

Economic impact of a Regional Wood Energy Strategy



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The team

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Executive Summary

This report sets out the economic impact of wood fuel based on the sector growth outlined in the *Regional Wood Energy Strategy and Action Plan* (Luker/DARE 2007). The strategy presents three market development scenarios and a 'do nothing' counterfactual position over two timescales, 2010 and 2020. The report recommends that the 'medium scenario' is used, as it represents a *"logical balance between the available resources, the national targets and the likely way in which the external environment would impact upon the region"*. The economic impacts presented in this report focus on the medium scenario in 2020, the end point of the strategy.

Economic impacts have been estimated from income and employment data provided by Luker/DARE and through consultation with commercial wood heat suppliers in Ireland. The gross impacts of the medium scenario in 2020 relate to 477MW heat capacity installed (including CHP) and are summarised as follows:

- use 472,000 tonnes of timber with an annual value of €1.7 million to the farming sector
- increased annual Gross Value Added (GVA) in the Western Region of €15 million by 2020
- 887 FTE jobs created

Most of this impact is direct, from new jobs (1.3 FTE jobs per MW) and associated wage income and company profit (€30,454 per MW) within the wood energy supply chain. There is relatively little indirect impact as almost all of the equipment is manufactured abroad. Induced impacts are more significant (0.5 FTE jobs per MW) due to the local nature of employment and likely subsequent spend within the region. The Type 2 Employment Multiplier is estimated at 1.4 and the Type 1 Income Multiplier at 1.05.

There is significant deadweight based on sector growth under the 'do nothing' option, as characterised by Luker/DARE. This counterfactual position assumes 105MW of capacity is installed in the absence of the strategy and with discontinuation of the SEI boiler grants after 2010.

Displacement is expected to be very limited as the timber resource already exists as farm woodland and does not displace other crops. The only tangible element of displacement is jobs in the heating oil supply chain. This is estimated to be equivalent to 15 to 20 jobs under medium scenario in 2020.

After allowing for deadweight and displacement, the net economic impact of medium scenario in 2020 is estimated as follows:

- use 352,000 tonnes of timber with an annual value of €1.2 million to the farming sector
- increased annual GVA in the Western Region of €11 million by 2020
- 672 FTE jobs created

The (net) annual average construction impact of medium scenario to the year 2020 is estimated at €0.7 million and 19 FTE jobs. These impacts are temporary and need to be separated from operational impacts, which are ongoing. Construction impacts are likely to be spread relatively evenly over the period of sector development, given the reliance on small installations and organic sector growth. As such, demand for construction and installation workers should be relatively even and be able to be resourced locally, and capacity will build as the sector grows. If growth is more rapid and demand exceeds the capacity of local skilled workers, some of these benefits will accrue to workers outside the region.

CO_{2e} savings for wood versus oil energy are estimated at 619,000 tonnes (462,000 tonnes net) under the medium scenario in 2020. The economic value for carbon saved would be realised by reducing the number of credits the government needs to purchase to meet its Kyoto commitments. The value of this carbon offset at €15 per tonne

(the price assumed by government for credits purchased for the 2008 to 2012 period) is €6.9 million. This value would increase to €9.2 million at €20 per tonne and €23 million at €50 per tonne. This highlights that the economic value of carbon savings in 2020 may be comparable with the direct economic impacts.

As most of the installations are small to medium scale and below EUETS limits, the carbon cannot be traded through the EU trading mechanism and would need to be realised through trading in voluntary markets. This may be difficult to realise in practice due to the administration of large numbers of small sites.

There may be wider socio-economic impacts due to the development of the wood energy sector, although these may be largely intangible. They include increased viability of small farming business and associated community cohesion, greater awareness of the carbon economy and environmentally sensitive behaviours (both personal and corporate), increased capacity of workers in terms of engineering skills which are transferable to other sectors.

One potential negative impact is competition for wood resources and consequent production cost increases for the sawmills or panel board mills.

1.0 Introduction



This report was commissioned by the Western Development Commission (WDC) in July 2007 to consider the economic impact of a regional wood energy strategy for the Western Region of Ireland.

The WDC previously commissioned a research report to consider the scope for development of wood energy in the Western Region¹. Following the completion of the research report in April 2007, the WDC commissioned Steve Luker Associates and DARE consultants to develop a regional wood energy strategy. The purpose of the strategy is to underpin and support market growth and ensure the potential economic benefits of a regional wood energy sector are realised. The strategy provides a roadmap for the development of the sector in the region and the targets and scenarios provide the basis for this *Economic Impact Study*.

1.1 Terms of reference

The terms of reference for this work are set out as follows:

“The Economic Impact Study should compile economic impacts and associated data, assumptions and conclusions into a short, accessible report that can be used to help the WDC and others to justify investment in the wood energy sector in the Western Region and to develop the appropriate policy responses to allow for the development of this sector. This is particularly important given the clear need to support market development. Justification for this support will, in part, be based on the findings of the Economic Impact Study.

Specific Requirements

This Economic Impact Study must provide estimates of the contribution of the implemented Strategy (in numerical form) to:

- gross value added per annum
- employment effects (both construction and wood fuel effects)
- value of carbon offset and its contribution to national climate change targets
- other economic effects deemed significant”

¹ www.wdc.ie/publications_reports.html

1.2 Strategy scenarios and targets

Our economic impact analysis uses the scenarios and targets for three growth scenarios combined with two forecast periods, which are set out in the *Regional Wood Energy Strategy and Action Plan*².

As the strategy is focused on heat, the heat element of energy generation from new CHP plants is included in the target scenarios; it is assumed that wood energy CHP will be restricted to a few single projects in the Western Region.

The strategy identified a counterfactual ('do nothing') position and three growth scenarios, representing the varying degrees of market penetration associated with varying degrees of public support and market conditions. These are defined as follows:

'do nothing' scenario

Static market environment and no additional public intervention; the current SEI boiler installation grant scheme is discontinued in 2010 as the current programme ends.

low scenario

A static market environment for wood energy but an action plan is implemented to promote market development; the current SEI grant support for boiler installation is continued after 2010.

medium scenario

The action plan is implemented to support market development and fossil fuel prices continue to rise above the rate of general inflation in the economy. More supportive policy and regulation and the current SEI grant support for boiler installation is continued after 2010.

high scenario

The action plan is implemented to support market development and fossil fuel prices increase at 15% per year. Carbon taxation is introduced with aggressive renewable energy targets, additional policies and very supportive regulations. The current SEI grant support for boiler installation is continued after 2010.

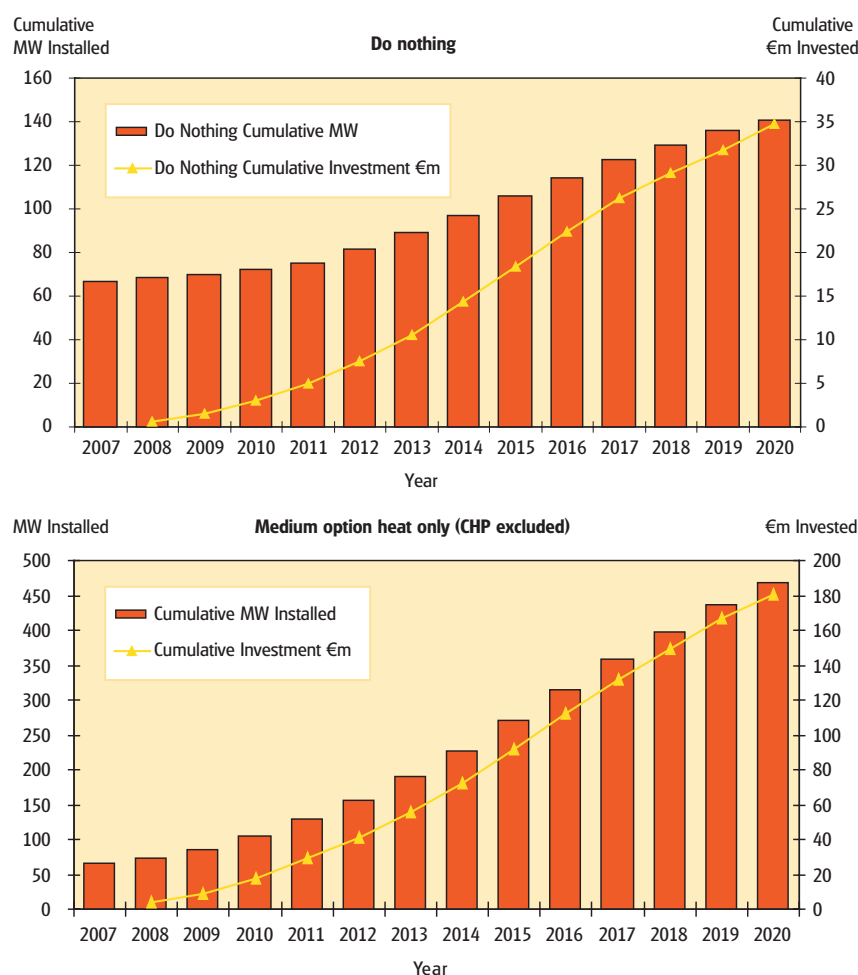
Targets for installed capacity of wood heat for each scenario and each time period are set out in the *Regional Wood Energy Strategy and Action Plan* and are summarised in Table 1. These figures represent newly installed capacity and are additional to the estimated baseline position for 2007 of 65.5MW. GVA and employment associated with the latter are excluded from the analysis.

² Steve Luker Associates Ltd and DARE (2007); *Regional Wood Energy Strategy and Action Plan*; report for Western Development Commission.

Table 1: Summary of growth scenarios and targets (from baseline)

	'Do nothing' (MW)	Low scenario (MW)	Medium scenario (MW)	High scenario (MW)
wood heat energy by 2010	5.5	20.0	40.0	70.0
CHP heat energy by 2010	15.0	15.0	15.0	15.0
total heat energy by 2010	20.5	35.0	55.0	85.0
wood heat energy by 2020	75.0	232.0	402.0	532.0
CHP heat energy by 2020	30.0	60.0	75.0	90.0
total heat energy by 2020	105.0	292.0	477.0	622.0

The pattern of development of the sector is demonstrated for the medium scenario against the 'do nothing' option at Figure 1.

Figure 1: Medium scenario vs Do nothing

Source: Luker/DARE

The graphs imply that a supportive policy environment combined with moderately rising market prices would lever almost €150m of additional investment by 2020. It is difficult to isolate the impact of the relatively modest investment made under the strategy over the next three years from the SEI grant (2010 to 2020), wider policy and market effects.

2.0 Economic impact

This study aims to estimate the economic effects that might result from the establishment and sustained expansion of a wood fuel supply chain in the Western Region. Two measures of economic impact are estimated in this study, (a) Gross Value Added, and (b) employment in the Western Region.

Gross Value Added per annum (GVA)

Government uses GVA as the principal measure of regional economic success. In simple terms GVA is the difference between the value of monetary outputs (goods and services) and the money the business has to pay for inputs, such as raw materials, to produce the monetary outputs. These inputs and outputs are very difficult to measure accurately at a local, industry-specific level. As a result, GVA can be assessed using proxy measures. The two key proxies are wages paid to staff and operating surpluses (or profits).

Employment effects

Employment effects relate to construction, fitting and maintenance and to the wood fuel supply and processing chains. Often jobs are a mix of full and part time and the protocol for economic impact analysis is to measure employment in terms of full time equivalent (FTE) jobs.

2.1 Measuring economic impact

The economic impact of a policy or programme represents the net effect of interventions relative to the counterfactual position, that is, the absence of intervention. Economic development initiatives often involve the injection of capital into sectors or regions over a time limited period in order to generate economic activity, which continues beyond the programme life. There are several considerations.

1. **Deadweight.** It may be that some sector growth would occur in the absence of the intervention. To this extent, we need to measure the 'additional' impact on GVA and employment, rather than the absolute change.
2. **Displacement.** This is defined as the "degree to which an activity promoted by government policy is offset by reductions in activity elsewhere. A policy or programme might promote investment in certain areas but this might draw resources from other areas of activity accompanied by less investment - this reduces the benefits of the intervention" (DTI).
3. **Multiplier effects.** Economic activity has a direct impact on employment and GVA through creation of jobs and generating income in the supply chain. There are also indirect effects on businesses in the local area, e.g. those supplying the wood energy industry. Induced effects result from households spending in the local area some of the additional income they receive as a result of employment in the wood energy industry, plus additional household spending from people employed in other industries in the local area supplying the wood energy industry. These secondary impacts are called the multiplier effect.

Thus, "the net benefit of an intervention equals the gross benefits less the benefits that would have occurred in the absence of intervention (the 'deadweight') less the negative impacts elsewhere (including 'displacement' of activity), plus multiplier effects" (Green Book).

2.2 Multiplier analysis

The regional economic impact of the wood energy industry can be assessed by the constructive means of, either (a) a Keynesian local economic multiplier model, or (b) an input-output (I-O) model. As a local I-O table is not available³ for the Western Region in Ireland, this study proposes to use a Keynesian local economic multiplier model to estimate the economic impacts. The basis for this approach is detailed at Appendix 1.

It was necessary to source data for a 'typical' wood energy supply chain, both construction and operation, and then to scale up the impacts according to the uptake in the three scenarios and two timescales. Steve Luker Associates and DARE consultants have provided the heat capacity data and background to the supply chain. In addition, ADAS has consulted with four energy supply companies operating in the Western Region of Ireland to validate assumptions and provide more detailed information.

The data from the Luker/DARE analysis and energy supply companies have been used to inform a 'typical' installation of 500kW, which might represent a hotel with leisure facilities. In practice a range of installations will contribute to the heat targets but it is not practicable to characterise all of these and aggregate. The use of a 500kW installation is a good proxy, given the other uncertainties.

However, in a developing and relatively new industry, there is some front-loading of the sales and market development function; as the sector builds critical mass, we can expect some streamlining of staffing and reduced reliance on specialist staff from Northern Europe. There may also be some economies in terms of the supply chain over time.

The analysis includes two elements:

1. the impact of the initial capital injection required to design and install the wood energy boilers on the local economy (which is temporary)
2. the impact of the continuing operation of the wood energy installations and the woodchip supply chain on the local economy (which is permanent)

Employment effects

Employment effects relate to construction, fitting and maintenance, and to the wood fuel supply and processing chains.

An employment multiplier measures the total number of jobs that will be created in the local area as a result of the wood energy industry. The employment multiplier for a local economy is defined as the ratio of the employment in the wood energy industry plus employment change in other local industries as a consequence of supplying the wood energy industry, to the employment in the wood energy industry:

$$KE = \Delta(EW + EL) / \Delta EW$$

This is a Type 1 employment multiplier, based upon direct and indirect employment change. Where KE is the employment multiplier, EW is the employment in the wood energy industry and EL is the employment elsewhere in the local economy.

A Type 2 employment multiplier equals (direct + indirect + induced effects) divided by direct effects. A Type 2 employment multiplier thus includes the effect of increased employment in backward linked industries supplying the wood energy industry, as well as the employment effects of induced consumption. Output multipliers are calculated in an analogous manner.

³ In the previous WDC commissioned research report on *Wood Energy Development in the Western Region*, Scottish Input Output Tables (2001) were used as a proxy to estimate the economic impact.

Data to construct the Keynesian employment and output multipliers relies on two sources:

- information from wood energy firms on payments to locally based factors of production, and also information on the initial capital injection to set up the wood energy facility
- information from employees on their expenditure (by type and spatial area) and savings

For the purpose of this study we would expect to use indicative data for both sources with reliance on relevant published studies of similar type and scale industries informing employee spend/savings.

In terms of income, the Keynesian economic multiplier traces spending through the economy and measures the overall effects comprising direct, indirect and induced impacts.

3.0 Methodology

3.1 Economic multiplier model

We employed the BIOSEM model to look at the economic impacts of wood energy deployment in the Western Region of Ireland. A detailed description of BIOSEM model is in Appendix 2.

BIOSEM is based on Keynesian Multiplier Theory and is able to capture both the employment and income impacts from the installation of a bioenergy project on both the supply side and the installation itself. BIOSEM has been used extensively in both the UK and across Europe.

Results from previous studies give a benchmark for expected impacts in the Western Region. These include:

- BIOSEM scenarios for 2 MW biomass heat system, Ortenaukreis, Baden-Württemberg⁴. It was estimated that the project will generate additional labour income of €80 000 to €86 000; net additional profit of €22 000 to €30 000; a total net additional income and profit of €102 000 to €116 000. The employment effects were estimated as generating 2.9 direct jobs, 1.1 to 1.4 indirect jobs, 0.6 to 0.9 induced jobs and 4.8 to 5.2 jobs in total.
- Finland, the municipality of Perho, energy co-operative, 1.5 MW biomass heat system⁵. It was estimated that the project would generate local net additional income and profit of €51 300 and local direct incomes approximately accounting for 55 % of the total impact. It would also generate 2.5 direct employment and 0.5 indirect jobs.
- BIOSEM case study for 1 MWe combined heat and power plant, Fermanagh, Northern Ireland⁶. It was estimated that the project will generate net additional regional income and profit of €85 804 and 2.4 net additional direct jobs, 0.5 indirect jobs, 1.4 induced jobs and 4.3 jobs in total.
- Pischelsdorf: 1.7 jobs/MW; Kirchberg: 1.6 jobs/MW and 5MW 6.2 jobs/MW in Passail in Austria⁷; Steinmüller estimated that 1 MWh sold requires an input of 4.56 working hours, which would result in approximately 3 jobs/year for a 1 MW plant.
- Wood Heat for Warmth, Scotland⁸: It was stated that there will be temporary jobs associated with construction of equipment, ranging from a few days for a small boiler installation to 5 jobs per MW (electricity) over a period of 2 years for a power plant.

These studies suggest an employment impact of approximately 1.5 to 2.0 FTE per MW heat capacity installed, except for the Northern Ireland plant, which is a CHP installation. GVA figures range from €30,000 to €50,000 per MW capacity.

⁴ Becker, R., 1999, BIOSEM German case study, *Final Report for the Concerted Action under the FAIR Programme*.

⁵ Ahonen, A. 2004, Pienpuuhakkeen ja hakkuutähdehakuun energiakäytön sosio-ekonomiset vaikutukset. Case-tarkastelu. Puuenergian teknologiaohjelman päätösseminaari. Oulun yliopisto, maaliskuu 2004.

⁶ ETSU (Renewable and Energy Efficiency Organisation), 1999, *Conclusions from the UK Case Study*, BIOSEM (Biomass Socio-Economic Multiplier) case studies.

⁷ Applying BIOSEM (Biomass Socio-Economic Multiplier): *Conclusions from the Styrian (Austrian) Case Study*. <http://www.iea-bioenergy-task29.hr/pdf/Cavtat.pdf>.

⁸ Evans, S. 2004, *Financing the Development of a Wood fuel Energy Industry in Scotland*, quoted in the *Wood Fuel for Warmth* report by SDC, Scotland.

The BIOSEM model is not as comprehensive as an I-O model⁹ but gives a useful estimate of the multiplier effect. The advantage of using BIOSEM is that it allows a simple socio-economic assessment to be made for case-specific investigations where data is available at company level¹⁰. One area of limitation is that BIOSEM was originally designed to model the impacts of biomass energy deployment with a focus on biomass crop production, construction and operation of a biomass energy plant. In this study, although we calibrated the BIOSEM to suit the specific needs for the impact analysis of wood energy strategy, there are still some areas that are not ideal for this analysis.

3.2 Source of data for modelling

To estimate the economic impact using the BIOSEM model, the data required for the analysis is considerable. The data is based on three main sources:

- relevant published data signposted by WDC
- expert opinions based on professional knowledge and experience
- consultations with wood energy companies

Steve Luker Associates and DARE, the consultants appointed to develop the strategy, have been one of our main points of contact for details of data information. In addition, we have carried out consultations with wood fuel suppliers and boiler installers in the region/supplying the region for detailed financial and employment data.

The information we collected from desk based research has been used to complement and validate data provided by experts and wood energy companies, together forming the basis for input into the BIOSEM model. The data was entered into the model on a 'per MW' or 'per tonne' basis after several rounds of consultation and validation activities between experts, wood energy companies and ADAS.

The technical and financial data used to inform the model is indicative rather than absolute. It is based on consultation with experts and energy supply companies in Ireland therefore should be representative of the situation. The energy supply companies are at the early stages of development and the level of resources and scale of production may change as the sector achieves critical mass. In terms of woodchip supply, a large number of the jobs are currently part time as few can operate on a full time basis at this stage; again this is likely to change over time.

3.3 Modelling the scenarios

Data on costs and labour use was entered for the three key stages of the supply chain:

1. boiler installation
2. boiler operation and maintenance
3. woodchip supply

These relate to an 'average' installation, based on a 500kW boiler, e.g. for a hotel with a leisure facility. Key input and output assumptions are set out in Table 2.

⁹ As noted in Section 2.2 regional IO tables are not available.

¹⁰ Hayley Myles 2001, *Socio-Economic Modelling of Bioenergy Systems*, paper prepared for the IEA Bioenergy Task 29 Workshop in Alberta, Canada, 28-31 May 2001. http://www.iea-bioenergy-task29.hr/pdf/canada_papers/Myles_2001.pdf.

Table 2: Assumptions for wood fuel supply chain inputs and outputs

Criterion	Assumptions (per MW installed)
boiler output	500kW
installation cost	€225,000 total cost (before grant). This includes infrastructure (boiler house, fuel store and connections) plus the boiler. Assumes a mix of retrofit and new build projects.
installation grant (SEI)	30% up to SEI limit per kWh. This is assumed to pass from government to manufacturer (overseas) and makes no contribution to the estimate of GVA
heat price	3.5 cents per kWh, based on data provided by Luker/DARE and commercial wood heat suppliers.
wood fuel use	1000 tonnes of wood @ 50% mc (including losses)
wood fuel price	€120 per tonne woodchip @ 15% mc (€70 per tonne woodchip @ 50% mc)

Source: costs and prices based on information provided by Luker/DARE and commercial wood heat suppliers.

Data was also gathered on the labour requirement for the three key stages of the supply chain. This is set out on Table 3. There was a good level of consensus around the data and as such a good level of confidence in its robustness.

Table 3: Characterisation of the three key stages of the wood fuel supply chain

	Boiler installation	Boiler O & M	Woodchip supply
description	construction of infrastructure and boiler installation	annual maintenance of the boiler	harvesting, drying/storage, chipping and delivery of woodchip to the boiler site
labour requirement	construction engineers and workers; boiler engineers (design and build)	specialist engineers	specialist harvest and chipping contractors, farmers and drivers
estimated labour (FTE) per MW capacity installed*	0.6	0.4	0.8

*Labour for installation is a one-off impact when the plant is commissioned; O&M and woodchip supply impacts are repeatable impacts for the lifetime of the plant.

All elements of the supply chain involve an office function (management, sales and administration), which has been included in the analysis at 30% of total labour, based on data provided by the wood heat supply companies.

4.0 Results

The BIOSEM model estimated the 'average' annual GVA and employment on a 'per MW' basis associated with the three scenarios set out in the strategy. This has been scaled up to the aggregate additional wood energy installed in year 2010 or 2020 to give a gross impact per MW. As such, the results represent the annual impact at that point in time, rather than the aggregate impact over the period from 2008. The latter can be calculated but is more difficult to interpret. Construction impacts have been annualised over the expected lifetime of the installation and combined with the operational impacts.

4.1 Gross Value Added

Using wages plus profits as a proxy for GVA, the financial impact of developing the wood energy sector has been estimated (Table 4).

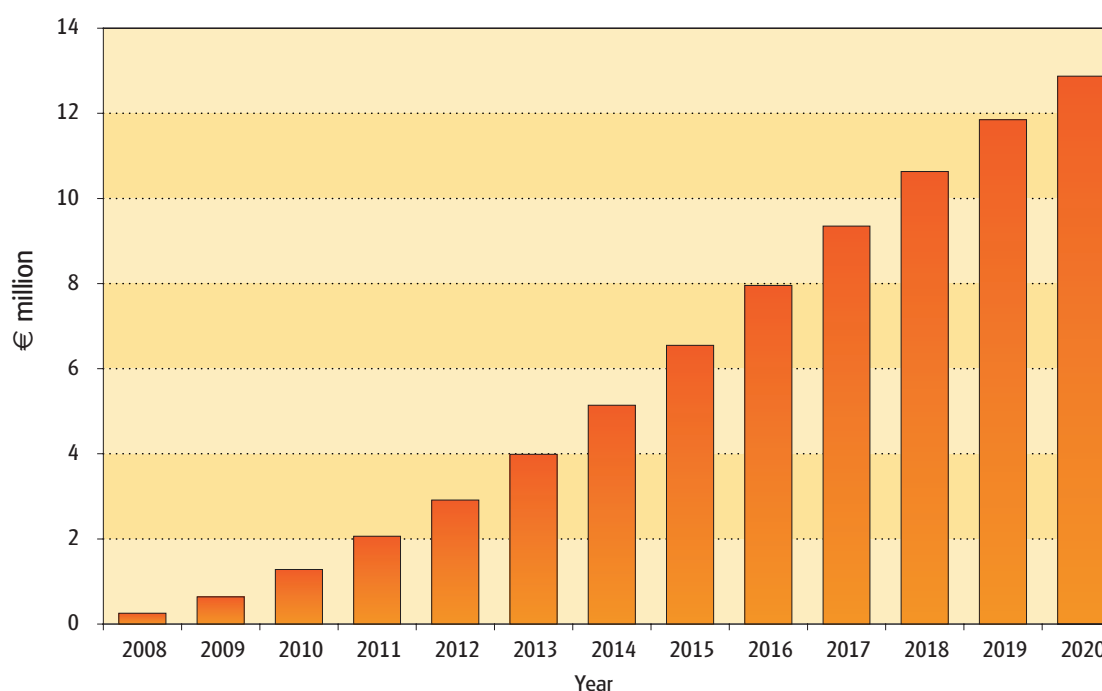
Table 4: GVA Impacts for wood energy strategy scenarios

	Direct output (€ million)	Indirect output (€ million)	Induced output (€ million)	Total (€ million)
2010				
do nothing	0.6	0.0	-	0.7
low scenario	1.1	0.1	-	1.1
medium scenario	1.7	0.1	-	1.8
high scenario	2.6	0.1	-	2.7
2020				
do nothing	3.2	0.2	-	3.4
Low scenario	8.9	0.5	-	9.4
medium scenario	14.5	0.8	-	15.3
high scenario	18.9	1.0	-	19.9

Note: GVA is estimated at current prices.

These are annual impacts, (i.e. GVA in 2010 and 2020). For intermediate years, the impact will be increasing according to the capacity installed. Figure 2 illustrates the growth in GVA over the period from wood heat installations (excluding CHP heat). The cumulative impact in terms of GVA up to 2020 from these plants is estimated at €75 million.

On the assumption that the additional capacity is fuelled by farm woodland, the annual value of thinnings to farmers under medium scenario in 2020 will be €1.7 million based on 477MW of new capacity installed and a farmer price of €3.50 per tonne.

Figure 2: Annual GVA from wood heat sector under medium scenario (2008 to 2020)

4.2 Employment

The estimated employment impacts for the four growth scenarios in 2010 and 2020 are detailed at Table 5.

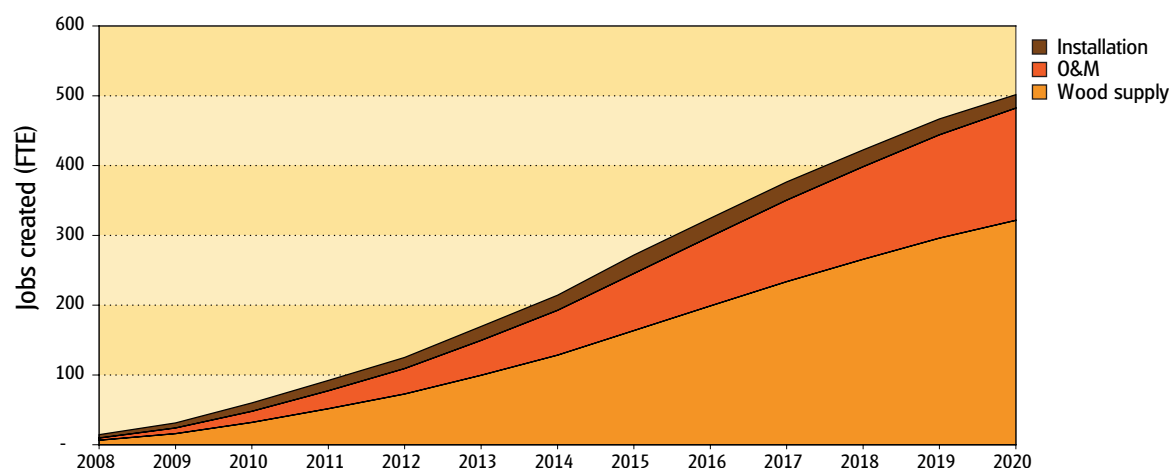
Table 5: Employment impacts for wood energy strategy scenarios

	Direct employment (FTE)	Indirect employment (FTE)	Induced employment (FTE)	Total (FTE)
2010				
do nothing	27	1	10	38
low scenario	47	2	16	65
medium scenario	73	3	26	102
high scenario	113	5	40	158
2020				
do nothing	140	6	49	195
low scenario	388	18	137	543
medium scenario	634	29	224	887
high scenario	827	37	292	1,157

The employment effects are not dissimilar to the previous BIOSEM studies cited earlier (1.6 to 4.3 jobs per MW), although many of these have been based on single plant impacts, rather than a region wide sector. As such, the analysis here reflects some economies of scale. The other factor limiting employment effects is the use of established woodland as feedstock rather than dedicated energy crops.

The creation of jobs over time is relatively even but there is an exponential effect as installed capacity increases and the operational impacts build. It is important to note that while jobs created for operation and maintenance, and wood supply are ongoing, those for installation are temporary.

Figure 3: Direct jobs created under medium scenario over time (excluding CHP)



The data indicates substantial job creation levels and it is important to consider how these will be realised in practice. At least some of the jobs will be part time additions to core employment for farmers and contractors. This does not undermine the headline data but suggests that rather than just a job creation effect, developing the sector would increase the viability of many existing rural businesses with further social and community benefits. Indeed, as marginal income for these households, it is more likely that wages for these workers will find their way into the local economy as spend on leisure activities and services.

In the context of total employment in the Western Region (277,219 in 2002), the impact on the job market and wage rates would not be expected to impact on other sectors or distort market rates. The small scale and local nature of the supply chain should also ensure impacts are dispersed.

4.3 Deadweight

The policy, economic and environmental drivers for expansion of the wood energy sector are substantial and it is reasonable to expect that there would be some sector development in the absence of further market intervention (the SEI grants for boiler installation will continue to 2010). The net impact of the strategy therefore relates to the net additional capacity installed under the three scenarios relative to the 'do nothing' counterfactual position, as defined by Luker/DARE.

The Luker/DARE report indicates a modest level of growth under the 'do nothing' scenario, leaving substantial net growth under the three scenarios (Table 6).

Table 6: Growth scenarios and targets net of deadweight

	'Do nothing' (MW)	Low scenario (MW)	Medium scenario (MW)	High scenario (MW)
gross heat energy by 2010	20.5	35.0	55.0	85.0
net heat energy by 2010	-	14.5	34.5	64.5
total heat energy by 2020	105.0	292.0	477.0	622.0
net heat energy by 2020	-	187.0	372.0	517.0

If the gross impacts are adjusted for deadweight on this basis, impacts are reduced (Table 7). The net change or deadweight effect in terms of GVA in 2020 is a fall of €3.4 million while in terms of employment it represents 195 jobs.

Table 7: Impacts of growth scenarios net of deadweight (2020)

	GVA (€ million)	Employment (FTE)
low scenario	6.0	348
medium scenario	11.9	692
high scenario	16.6	962

4.4 Displacement

There are two potential displacement issues:

1. jobs and GVA in the heating oil supply chain
2. jobs and GVA in agriculture, relating to change of land use

While it is evident that (at constant heat demand), wood energy will directly displace heating oil, this is a real and substantive displacement. The scale of loss of GVA and jobs is difficult to estimate but on the assumption that the oil companies are based outside the region and would retain any profits, the main issue is oil distribution. The strategy report suggests the total Western Region heat energy market is equivalent to at least 600 million litres of oil. Assuming one tonne of green wood fuel replaces 300 litres of oil, the medium scenario represents displacement of 132 million litres of heating oil and an estimated 15 to 20 distribution jobs¹¹.

With respect to agriculture, the reality is that the woodland is already planted and available for harvest. It has been assumed that in the absence of development of the wood energy sector, the woodland would not be thinned due to the cost of harvesting, relative to demand and returns from the pulpwood market. This would discourage an already marginal farming sector from using woodland. As such, a wood energy sector would not displace any existing agricultural activity.

¹¹ DARE consultants

4.5 Impacts over time

The analysis of impacts includes both the initial construction phase, which is temporary and the operational phase which is ongoing. The construction impacts have been spread over a 20 year period in order to give an annual impact. In practice the effects will be uneven, with a concentration of construction in the early years of sector development but with an increasing operational impact as capacity builds towards 2020.

To understand the dynamic better, construction and operation impacts have been separated (Table 8). Unlike many economic development programmes, the construction impact is spread across the entire programme as capacity is increased. This has the effect of evening out the impact, making it easier for the local employment market to absorb and helping to retain benefits within the Western Region.

Table 8: Construction and operational net Impacts under the medium scenario (2020)

	GVA (€ million)	Direct employment (FTE)
construction (annual average to year 2020)*	0.7	19
operation (ongoing from 2020)**	10.7	653

*GVA and jobs from construction relate to 372MW net installed capacity, divided across 12 years.

**Operational impacts are based on total new installed capacity by 2020, allowing for deadweight and displacement.

This analysis is indicative but indicates the organic nature of sector growth and even distribution of impacts.

4.6 Savings in fuel costs

The current price of delivered heat energy for larger installations is quoted as approximately 3.5 cents per kWh relative to approximately six cents for oil based systems. It might be argued that substitution of part of the oil heating by wood energy would deliver savings for the companies and public organisations involved. In practice much of the saving would be realised as increased company profits or reduced public sector costs; neither may be available to the local economy. More importantly, this price gap may be transient, relying on some degree of public funding to plant the woodland and install the boilers. In the longer term, wood energy will need to be competitive with oil based heating systems but it cannot be assumed that the current differential will exist.

Given the above, we have not allowed for any impacts of savings in heating costs being returned to the local economy with consequent multiplier impacts on GVA and employment.

4.7 Other impacts

There may be wider socio-economic impacts due to the development of the wood energy sector, which relate to increased incomes, transferability of knowledge and skills or competition for resource. These include:

- increased viability of small farming business and associated community cohesion
- greater awareness of the carbon economy and environmentally sensitive behaviours (both personal and corporate), including green technologies
- increased capacity of workers in terms of engineering skills that are transferable to other sectors, e.g. food and manufacturing

One potential negative impact is competition for wood resources and consequent production cost increases for the sawmills or panel board mills.

4.8 Conclusion

In summary, development of the wood heat sector in the Western Region is expected to contribute significant benefits in terms of GVA and employment. The results are summarised in Table 9.

Table 9: Net impacts of wood heat in the Western Region (medium scenario in 2020)

	Annual GVA (€ million)	Employment (FTE)
direct sector impact	14.5	634
less deadweight	3.2	140
less displacement	0.6	20
gross sector impact	10.7	474
multiplier*	1.05	1.4
net economy impact	11.3	672

* Type 1 multiplier for GVA, Type 2 for employment.

These impacts are lower than those reported by other studies on a 'per MW installed' basis e.g. results of other projects using BIOSEM model. This relates to economies of scale associated with the development of a significant wood energy sector rather than individual plants and the use of existing woodland as feedstock. In addition, the analysis is sensitive to the extent of deadweight as represented by the 'do nothing' scenario.

The small scale nature of wood boiler installations and organic development of the sector means that construction impacts are phased over the period to 2020. Thus, while these are 'one-off' temporary impacts, the GVA and employment impacts are expected to be relatively even. This suggests that the sector can develop sustainably, building capacity as it does so, with minimal reliance on imported labour.

The analysis is sensitive to prices at two levels.

1. Lower prices for heat energy or higher cost of woodchip would reduce the GVA through reduced profits, and ultimately may stem sector growth. This would also impact on employment and induced impacts but seems unlikely in view of the differential between the price of heat energy and oil energy.
2. Higher prices for heat energy or lower cost of woodchip would not be expected to drive sector growth significantly as the economic case is already strong and capacity/confidence is the main limiting factor. However, there would be some impact on GVA and induced impacts through increased profits. If sector growth were faster than the regional capacity to respond, some benefits would accrue outside the region from use of 'imported' labour.

5.0 Value of carbon saving effects

The main focus of this report has been the direct socio-economic impact of wood fuel on the local economy in the WDC Region. However, the use of carbon neutral wood fuel also produces environmental benefits, which may also have an economic value through the tradable value of carbon. We explore these issues more fully in this section.

5.1 Using forestry products for carbon management

The principles behind using forestry and forest products as a way of combating climate change is well understood. CO₂ is taken up by plants through photosynthesis and stored in the wood and roots. The forest can then be left as a standing store of sequestered carbon (a sink), or, it could be harvested as wood fuel and burned, offsetting the equivalent amount of CO₂ released by the burning of fossil fuel. In contrast to the combustion of fossil fuels where ancient carbon stores are released into the atmosphere, burning of wood fuel is effectively carbon neutral as the carbon released has been only recently taken from the atmosphere by the growing tree. Additionally, some carbon remains locked in unharvested roots and soil organic matter, only slowly returning to the atmospheric carbon pool.

5.2 An introduction to carbon markets

Carbon markets currently consist of the regulated and unregulated markets. The regulated markets have been developed from the demands of the Kyoto Protocol and are principally the UN's Clean Development Mechanism (CDM), Joint Implementation (JI) projects, and the EC's EU Emissions Trading Scheme (EUETS). The unregulated, voluntary or over the counter (OTC) markets have developed to provide, amongst other activities, carbon offsetting services.

Under the EUETS, countries are allocated a number of allowances based on a National Allocation Plan (NAP) which covers emissions for that country for a specified period. NAPs (and thus allowances gained for each country) should ideally be less than estimated under a 'business as usual' scenario and thus actively promote reductions in the CO₂ emitted. Installations that cut their CO₂ below the limit for which they have allowances for can sell these surplus allowances under the EUETS scheme to companies who have failed to reduce their emissions in line with their allowances. Using wood in place of fuel oil will contribute to reducing emissions from the 'business as usual' scenario.

The voluntary or OTC markets are not subject to CDM/EUETS regulation and involve the purchasing of carbon credits for individuals or institutions to offset their emissions, and the donation to GHG reduction projects by developers in exchange for credits. These markets may be operated through a formal structure such as the Chicago Climate Exchange (CCX) and the more recent European Climate Exchange (ECX) where members legally sign up to cap their emissions and trade the remainder through the non-binding, more accessible, other voluntary markets. There has been quite a lot of 'negative press' about the efficacy of these markets and the compatibility of their audit processes with the methodologies developed by the IPCC12 and CDM.

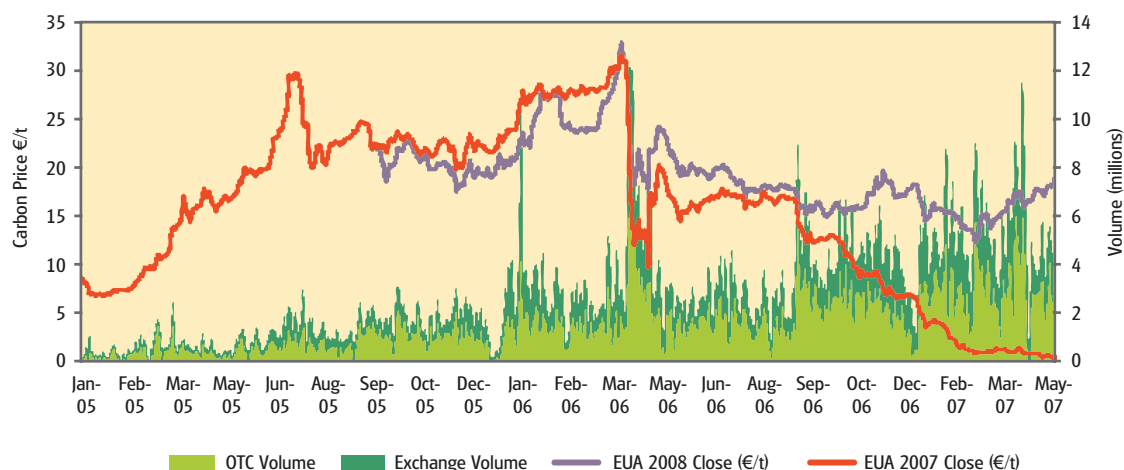
Ireland's Kyoto target was to contain emissions within 113% of 1990 levels in the period 2008 to 2012. The latest figures for 2005 emissions placed national emissions at 25.4% higher than in 1990. Whilst some of this target will be met by NAP limits on large industrial establishments, if Ireland is to remain compliant with Kyoto, emissions reductions will need to be sourced from other markets. Home based schemes remain an option to be judged alongside others.

¹² Intergovernmental Panel on Climate Change

5.3 Carbon offset values

The value of carbon has varied significantly both within the EUETS and in the voluntary offset markets. Figure 4 shows the variability in EUETS carbon prices over the initial 28 month trading period from January 2005 to April 2007. The average over this period is €16 per tonne.

Figure 4: Volumes and value of carbon traded (as tonnes CO₂) under the EUETS scheme



Source: Defra (2007)¹³

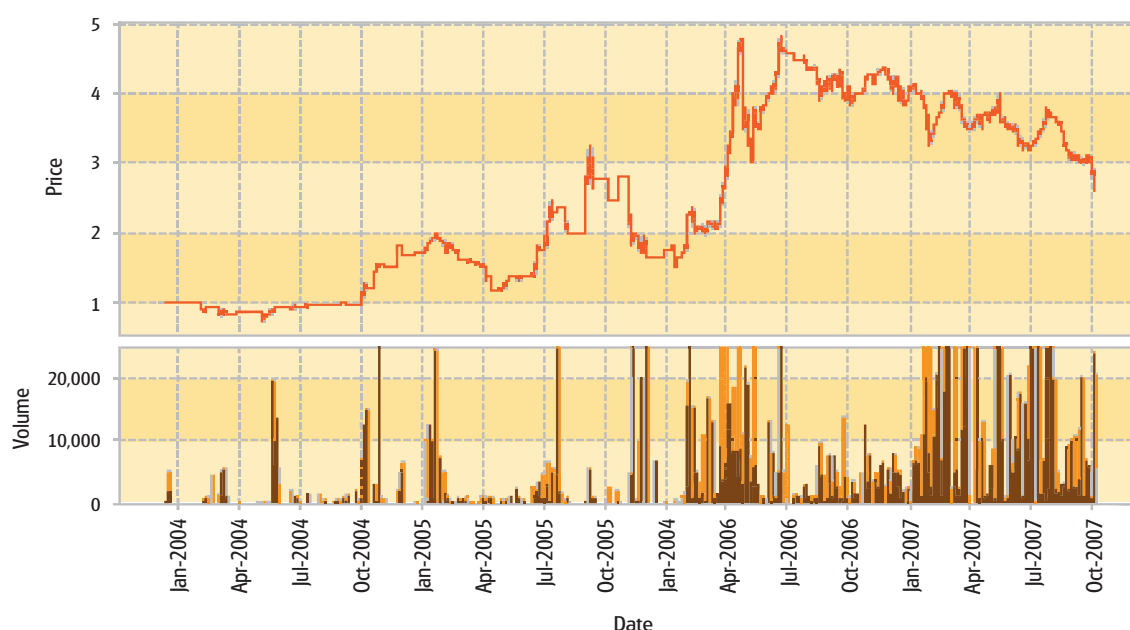
Carbon prices in the EUETS have varied widely to date, most notably with large falls in the price of carbon in April 2006 and with a slump from August 2006 to April 2007, largely as a result of the allowances being higher than the actual emissions. Tighter controls of allowances under each NAP in the second and third rounds of the EUETS scheme will provide a real incentive for companies to reduce their carbon emissions and for carbon to become a valuable tradable commodity¹⁴.

The value of carbon in the voluntary markets has varied according to provider and the quality of the scheme, from \$0.45 to \$45, with the highest prices being paid for projects that had high quality, verifiability characteristics and those involved in long term sustainable development projects¹⁵. Figure 5 below shows data from the CCX over a 3.5 year period from January 2004 to October 2007 (both price (in \$) and volume are reported in metric tonnes CO₂).

¹³ Defra (2007), analysis paper on *EU Emissions Trading Scheme Review options*; report for Defra and the Office of Climate Change.

¹⁴ Stern Review (2007), *The Economics of Climate Change*.

¹⁵ Hamilton, K., Bayon, R., Turner, G., Higgins, D. (2007), *State of the Voluntary Carbon Markets 2007: Picking Up Steam. Report for Ecosystem Marketplace and New Carbon Finance*.

Figure 5: Volume of carbon traded and average price of traded carbon on the CCX

Estimating the price in 2020 however is far more risky as there are many factors that make such an exercise too open to be of much value. The EU allowances have become the benchmark for carbon prices (hence the €16 value from the EUETS chart). But shortly, the International Transaction Log (ITL) will increase the flexibility of carbon trading, bringing the CDM's CERs into the same virtual market. This may bring a steadying of carbon prices, but much will continue to depend on national allowances and actual emission levels. As the CDM only continues in its present form until 2012, the longer term future of these schemes and carbon trading is unclear.

Other changes include the introduction of Assigned Amount Units (AAUs). From 2008, governments may begin to buy AAUs from Kyoto Annex B countries, mainly former Soviet Union countries, including EU new Member States whose actual emissions are below their Kyoto commitment. The plentiful volume of these units traded has the potential to influence the long term demand for CERs and thus CO_{2e} prices.

Other factors that will affect CO_{2e} prices include decisions about the limit for National Allocation Plans (NAP), limitations set on the number of allowances that can be sold; fuel prices especially the coal/gas price differential and the impact of weather on global and local energy demand. These factors all add to uncertainty in price forecasting.

Ultimately, the price of the allowances must incentivise practicable reductions in GHGs. If these reductions are too easy, (i.e. below the NAP limits) as we have seen, the price is devalued. Strong economic growth may allow businesses to tolerate high CO_{2e} prices but the prices must be punitive enough to encourage GHG reductions without generating economic and political resistance. The risk that schemes may not deliver must also be factored into the agreed price.

However, there is an understandable reluctance on the part of market operators to 'second guess' the 2020 market price for carbon¹⁶. In Europe particularly, large shares of the electricity generation portfolio need replacement before 2020, with plant that should then operate for several decades. The trade-off between traditional and more expensive clean technologies is likely to affect how carbon prices develop.

¹⁶ *Equal Exchange: Determining a Fair Price for Carbon* Eds G Hodes & S Kamel, UNEP 2007.

The displacement of fossil fuel by wood in Western Ireland would, by 2020, provide a low risk annual carbon saving using established technology that is repeatable annually. As such, the saving would be similar to that accruing say, from wind farm investment. It may be that prices in the range €10 to €40 per tonne CO_{2e} should be anticipated, simply on the basis of a 'business as usual' scenario. As the factors outlined above will affect the general carbon price, government purchases for established schemes may provide some buffering which is reflected in the 'normal' ranges indicated.

Given the current uncertainty over the value of carbon, long term planning of the value of the wood resource in the region for carbon sequestration rather than fuel *per se*, will require a wider range of values to be considered to cover the future development of the market.

5.4 Scenarios for carbon offset promoted by forestry use in the Western Region

The wood fuel resource in the region could be used for carbon offsetting either through a market trading approach or by reducing the number of allowances the government needs to purchase to meet its Kyoto commitments, valued at €15 per tonne/credit for the 2008 to 2012 period¹⁷. These are discussed below for the 'do nothing' scenario and three levels of market penetration¹⁸ for wood fuels in 2010 and 2020, at varying carbon prices.

The Luker/DARE report (*Wood Energy Strategy and Action Plan*)⁴, suggested that in the Western Region as a whole, oil for heating is the dominant energy market, accounting for more than 50% of the total heat market, and so consequently, figures for future growth of the wood heat sector in the region are expressed in terms of tonnes of oil equivalents. In the analysis, we have calculated the value of the carbon in the wood fuel under each scenario, its equivalent as tonnes of oil, and from this the tonnes of fossil CO₂ that would be displaced by the switch to wood fuel.

The low penetration scenario for 2020 of 69,328 tonnes of oil equivalents (Table 10) represents close to 10% substitution of the Western Region's heat market proposed by the Luker/DARE report.

¹⁷ Department of the Environment, Heritage and Local Government, personal communication, 2007.

¹⁸ Steve Luker Associates Ltd and DARE (2007) *Regional Wood Energy Strategy and Action Plan*, report for Western Development Commission, November 2007. Luker et al expressed these tonnages in terms of 50% moisture content whereas woodchips would more typically have a moisture content of approximately 30% when sold for combustion. In this section, all figures have been adjusted to a dry weight basis.

Table 10: The carbon release (as tonnes CO_{2e}) from using forestry in the Western Region

Wood fuel market penetration				
2010	'do nothing' (34kt per annum)	low (46kt per annum)	medium (62kt per annum)	high (86kt per annum)
tonnes of woodfuel required (dry) ♦	17,200	23,000	31,000	43,000
tonnes of CO ₂ (in wood fuel) ☆	31,533	42,167	56,833	78,833
energy content (MWh) ❖	90,752	121,385	163,607	226,938
tonnes oil equivalent ✱	7,804	10,436	14,065	19,510
tonnes of CO ₂ (in oil) ◇	76,687	102,547	138,215	191,718
CO ₂ saving of wood versus oil (tonnes) ✧	45,154	60,380	81,382	112,885
net impact of wood fuel strategy (tonnes) †	-	15,226	36,228	67,731
2020	'do nothing' (120kt per annum)	low (306kt per annum)	medium (472kt per annum)	high (606kt per annum)
tonnes of woodfuel required (dry) ♦	60,000	152,800	235,800	302,800
tonnes of CO ₂ (in wood fuel) ☆	110,000	280,133	432,300	555,133
energy content (MWh) ❖	316,578	806,422	1,244,465	1,598,066
tonnes oil equivalent ✱	27,223	69,328	106,987	137,386
tonnes of CO ₂ (in oil) ◇	267,513	681,267	1,051,327	1,350,051
CO ₂ saving of wood versus oil (tonnes) ✧	157,513	401,134	619,027	794,918
net impact of wood fuel strategy (tonnes) †	-	243,621	461,514	637,405

- ♦ The Luker/DARE report presents the wood fuel market penetration scenarios at 50% moisture content. We have adjusted these figures to a dry basis for ease of calculation, by dividing the Luker/DARE penetration scenarios by two.
- ☆ Assumed CO₂ emissions from one tonne of wood is based on 50% of the dry weight of the biomass being carbon multiplied by 44/12 to convert the carbon to carbon dioxide.
- ❖ The energy density of woodchip has been based on energy values for Norwegian Spruce woodchip¹⁹ at 19GJ/dry tonne²⁰. The tonnage of woodchip has been multiplied by 19 to give the energy density of the whole woodchip resource, then multiplied by 0.2777 (since 1 GJ is equivalent to 277.78 kWh, this is divided by 1,000 to convert kWh to MWh). This gives the energy content of the woodchip resource in MWh.
- ✱ 'Tonnes of oil equivalent' has been calculated as the equivalent energy value in terms of MWh provided by woodchip. 1 MWh = 0.0859845228 tonnes of oil equivalent.
- ◇ CO₂ emissions from oil are calculated by multiplying the tonnage of oil by the factor 2.68.
- ✧ Derived from subtraction of the tonnes of CO₂ in woodchip from the tonnes of CO₂ in oil.
- † Derived from the carbon savings of each scenario minus that of the 'do nothing' scenario, gives the net carbon benefits of implementing each scenario.

¹⁹ Electrowatt Ekano UK Ltd (2003), Coford Strategic Study- Maximising the Potential for Wood Use for Energy Generation in Ireland. The report quotes figures of 19-20.5 GJ/dry tonne.

²⁰ Figures quoted by the Biomass Energy Centre (<http://www.biomassenergycentre.org.uk>) give figures of 17-18 GJ/dry tonne. Ultimately, the energy content at use is dependent upon the moisture content, species and the composition of the woodchip.

As the price per tonne of CO_{2e} varies so will the value of the carbon saving due to the replacement of oil by wood in the different scenarios. Table 11 shows the impact of a range of different carbon prices on each of the four market penetration scenarios outlined in the report by Luker/DARE. Low, medium and high penetration scenarios are adjusted for the 'do nothing' scenario to give the net additional effect of implementing the WDC wood fuel strategy on the value of tradable carbon. The net figures are indicated in parenthesis beside the gross impact.

Table 11: Gross and (net) value of carbon savings by using wood fuel

2010	'do nothing' (34.4kt per annum)	low (46kt per annum)	medium (62kt per annum)	high (86kt per annum)
CO _{2e} (ex table 10)	45,154	60,380	81,382	112,885
price of carbon (€/t CO _{2e})				
10	451,540	603,800 (152,260)	813,820 (362,280)	1,128,850 (677,310)
15	677,310	905,700 (228,390)	1,220,730 (543,420)	1,693,275 (1,015,965)
20	903,080	1,207,600 (304,520)	1,627,640 (724,560)	2,257,700 (1,354,620)
50	2,257,700	3,019,000 (761,300)	4,069,100 (1,811,400)	5,644,250 (3,386,550)
100	4,515,400	6,038,000 (1,522,600)	8,138,200 (3,622,800)	11,288,500 (6,773,100)
2020	'do nothing' (120kt per annum)	low (306kt per annum)	medium (472kt per annum)	high (606kt per annum)
CO _{2e} (ex table 10)	157,513	401,659	619,552	795,442
price of carbon (€/t CO _{2e})				
10	1,575,133	4,011,339 (2,436,207)	6,190,273 (4,615,137)	7,949,172 (6,374,047)
15	2,362,695	6,017,005 (3,654,310)	9,285,405 (6,922,710)	11,923,765 (9,561,070)
20	3,150,266	8,022,678 (4,872,414)	12,380,546 (9,230,274)	15,898,344 (12,748,094)
50	7,875,666	20,056,695 (12,181,034)	30,951,366 (23,075,684)	39,745,859 (31,870,234)
100	15,751,331	40,113,390 (24,362,069)	61,902,732 (46,151,401)	79,491,718 (63,740,469)

5.5 Practicalities of using wood fuel to offset carbon in the Western Region

The following points should be considered if the WDC wishes to exploit the utilisation of wood fuel in place of fossil fuels in the Western Region.

1. The government will need to buy in credits from other projects in order to meet its Kyoto targets as current estimates suggest that national emissions will not be reduced enough from current schemes to meet these targets. These credits could be derived from projects at home or abroad, but the longer term future of some schemes is not clear.
2. Nationally, less than 100 installations are currently involved in the EUETS scheme. These installations belong to specific industry sectors with a generation or production capacity exceeding thresholds set by the EU. Smaller schemes (including domestic, municipal and small industrial) are currently excluded from the EUETS scheme. Concerns over the logistics of verification of smaller schemes suggest that this is unlikely to change through reviews of the scheme from 2012 onwards. Therefore, unless the wood resource was destined for use by one of these large emitters covered by the scheme, using the wood fuel for offsetting in the EUETS scheme is unrealistic. This may change by 2020.
3. The carbon reductions from using wood fuel in the Western Region in place of oil can be used to contribute to the national emissions target, and thus will reduce the number of certified emissions reduction credits the government needs to 'buy in' to reach its emissions targets through the flexible mechanisms provided for under the Kyoto Protocol.
4. The carbon saved from using the wood fuel could be traded on the voluntary markets. In the short term this will have the benefits of requiring less extensive and expensive verification procedures. However, this needs to be considered against potentially lower carbon prices on these markets. The quality of the offset will become increasingly important as the voluntary market has been extensively highlighted in the media recently for concerns over whether bought offsets have actually contributed to any reduction in CO₂ levels over what would be already in place (termed additionally, i.e. are the savings truly additional). Consumers will increasingly require information on how their money has been spent. The option of trading on the voluntary markets will not be available if the wood fuel utilisation is covered in the future by EUETS or a possible domestic JI programme as 'double counting' of the credits would be a problem.
5. Verification of resources costs time and money, and this is likely to increase depending upon the size and disparate nature of the fuel utilisation. Costs of verification therefore need to be offset against potential gains from carbon trading. Verification will become increasingly important and is a must for trading of carbon credits on the ECX and CCX.

5.6 Conclusion

The CO₂ savings arising from the use of wood instead of oil increase in proportion to the level of wood fuel market penetration. Luker et al (2007) suggested that the medium market penetration scenario was the most sustainable option both in terms of the available resources, national renewable heat targets and the development of the wood fuel industry in the region. By 2010, the medium penetration scenario could produce savings of 81,382 tonnes of CO_{2e} and by 2020 the same scenario could result in savings of 619,027 tonnes of CO_{2e}. This could be used to reduce the level of credits needed by the government to meet their Kyoto commitments. Using the price provided for CO_{2e} of €15 per tonne for 2008 to 2012, the savings under the medium penetration scenario would be worth €1,220,730 by 2010 and €9,285,405 by 2020.

As most of the installations are small to medium scale and below EUETS limits, the carbon cannot be traded through the EU trading mechanism but could perhaps be traded through voluntary markets.

The above benefits do not take account of carbon savings under a 'do nothing' scenario. By 2010, the medium penetration scenario would result in a net saving of 36,228 extra tonnes of CO_{2e} per annum, which at a carbon price of €15 per tonne would be valued at €543,420. By 2020, the medium penetration scenario would result in the additional saving of 461,514 tonnes of CO_{2e}, which at a carbon price of €15 per tonne would be worth an additional €6,922,710. These are potentially significant benefits to the national budget as well as to the environment and contribute to the strong socio-economic case for a proactive support strategy by the WDC and the national government.

6.0 Conclusions

There are key conclusions to be drawn from this work (figures relate to the medium scenario in 2020).

1. Development of the wood energy strategy will result in significant direct impacts by 2020, both in terms of employment (over 600 FTE jobs) and GVA (€14.5 million).
2. The largest share of these impacts is from employment and income in the wood energy supply chain, from timber harvesting to boiler maintenance, with woodchip production being most significant component (75 to 85% total direct impacts). This reflects the relatively low boiler maintenance requirement.
3. On the assumption that the additional capacity is fuelled by farm woodland, the annual value of thinnings to farmers under will be €1.7 million based on 477MW of new capacity installed and a farmer price of €3.50 per tonne.
4. Indirect impacts from the wood energy supply chain relate mainly to equipment service and maintenance and are limited (29 FTE jobs and €0.7 million GVA). This is generally lower than the results from other BIOSEM studies (0.3 to 0.6 FTE per MW) due to reliance on feedstock from existing forests rather than dedicated energy crops and economies of scale.
5. Induced impacts are more substantial (224 FTE jobs) due to a significant multiplier effect (Type 2 Employment Multiplier = 1.4) from wages and profit spend in the local economy.
6. These impacts are significant if deadweight (capacity installed under a 'do nothing' scenario) is taken into account. It should be noted that this counterfactual situation for sector development assumes that SEI boiler grants are discontinued after 2010 and there is no continuing action plan.
7. In terms of displacement, there is no agricultural impact as the woodland is already there and would not be harvested in the absence of a wood energy sector. There is a small element of displacement of jobs in the oil supply chain, mainly relating to distribution. The impact is estimated at 15 to 20 FTE jobs.
8. The small scale nature of wood boiler installations and organic development of the sector means that construction impacts are phased over the period to 2020. Thus, while these are 'one-off' temporary impacts, the GVA and employment impacts are expected to be relatively even.
9. Estimated CO_{2e} savings of wood versus oil of over 600,000 tonnes under medium scenario in 2020. The value of this carbon offset at €15 per tonne is over €9 million. After allowing for deadweight (from the 'do nothing scenario'), the net CO_{2e} saving is estimated at 461,514 tonnes or almost €7 million at €15 per tonne. Higher future values for carbon would add significantly to the economic benefit.
10. There are also opportunities to use the remaining forest (after thinnings are taken) as a revenue attracting carbon sink.
11. There may be wider socio-economic impacts due to the development of the wood energy sector, although these may be largely intangible. They include increased viability of small farming businesses and associated community cohesion, greater awareness of the carbon economy and environmentally sensitive behaviours (both personal and corporate), increased capacity of workers in terms of engineering skills that are transferable to other sectors.
12. One potential negative impact is competition for wood resources and consequent production cost increases for the sawmills or panel board mills.

Appendix 1: Keynesian Economic Multiplier

Local income and output multipliers measure changes in regional income and output with respect to some autonomous change in local expenditure or economic injection into a region, such as that associated with investment in renewable energy sources. The size of the local multiplier depends directly on the proportion of income spent locally or, inversely, on the proportion of income at each round of spending that leaks out of the local stream into savings, taxation, reduced transfer payments, or import purchases. The size of the multiplier, therefore, tends to vary directly according to the size of the local area, since import leakage declines as the size of the area increases. Three types of local multipliers have played a prominent role in regional impact analysis: economic base multipliers, Keynesian multipliers and input-output (I-O) multipliers.

The simplest, and earliest, multiplier models are based on regional economic-base models. These are derived from the export or economic base theory of growth, a theory that explains development and decline in terms of the performance of an area's export or economic base. The economic base comprises those sectors of economic activity that serve the export market. The economic base multiplier is defined as the ratio of total economic activity to base activity. If it is assumed employment is proportional to income, the proportion of income spent locally is equal to non-basic or residuary employment divided by total employment.

The model can be developed further by including the accelerator component related to induced investment (or the reverse - disinvestment). Unfortunately, information on income flow to use this approach is pragmatic and fragmented. The reliability of the approach is therefore questionable, relying as it does on the amalgamation of fragmented and incomplete data, assumptions and personal judgements of the research investigators in aggregating the data for our case study areas. Moreover, the economic base model has several methodological shortcomings. First, local or residuary activity may grow independently of any growth in export activity as a result of autonomous investment (private or public) in the area. Second, imports, and the multiplier effect of import substitution are ignored. Third, the economic base multiplier underestimates income multiplier effects in so far as interaction effects among the basic industries themselves and feedback from the residuary to the basic sector are precluded. Fourth, differences between local industries in the extent of inter-industry linkages and hence the size of industry multipliers are not captured.

More satisfactory than economic base multipliers are Keynesian multipliers, which explicitly take into account leakage from the income stream into savings, taxation, lost transfer payments and imports. The regional Keynesian (k_r) multiplier is expressed as

$$k_r = 1$$

$$1 - c(1 - t_d - u)(1 - m - t_i)$$

where c = marginal propensity to consume; t_d = marginal rate of direct taxation; u = change (decline) in transfer payments; m = marginal propensity to import; t_i = indirect taxation associated with increased expenditure for the region. Typical values for a case study area might be: $c = 0.9$; $t_d = 0.2$; $u = 0.15$ (decline in transfer payments); $m = 0.55$; $t_i = 0.15$. This would give a $k_r = 1.21$. Many studies have estimated local Keynesian income multipliers at approximately 1.20.

A Keynesian multiplier provides an estimate of the general effects in an area of a change in a capital injection, money flow, tax or transfer payment amount.

Appendix 2: BIOSEM model²¹

BIOSEM is a quantitative model designed to capture the socio-economic effects of local bioenergy production. It can trace both the extent and distribution of income and employment gains, and can assess the merits of differing (energy and agricultural) policy packages, such as grants and subsidies on bioenergy production.

A range of biomass fuels and conversion processes can be modelled, (e.g. from residues to dedicated energy crops), as can the recipient markets for heat and electricity. Modelling takes place in two phases:

1. Firstly, to identify the financial feasibility of the plant, and secondly, to determine the employment and income benefits from the complete bioenergy chain. It evaluates both the backward linkages, (i.e. the impact of increased demand in the supply chain) and the forward linkages, (i.e. the re-spending of additional regional income) before combining these figures to provide a complete analysis of the impact of bioenergy production on a local economy.

Phase 1 of the model, the financial assessment, is based on a cash flow analysis of the plant over a twenty year period. During this time, investment and profit margins can be traced to determine key financial indices for both feedstock production (gross margin) and for the conversion plant (such as the net present value, the internal rate of return, and the payback period). These can be used to assess the actual commercial feasibility of the plant. This is an important element, because unless the plant is economically viable, then no developer would undertake the investment. Consequently, all employment and income forecasts would be meaningless.

2. Phase 2, the socio-economic analysis, is based upon the Keynesian income multiplier technique. By this means, the model captures the following impacts:
 - direct and indirect employment and income impacts for both agricultural and bioenergy plant activities
 - direct displacement impacts for any displaced agricultural activities
 - induced impacts caused by the spending of additional wages and profits for both agricultural and bioenergy plant activities

To this end, the technique uses a spreadsheet structure to allow full transparency between all the calculations.

It is available in three versions allowing a variety of feedstock inputs to be used:

- BIOSEMV8 for crops having a three year rotation cycle, such as Short Rotation Coppice (SRC)
- BIV8-ANN for annual crops that undergo yearly planting and harvesting cycles
- BIV8-PER for perennial crops (and agricultural or forestry residues), where the establishment costs are borne only once (or not at all) throughout the life of the feedstock production process

²¹ From user's manual of BIOSEM model.

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