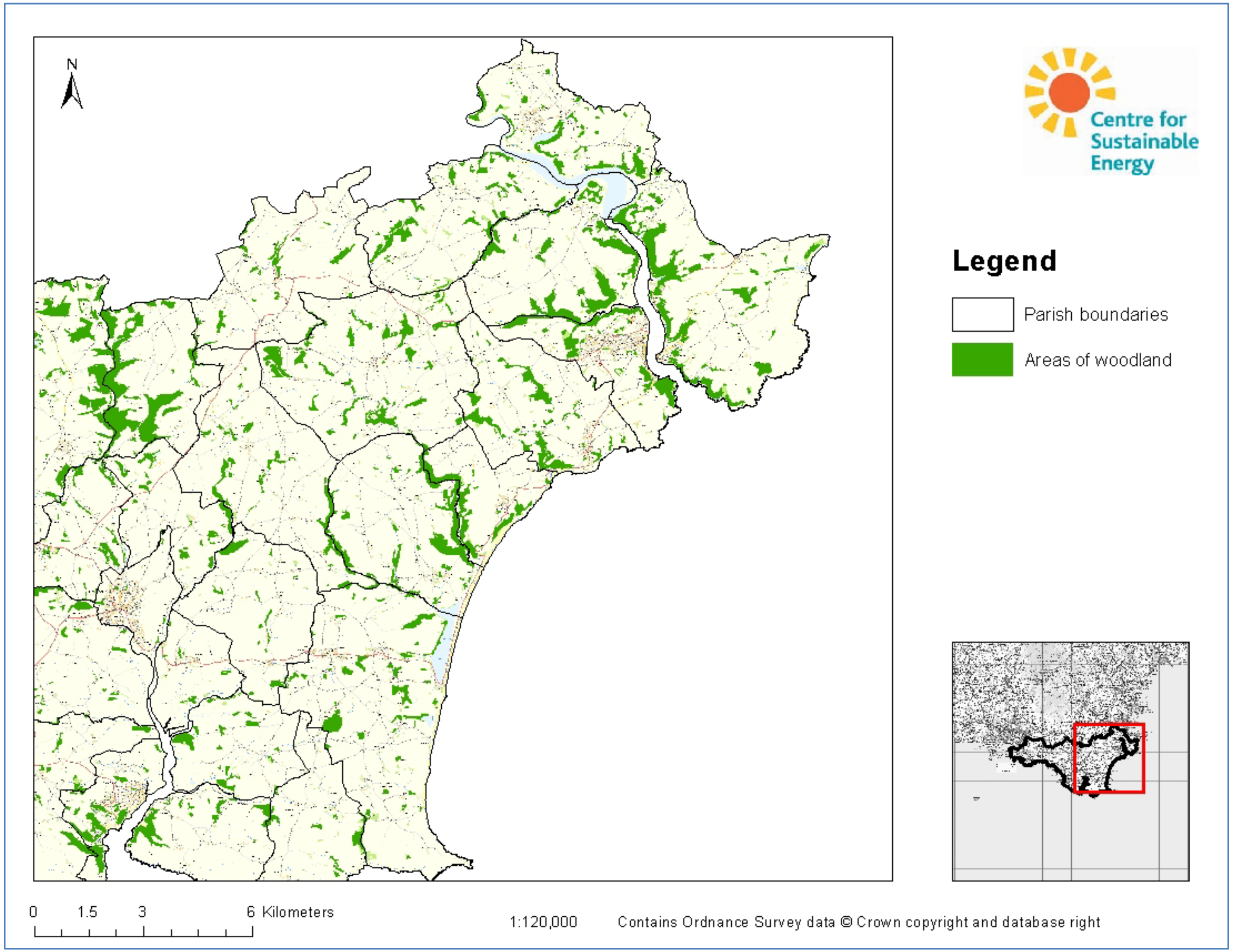
Appendix 2: Woodland resource maps: west sector



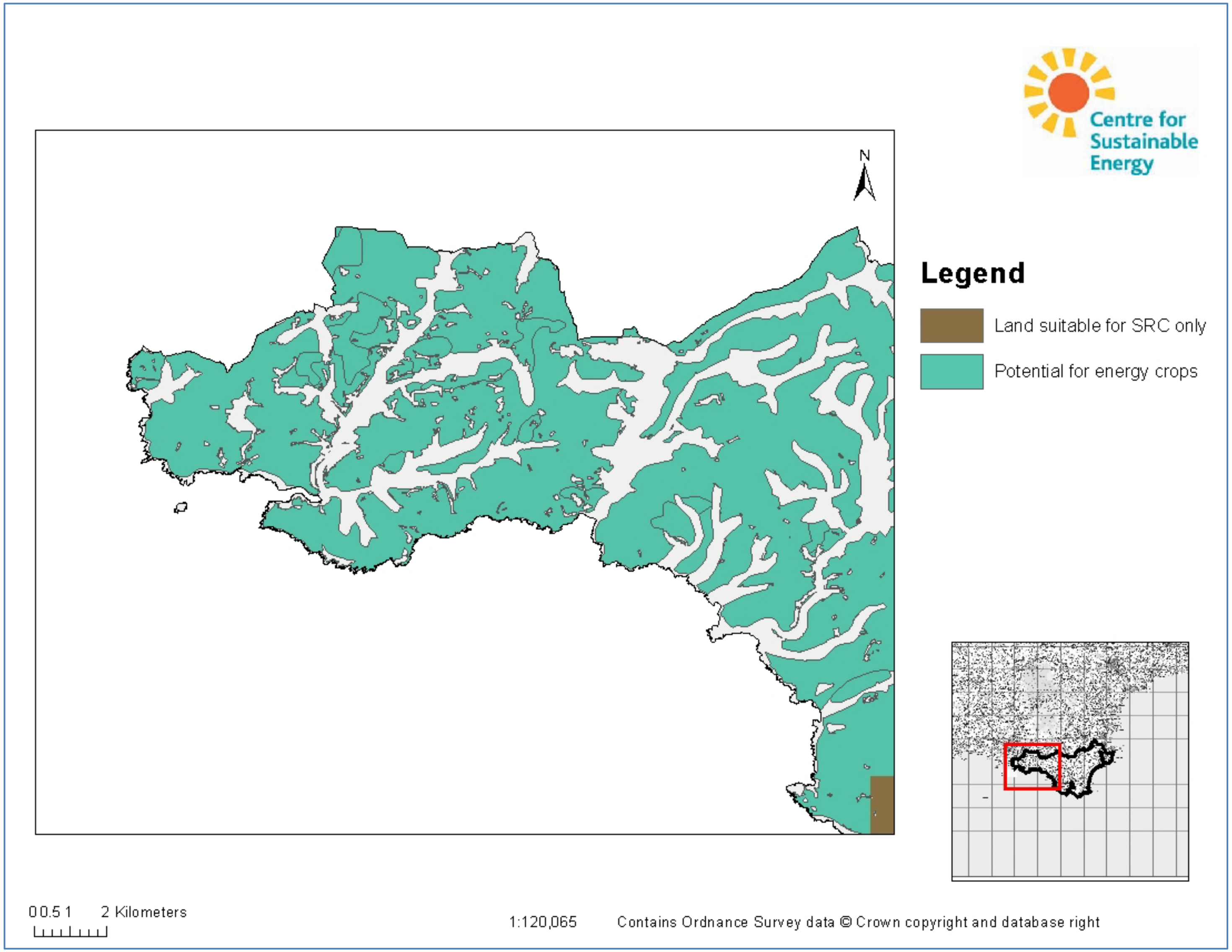
Woodland resource maps: central sector



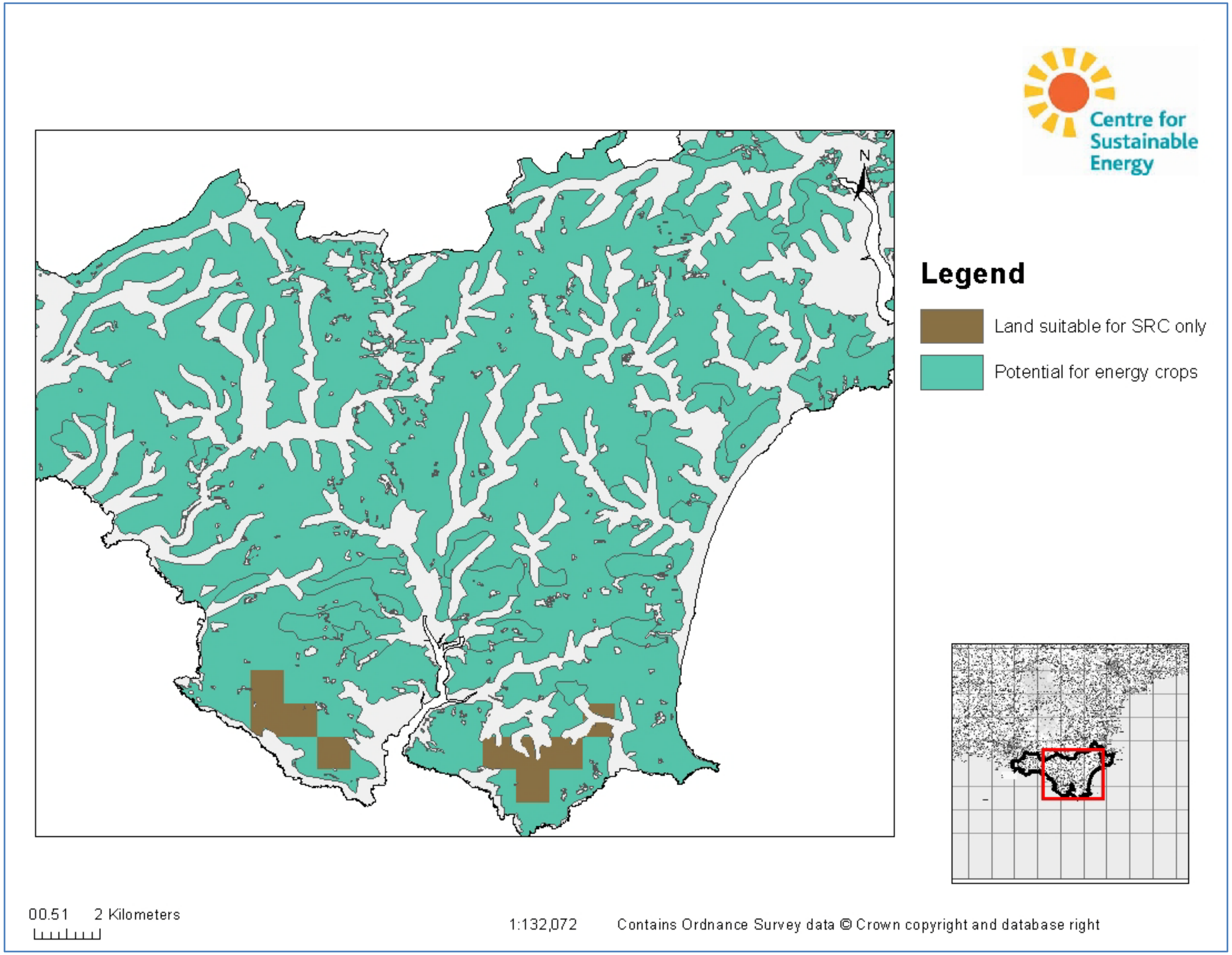
Woodland resource maps: east sector



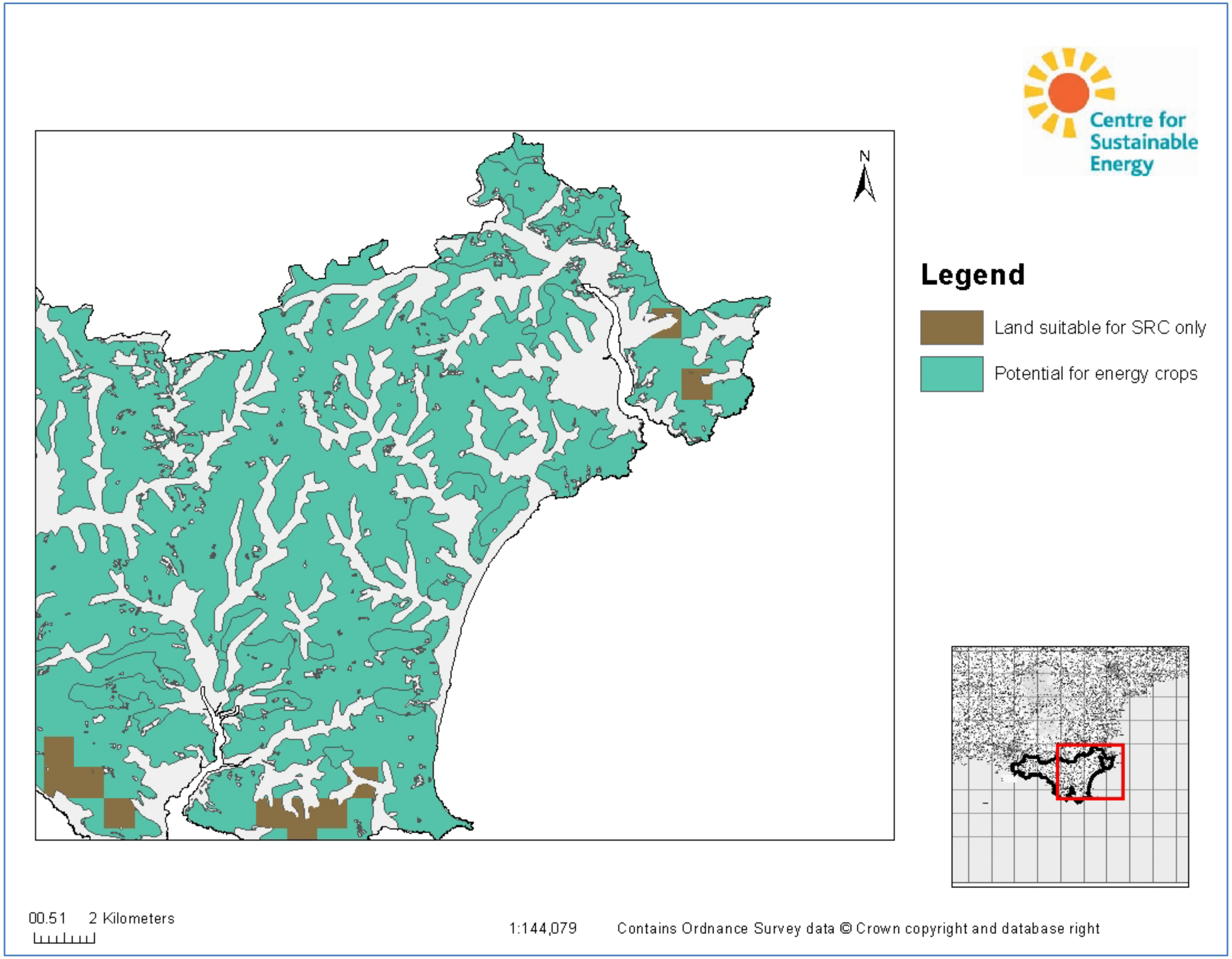
Appendix 3: Energy crop resource maps: west sector



Energy crop resource maps: central sector



Energy crop resource maps: east sector



Appendix 4: Production costs of different woodfuels

	Management	Fuel	8 year yield (odt)	Establish-ment	Felling		Extraction		Chipping		Log splitting		Total	Production costs		CV (kWh/ tonne)
					Cost/odt	Total cost/ha	Cost/odt	Total cost/ha	Cost/odt	Total cost/ha	Cost/ odt	Total cost/ha		£/odt	£/tonne @ 35%	
SRF Eucalyptus	Fenced	Chip	104	£2,500	£20	£2,080	£8	£801	£15	£1,560	/	/	£6,941	£66.74	£43.38	3100
	Unfenced	Chip	104	£1,800	£20	£2,080	£8	£801	£15	£1,560	/	/	£6,241	£60.01	£39.01	3100
	Fenced	Logs	104	£2,500	£20	£2,080	£8	£801	/	/	£45	£4,680	£10,061	£96.74	£62.88	3100
	Unfenced	Logs	104	£1,800	£20	£2,080	£8	£801	/	/	£45	£4,680	£9,361	£90.01	£58.51	3100

	Management	Fuel	8 year yield (odt)	Establish-ment (-grant)	Harvesting £/ha	Process-ing and transport £/ha	Lost revenue over 8 years	Total costs	£/odt	£/tonne @ 35%	£/tonne @ 25%	£/tonne @ 20%	CV (kWh/ tonne)	Cost p/kwh
SRC willow	Fenced	Chip	70	£1,250	£900	£600	£1,800	£4,550	£65	£42.25	/	/	3100	**1.36**
	Fenced	Chip	70	£1,250	£900	£600	/	£2,750	£39	£25.54	/	/	3100	**0.82**
	Unfenced	Logs	36	£1,250	£1,200	£1,908	/	£4,358	£121	/	/	£96.84	3980	**2.43**
Miscanthus	Unfenced	Chip	91	£1,500	£1,400	/	£1,800	£4,700	£52	/	£38.74	/	3600	**1.08**
	Unfenced	Chip	91	£1,500	£1,400	/	/	£2,900	£32	/	£23.90	/	3600	**0.66**
	Unfenced	Bale	91	£1,500	£2,100	£364	£1,800	£5,764	£63	/	£47.51	/	3600	**1.32**
	Unfenced	Bale	91	£1,500	£2,100	£364	/	£3,964	£44	/	£32.67	/	3600	**0.91**

	Fuel	Felling	Extraction	Chipping	Log splitting	Total product-ion costs	Total product-ion costs	£/tonne @ 20%	CV (kWh/ tonne)	Cost p/kwh
		Cost/ tonne @ 30% MC					£/odt			
Existing woodland	Chip	£20	£10	£15	/	£45	£61.43	/	3100	**1.45**
	Logs	£20	£10	/	£45	£75	£107.14	£85.71	3980	**2.15**

Appendix 5: Case studies of farmers using miscanthus to heat their farm businesses

Below are two examples of farmers who are producing their own renewable heating using their own miscanthus chip.

		Poultry farmer, Somerset	Holiday cottages, Cornwall
		40,000 indoor reared chickens	8 holiday lets, farmhouse and swimming pool
Fossil fuel replaced		LPG	Oil
Amount used (litres/yr)		32,534	32,000
Amount of miscanthus required	Tonnes at 25% MC	106	89
	Hectares	8	5.7
Boiler size (kW)		130	199
Boiler capacity using miscanthus* (kW)		95	150
System costs		£50,000	£150,000
Potential rebate from RHI**		£16,578	£21,795
Savings compared to fossil fuel		£3,700***	£11,805
Annual savings		£20,278	£33,600
Simple payback		2.5 years	4.5 years

* Boiler size is downgraded when using miscanthus because of the low bulk density of the fuel.

** Neither farmer has been fully RHI accredited by Ofgem at the time of writing.

*** LPG will provide 15% of annual heating requirement.