RASLRES

Energy Crop Opportunities in the Western Region

June 2011

A report by

WDC
WESTERN DEVELOPMENT COMMISSION
COIMISIÚN FORBARTHA AN IARTHAIR

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Teagasc
Agriculture and Food Development Authority

Northern Periphery Programme 2007–2013
Innovatively investing in Europe's Northern Periphery for a sustainable and prosperous future

European Union
European Regional Development Fund

What is Biomass?

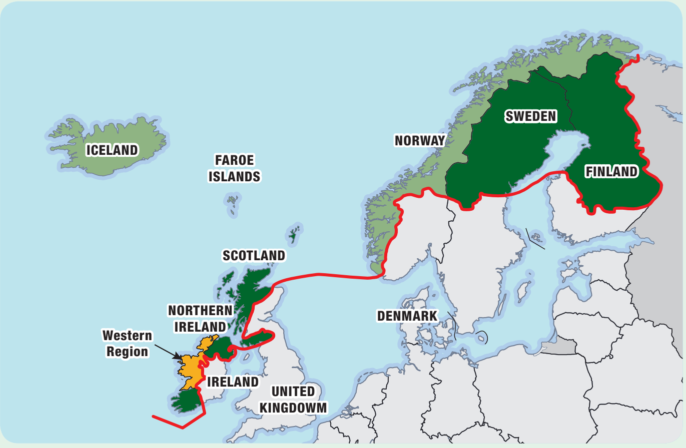
Biomass is the biodegradable fraction of products, wastes and residues of biological origin from agriculture (including vegetable and animal substances), forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction from industrial and municipal wastes.

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

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

Table of Contents

continued >>



What is the RASLRES project?

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

RASLRES is an international partnership which includes:

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

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

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

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

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

Glossary of Terms

Combined Heat and Power (CHP): CHP is the simultaneous generation of usable heat and power (usually electricity) in a single process.

District heating (DH): DH is a system for distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating. Instead of having a number of separate units for different buildings or apartments, there is one unit in a central location.

Joule: A unit of energy in the International System of Units. It is equal to the energy expended (or work done) in applying a force of one newton through a distance of one metre (1 newton metre or N·m), or in passing an electric current of one ampere through a resistance of one ohm for one second. This unit of energy is scaled as follows: Gigajoule (GJ) = 10^9; Terajoule (TJ) = 10^{12}; Petajoule (PJ) = 10^{15}.

Moisture content (MC): The weight of the water contained in wood, usually expressed as a percentage of weight, either oven-dry or as received.

One tonne of oil equivalent (toe): TOE is an international standard measure of energy value and is defined as 10^7 kilocalories. For example the conversion rates are: 1 tonne of Kerosene = 1.0556 toe; 1 tonne of LPG = 1.1263 toe

Oven Dried Tonnes (ODT): Moisture content is at 0%. As wood chips can be produced and supplied to differing moisture contents it is usual to purchase fuel based on odt's.

Total Primary Energy Requirement (TPER): TPER is a measure of all energy consumed including that consumed and/or lost in transformation and transmission/distribution processes (e.g. electricity generation transmission and distribution; oil refining).

Watt (W): The unit, defined as one joule per second, measures the rate of energy conversion.

Kilowatt (kW): A measure of electrical power equal to 1,000 watts. 1 kW = 1.341 horsepower.

Kilowatt hour (kWh): A measure of energy equivalent to the expenditure of one kilowatt for one hour. For example, 1 kWh will light a 100-watt light bulb for 10 hours.

Megawatt (MW): A unit of power equal to one million watts (10^6). This unit of power is scaled as follows: Gigawatt (GW) = 10^9; Terawatt (TW) = 10^{12}; Petawatt (PW) = 10^{15}.

Conversion Rates

An energy unit conversion calculator is available for download at
http://www.seai.ie/Publications/Statistics_Publications/Fuel_Cost_Comparison/

1 oven dried tonne of wood chip = approx. 2.5 metre^3 of harvested timber

1 oven dried tonne of wood chip = approx. 5MWh of energy

1 tonne of wood chip (50% MC) = approx. 2MWh of energy

1 tonne of oil equivalent = 11.6MWh of energy

1 tonne of oil equivalent = approx. 2.5 oven dried tonnes of wood chip

1 Megawatt hour of energy = 3.6 gigajoules

Relevant Publications

Biomass CHP Market Potential in the Western Region: An Assessment.
Western Development Commission (2008).

Census 2006: Volume 1 – Population Classified by Area.
Central Statistics Office (2007).

CO_2 Emissions from fuel combustion, Highlights.
OECD/IEA (2010).

Energy Forecasts for Ireland to 2020, 2010 Report.
Sustainable Energy Authority of Ireland (2010).

Miscanthus Best Practice Guidelines.
Teagasc (2011).

National proximity analysis of spreadlands and large pig enterprises (Sub-project No: 4).
Teagasc project conference (2009).

Willow Best Practice Guidelines.
Teagasc (2011).

Wood Energy from Farm Forests: A Basic Guide.
Teagasc (2009).

Wood Energy Strategy for the Western Region.
Western Development Commission (2008).

Acknowledgements

The WDC acknowledge the support and assistance of SEAI and Teagasc in producing this report. The report was delivered by the WDC under the EU bioenergy RASLRES report. The BGIS analysis was completed by Michael Wilson, SEAI and the contributing team members included: Pearse Buckley, SEAI; Barry Caslin, Teagasc; and Bernadette Phelan, WDC/RASLRES.

Thanks also to Action Renewables (Michael Doran) and the Irish Bioenergy Association (Jimmy Scott) who carried out the peer review of the report.

Executive Summary

The Western Development Commission (WDC) is lead partner of the EU bioenergy project *RASLRES* (*Regional Approaches to Stimulating Renewable Energy Solutions*) funded under the Northern Periphery Programme (NPP) of INTERREG IVB. In the Western Region of Ireland, the RASLRES project focuses on the development of biomass fuel supply for use in the commercial and industrial heat markets. This market research report aims to inform and guide on the development of the regional heat market. The WDC delivered the report under RASLRES in partnership with the Sustainable Energy Authority of Ireland (SEAI) and Teagasc.

The report presents an analysis of the potential of energy crops in the Western Region based on the application of the SEAI bioenergy Geographical Information System (BGIS), and discusses key factors impacting on the future development of the energy crop sector. The market analysis is of interest to existing and potential fuel producers and processors, private developers of bioenergy projects, local development companies and activists, and public sector players at a policy level and also public procurement of energy.

Over the next decade, the wood energy market is predicted to grow significantly in response to:

- increasing oil prices which is particularly significant given the Western Region's high rate of dependency on oil
- limited access to the gas network in the region and the resulting impact on regional economic competitiveness
- EU and national policy targets and measures such as carbon taxes, and
- the need to create indigenous enterprise and jobs through expansion of the renewable energy sector

The wood energy heat market in the region is estimated at 65megawatts(MW) of installed capacity consuming 31,000 oven dried tonnes (odt) of wood fuel, representing about 1.5% of the total regional heat market. By 2020, if wood energy supplied 11% of the regional heat demand it is projected to require between 217,000odt and 240,000odt of wood fuel. In addition modest growth in the Combined Heat and Power (CHP) sector has the potential to consume 125,000odt. There is also a national target for co-firing with biomass with a projected total demand of 475,000odt.

The projected production from private forests in the form of round logs was 65,800odt in 2010 and by 2020 will increase to 153,714odt. By 2020 the estimated combined outputs of round logs and co-product from the private forests is 252,000odt. These estimates assume that *all* existing private forestry will be actively managed. In reality a range of economic and social factors (such as plantation size, road access, market prices) impact on what percentage is supplied to the energy market.

Based on these 2020 projections, market demand will potentially exceed the supply available from private forestry. The region therefore has two options: either import woody biomass, or build an energy crop sector to supply the bioenergy markets. **The development of an energy crop sector is the recommended market strategy for reasons of energy sustainability, energy security, regional economic competitiveness and enterprise opportunities.**

Energy crop development is in its infancy across Ireland and in the Western Region. In the Western Region, there were only 241 hectares of miscanthus (8% of national total) and 84 hectares of willow (15% of national total) planted. The BGIS indicates that approximately 37% (710,716ha) of the available land area (1.9 million hectares) in the region is highly suitable for energy crops. Each county has the potential to supply a notable solid biomass demand from within the county boundaries.

The limitations of the BGIS analysis must be acknowledged and a range of complex factors impact on the adoption of energy crops by farmers and landowners. In this context, various growth scenarios for energy crops are considered. By 2020 achieving 10% planting of highly suitable land for SRC willow would supply nearly 4 times the projected wood fuel demand, and 50% planting of highly suitable land would supply over 22 times the projected demand. The cluster examples illustrate that a **substantial demand can be met through conversion of a relatively small fraction of land** to energy crops in areas close to centres of demand.

The BGIS analysis demonstrates the significant impact of transport costs on building commercially viable fuel supply chains. Another critical issue is that available fuels are compatible with the bioenergy installations. Given the current regional market profile, SRC willow is the preferred energy crop. If miscanthus plantations are to be progressed, appropriate market users need to be identified in tandem with the establishment of plantations. These two issues demonstrate the importance of **local loops of demand and supply** to support development of this immature sector and assist in building scale in the bioenergy market.

A complex range of factors impact on the uptake of energy crops including:

- increased demand and market price from biomass users in the heat, CHP and co-firing markets
- limited access to finance to establish plantations
- generally no financial returns on plantations in first 3 years
- the current low base of required infrastructure for crop production and fuel processing
- limited routes to markets and lack of expertise in business models to establish new supply chains
- lack of clarity of bioenergy policy, and
- relatively low levels of relevant expertise and skills in the sector

This report recommends an energy crop market development strategy based on the establishment of local loops of demand and supply. A co-ordinated approach is necessary across the demand and supply side actions to build a regional network of supply fuel chains. A coherent and supportive policy framework at the national, regional and local levels is required to provide market confidence and underpin the recommended actions to support bioenergy market growth.

Local development players (such as Local Authorities, rural development companies, Teagasc, public sector heat users) together with the private stakeholders from forestry, biomass installers and users, have the capacity to unlock the potential of the energy crop sector though a co-ordinated, partnership approach to biomass project development.

Recommended actions include:

- Supply side actions to support the set-up of producer groups, audit and investment programme to build the necessary production and processing infrastructure, provision of production, technical and business planning training
- Demand side actions to install clusters of wood energy units in defined geographic areas across both the public and private sectors, development of local heat maps to identify market opportunities and aid long term planning
- Supply chain co-ordination through application of a strategic planning approach achieved by consultation and joint project planning by the various actors across the supply chain
- Research and demonstration to inform on new energy crop species, production issues for more marginal land, and progression of bioremediation options for plantations

1 Introduction

Since 2007 the Western Development Commission (WDC) has actively supported the development of the bioenergy sector in the Western Region[1]. Presently the WDC is lead partner of the EU bioenergy project *RASLRES*[2] (*Regional Approaches to Stimulating Renewable Energy Solutions*) funded under the Northern Periphery Programme (NPP) of INTERREG IVB.

Commencing in September 2009, this three year project aims to increase the local bioenergy market in rural communities of the NPP area. RASLRES will deliver on pilot actions in regard to wood energy, energy crops and marine biomass fuels, and seeks to inform on development models for market growth in rural areas. The project partners are drawn from Northern Ireland, Scotland, Sweden, Faroe Islands and Finland.

In the Western Region the RASLRES project focuses on the development of biomass fuel supply for use in the commercial and industrial heat market[3]. The rationale for targeting the heat market is outlined in the report *Wood Energy Strategy for the Western Region*[4] (2008). Wood fuel as an energy source has considerable potential given that the region has 40% of the national forest estate and is heavily reliant on oil with limited access to the gas network.

The following report presents an analysis of the potential of energy crops in the region and discusses key issues impacting on future growth scenarios for energy crops. The report was delivered by the WDC under the RASLRES project in partnership with the Sustainable Energy Authority of Ireland (SEAI) and Teagasc. The analysis mainly deals with issues impacting on the woody biomass fuel supply chain to commercial/industrial heat users as this is the main focus of RASLRES in the region.

The aims of the report are:

- To develop a regional profile and detailed understanding of the potential of energy crops in the region based on the application of SEAI's Bioenergy Geographical Information System (BGIS[5])
- To identify key issues impacting on the development of the energy crop sector
- To highlight the opportunities presented by energy crops and renewable energy requirements in the heat sector

---

1 The Western Development Commission (WDC) is a statutory body under the Department of Environment, Community & Heritage and was set up to promote both social and economic development in the Western Region (includes counties Donegal, Leitrim, Sligo, Mayo, Roscommon, Galway and Clare).

2 Please see the project website www.raslres.eu for more information.

3 The commercial and industrial installations are typically boilers >100kw capacity

4 This report is available for download at www.wdc.ie

5 http://www.seai.ie/Renewables/Bioenergy/Bioenergy_Maps/

- To inform and stimulate debate with public and private players on high potential areas for bioenergy development
- To provide complementary information to the fuel resource projections based on the regional forestry resource
- To demonstrate how the BGIS can be applied to generate useful data and scenarios

The core part of the report is the analysis of existing and potential energy crop development using the BGIS. It is hoped that this data will inform current biomass users and fuel suppliers about potential fuel supply from energy crops. Critically the report aims to stimulate debate and action on new entrants into the market, both energy crop growers and heat energy users. In addition the report includes a 'users guide' on how the BGIS was applied to generate the information (please see section 11).

The report provides useful information and commentary for a range of players in the bioenergy sector including:

- Farmers, landowners and the wider agricultural sector in the region
- Existing bioenergy installers and fuel suppliers
- Existing and potential wood energy users
- National and regional policy makers in areas of renewable energy, climate change, agriculture and rural development
- Local authorities in their capacity as local policy makers and potential wood energy users
- Regional and local development actors such as LEADER companies and private industry associations

By assessing the potential output from energy crops, policy makers are assisted in the design of renewable energy and carbon reduction strategies at county, regional and national levels. Potential private and public project developers and investors are informed about the potential supply available for biomass installations. Finally this analysis aids farmers and businesses in understanding how to use the BGIS to model the supply chain and assess the best locations for developing supply hubs. By presenting potential growth scenarios for the energy crop market, the report seeks to inform on the long term biomass fuel supply available within the Western Region.

The report methodology included a number of components. Firstly SEAI carried out the exercise of applying the BGIS to the region including county level and cluster based analyses. A detailed overview of the BGIS methodology is presented in section 11. To complement this analysis, market and fuel resource analysis generated by WDC under the RASLRES project was incorporated into the report. Teagasc research informed on energy crop cost data, supply chain analysis and factors impacting on market development. The project team held regular review meetings to discuss findings and conclusions. A peer review of the draft report was carried out by experts from Action Renewables (www.actionrenewables.org) and the Irish Bioenergy Association (www.irbea.org).

The report is structured as follows:

- Section 2 is a commentary on the biomass market specifically the wood energy sector in the region
- Section 3 presents the analysis of existing and potential energy crop development across the region
- Section 4 outlines examples of cluster analysis for a geographic area and the hinterland of a town
- Sections 5 and 6 addresses some of the key issues impacting on the supply chain and potential growth scenarios for the energy crop sector
- Section 7 outlines the main conclusions from the analysis and the resulting recommended actions

Wood Energy in the Western Region 2

This section outlines the factors driving bioenergy development in Ireland and presents a profile of the wood energy sector in the Western Region. Market demand projections for 2020 are compared to the fuel supply projections based on the region's private forestry resources.

2.1 National Context

The National Renewable Energy Action Plan (NREAP), published in June 2010, sets out the Government's strategic approach and measures to deliver on Ireland's 16% renewable energy target required under EU Directive 2009/28/EC *Promotion of the use of energy from renewable resources*. The NREAP follows on from the White Paper on Energy, *Delivering a Sustainable Energy Future for Ireland*, published in March 2007. For Ireland there are four core energy issues namely sustainability of energy supply, security of energy supply, international competitiveness of our industrial base and the economic development opportunities presented by growth of the sector. The bioenergy sector will play a key role in addressing each of these energy issues.

The national renewable energy targets by 2020 are:

- 12% renewable energy share in the heating sector
- 40% renewable energy share in the electricity sector
- 30% co-firing in peat stations by 2015
- 800MW$_e$ of CHP with an emphasis on biomass fuelled CHP
- 10% renewable energy in transport

In 2009 the national contribution of renewable energy to overall energy demand was 4.9%[6] (with 2020 target of 16%). In 2009 renewable electricity contributed 2.6% to the Directive target; renewable transport energy contributed 0.6%; and the renewable heat contribution was 1.7%. Ireland's import dependence rate was 89% (oil, natural gas and coal), one of the highest import dependency rates of the EU member states. The national agenda is to increase our energy independence through improved energy efficiency and increased uptake of renewable energy sources.

6 Energy Forecasts for Ireland to 2020: 2010 Report. Sustainable Energy Authority of Ireland.

Bioenergy is expected to make a notable contribution to achieving our national targets. The bioenergy approach and targets were presented in the *Bioenergy Action Plan for Ireland* (March 2007). The majority of renewable heat energy is anticipated to come from bioenergy, transport biofuels will deliver the majority of transport, and bioenergy will make a significant contribution to the renewable electricity target. Presently wood based bioenergy is one of the most mature bioenergy markets in Ireland and it is proven to be economically viable particularly in areas without access to the gas network. Bioenergy technology is readily available for the heat market. These are key consideration in deciding to focus on woody biomass fuel sources in this report.

2.2 Regional Wood Fuel Markets

Woody biomass fuels are used in four market segments:

- electricity generation
- Combined Heat and Power (CHP)
- co-firing, and
- heat

The electricity, CHP and co-firing markets typically require the supply of large volumes of biomass fuel and the conversion units are therefore capable of handling a wide variety of biomass fuel types. The heat market installation units, from domestic to larger industrial boilers, are generally designed to handle more standardised woodchip, wood pellet or wood log fuels. For biomass market development, it is critical to consider fuel types, fuel characteristics, potential volumes available, geographic spread and general fuel suitability in relation to the existing or potential market segments. There must be an appropriate match between the available fuel types in a geographic area and the various market demands.

In the Western Region the wood energy heat market is currently estimated to be approximately 65megawatts (MW) of installed capacity consuming 31,000 oven dried tonnes (odt) of wood fuel. Over the next decade the regional market is anticipated to grow significantly, driven by increasing oil prices and the national 12% renewable heat target. By 2020:

- the potential renewable heat market is estimated to be between 430MW and 477MW of installed capacity requiring between 217,000odt and 240,000odt of wood fuel[7]
- the estimated CHP market potential is 42MWe (across 22 installations) requiring over 125,000odt of wood fuel[8]

The national co-firing target of 30% by 2015 is estimated to require approximately 475,000odt.

The amount supplied by fuel producers and processors to the various biomass markets will be significantly dependent on the gate price for fuel in the specific market segment. Given the bulky nature of biomass fuels, the cost of road transport will be a key factor influencing market development. However, the future growth scenarios of the biomass market are influenced by a complex range of factors. For the renewable heat market some of the key factors impacting on growth include:

- energy prices for oil and gas
- rates and structure of carbon tax
- access to the gas network
- electricity prices
- expertise and capacity across the sector to deliver projects
- fuel supply chain development

7 Please refer to the *Wood Energy Strategy for the Western Region* available for download at www.wdc.ie

8 Please refer to *Biomass CHP Market Potential in the Western Region: An Assessment* available for download at www.wdc.ie

- market confidence and awareness
- growth of CHP and co-firing markets, including the prices availability under the Renewable Energy Feed in Tariff (REFIT)
- adoption of the Renewable Heat Incentive in the UK and Northern Ireland markets

2.2.1 Regional Renewable Heat Market

Nationally the renewable energy contribution to heat energy increased from 3.6% in 2008 to 4.2% in 2009, due to a 9% reduction in heat energy use and a 7% increase in biomass. Industrial biomass energy use (mostly in the wood and food sectors) accounted for 70% of all renewable heat energy used in 2008. However there has been a decrease in industrial renewable heat recently with an average annual reduction of 5.6% since 2005[9].

As stated approximately 65MW of the heat market is supplied by wood fuel in the region, an estimated renewable heat market share of 1.5% of total heat demand[10]. Based on 2008 research by the WDC the profile of the regional wood heat market is as follows:

- 52MW in five sites with installations >1MW (80% of the total installed capacity)
- 10.6MW in 30 sites with installations between 60kW and 1MW (16% of the total installed capacity)
- 2.9MW in the domestic boiler market (4% of the total installed capacity)

The domestic boiler market is mainly supplied by wood pellet, log or briquette. The installations of >1MW are primarily in the timber industry and related processing sectors and these installations typically consume their own waste wood products as fuel on-site. It is estimated that the wood chip fuel supply chain delivering into the commercial and industrial boilers is in the range of 5,000 to 6,000odt.

By April 2010 the SEAI ReHeat Programme had supported approximately 15MW of installed capacity in the region across 37 projects (installations between 60kW and 1MW). Nationally approximately 84MW of installed capacity was supported across 181 projects. Table 1 outlines the number of projects and installed capacity in each county supported under the ReHEAT Programme. The estimated wood chip fuel supply into these boilers is approximately 7,500odt.

Table 1: Number of projects and installed capacity per county supported by the ReHEAT programme

County	Projects	Installed kW
Mayo	5	3,285
Donegal	10	3,109
Sligo	2	3,060
Clare	7	2,180
Galway	7	1,398
Leitrim	3	990
Roscommon	3	545
TOTAL	**37**	**14,567**

9 Energy in Ireland 1990- 2009. SEAI

10 The estimated 65MW consuming 31,000odt converts to approximately 155GWh. The total regional heat market is estimated at 10,780GWh.

The report *Regional Energy Balance and Biomass Heating Demand Estimates for 2020*[11] (March 2010), completed under the RASLRES project, estimated that:

- approximately 10,780GWh (927,000 tonne of oil equivalent) of heat energy was used in the region based on 2008 data. Galway had the highest heat demand at 3,303GWh, followed by Donegal, Mayo and Clare, all having over 1,163GWh of heat energy demand. Other counties had a smaller heat market, generally reflecting smaller populations and lower levels of commercial and industrial activity.
- A modest 10% biomass heat by 2020 will have a fuel demand of approximately 217,000odt supplying an estimated 1,085GWh of energy (across units with an installed capacity of 430MW). This biomass heat estimate would see Galway accounting for 31% of biomass heating, Clare and Mayo 16%, Donegal 17% and the balance in the remaining counties.

It is important to note that this estimate does not include biomass for other uses such as co-firing or other large bioenergy conversion units. Therefore this modest 10% biomass heat target alone will not result in the Western Region making a proportional contribution to the achievement of the national 12% renewable heat target, and the region must aim to develop markets in areas such as CHP and district heating.

Table 2 presents a 2020 estimate of biomass heat demand by county and sector. The residential heat market accounts for 48% of the estimated biomass heat demand, with industrial accounting for 35% and services 16% of the remaining market share. Counties Galway, Mayo and Donegal have the highest estimated rates of demand due to factors such as population size and the profile of the industrial base.

Table 2: Biomass Heating Demand Estimates by County and Sector 2020[12]

'000 odt biomass 2020	Residential		Industry		Services		Total		
National	584		423		240		1247		
							'000 odt	% market	Heat demand
Western Region	105	48%	77	35%	35	16%	217	100%	1,085GWh
Galway	31		26		9		66	**30%**	330GWh
Donegal	20		11		7		38	**18%**	190GWh
Mayo	17		12		6		35	**16%**	175GWh
Clare	15		14		6		35	**16%**	175GWh
Sligo	9		6		3		18	**8%**	90GWh
Roscommon	8				3		17	**8%**	85GWh
Leitrim	4		3		1		8	**4%**	40GWh

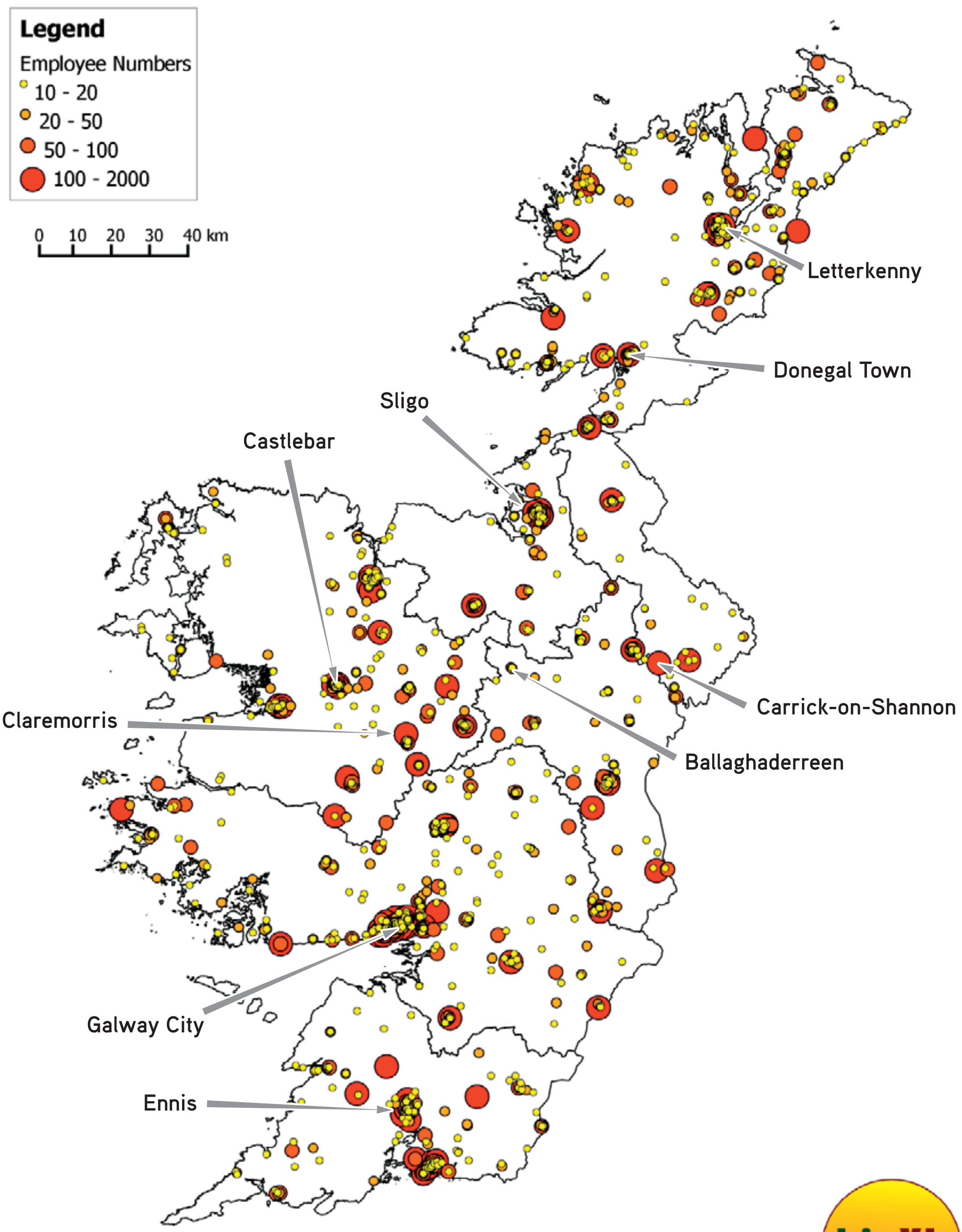
As stated earlier, there are many factors impacting on the growth of the wood fuel market. There are also variables unique to the region, and variations across the region, which will influence the uptake of biomass heating across the seven counties. For example, there is no natural gas infrastructure in Donegal, Sligo, Roscommon or Leitrim which gives woody biomass fuels a competitive advantage. The established use of another solid fuel (peat) in the region may lead to a greater uptake. The proximity of heat users to significant forest resources could influence the pattern of growth of the biomass for energy market.

11 The report is available for download at www.raslres.eu

12 Tables sourced from *Regional Energy Balance and Biomass Heating Demand Estimates for 2020*

The following map presents the regional heat demand based on using employee numbers as an indicator of heat demand. While the map is based on a crude indicator for heat demand, it does serve to illustrate the main centres of heat demand in the commercial/industrial sectors across the region. Galway, Clare and Mayo have relatively large clusters of heat demand, with a more dispersed pattern in the rest of the counties. Further detailed mapping of heat demand would inform analysis of the regional market demand profile and is a useful tool in supporting market development.

Heat Map Example: Employee Number as Proxy for Demand



2.3 Wood Fuel from Forestry[13]

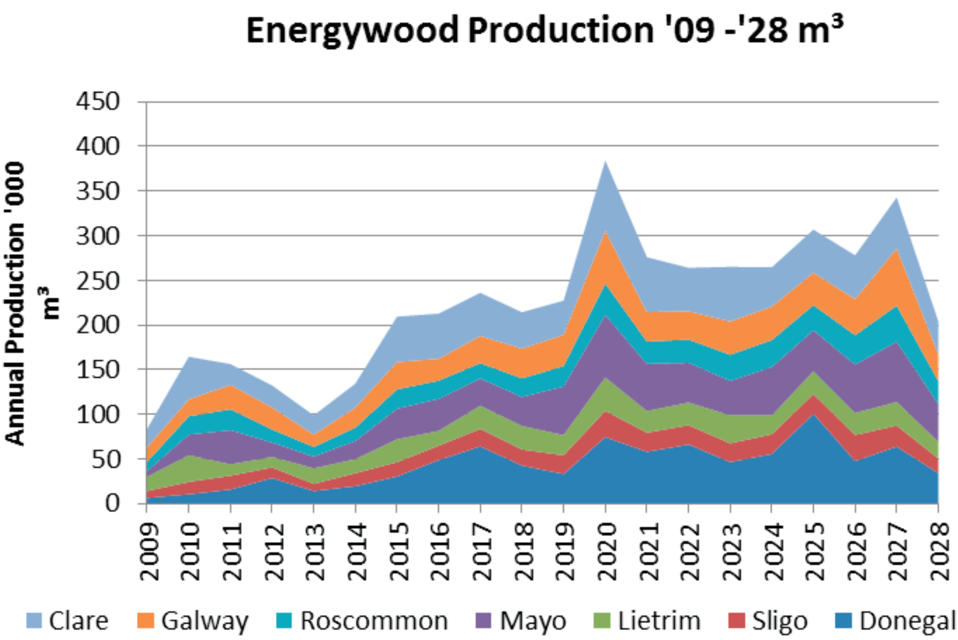
In the Western Region the net forestry estate is estimated at 260,000ha (national net forestry estate is approximately 715,000ha), with private forest owners accounting for 110,000ha (43% of total net area). Section 10 shows the private forestry maps for each county and the region. Public sector forestry (i.e. Coillte's) supplies are forecast to remain at current levels or to decline slightly over the medium term. Therefore private forestry is potentially the main source of expansion in the wood fuel supply, particularly if demand from existing timber markets remains largely unchanged.

When assessing the potential wood fuel volumes from forestry, the age profile of the forest is a key factor in determining its sustainability for production. The age groups of most relevance are the 11-15 and 16-20 age classes (approximately 45,000ha in the region) as these forests are currently at or rapidly approaching the age of first thinning[14]. The estimated total area of private forestry suitable for thinning in the region is approximately 85,000ha.

Whether the forestry plantations are thinned is dependent on a range of economic, physical and social factors e.g. age profile of private forest owner, size of plantation, road access; however the critical variables impacting on the decision to thin are market demand and price. If market demand is low or prices fail to meet the owners' expectations, the area left unthinned will be comparably higher than in more favourable market conditions.

In 2010 the regional supply of wood biomass was approximately 31,000odt annually, with most of this used by the timber processing sector. Figure 1 shows the forecast for wood energy equivalent production in the form of round logs for the period 2009 to 2028 based on accepted forestry management assumptions. The potential yield for 2010 is 65,800odt and by 2020 will increase to 153,714odt. Between 2020 and 2028 the volume fluctuates between 81,200odt and 120,800odt, averaging 110,000odt per annum.

Figure 1: Wood energy forecast in the Western Region.



*Please note 1m^3 converts to 0.4odt

[13] Data in this section taken from the report *Regional Wood Fuel Projections (April 2010)* available for download at www.raslres.eu This analysis is based on projections from COFORD and such tools as FORECAST Model.

[14] Thinning is the removal of a portion of the crop at a rate which does not reduce the overall production of the site and it is therefore considered to be sustainable.

By 2020 the combined output of round logs and co-product derived from private sector forests is estimated to provide approximately 252,000odt per annum. As already stated the potential supply will be significantly impacted on by a range of economic and physical factors including plantation size, site access from public and forest roads, market demand and prices. In addition it must be noted that fluctuations in volumes will occur on a yearly basis reflecting the age profile of the plantations. It is in this context that the potential of energy crops can be considered as a complementary wood fuel stream to forestry derived fuel resources.

2.4 Conclusion

Over the next decade, the wood energy market is predicted to grow significantly in response to increasing oil prices, limited access to the gas network, policy targets and measures such as carbon taxes, and the need to create indigenous enterprise and jobs through expansion of the renewable energy sector. Currently the wood heat energy sector in the region is estimated at 65MW of installed capacity consuming approximately 31,000odt of wood fuel. It is estimated that by 2020 the region's heat market alone will require between 217,000odt and 240,000odt of wood fuel.

Based on this market analysis, *all* existing forestry resources in the region must be actively managed to meet the projected market demand for *heat energy alone.* In reality, not all forestry theoretically available for thinning will be thinned due to range of socio-economic factors. Additionally, demand from other markets e.g. co-firing, CHP, will potentially increase biomass fuel demand beyond the supply capability of private forestry. Therefore the Western Region has two options to build a viable wood energy market – import woody biomass into the region, or develop an energy crop industry to top up supply and provide a ready source of material to enable even more rapid expansion of bioenergy production.

Energy Crop Analysis: Existing and Potential Development

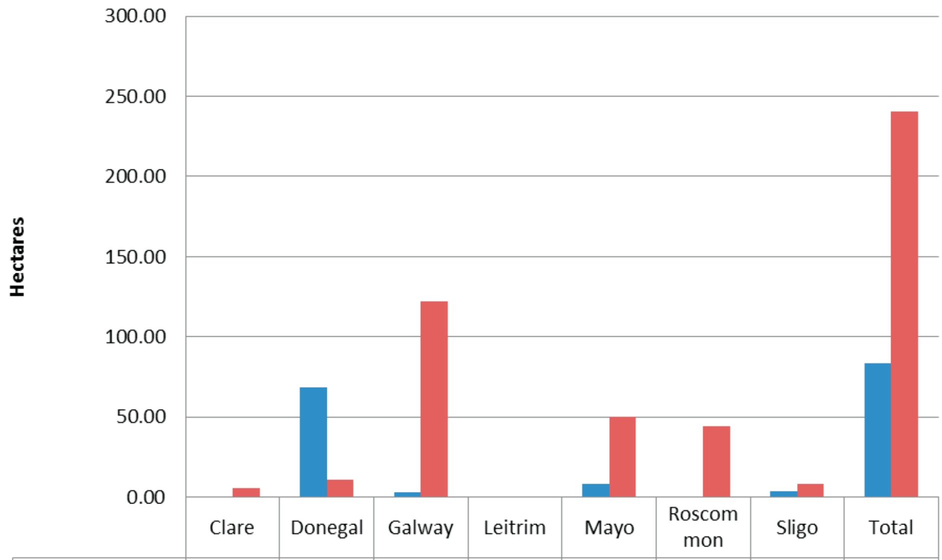
3

This section presents the results of the BGIS analysis for the region. The existing energy crop output is outlined based on the available data for the region and each county. Potential energy crop production is demonstrated for each county and the region, and seeks to inform on how the energy crop market could expand.

3.1 Existing energy crop output in the Western Region

Energy crop development in the Western Region is in its infancy, as it is across Ireland. In 2008, there were only 241 hectares of miscanthus and 84 hectares of SRC willow planted in the region. This compares to national plantations of 3076 hectares of miscanthus and 557 hectares of SRC willow. In the region existing plantations of energy crops are primarily in counties Galway and Donegal, as can be seen in Figure 2.

Figure 2: Existing plantations of energy crops in the Western Region (2008).



	Clare	Donegal	Galway	Leitrim	Mayo	Roscom mon	Sligo	Total
SRC Willow (ha)	0.00	68.51	3.32	0.00	8.39	0.00	3.58	83.80
Miscanthus (ha)	5.36	10.67	121.93	0.00	49.98	44.28	8.50	240.72

There is a significant preference for miscanthus over SRC willow, except in County Donegal. The overall level of plantation remains very small. Even when adding the miscanthus and SRC willow plantations delivered under the Energy Crop Scheme in 2009 and 2010 (see Table 3), the plantation level remains very small. The analysis is conducted using the Land Parcel Information System (2008) data as it is the most recent complete data available.

Table 3: Plantations of SRC willow and miscanthus supported by the Energy Crop Scheme for the period 2009-2010 in the Western Region. All numbers in hectares.

	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo	Total
SRC Willow	0.00	15.71	2.96	0.00	0.00	4.22	0.00	22.89
Miscanthus	6.30	0.00	45.84	0.00	20.10	0.00	0.00	72.24

The 2008 existing plantations of miscanthus and SRC willow could potentially deliver 12,857MWh of heat. This assumes that all plantations are in full production; and all the material produced is used in efficient boilers to produce heat. The potential delivered heat energy[15] for each county is given in Figure 16 of section 8.1. County Galway had 121.9 hectares of miscanthus and 3.3 hectares of SRC willow planted in 2008, giving rise to nearly 5 million kWh of potential delivered energy (estimated). Donegal is the only county with more than an isolated pocket of willow production, with 68.5 hectares. As a result it has the second largest potential production of bioenergy from existing energy crops in the Western Region. Sligo, Clare and Leitrim had negligible production of energy crops in 2008.

Even at these very small levels of plantation, up to 3755 tonnes of carbon, valued at €93,875 at a carbon price of €25/tonne, could potentially be abated by using existing energy crops in the region. This would be achieved only under the conditions already stated, and was calculated using the Energy Crop Calculation Tool[16] in the BGIS.

3.1.1 Density of energy crop production

The density of energy crop production in the Western Region provides a better indicator of relative development than absolute figures, due to the diversity in area, population and landscape of the constituent counties. To enable this comparison, production per hectare and per capita have been calculated and are presented here.

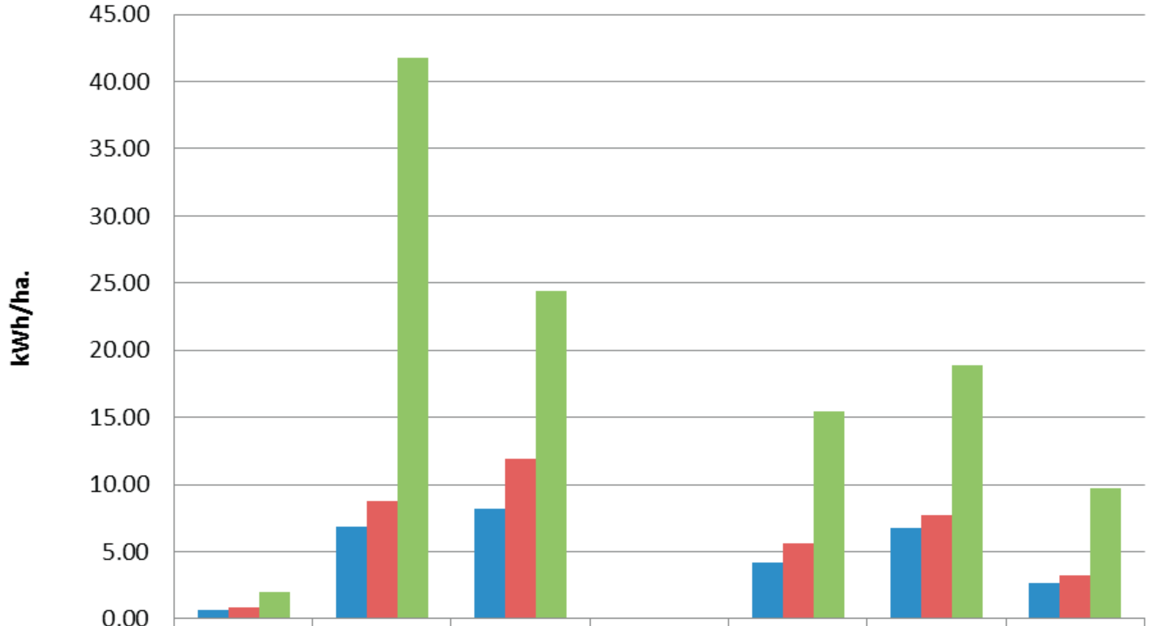
The density of potential heat production from SRC willow and miscanthus in each of the counties is shown in Figure 3. Only when land highly suitable[17] for growing energy crops is considered is there a change of order between counties. In this case, it can be seen that production density of miscanthus and willow in Donegal is greater than in other county, hence Donegal is further advanced in exploiting the available land for developing energy crop production for solid biomass fuels.

[15] In this report information for energy from solid biomass is given in terms of delivered heat energy. See Appendices for details on the BGIS Energy crop tool calculations and assumptions.

[16] Note that a correction factor was applied, as an updated carbon abatement factor of 0.29207 kgCO_2/kWh was used, not the 0.221 in the calculation tool.

[17] Refer to the appendices for how highly suitable land is calculated.

Figure 3: Potential production of heat energy (kWh) from existing SRC willow and miscanthus plantations per county, per land area. Land areas used are: total land area of the county; total available land area of the county (total land area – unavailable areas which include Special Areas of Conservation; Special Protection Areas; Natural Heritage Areas; and urban areas); and total county land highly suitable for growing energy crops (see section 8 for how this is determined).



	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo
Total	0.66	6.84	8.18	0.00	4.16	6.78	2.62
Available	0.90	8.82	11.91	0.00	5.64	7.73	3.23
Highly suitable	2.04	41.74	24.41	0.00	15.43	18.87	9.77

Comparing energy production per capita provides an assessment of which counties are further ahead in terms of meeting their energy requirements from energy crops. This assumes population can serve as an indicator for heat for demand. Based on this indicator (presented in Figure 17 of section 8.1) county Roscommon is performing better than any other county in the region.

Current production of solid biomass from SRC willow is sufficient to meet nearly 35% of Donegal's total existing solid biomass demand. However, it can make only a negligible contribution in the remaining six counties, and only 5% across the region. Even if miscanthus[18] is included in the consideration, the total contribution of existing production to solid biomass demand in the region amounts to only 19%. There is also expected to be substantial additional cross-border demand from Northern Ireland in the near future as a result of the implementation of the Renewable Heat Incentive. There is, therefore, substantial scope to develop energy crop production in the Western Region even without further biomass installations in the Western Region. Figure 18 in section 8.1 shows the total potential heat production from existing energy crop production, compared with total estimated existing biomass demand.

[18] Note that Miscanthus is unsuitable for most existing installed biomass boilers in Ireland and the Western Region.

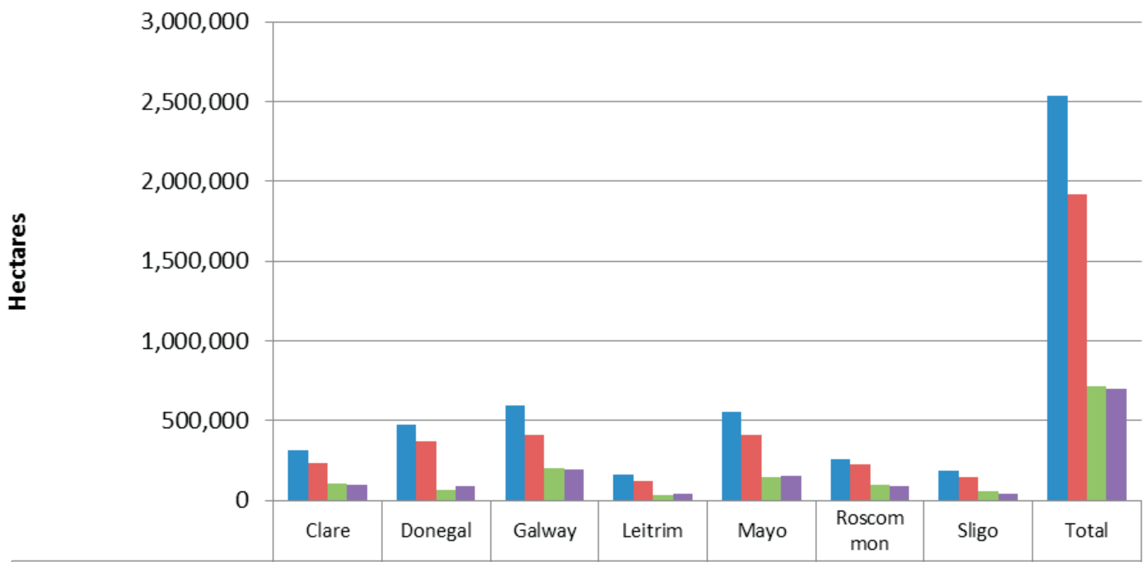
3.2 Potential energy crop production in the Western Region

The suitability of land for growing energy crops, and the potential energy and value output from that potential was assessed for the region using the SEAI Bioenergy Geographic Information System (BGIS, http://www.seai.ie/Renewables/Bioenergy/Bioenergy_Maps/). The BGIS includes this facility for miscanthus, short rotation coppice (SRC) willow, oil seed rape and reed canary grass. The BGIS assessment is made based on a weighted assessment of the suitability of soil type, rainfall, slope, aspect and height. Each unit of land is given a suitability factor of unavailable, unsuitable, low suitability, medium suitability, or high suitability. More details can be found in section 8.2, and in the wiki associated with the BGIS. The suitability grids can are mapped and displayed in the BGIS.

3.2.1 BGIS estimate of potential output

Figure 4 below presents actual land areas for each county and areas identified as highly suitable for energy crops. In all counties there is a very substantial amount of land that is highly suitable for the production of energy crops, and hence all counties have the potential to supply a very substantial solid biomass demand from within their county borders. The density of highly suitable land is greatest in counties Roscommon, Galway and Clare.

Figure 4 Land areas in the Western Region. Land areas shown for each county are the total land area; the available land area (i.e. not in restricted areas such as special areas of conservation); and the land that is highly suitable for growing either SRC willow or miscanthus. All land areas are given in hectares. The areas for SRC willow and miscanthus are not additive (i.e. land highly suitable for SRC willow may also be counted as highly suitable for miscanthus). The proportion of available land highly suitable for energy crops is particularly low in both Co. Donegal and Co. Leitrim.

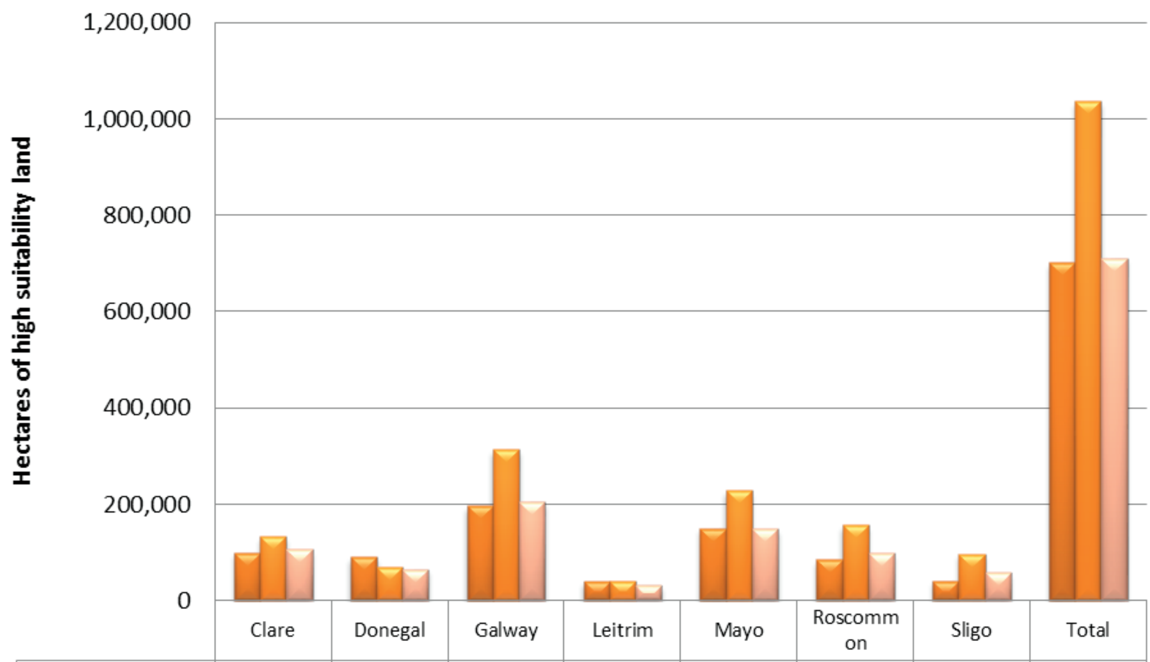


	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo	Total
Size (ha.)	317,479	475,308	598,045	158,687	552,175	254,798	182,759	2,539,251
Available area (ha.)	231,932	368,648	411,005	124,766	407,417	223,584	148,387	1,915,739
SRCW highly suitable	105,827	65,446	204,651	31,227	147,993	98,047	57,525	710,716
Miscanthus highly suitable	99,310	90,296	196,347	39,619	149,787	84,992	40,719	701,070

Size (ha.) Available area (ha.) SRCW highly suitable Miscanthus highly suitable

Figure 5 gives, for each county, the hectares of land highly suitable for miscanthus, SRC willow and reed canary grass.

Figure 5 Hectares of land highly suitable for growing energy crops in the counties of the Western Region. The areas are not mutually exclusive (i.e. some of the miscanthus area is also counted under the SRC willow area). Counties Galway and Mayo show the biggest total potential resource.



	Clare	Donegal	Galway	Leitrim	Mayo	Roscomm on	Sligo	Total
Miscanthus HS (ha)	99,310	90,296	196,347	39,619	149,787	84,992	40,719	701,070
RCG HS	132,155	68,969	312,885	40,712	228,157	156,394	96,626	1,035,898
SRC Willow HS	105,827	65,446	204,651	31,227	147,993	98,047	57,525	710,716

County suitability maps for SRC willow are included in section 9. At a county level the BGIS maps indicate that significant areas of high suitability land for the production of SRC willow are located in:

County	Main area(s)	Others
Clare	Broad band from Shannon extending NNW across the county.	Several areas along the Western coast
Donegal	Between Ballybofey, Letterkenny and the N.I. border	Some patches around and south of Donegal town.
Galway	Most of Galway east of Galway city, extending to both north and south county boundaries.	
Leitrim	None	Patchy coverage in southern Leitrim.
Mayo	Area bordered by the N5 and the N84; large section around Ballina and the NE coastline	
Roscommon	Most of Roscommon south of Tulsk	Substantial patchy areas North East of Tulsk.
Sligo	Coastal Co. Sligo	Patchy coverage in central Sligo.

To compare the hectares classified as highly suitable for energy crops in the region to the national hectares shows that the region has been 29% and 36% of the national resources. Therefore the rates of uptake in the region will impact on the overall contribution of energy crops at a national level.

Energy Crop	National (ha)	Western Region (ha)	WR as % total national potential
Miscanthus	1,925,012	701,070	36%
Reed Canary Grass	3,374,798	1,035,898	31%
SRC willow	2,437,217	710,716	29%

In Ireland heat energy demand in 2009 represented approximately 34% of total energy demand[19]. Converting this to a demand for each county (using population) and comparing to the SRC willow potential shows that each county could meet all of its heat energy requirements through conversion of highly suitable land to SRC willow production (please see Figure 19 in section 8.1). For Roscommon, as little as 13% of this land would be sufficient to meet demand, with all others needing to convert less than a quarter of this land except Galway (25%) and Donegal (50%). The numbers are similar for the other energy crops (miscanthus, reed canary grass) provided suitable, economic conversion facilities can be installed to match supply.

The existing demand for solid biomass in the Western Region (as represented by Greener Homes and ReHEAT funded installations) is a small fraction of the total thermal demand. Analysis (as presented in Figure 20 and Figure 21 of section 8.1) demonstrates that comparatively small areas of SRC willow are required to completely meet the existing demand for solid biomass, even when assuming that domestic biomass boilers could operate on SRC willow product. Comparing the potential energy crop production on highly suitable land to existing demand indicates that only 0.18% - 0.45% of highly suitable land for SRC willow in each of the seven counties would need to be converted to supply the entire current demand for solid biomass. There exists, therefore, significant potential to encourage co-development of bioenergy conversion facilities and energy crop production in the Western Region.

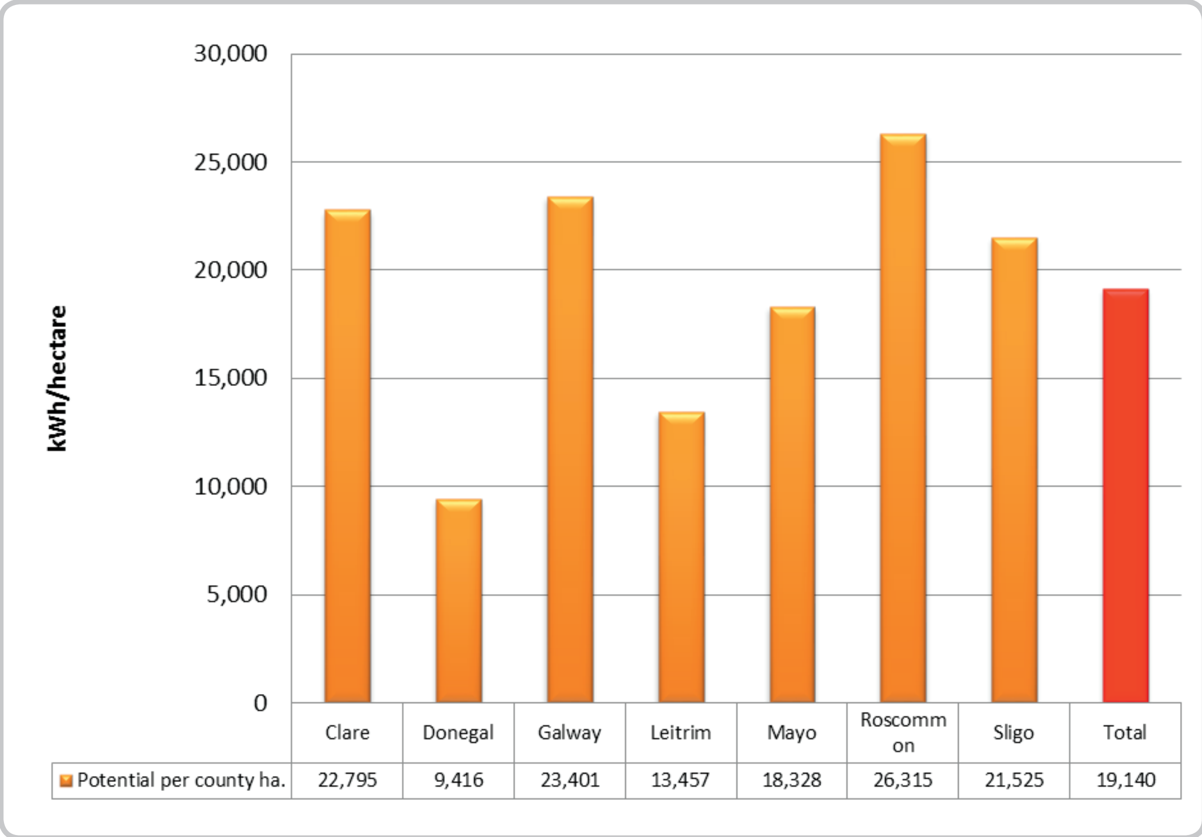
3.2.2 Density of potential per county

Assessing the density of highly suitable land for energy crop production is an important factor in determining where to initiate a centre of energy crop plantation, and where new conversion facilities can most economically be located. Although such locations are best assessed by referring to the maps, county level information can provide some direction.

The density of potential output from SRC willow shows a different variation to current energy crop development in the seven counties. Although Donegal is the furthest advanced in developing SRC willow plantations in the seven counties, it has the least geographic spread of highly suitable land for growing SRC willow, as seen in Figure 6. Roscommon shows the greatest density of high suitability land for growing SRC willow, with Galway, Clare and Sligo also showing significant areas.

[19] *Energy Forecasts for Ireland to 2020, 2010 Report.* Sustainable Energy Authority of Ireland (2010).

Figure 6: Relative suitability of land in each county for growing SRC willow.



This graph shows the average potential output from SRC willow, per hectare in each county, if every hectare of land highly suitable for growing SRC willow was to be planted. It is a measure of the density of highly suitable land in each county. Counties with a higher density of suitable land have greater scope for developing a large scale energy crop based bioenergy industry. Counties with lower density can still develop substantial regional energy crop centres.

3.3 Conclusion

Energy crop development is in its infancy across Ireland and in the Western Region. In 2008 there were national plantations of 3076 hectares of miscanthus and 557 hectares of SRC willow. In the Western Region, there were only 241 hectares of miscanthus (8% of national total) and 84 hectares of willow (15% of national total) planted. The total contribution of existing production to solid biomass heating demand in the region amounts to at most 19%.

In the Western Region, the BGIS indicates that approximately 37% (710,716ha) of the available land area (1.9 million hectares) is highly suitable for energy crops. The potential for energy crops in the region is as follows:

- 710,716 of hectares highly suitable for **SRC willow**, with potential delivered energy of ***48,602GWh*** and potential carbon abatement of 12,023Mtonnes
- 701,070 of hectares highly suitable for **miscanthus**, with potential delivered energy of ***43,050GWh*** and potential carbon abatement of 10,649Mtonnes
- 1,035,898 of hectares highly suitable for **reed canary grass**, with potential delivered energy of ***39,757GWh*** and potential carbon abatement of 9,835Mtonnes

In each of the seven counties in the region, there is a very substantial amount of land that is highly suitable for the production of energy crops. Donegal has the highest level of existing SRC willow plantations in the region (69 hectares planted in 2008). Roscommon shows the greatest density of high suitability land for growing SRC willow, with Galway, Clare and Sligo also showing significant areas.

The BGIS analysis shows that each county has the potential to supply a notable solid biomass demand from within their county borders. What percentage of this potential is realised will be dependent on a complex range of market factors and agricultural issues some of which are discussed in section 6. It is important to also recognise the limitations in the energy crop suitability analysis – for instance many soil areas identified as suitable may be found, in practice, to either be too shallow for energy crop production, or reliant on a closed field drainage system that would likely be damaged by energy crops.

To account for the limitations of the BGIS analysis and the other economic factors impacting on the adoption of energy crops, the following growth scenarios for energy crops may be more realisable targets:

- High growth scenario - 50% of the theoretical potential for SRC willow with plantations of 355,358ha, potential delivered energy of 24,301GWh
- Medium growth scenario - 25% of the theoretical potential for SRC willow with plantations of 177,679ha, potential delivered energy of 12,150GWh
- Low growth scenario – 10% of the theoretical potential for SRC willow with plantations of 71,072ha, potential delivered energy of 4,860GWh

As outlined in section 2, by 2020 a 10% regional wood heat market will require an estimated 217,000odt to generate heat energy of 1,085GWh; the above low growth scenario would supply nearly 4 times this projected wood fuel demand, and the high scenario over 22 times the demand. Based on 2008 heat energy estimates, the high growth scenario for energy crops would supply twice the *total heat energy demand* of 10,780GWh.

These simple calculations serve to illustrate that relatively modest uptake rates of energy crops, compared to the total potential, would make a significant contribution to supporting the growth of the wood fuel market and thereby increase deployment of renewable heat technologies.

Analysis of cluster areas

4

Analysis of the energy crop development around key sites in the Western Region can highlight some of the opportunities and issues for market development. A number of potential demand centres were assessed using the energy crop suitability tool for potential to supply solid biomass through energy crop production.

4.1 Cluster analysis

Demand centres were selected on the basis of known areas of: high energy demand (relatively high population, high industrial capacity); RASLRES pilot projects; and also to highlight some of the key issues that arise when considering development for a specific centre. The centres selected are:

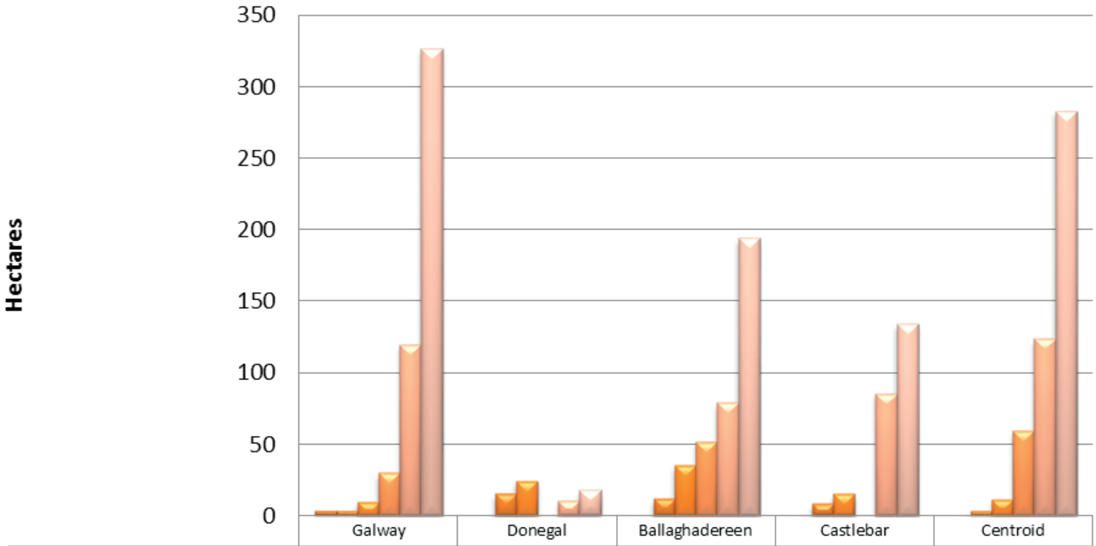
- **Donegal town** (proposed public sector developments supported by RASLRES, adjacent to Northern Ireland and significant offshore area in catchment radii)
- **Galway city** (largest population centre in the Western Region, close to RASLRES supported Athenry proposed bioenergy facility)
- **Ballaghadereen** (potential for industrial bioenergy facility)
- **Castlebar** (industrial centre)
- **Centroid** (midway between the above three sites, more details in the supply chains section below)
- **Ennis** (This is covered in the supply chains section below).

In each case radii of 25km, 50km and 75km were drawn centred on each of these locations and the existing bioenergy and potential bioenergy supply assessed. These distances were chosen to reflect what is considered to be economic travel distances, whilst still providing a significant catchment area.

4.1.1 Existing energy crops

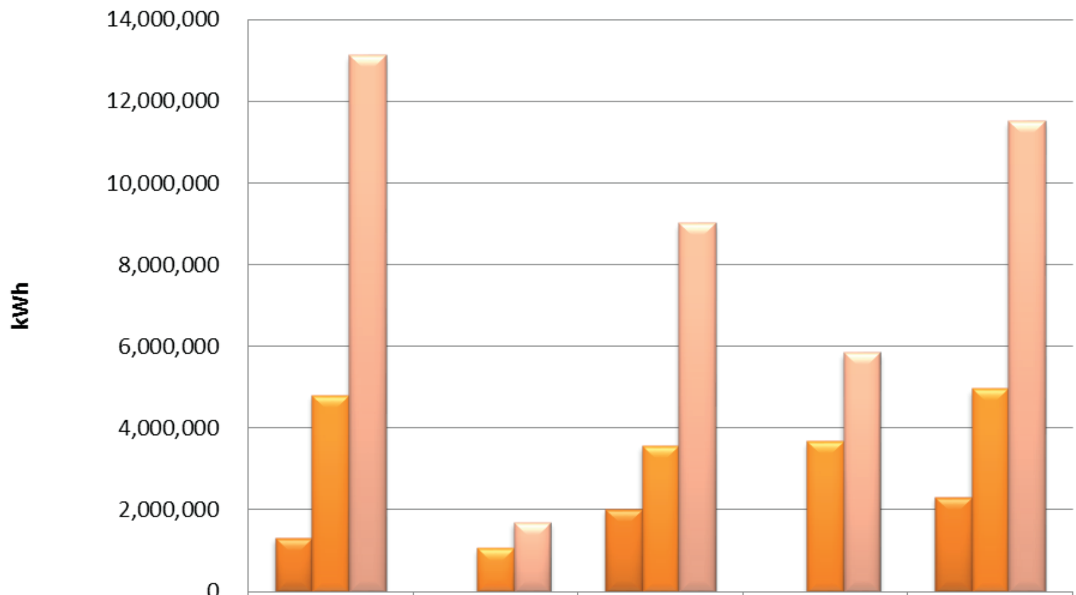
The expected delivered heat energy from conversion of the existing miscanthus and SRC willow plantations, assuming each plantation is in full production, are shown in Figure 8. As can be seen, no location has a substantial energy crop supply within a 50km radius. A 75km radius represents a substantial increase in the area covered (more than double 50km). However, even at this distance, the existing output only reaches 13.1GWh for Galway, the centre with the greatest output. This level of output could be considered equivalent to roughly 3250kW of installed biomass conversion capacity for moderately heavy use such as leisure centres or hotels, or roughly 10 such installations. It is notable that neither Castlebar nor Donegal towns have any existing energy crop plantations within a 25km radius. It should also be noted that several of the radii will overlap each other – for instance the Centroid is roughly 38km from each of Castlebar, Ballaghadereen and Galway. Hence the plotted delivered energy is over-optimistic as it involves some double counting.

Figure 7: Existing (2008) land area under SRC willow and miscanthus at radii of 25km, 50km and 75km of the given centres.



	Galway	Donegal	Ballaghadereen	Castlebar	Centroid
Actual supply (ha) SRC Willow 25km	3	0	0	0	0
Actual supply (ha) SRC Willow 50km	3	16	12	8	3
Actual supply (ha) SRC Willow 75km	10	24	35	15	12
Actual supply (ha) Miscanthus 25km	30	0	52	0	59
Actual supply (ha) Miscanthus 50km	120	11	79	85	124
Actual supply (ha) Miscanthus 75km	326	18	194	134	283

Figure 8: Potential delivered heat energy from conversion of existing miscanthus and SRC willow plantations within 25km, 50km and 75km of the given locations. The Centroid is located just north of Tuam, at roughly Irish Grid 14269000; Northing 26294700.



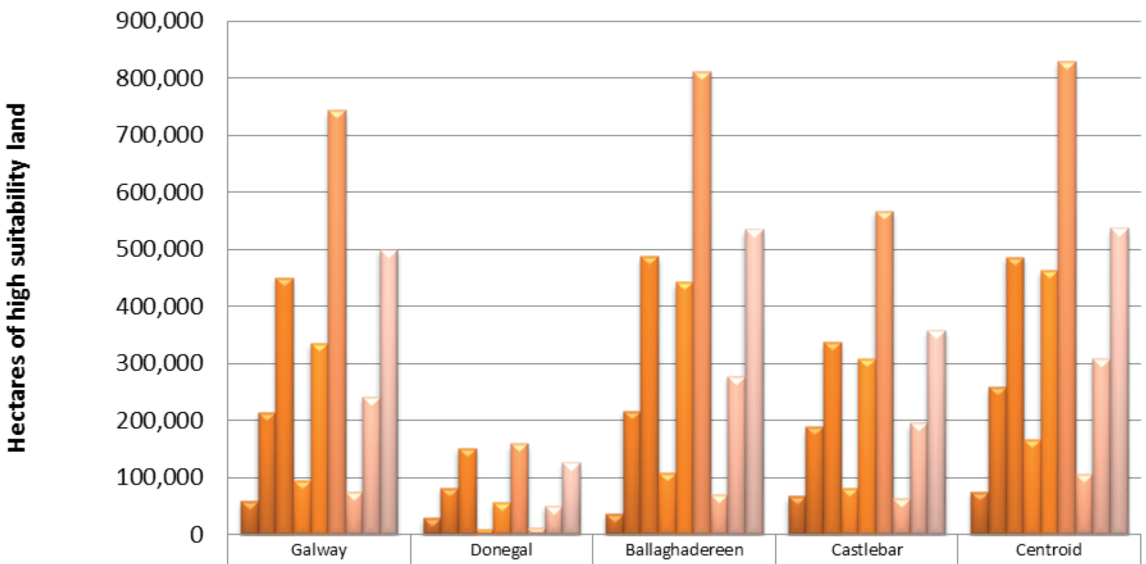
	Galway	Donegal	Ballaghadereen	Castlebar	Centroid
Actual supply (solid, 25km)	1,310,706	0	2,024,110	0.00	2,318,618
Actual supply (solid, 50km)	4,808,917	1,058,716	3,578,390	3,676,417.22	4,966,508
Actual supply (solid, 75km)	13,128,375	1,698,727	9,019,965	5,856,877.08	11,522,475

4.1.2 Energy crop potential

At each centre, significant areas are classified as highly suitable land for energy crops at radii of 25km, 50km and 75km as presented in Figure 9. For instance, 241,636ha of land are highly suitable for SRC willow at a 50km radius from Galway City. The potential delivered energy from SRC willow for each centre is substantial, even at a radius of 25km. Figure 10 shows the potential in a 25km radius from Galway is 100 times greater than the current planted output in a 75km radius. This strongly suggests that energy crop supplies can be developed very close to the demand source, and take advantage of minimised transportation costs.

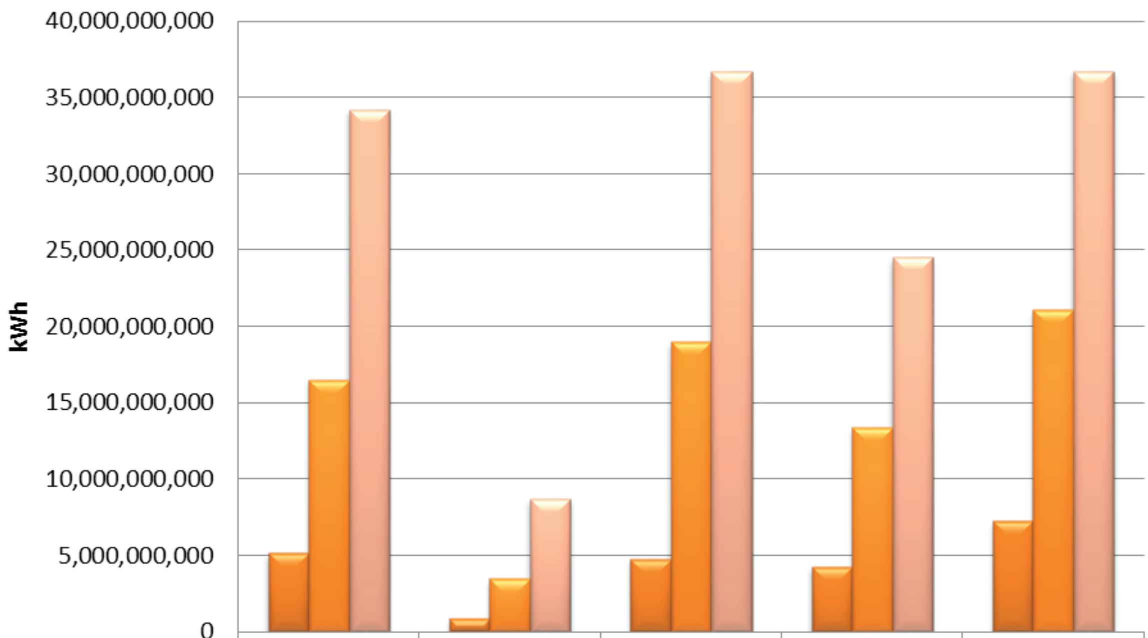
Figure 10 also shows that each site can provide for its current and potential solid biomass requirements many times over from land in its immediate vicinity. To give an indication of this, the expected energy output from highly suitable available land within 25km for each centre point has been graphed in Figure 11 as the potential number of industrial biomass boilers (average size 1.5MW) or commercial boilers (average size 350kW) that could be supplied. It shows that for all centres, far more supply can be delivered than would be required for expected demand even with a very high rate of changeover to biomass systems.

Figure 9: Number of hectares of high suitability land for each energy crop type, within set radii of the centres given.



	Galway	Donegal	Ballaghadereen	Castlebar	Centroid
Miscanthus 25km	58,461	29,097	36,784	67,133	74,654
Miscanthus 50km	213,820	81,251	217,074	188,953	258,631
Miscanthus 75km	449,761	151,010	486,973	336,408	485,932
Reed Canary Grass 25km	94,395	10,151	108,199	81,818	166,074
Reed Canary Grass 50km	336,041	56,537	442,062	308,695	464,327
Reed Canary Grass 75km	743,996	159,002	812,561	567,399	830,277
SRC Willow 25km	75,142	12,687	69,806	62,290	105,667
SRC Willow 50km	241,636	50,503	277,267	195,452	308,023
SRC Willow 75km	500,110	127,293	536,040	358,362	537,112

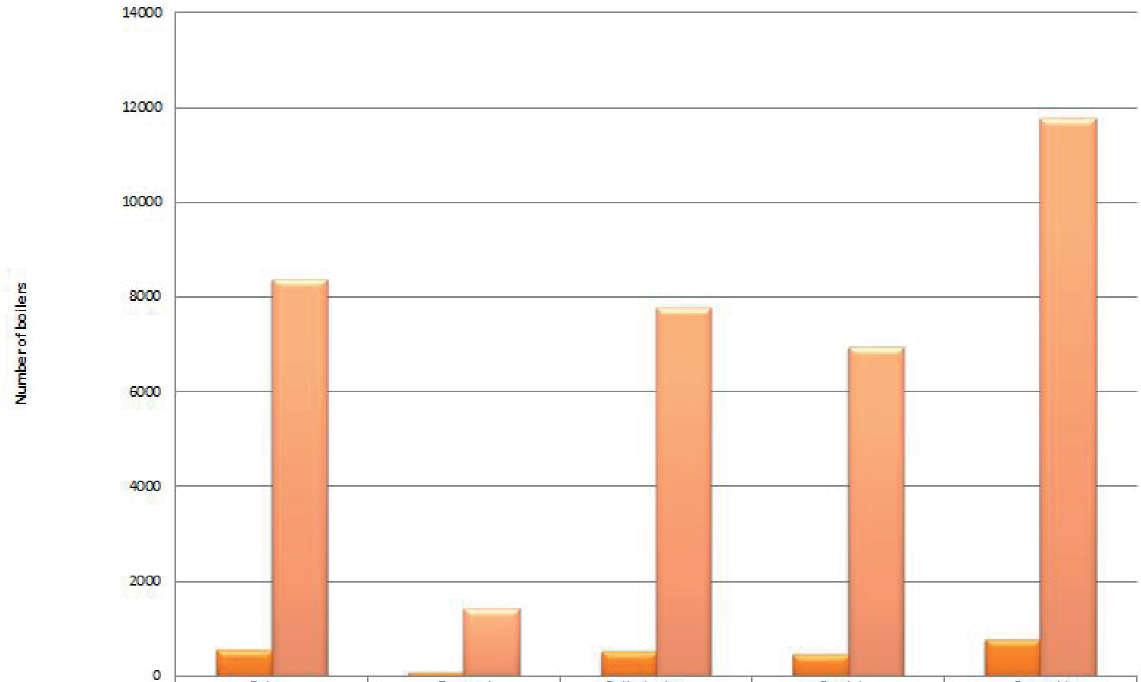
Figure 10: The potential delivered heat energy from SRC willow from planting highly suitable available land within 25km, 50km and 75km of the given centres.



	Galway	Donegal	Ballaghadereen	Castlebar	Centroid
Potential Supply (25km)	5,138,540,585	867,592,883	4,773,641,426	4,259,664,276	7,225,974,395
Potential Supply (50km)	16,524,132,878	3,453,617,353	18,960,737,435	13,365,867,749	21,063,968,041
Potential Supply (75km)	34,199,722,284	8,704,855,429	36,656,773,776	24,506,370,353	36,730,081,853

The relatively small potential around Donegal compared to the other centres is due to a combination of lesser available land and a lesser percentage of highly suitable land. In drawing radii centred on Donegal, a substantial and increasingly large portion of each successive radii (25km, 50km, 75km) covers area of ocean, or Northern Ireland. Neither of these areas are considered when assessing land for potential energy crop development. These two areas amount to 28% of the total area within 25km; 46% of the total area within 50km; and 59% of the total area within 75km. By comparison, the numbers for the centroid are 0.4%; 2.4% and 9.2%. In looking at the land that is available within these radii, there is a smaller proportion of land that is highly suitable for growing energy crops due to the combination of soil types, rainfall and topography, compared to the other areas presented here. Centres located close to both Northern Ireland and the sea (Sligo being another example) will necessarily need to convert a larger proportion of the nearby highly suitable land for energy crops to plantations than other areas to supply the same biomass demand.

Figure 11: Potential number of industrial (average size 1.5MW) or commercial (average size 350kW) biomass boilers that could be supplied by SRC willow planted on highly suitable, available land within 25km of each specified centre. Assumes load factors of 70% and 20% respectively (equivalent to 6132 and 1752 operating hours per year). Domestic boilers are not considered as they are primarily pellet based.



	Galway	Donegal	Ballaghadereen	Castlebar	Centroid
Industrial (1500kW)	559	94	519	463	786
Commercial (350kW)	8380	1415	7785	6947	11784

The cluster analysis illustrates that notable potential of energy crops exists close to areas of high heat demand. By locating energy crop supplies close to the demand source, fuel suppliers can take advantage of minimised transportation costs. The development of energy crop plantations close to existing and potential heat demand clusters would support the development of commercially viable supply chains, ensuring a price sufficient to attract both energy crop growers and biomass users into the market.

Analysis of supply chains

5

In this section supply chain issues such as centralised versus dispersed energy crop development are considered. This analysis informs on designing commercial viable supply chains and assessing various options for routes to markets for fuel producers and processors.

5.1 Supply chain models

5.1.1 Localised energy crop development

The town of Ennis was selected for reviewing the possibility of highly localised energy crop development. Although a relatively small town, it contains three ReHEAT supported biomass boilers, hence has an existing demand for solid biomass. It is estimated that these three installations require sufficient material to deliver 1,620,600kWh of energy. The potential delivered energy from SRC willow plantations on highly suitable, available land within 5km, 10km and 25km of Ennis is given in Figure 13. Existing demand isn't visible on the same scale. The potential energy from SRC willow within a 5km radius is more than 120 times existing demand. This demonstrates that there is the potential to develop highly localised energy crop – supply chain – conversion facility networks within the Western Region. Substantial demand can be met through conversion of only a small fraction of nearby land to energy crop production. Ennis is also a demonstration of selecting a centre in a region of high suitability land for energy crop production, as seen in the map (Figure 14)

Figure 12: Number of hectares of high suitability land for miscanthus, Reed Canary Grass and SRC willow within 5, 10 and 25km of Ennis, County Clare.

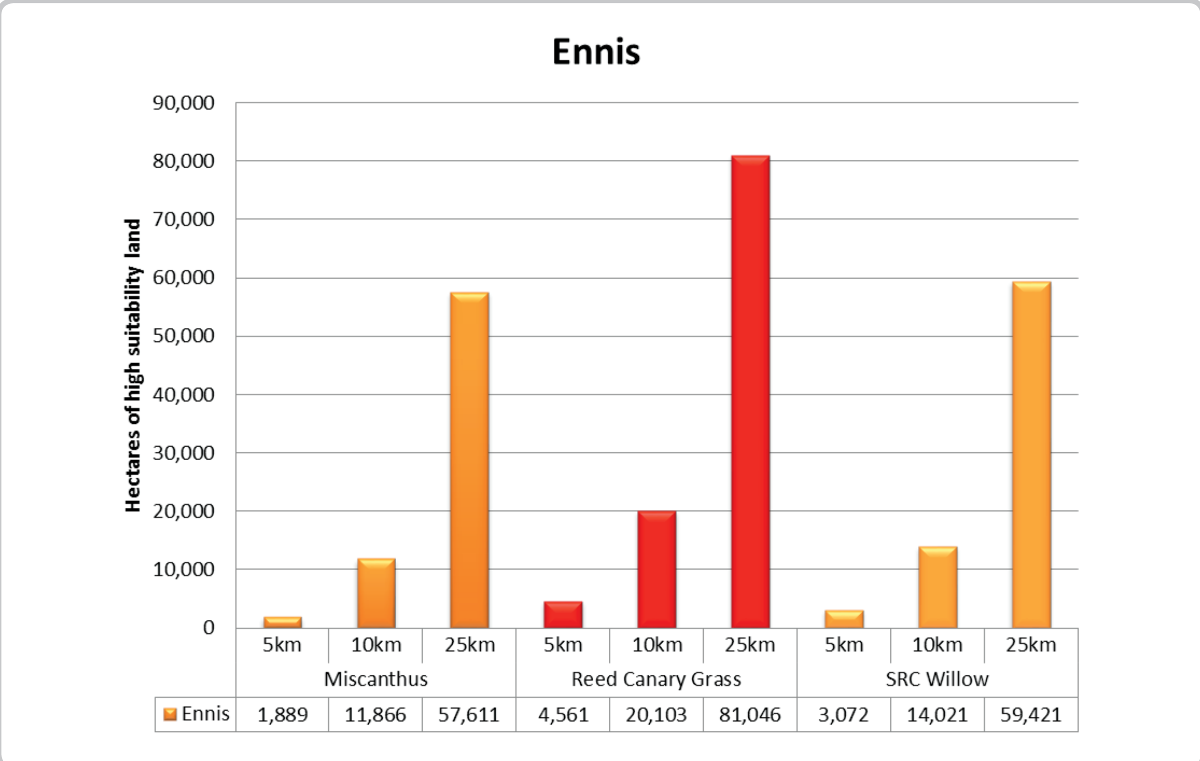


Figure 13: Delivered heat energy potential from SRC willow planted only on highly suitable, available land within 5, 10 and 25km of Ennis, Co. Clare.

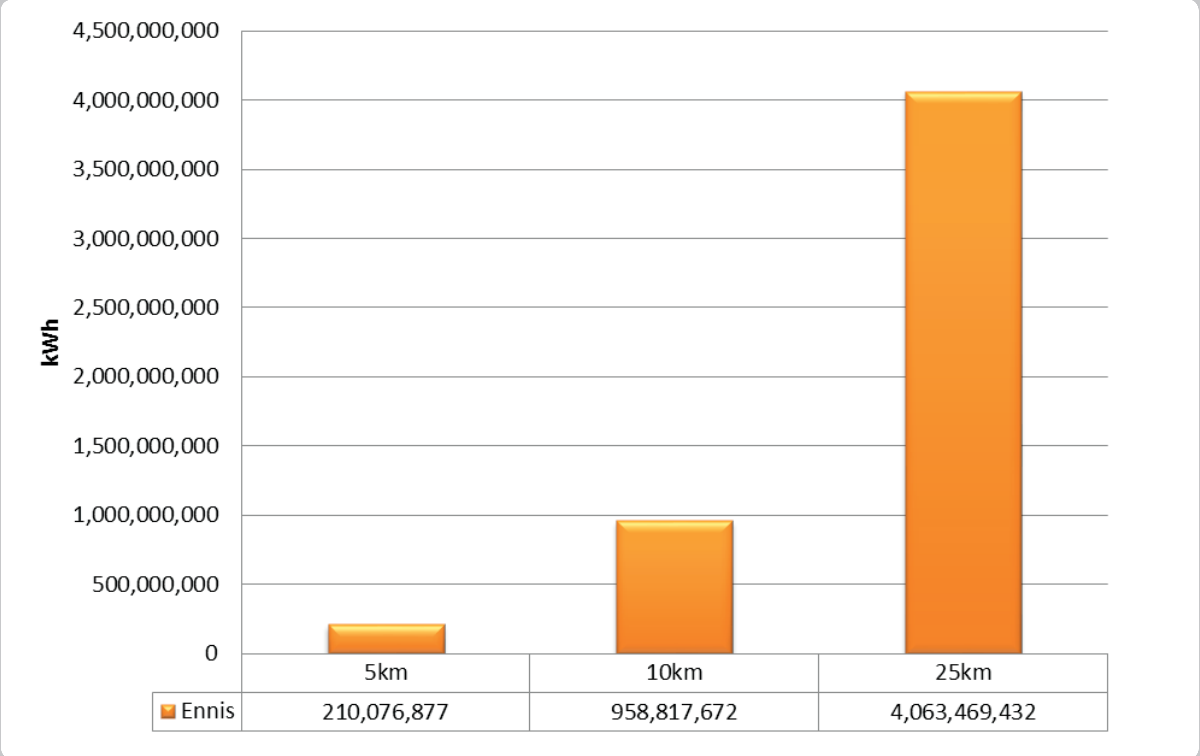
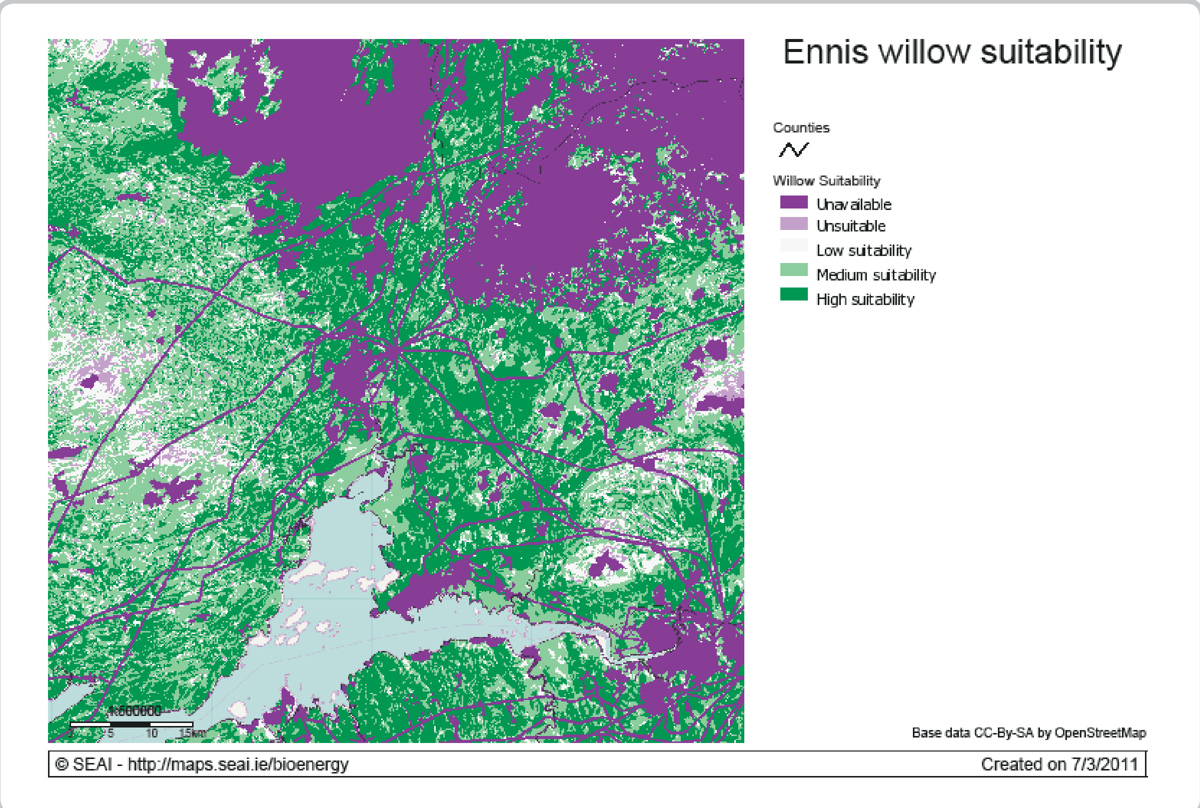


Figure 14: Map of willow suitability in the area around Ennis. High suitability areas are found to the North, East and South East of Ennis, which is roughly in the centre of the map (where the network of lines intersect).



5.1.2 Impact of transport distance on the cost of delivered heat

In comparing potential supply chain models, it is important to understand the impact that distance will have on the cost of delivered energy. Using the supply chain cost calculator built into the BGIS, a comparison of the impact of sourcing energy crop feedstock at a range of distances was calculated. The BGIS calculator outputs the cost of delivered energy after the conversion process.

For this exercise, it is assumed that heat is the delivered energy type. The only variable that was changed was transport distance. The transport distance used in each case was 1.5x[20] the straight line distance from the centre to a distance covering half of the area of the circle in question. (E.g. a circle of radius 10km covers an area of 314km^2. A circle of radius 7.07km covers an area half this, or 157km^2. The average transport distance for the circle, radius 10km, is then 1.5 x 7.07km).

The results, in Table 4, demonstrate that, all else being equal, sourcing energy crop feedstock from a region within 10km of the conversion facility will decrease the cost of delivered energy by 0.36c/kWh, or 9% compared to sourcing the same material from a region of radius 75km. For an industrial facility of 1MW, operating 70% of the year, this saving will amount to nearly €23,000 per annum. It is not always possible to realise this level of savings, and other factors may raise costs locally, however it does indicate that transport is a significant cost factor and developing local sources of supply is highly desirable.

Table 4: Impact of sourcing energy crop material from an increasing distance on the cost of delivered energy.

Circle radius (km)	Distance to cover half the area (km)	Travel distance (km)	Cost of delivered energy (c/kWh)
5.00	3.54	5.30	4.09
10.00	7.07	10.61	4.12
25.00	17.68	26.52	4.20
50.00	35.36	53.03	4.34
75.00	53.03	79.55	4.48

5.1.3 Preferred energy crop models

The concept of local production of energy crops raises a number of questions. Issues such as what production is being displaced by energy crops, and the possible economic and sustainability implications arising are beyond the scope of this report, as are the social acceptance and legislative barriers to converting to energy crops. However three aspects are considered briefly as they lead on to further supply chain concepts:

1. the impact of existing demand on energy crop selection
2. the impact of existing farming on energy crop selection
3. the impact of possible bioremediation on energy crop development

Existing solid biomass demand in Ireland is nearly exclusively built upon wood-burning systems. The non-domestic conversion units will ordinarily be able to accept SRC willow, provided it is processed correctly, however many, if not all, will suffer from severe corrosion issues if miscanthus is used. Against this, miscanthus pellets have already been produced, however it appears that it is difficult to pelletise SRC willow. Hence if miscanthus is the energy crop of choice for a particular region, new miscanthus-compatible conversion units will need to be installed to enable the supply to be utilised.

20 Derived from Reamonn Feally, Teagasc project RMIS 5512, Efficient and reliable utilisation of nutrients in animal manure.

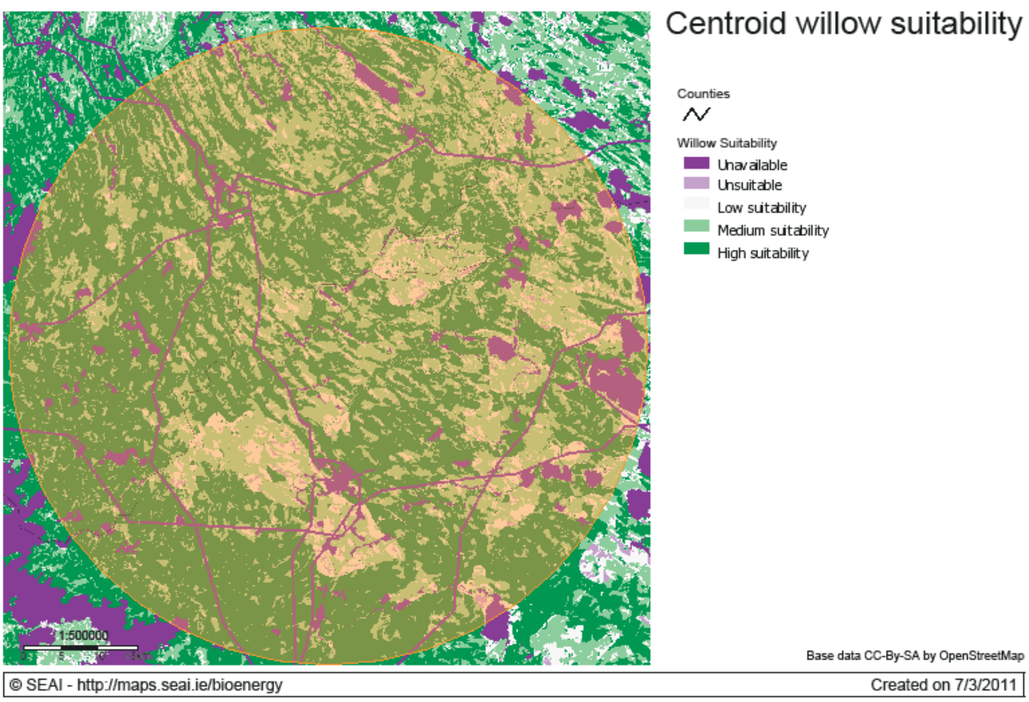
The cultivation, harvesting and processing of SRC willow and miscanthus is still evolving rapidly. However, at the start of 2011 miscanthus is more readily managed and harvested by tillage farmers using existing equipment than SRC willow. The requirements for more specialised equipment for SRC willow may have implications for the minimum plantation area and supply costs.

In some cases, bioremediation may offer energy crop growers a substantial additional income stream. It has the added benefit of improving energy crop yields. However, licensing fees and procedures vary, as do gate fees according to the material being remediated. Potential changes to European sludges regulation focussing on soil protection are likely to continue to limit the opportunities available for a bioremediation income stream.

The answers to these issues suggest a preferred model for energy crop development in the Western Region. This is for larger energy crop plantations located close to centres of demand, population and industrial facilities. The choice of energy crop will, to a large extent, be predicated by the existing demand unless a full supply chain is being developed simultaneously. For now, this means that SRC willow is the energy crop of choice. The preference for SRC willow, combined with issues regarding equipment availability, suggests development of centres of SRC willow plantation. This would reduce the costs of cultivation, management, harvesting and processing.

As a worked example, a possible location for a centre of energy crop development was suggested by the preceding cluster analysis. The Centroid analysis in the section 4 represents this centre. It is equidistant from the large population centre of Galway, the industrial centre of Castlebar, and Ballaghaderreen. This centroid could take advantage of bioremediation possibilities from all three centres; and efficiently supply all three centres with energy crop feedstock for biomass conversion facilities. As seen in the preceding analysis, at a radius of just 25km there is the potential to develop SRC willow supply sufficient to deliver over 7000GWh of heat. This is sufficient to supply more than 1100MW of installed industrial capacity. A conservative start to development of industrial bioenergy in the region might be 25MW of capacity, which would require just 2.2% of the highly suitable land within this 25km radius to be converted to SRC willow production to provide sufficient feedstock. This centroid is also fortuitously located in a dense area of high suitability land for the production of SRC willow, as seen in Figure 15.

Figure 15 Suitability of land for production of SRC willow in the Centroid area. The circle is a 25km radius centred on the Centroid between Castlebar, Ballaghadereen and Galway. A substantial portion of the area under the circle is shown as being highly suitable for SRC willow production.



Under the current financially constrained circumstances, all efforts to develop bioenergy must remain highly cognizant of cost and efficiency. For the above reasons, it is recommended that the Western Region, and in particular the county councils of Galway, Mayo and Roscommon, consider an SRC willow centre of development centred near Tuam, and work with nearby public, commercial and industrial organisations to ensure development of conversion facilities appropriate to this feedstock.

It should be recognised that this is just one worked example, and further investigation may suggest other, possibly even superior areas for focussed energy crop development. Any such centre of development should be supported by appropriate changes to county planning maps and regulations.

5.2 Example of a willow supply chain

The following section presents a worked example of a willow supply chain and serves to outline the costs and key issues impacting on fuel supply.

5.2.1 Willow planting and harvesting

The majority of the costs associated with willow production are incurred in the first year of establishment. The approximate cost of establishment is €2,600 per hectare, which includes material and operational costs.

The first crop will not give a maximum yield however, and the average expected yield over the 20 years of the crop growing cycles is 10odt per hectare per year. Based on a two year harvest cycle this would mean a harvest of 20odt or 44 fresh tonnes (55% moisture content). The harvesting costs will vary depending on transport distances to a drying facility. Assuming a 20km travel distance the approximate harvest cost per hectare is €550 or €12.50 per fresh tonne. Assuming that the willow is dried to 15% MC the tonnage will be reduced from 44 tonnes to approximately 23 tonnes giving a harvest cost per dried tonne of €24 per tonne.

This cost will be of relevance depending on whether the supply chain group absorbs the cost of willow harvesting or whether that cost falls on the farmer to pay as part of a contractual agreement.

5.2.2 Willow chip drying

The preferred method of willow chip drying is the use of ventilated grain drying floors. Some of these systems have a total drying capacity of 400 tonnes of dry (15% MC) chip per batch. Drying takes place in batches lasting approximately five weeks, using approximately 300kW/hr of renewable heat and 50kW/hr of renewable electricity per batch.

The drying period depends on four key elements:

- the amount of moisture to be removed
- the relative humidity of the air
- the temperature of the air, and
- the uniformity and velocity of the air through the woodchip dryer.

Harvested woodchip moisture content can range from 54%, during the plants' dormancy in the middle of the winter, to 70% in late May, when the plant is back in full growth, with sap up and leaves on the trees. The energy consumption in drying the willow chip would come to approximately €33.30 per tonne as per table 5 and the repayment cost of the infrastructure to dry the willow come to approximately €12.60 per tonne giving a total cost of €46 per tonne.

Table 5: Average Energy Consumption for drying 400 tonnes of wood chip to 15% MC

Energy Source	Energy required	No of hours	Total energy	Energy unit cost	Total cost
Heat	300 kW	840	252,000kWh	3 cent	€7,560
Electricity	50 kW	840	42,000kWh	13.7 cent	€5,754
Total cost					**€13,314***

*This equates to a cost of **€33.30** per tonne

Table 6: Investment cost for drying infrastructure for 2,000 tonne drying facility

	Total Cost	Cost per tonne
Investment Cost	€200,000	
Depreciation Cost	€10,000 per year	
Interest @ 6% per year	€7,190	€3.60
Principal repayments	€10,000	€5
Loading / Unloading €2 each way or €4 / tonne	€ 8,000 per year	€4
Total cost per tonne		**€12.60**

5.2.3 Haulage to end use

The haulage rates will vary depending on the price of fuel and contractual agreements. Table 7 gives an indication of transport costs at the time of publication (June 2011) based on distance travelled.

Table 7: Transport costs of 100m³ (26 tonnes) on a moving floor trailer

Distance	Cost/load	Cost/tonne
0 – 20 km	€180	€6.92
20 – 40 km	€230	€8.85
40 – 60 km	€290	€11.15
60 – 80 km	€340	€13.08
80 – 100 km	€370	€14.23

The haulage costs will depend on the tonnage of woodchip required by the customer or possible nearby deliveries to reduce the overall costs of delivery.

5.2.4 Summary of supply chain costs

If a supply chain group purchase willow from a farmer at €60 per fresh tonne, they are paying the farmer €8.67 per Giga Joule (GJ) of energy supplied. Table 8 gives a summary of the additional costs to the initial purchase price. The market price of delivered fuel energy is 5.4c/kWh.

Table 8: Summary of supply chain costs

Activity	Cost per tonne	Cost per GJ	Cost per MWh***
Willow Purchase	€60 @ 55% mc	€3.93	€14.15
Harvesting cost	€24*	€1.57	€5.65
Drying	€46*	€3.01	€10.83
Transport	€13**	€0.86	€3.10
Supply chain margin	€15	€0.98	€3.53
Total end market price	**€158**	**€10.35**	**€37.26**

*Cost of the dried tonne to 15% mc and 15.26 GJ per tonne
**Assumes a transport distance to market of 60 – 80 km
***Assumes a conversion rate of 1MWh=3.6GJ

5.2.5 Cost to end user

Willow at 15% moisture content has an energy value of 4,238kWh per tonne (15.26 GJ). A delivered cost of €158 per tonne would cost the consumer 3.7 cent per kWh. If we assume an oil price of 80 cent per litre, the oil is costing 7.8 cent per kWh. Therefore the delivered price of the willow chip is still less than half the cost of oil. Table 9 makes a comparison between the cost of various fuels.

Table 9: Fuel cost comparison

Fuel	Price per unit	kWh per unit	Cent per kWh
Willow chip (15% MC)	€158	4,238 kWh/t	3.7 cent/kWh
Wood pellets	€220	4,800 kWh/t	4.6 cent/kWh
Natural gas	4.6 cent/kWh	1	4.6 cent/kWh
Heating oil	€0.80 per litre	10.2	7.8 cent /kWh
Electricity	€0.14 cent/kWh	1	14 cent/kWh

Influencing factors

6

While there is considerable potential for energy crop development in the Western Region, the market is presently in its infancy. A range of agronomical, economic, and social factors will impact on the rate of establishment of new plantations supplying into the various wood energy markets. This section briefly comments on some of the key factors impacting on uptake of energy crops from the perspective of farmers and landowners.

6.1 Issues for potential producers

Based on uptake rates by farmers to date, there is a degree of interest in establishing energy crops plantations. The market entrants to date include:

- young farmers working away from the land who are mostly interested in energy crops as a land-use alternative; typically they have inherited a family farm and wish to reduce their work load while retaining the family farm in their own name.
- older farmers nearing retirement with no successor are showing interest in energy crops as a way of retaining ownership and reducing their workload.

Irrespective of the farmer profile, new growers into the market will require medium to long-term supply contracts which give a guaranteed return over a fixed period.

Many potential growers have land classified as "marginal land," land which is deemed not suitable for food crops due to low productivity levels and nutrient issues. Marginal land is also generally not suitable for energy crops such as SRC willow or miscanthus. While such energy crops will grow on poorer quality soils, they will typically not achieve sufficient yields to give an adequate return on the investment.

Based on feedback to Teagasc from farmers, the main factors influencing their decisions in regard to energy crop plantations include:

1. **financial**
   - no income generated for the first three years
   - current prices for other farm enterprises such as cereals, beef etc
   - requirement to provide finance before grant is obtained from DAFF
   - lack of access to finance from banking institutions

2. **limited infrastructure**
    - absence of harvesting equipment
    - lack of suitable drying facilities
    - inadequate storage facilities for large quantities of bulky chip material
3. **policy**
    - unclear policy direction on biomass sector
    - no REFIT (Renewable Energy Feed-in-Tariff) for co-firing
4. **on-farm related issues**
    - issues in regard to 'locking' in quality land for 20 years under a specific land use
    - personal/land title issues
5. **fear of the 'first mover'**
    - many prefer to adopt a 'wait and see' approach in regard to market development
    - fear of the unknown and not wanting to be an early adopter i.e. seen as being a guinea pig
6. **limited training and expertise**
    - lack of training for farmer supply chain groups
    - no local demonstration boilers or energy crop sites to inform on issues and technologies

The uptake of energy crops will be influenced by the above range of issues and attitudes. In addition the uptake of energy crops by farmers is impacted on by the range of factors relevant to the overall bioenergy market growth as presented in section 2 including price of oil, access to the gas network, levels of carbon tax, access to specialist expert, and levels of skills and relevant knowledge among potential growers and processors.

6.2 Factors in miscanthus uptake

The uptake of miscanthus has been greater than that of SRC willow both nationally and in the Western Region. The following section presents some of the keys issues impacting on miscanthus plantations from the growers perspective and hence informs on why planting have to date exceed that of SRC willow.

6.2.1 Enabling factors

- Planting of the crop is carried out by the rhizome suppliers with specialist equipment and only requires the grower to prepare the ground. This is similar to the situation for SRC willow.
- The annual yield from miscanthus, once well established, should average 12-15odt/ha compared with an average of 10odt/ha for SRC willow.
- The biomass is harvested dry, or at least much drier than SRC willow. Under normal/good conditions, harvesting at under 20% moisture is possible in Ireland, but under poor conditions the crop may need to be dried after baling or chipping at 25% to 35% moisture.
- Harvesting can be carried out by existing farm equipment such as mowers, balers and self propelled forage maize harvesters.
- The annual harvest could readily be carried out by contractors at a time when their equipment is not in use for any other purpose.
- Other than in the first two establishment years, the crop does not require any application of nutrients. As the crop senesces in the autumn/winter, nutrients are mostly returned to the rhizomes and then reused the following season.
- Once established, the crop provides an annual return to the grower.

- When returning to grassland or arable farming, miscanthus can be sprayed off with glyphosate, although it may take two applications to ensure a complete kill.
- For weed control, a wide range of cereal herbicides can be used on miscanthus.
- No significant disease infections or pest attacks have been reported. However, as the area of the crop being grown increases, the likelihood of disease infections or pest infestations increases.
- In terms of reducing carbon emissions, miscanthus has been calculated to provide a high level of savings, slightly higher than with SRC willow, particularly where grass-based enterprises are displaced and the biomass is used for electricity generation.
- Chipped miscanthus potentially has other markets, for example animal bedding.
- Once established, miscanthus requires virtually no inputs other than during the annual harvest in February/March.
- In the future, miscanthus may be particularly suited as a feedstock for the production of second generation biofuels from lignocellulosic materials.

6.2.2 Limiting factors

- Establishment from field planting of rhizomes is not proving to be reliable. It is known that the viability of rhizomes can decline rapidly between harvesting and replanting if not handled appropriately, but other factors such as method of planting, soil moisture status and soil temperature could also have an effect. Crops can recover from poor establishment but it may take longer to achieve an economic return.
- The crop takes several years to reach full production capability. Well established crops on fertile sites may reach their full yield potential by the third year, but it may take four or five years.
- The mild wet winter conditions in Ireland may lead to less complete senescence of the standing crop and higher moisture contents at harvest.
- Wet ground conditions may lead to excessive soil damage during harvesting operations.
- If the crop has to be regularly harvested at more than 20% moisture content, then artificial drying may need to be employed which will reduce the economic viability of the crop.
- The low yields in the first and second year means that it takes many years before a grower will receive an economic return.
- Potential markets for miscanthus in Northern Ireland are underdeveloped. In Ireland, the main market which has driven the increased planting of miscanthus has been the co-firing of power stations e.g. Edenderry.
- Not all biomass boilers suitable for SRC willow are capable of utilising miscanthus. Miscanthus has a higher silica and ash content than willow. The growing of miscanthus for biomass would have to be introduced hand-in-hand with the development of the capability to utilise the crop.

Conclusions and Recommendations 7

Market Drivers

The bioenergy sector will grow significantly in Ireland over the next decade due to economic and market drivers such as the increasing price of oil, limited access to the gas network, opportunities for indigenous enterprise development, and issues of energy security. Ireland has a target to deliver 12% of its heat energy from renewable energy sources by 2020. Currently approximately 3.6% of national heat energy is from renewables. In addition to the heat market, biomass fuels will also contribute to achievement of Ireland's renewable energy targets in the co-firing and CHP markets.

In the Western Region the wood energy market consumes about 31,000odt of wood fuel. By 2020, an 11% heat market share for wood fuels is projected to require between 217,000odt and 240,000odt of fuel. In addition to the heat market, a modest 2020 growth scenario for the CHP market estimated a fuel demand of 125,000odt. A proportion of the fuel requirements for co-firing at the Edenderry plant will potentially be supplied from the region. Export of wood fuel from the Western Region is expected to flow to Northern Ireland as the newly introduced Renewable Heat Incentive drives their demand.

Private forestry could potentially supply 252,000odt of wood fuel by 2020 (combined output of roundwood and co-product). In reality a range of economic, social and physical factors will have a significant impact on how much of the potential supply is actually harvested by 2020. Key influencing factors include plantation size, site access from public and forest roads, market demand and prices. The distance to end users and cost of road transport are also significant factors in achieving commercially viable fuel supply chains.

Energy crop plantations and/or biomass imports will be required to meet the projected 2020 fuel demand. For the Western Region, growth of the bioenergy sector creates an opportunity to maximise fuel supply for existing private forestry and in tandem build a new energy crop sector to supply the various biomass users. The development of an indigenous energy crop sector is the recommended strategy for reasons of energy sustainability, security, regional economic competitiveness and enterprise opportunities.

Energy Crop Potential

Energy crop development is in its infancy across Ireland and in the Western Region. In 2008 there were only 241 hectares of miscanthus (8% of national total) and 84 hectares of willow (15% of national total) planted in the Western Region.

The BGIS indicates that approximately 37% (710,716ha) of the available land area (1.9million hectares) in the region is highly suitable for energy crops. The potential for energy crops in the region is as follows:

- 710,716 of hectares highly suitable for **SRC willow**, with potential delivered energy of ***48,602GWh*** and potential carbon abatement of 12,023Mtonnes

- 701,070 of hectares highly suitable for **Miscanthus**, with potential delivered energy of ***43,050GWh*** and potential carbon abatement of 10,649Mtonnes
- 1,035,898 of hectares highly suitable for **Reed Canary Grass**, with potential delivered energy of ***39,757GWh*** and potential carbon abatement of 9,835Mtonnes

By 2020 a 10% regional wood heat market will require an estimated 217,000odt to generate heat energy of 1,085GWh; planting 10% of the land highly suitable for SRC willow would supply nearly 4 times this projected wood fuel demand, and planting 50% the potential area would supply over 22 times the demand. Based on 2008 heat energy estimates, planting 50% of the land highly suitable for SRC willow would supply twice the total heat energy demand of 10,780GWh.

The BGIS analysis shows that each county has the potential to supply a notable solid biomass demand from within their county borders. The cluster examples show that a substantial demand can be met through conversion of only a small fraction of land near to centres of demand to energy crop production.

The region has sufficient hectares of highly suitable land to build a commercial energy crop sector; energy crops are potentially an alternative enterprise for farmers/land owners. However a long term market demand must be evident to encourage new growers into the market. Key factors influencing the market price offered to farmers and fuel suppliers is the market segment supplied i.e. co-firing, heat or CHP, and distance to this market.

In addition to market price, there is a complex range of factors influencing the decision by farmers and landowners to establish energy crop plantations in the region. The policy environment must indicate a clear direction and long term commitment to supporting the growth of the bioenergy sector. Farmers must have access to finance to establish plantations and build the necessary supply infrastructure. There must be readily available expertise and training opportunities to build knowledge and skills in the sector. Given the current low base within the energy crop sector, farmers must be actively supported to ensure the latent potential is realised.

Development Strategy: Local Clusters of Demand and Supply

The preferred model for energy crop development indicated by the analysis is the creation of energy crop plantations located close to centres of existing and potential demand. The cluster analysis examples for Galway/Castlebar/Ballaghaderreen and Ennis demonstrate the rationale for recommending this market development strategy.

The analysis suggests that there is potential to establish localised fuel supply with plantations in a 5km radius of the demand centre/primary user. A wider clustering of demand and fuel supply could be established at a radius of up to approximately 50km. The BGIS can assist in the initial modelling of such fuel supply chains. Plantations in the wider cluster area could benefit from additional revenue potentially possible from bioremediation; proximity to centres of population would facilitate the economic viability of this waste management option.

Transport costs are a highly significant cost component in the energy crop supply chain. The supply chain examples show that, all else being equal, sourcing energy crop feedstock from an area within 10km of the conversion facility will decrease the cost of delivered energy by 0.36c/kWh, or 9% compared to sourcing the same material from a region of radius 75km. For an industrial facility of 1MW, operating 70% of the year, this saving will amount to nearly €23,000 per annum.

In local supply chains, it is imperative that the market demand (i.e. boiler installations) is compatible with locally available fuels. The choice of energy crop will, to a large extent, be predicated by the existing demand unless a full supply chain is being developed simultaneously. For now, this means that SRC willow is the energy crop of choice in the Western Region. The preference for SRC willow, combined with issues regarding equipment availability, suggests development of centres of SRC willow plantation. This would reduce the costs of cultivation, management, harvesting and processing.

The BGIS allows for the modelling of potential growth scenarios in specific geographic areas. For instance the cluster analysis for Galway/Castlebar/Ballaghaderreen indicates that a conservative start to development of industrial bioenergy in the region might be 25MW of capacity, which would require just 2.2% of the highly suitable land within this 25km radius to be converted to SRC willow production to provide sufficient feedstock. This modelling shows that Tuam is an optimum location to develop a SRC willow growing centre to serve installations in the counties of Galway, Mayo and Roscommon. This is just one worked example, and further investigation may suggest other, possibly even superior areas for focussed energy crop development.

The BGIS modelling shows that energy crop plantations can make a notable contribution to the development of local clusters of bioenergy demand and supply. This model of market development will allow rural communities to achieve energy independence and create new enterprise and employment opportunities. The establishment of energy crop plantations will increase market confidence in the long term fuel supply chain; users must clearly see that fuel supply is readily available at a commercially viable price in their immediate hinterland.

The forestry and energy crop sectors should work in parallel to build a regional network of sustainable fuel supply chains, and thereby facilitate a sustainable rate of uptake of bioenergy technologies in the commercial, industrial and services heat and CHP markets. The Western Region will achieve maximum economic benefits from growth of the bioenergy market if the fuel is supplied from within the region.

7.1 Recommended Actions

Based on this analysis, the following actions are recommended to support development of the wood energy market.

Development Strategy

1. A strategic approach to developing **local loops of demand and supply** across the region will facilitate increased rates of bioenergy deployment. The entire supply chain must be assessed to simultaneously increase market demand and the required fuel supply i.e. fuel volumes and infrastructure must scale up in parallel to increasing market demand. Partnership and interaction between energy users and fuel producers/suppliers is required to initiate bioenergy projects, and build a sustainable sector. By working together private industry and local development actors can identify a network of centres of local demand and supply across the region.

Supply side actions

2. An **audit of existing crop production and fuel processing infrastructure** would inform future industry planning. The region will need to build a network of fuel supply infrastructure in terms of fuel depots/ processing sites and also planting, harvesting equipment etc .
3. To achieve commercial viability fuel supply, clusters of energy crop plantations need to be developed in tandem with clusters of market demand. Adopting a **producer group approach** will create economies of scale for new entrants and help control costs e.g. shared costs of planting, harvesting, and equipment. A cluster approach to plantations will also facilitate the development of routes to market for growers e.g. ten local growers supply into one regional fuel depot business.
4. The provision of appropriate **training and skills programmes** to potential and existing fuel producers is critical to ensuring proper management of individual plantations and across the industry. Having a **network of demonstration sites** across the region could aid this up-skilling process for farmers.

Demand side actions

5. The development of robust **heat demand maps** at a local level will identify clusters of market demand and thereby inform on the optimum sites and business planning for potential and existing fuel producers and processors.
6. The **public sector has the potential to act as a driver for growth** through the adoption of biomass heat technologies in their own building stock. The uptake of biomass fuels by public sector heat users would provide a stimulus to initiate and/or expand existing fuel supply chains, and thereby increase fuel supply capacity and increase overall market confidence. A first step in this process could see the public sector assess the viability of progressing **clusters of public sites** as part of a process to initiate new loops of local demand and supply. In addition such public installations typically have an important demonstration effect for the sector.

Supply Chain Co-ordination

7. Further **cluster based analysis and industry consultation** will identify specific locations with the potential to act as hubs/centres for energy crop development, and thereby map out a viable regional network of local fuel supply chains. This process would need to be informed by the existing fuel supply from the forestry sector, and existing and potential market demand.
8. County planning maps should become cognizant of the suitability of land for energy crop production and allow this to inform on development decisions e.g. decisions regarding non-agricultural development on high suitability land.

Research and Development

9. Further research is required on energy crops as a technology for waste management though **bioremediation**. Both the technical and policy issues need to be addressed, particularly reclassifying energy crops so that they no longer come under waste facility and planning regulations for the purposes of bioremediation.
10. There are a **range of energy crops** which have yet to be assessed as options for Irish growing conditions. For instance given the significant potential of reed canary grass, further research should be carried out to assess how this crop could be developed. In addition faster growing forestry crops like poplar and eucalyptus may have application in the Irish market.
11. To date SRC willow and miscanthus have been planted on high quality soils. On-going and new **trials should include sites on more marginal lands** to assess productivity levels and crop yields.

Appendices

8

8.1 Analysis of existing and potential energy crop development

Figure 16: The potential delivered heat energy (kWh) from existing plantations of miscanthus and SRC willow in the Western Region, 2008. The percentage share for each county of the total regions production is also shown. These values assume each plantation is in full production, and all material produced is used in efficient boilers for heat production.

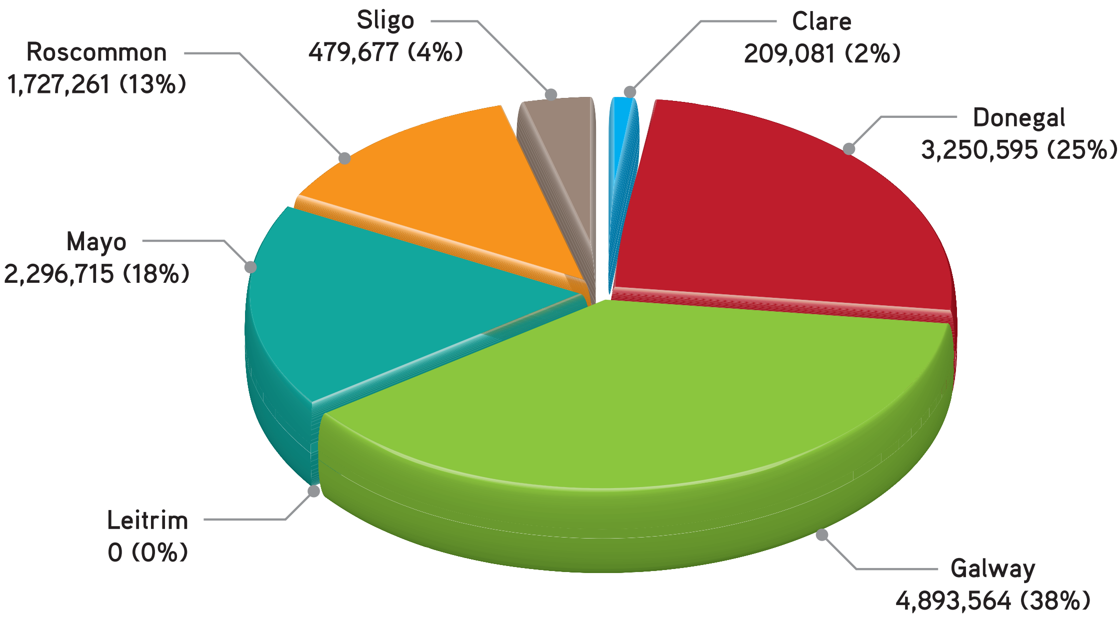
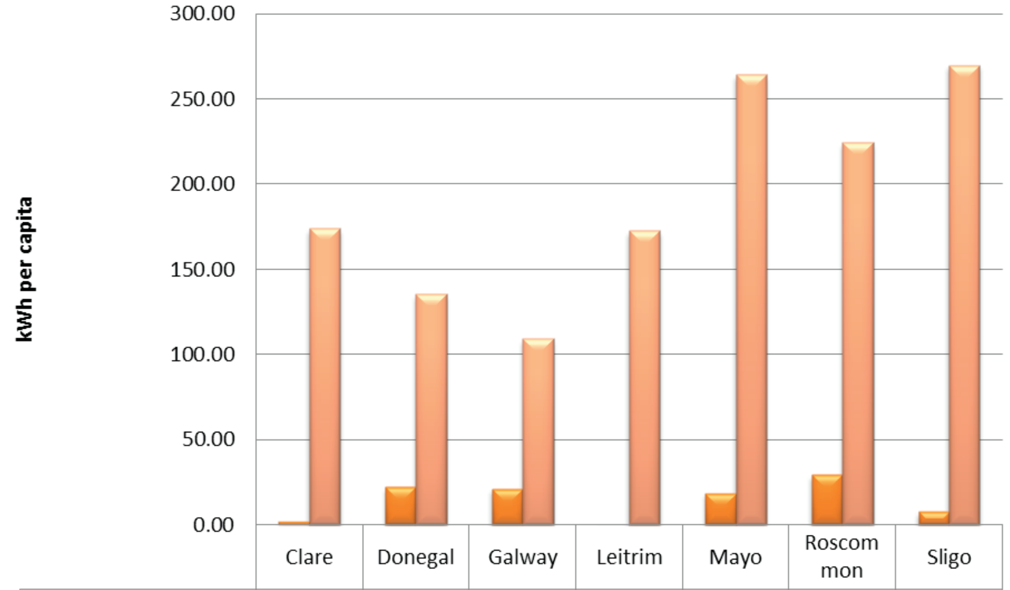
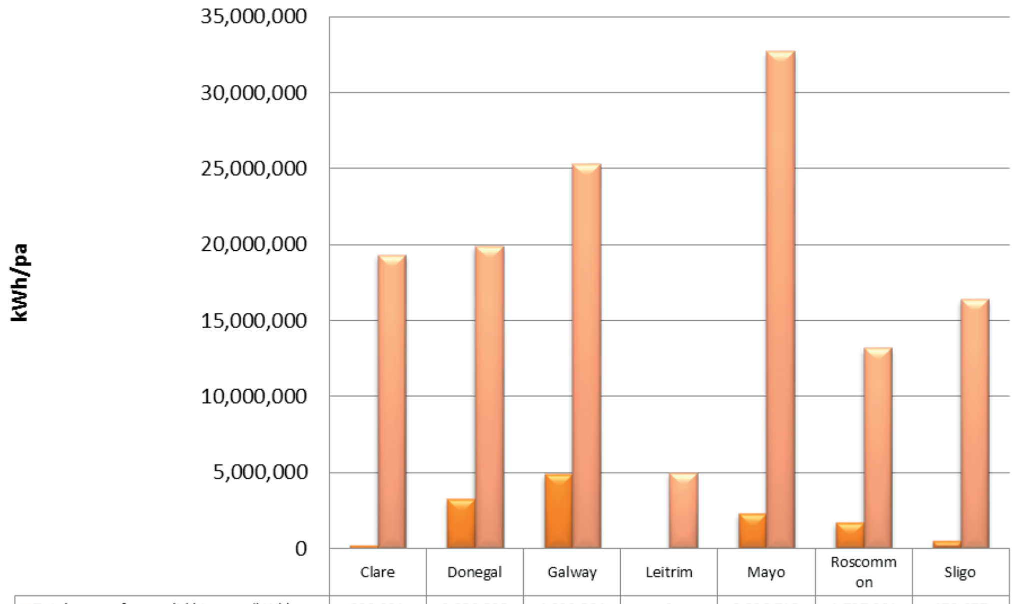


Figure 17: Existing production per capita per county, Comparing existing production from miscanthus and SRC willow in each county with existing demand from combined greener homes and ReHEAT funded installations. Comparison is given on a per capita basis.



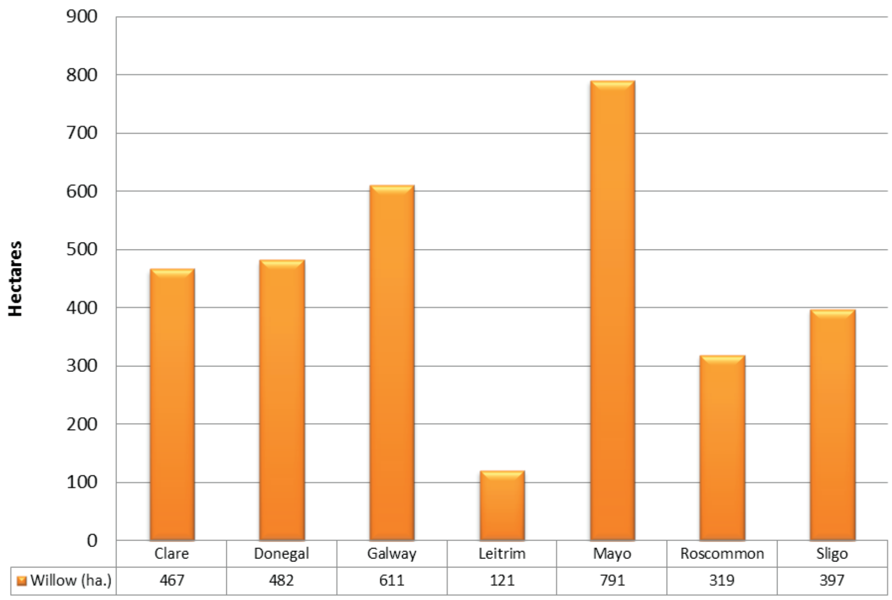
	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo
Production per capita	1.88	22.07	21.12	0.00	18.55	29.39	7.88
Demand per capita	174.00	135.34	109.13	172.54	264.15	224.48	269.98

Figure 18: Existing solid biomass demand (lighter coloured columns) compared with the potential delivered supply from existing energy crop plantations. Demand has been estimated from Greener Homes and ReHEAT installations using 10% and 20% load factors respectively. It is important to understand that Miscanthus is unsuitable for most existing biomass installations, and SRC willow is presently unsuitable for domestic biomass boilers (which are predominantly pellet based).



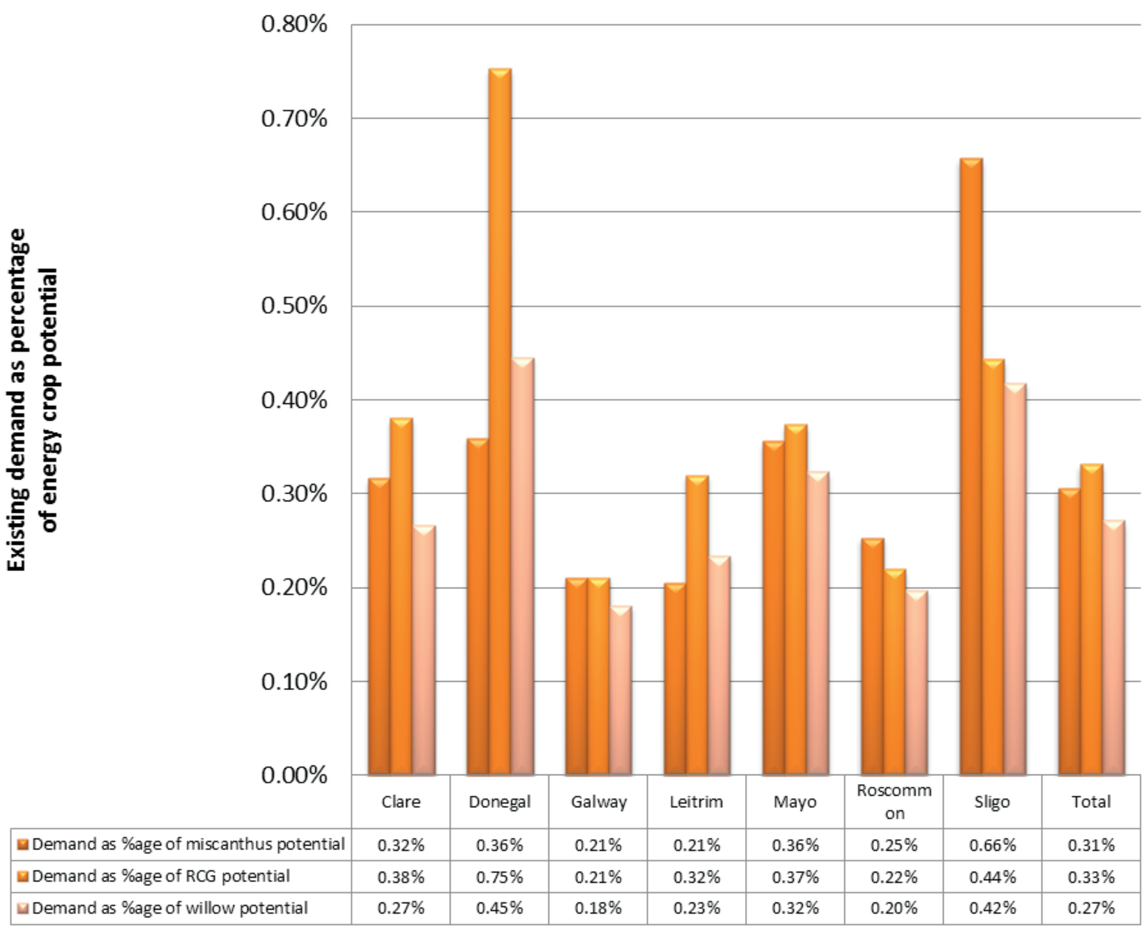
	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo
Total energy from solid biomass (kWh)	209,081	3,250,595	4,893,564	0	2,296,715	1,727,261	479,677
County estimated current biomass demand (kWh)	19,305,000	19,930,500	25,281,000	4,995,000	32,712,500	13,192,500	16,440,000

Figure 19: Number of hectares of SRC Willow required to meet estimated existing demand in the Western Region counties. Assumes SRC willow is planted on moderately productive land.



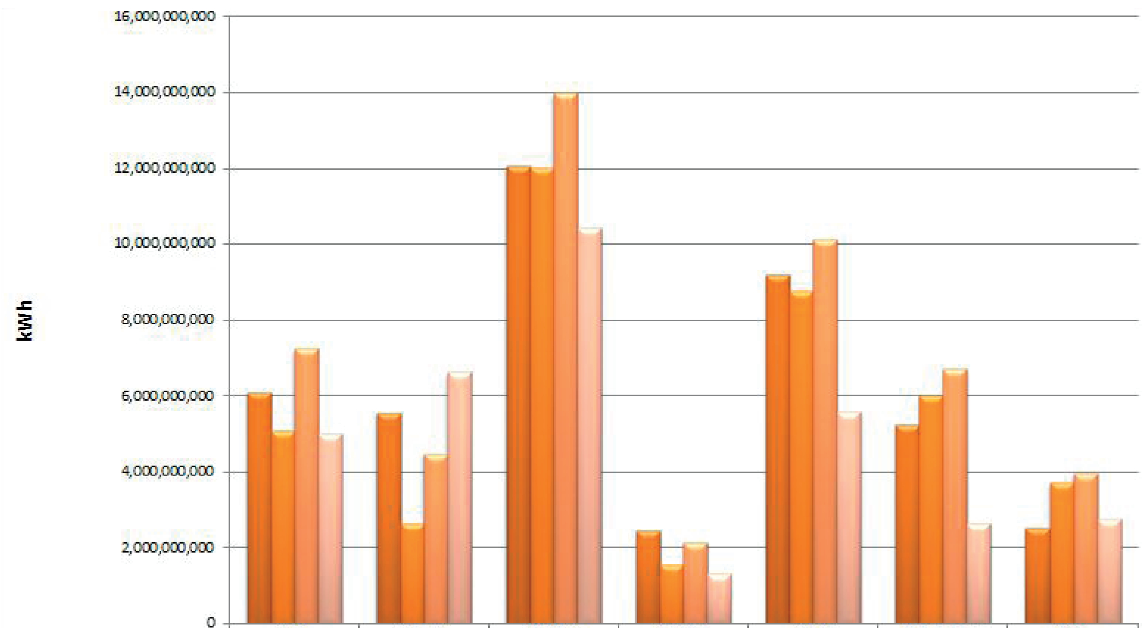
	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo
Willow (ha.)	467	482	611	121	791	319	397

Figure 20: Existing demand (as at December 2010) for solid biomass (combined Greener Homes and ReHEAT installations) as a percentage of energy crop potential from highly suitable land in the Western Region.



	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo	Total
Demand as %age of miscanthus potential	0.32%	0.36%	0.21%	0.21%	0.36%	0.25%	0.66%	0.31%
Demand as %age of RCG potential	0.38%	0.75%	0.21%	0.32%	0.37%	0.22%	0.44%	0.33%
Demand as %age of willow potential	0.27%	0.45%	0.18%	0.23%	0.32%	0.20%	0.42%	0.27%

Figure 21 Comparison of the potential energy crop production in each of the seven counties of the Western Region vs. the 2009 total primary energy requirement (TPER)[21] of each county calculated using population as a proxy for demand. The energy crop potential shown is only for production on land classified as highly suitable using the energy crop suitability tool, and is shown as delivered energy in the form of heat.



	Clare	Donegal	Galway	Leitrim	Mayo	Roscommon	Sligo
Miscanthus potential (kWh)	6,098,269,584	5,544,752,294	12,056,962,421	2,432,860,162	9,197,880,437	5,219,052,749	2,500,407,202
RCG potential (kWh)	5,071,976,745	2,646,961,251	12,008,213,415	1,562,485,848	8,756,437,503	6,002,245,326	3,708,409,254
Willow potential (kWh)	7,236,915,899	4,475,485,442	13,994,935,844	2,135,439,659	10,120,412,509	6,704,885,267	3,933,812,610
TPER (kWh)	4,991,149,541	6,624,755,710	10,421,808,150	1,302,332,395	5,570,968,617	2,643,712,269	2,739,351,601

21 From SEAI report, Energy Forecasts for Ireland to 2020. Population data taken from 2006 census as published by the Central Statistics Office, Ireland.

8.2 Crop suitability calculations

8.2.1 Land suitability grids

The bioenergy GIS has a built-in tool to predict the suitability of land for growing energy crops. Short rotation coppice willow; miscanthus; reed canary grass and oilseed rape are included. The parameters used to predict suitability, and the source of information for each parameter, are:

Parameter	Information source
Soil type	Teagasc soils dataset.
Rainfall	Met Eireann average rainfall grid, 1961 - 1991
Height	Ordnance Survey Ireland, Digital Terrain Model
Slope	Ordnance Survey Ireland, Digital Terrain Model
Aspect	Ordnance Survey Ireland, Digital Terrain Model (8 directions)

The approach taken in building a suitability model was based on the approach of the FAO.

The first step in building the suitability grid is to apply a "mask" whereby land that is not available for planting energy crops is removed from the calculation and from display. These will include, for instance, natural heritage areas; special areas of conservation; special protection areas; nature reserves; existing forestry and urban areas.

The suitability of the remainder of the country for each crop was then assessed. The country was divided into 50x50m grid squares. A suitability factor of unsuitable; low suitability; medium suitability or high suitability was assigned to each square, for each crop, for each suitability parameter. (e.g. the soil type, in a given square, might be highly suitable for growing willow). The individual suitability parameters for an energy crop, for each square are combined using weighting factors supplied by Teagasc. The combined, weighted figure then determines what overall suitability is given for that square, for that crop.

For more detailed information, refer to the wiki at http://maps.seai.ie/bioenergy.

Further information regarding land suitability for energy crops, and energy crop husbandry, can be found in the Teagasc publications:

- Short Rotation Coppice Willow Best Practice Guidelines
  http://www.teagasc.ie/publications/2010/20100916a/WillowBestPracticeGuide2010.pdf
- Miscanthus Best Practice Guidelines
  http://www.teagasc.ie/publications/2010/20100916a/MiscanthusBestPracticeGuide2010.pdf

8.2.2 Energy calculation tool (existing output)

The energy crop calculation tool enables calculation of the potential delivered energy from existing bioenergy and the main cereal crops. The following elements are included:

1. User selects an area of land (a polygon, a freeform circle, a circle of set radius, a county, or a set of counties)
2. The GIS returns a table, containing the number of hectares planted, in the selected area, with energy crops or the main cereal crops.

3. The calculation includes user modifiable default data for:
    a. Average yield
    b. Energy density of the material (toe/tonne)
    c. Farm gate cost (per tonne)
    d. Harvesting (cost and losses)
    e. Transportation (cost per km; distance of travel; losses)
    f. Storage (cost and losses)
    g. Processing (cost and losses)
    h. Conversion (efficiency)
    i. Energy production cost (€/tonne input material)
    j. Carbon abatement factor (kg CO_2/kWh)
4. The calculation returns:
    a. Total expected yield of material
    b. Delivered biomass energy (to conversion unit, in toe)
    c. The usable energy output (toe)
    d. The usable energy output (kWh)
    e. The cost of energy output (€/toe)
    f. The cost of energy output (€/kWh)
    g. The amount of carbon abated for the energy produced (kg)

The default data has been produced following consultation with industry, and is based on the following assumptions:

Crop	Assumptions
SRC willow	› Site is in full production › Material is chipped › Conversion in a commercial boiler, 90% efficiency
Miscanthus	› Site is in full production › Miscanthus baled at harvesting › Converted in a 90% efficient boiler
Oilseed Rape	› Crushed for rape oil › Converted to biodiesel (356L biodiesel per tonne rapeseed) › Biodiesel calorific value 32.9MJ/L › Biodiesel converted in 33% efficient car engine
Wheat & Barley	› Converted to Bioethanol › 355L Bioethanol/tonne grain › Bioethanol 21.2MJ/L calorific value › Bioethanol converted in 30% efficient car engine.

8.2.3 Details of calculating carbon abatement

The energy calculation tool detailed above includes a carbon abatement calculation. This calculation is an estimate of the amount of carbon abated through delivering the calculated energy output (post-conversion efficiency).

The calculation multiplies the energy output from the conversion unit by a carbon abatement factor (CAF). The carbon abatement factor is as provided by the Department for Environment Food and Rural Affairs (DEFRA) in the UK. These can be accessed at http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm

For bioethanol and biodiesel, Tables 9b Parts (i) and (ii) were used by subtracting the biodiesel Grand Total GHG emission from the Diesel Grand Total GHG emission, giving a saving of 41.060kg CO_2e/GJ when using biodiesel. This was converted to 0.1868kg CO_2e/kWh using the DEFRA energy conversion factor (Annex 12) of 277.78 kWh/GJ. A similar process for bioethanol gave a value of 0.1478kg CO_2e/kWh emissions saved.

The solid biomass conversion factors were calculated using a similar subtraction process. It was assumed that solid biomass would displace "burning oil" – kerosene or paraffin used for heating purposes, and the values were taken on a net calorific basis (i.e. assuming that energy lost in the water vapour produced is not recovered). The lifecycle grand total of greenhouse gas emissions for extraction, delivery and combustion of "burning oil" as given in Annex 1 is 0.30786 kg CO_2e/kWh. The equivalent value, as given in Annex 9, for wood chips is 0.01579 kg CO_2e/kWh. The difference is therefore 0.29207 kg CO_2e/kWh saved by using solid biomass. The moisture content of the woodchip is not stated, however in a linked website the moisture content used is 25%. Note that the CAF value given here has been used in this report, however an earlier value of 0.221 is currently implemented in the BGIS energy crop calculation tool and this will be corrected in the next update.

8.3 County statistics for existing and potential energy crops

8.3.1 Western Region

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (MWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	241	9,390	2743	4.17
Reed Canary Grass	1	20	6	4.17
SRC willow	84	3,467	1013	4.27

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (Mtonnes)
For solid biomass			
Miscanthus	701,070	43,050	10,649.70
Reed Canary Grass	1,035,898	39,757	9,834.97
SRC willow	710,716	48,602	12,023.08

8.3.2 County Clare

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (MWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	5	209	61	4.17
Reed Canary Grass	0	0	0	N/A
SRC willow	0	0	0	N/A

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (Mtonnes)
For solid biomass			
Miscanthus	99,310	6,098	1,508.58
Reed Canary Grass	132,155	5,071	1,254.70
SRC willow	105,827	7,237	1,790.26

8.3.3 County Donegal

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	11	416	122	4.17
Reed Canary Grass	0	0	0	N/A
SRC willow	69	2,834	828	4.27

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	90,296	5,545	1,371.65
Reed Canary Grass	68,969	2,647	654.80
SRC willow	65,446	4,475	1,107.14

8.3.4 County Galway

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	122	4,756	1,389	4.17
Reed Canary Grass	0	0	0	N/A
SRC willow	3	137	40	4.27

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	196,347	12,057	2,982.64
Reed Canary Grass	312,885	12,008	2,970.58
SRC willow	204,651	13,995	3,462.05

8.3.5 County Leitrim

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	0	0	0	N/A
Reed Canary Grass	0	0	0	N/A
SRC willow	0	0	0	N/A

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	39,619	2,433	601.84
Reed Canary Grass	40,712	1,562	386.53
SRC willow	31,227	2,135	528.26

8.3.6 County Mayo

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	50	1950	569	4.17
Reed Canary Grass	0	0	0	N/A
SRC willow	8.39	347	101	4.27

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	149,787	9,198	2,275.36
Reed Canary Grass	228,157	8,756	2,166.16
SRC willow	147,993	10,120	2,503.58

8.3.7 County Roscommon

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	44	1,727	504	4.17
Reed Canary Grass	1	20	6	4.17
SRC willow	0	0	0	N/A

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	84,992	5,219	1,291.08
Reed Canary Grass	156,394	6,002	1,484.83
SRC willow	98,047	6,705	1,658.65

8.3.8 County Sligo

Existing energy crops

Energy Crop	Hectares planted (2008)	Potential delivered energy (kWh)	Potential carbon abatement (tonnes)	Estimated cost of delivered energy (c/kWh) (avg. 40km delivery)
For solid biomass				
Miscanthus	9	332	97	4.17
Reed Canary Grass	0	0	0	N/A
SRC willow	4	148	43	4.27

Potential energy crops

Energy Crop	Hectares highly suitable	Potential delivered energy (GWh)	Potential carbon abatement (tonnes)
For solid biomass			
Miscanthus	40,719	2,500	618.55
Reed Canary Grass	96,626	3,708	917.38
SRC willow	57,525	3,934	973.14

County Suitability Maps for SRC Willow

9

County suitability maps for SRC willow are given in the following maps, the suitability legend is:

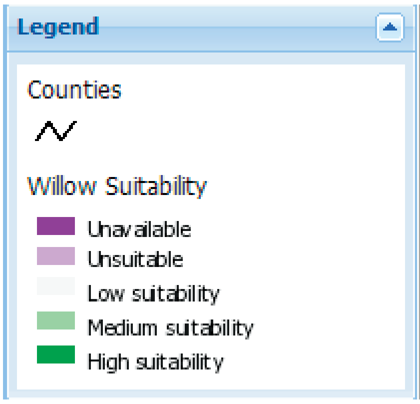


Figure 22: SRC Willow suitability in Co. Clare

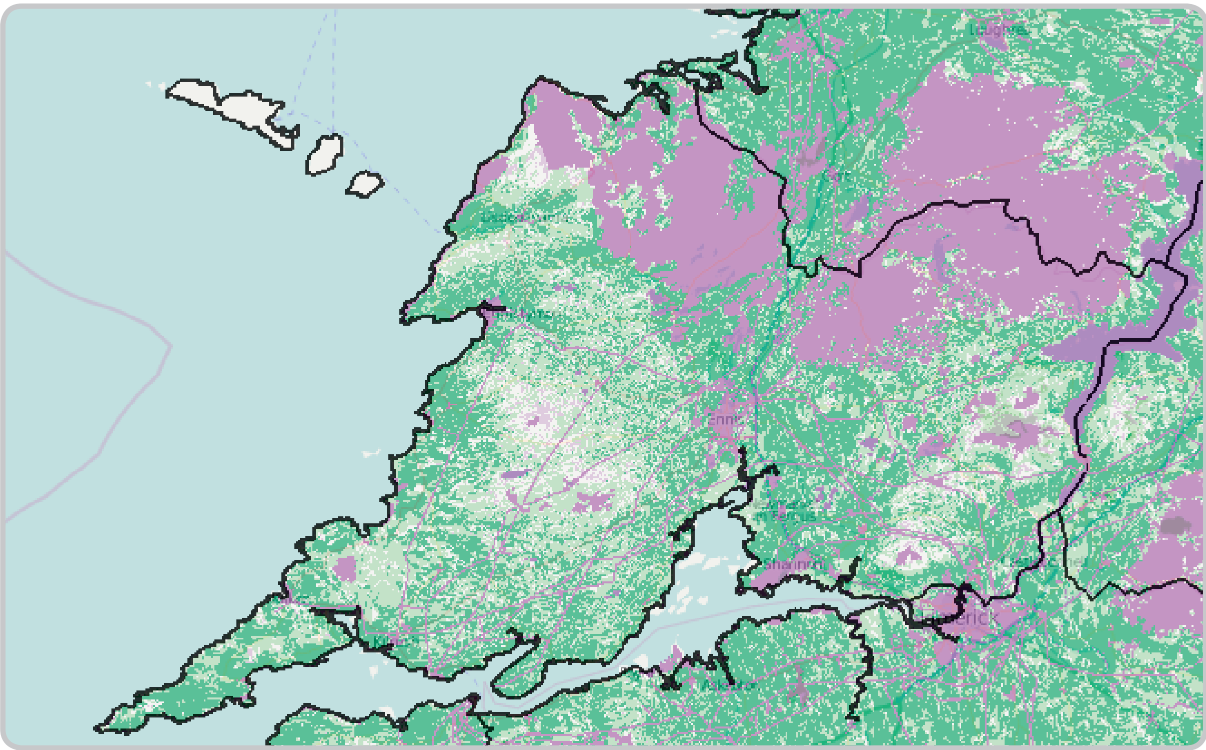


Figure 23 SRC Willow suitability in County Donegal

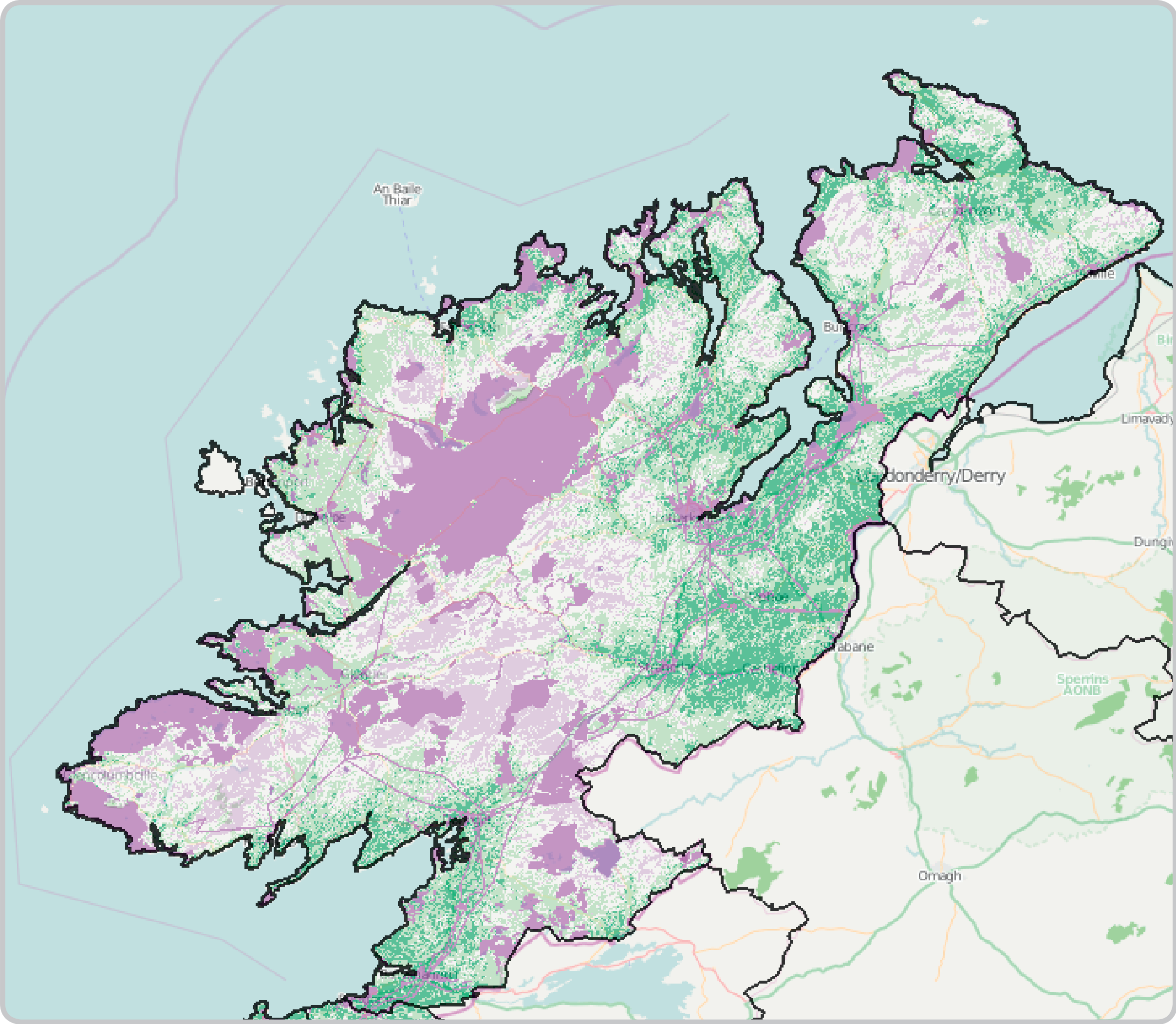


Figure 24: SRC Willow suitability in County Galway

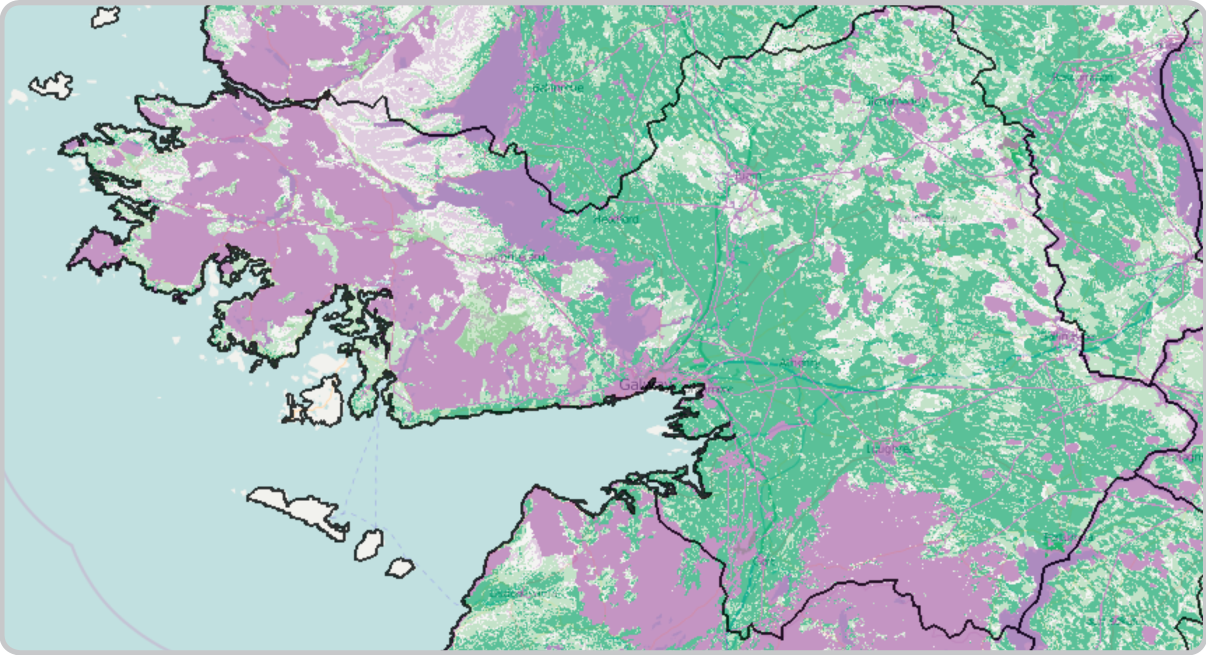


Figure 25: SRC Willow suitability in County Leitrim

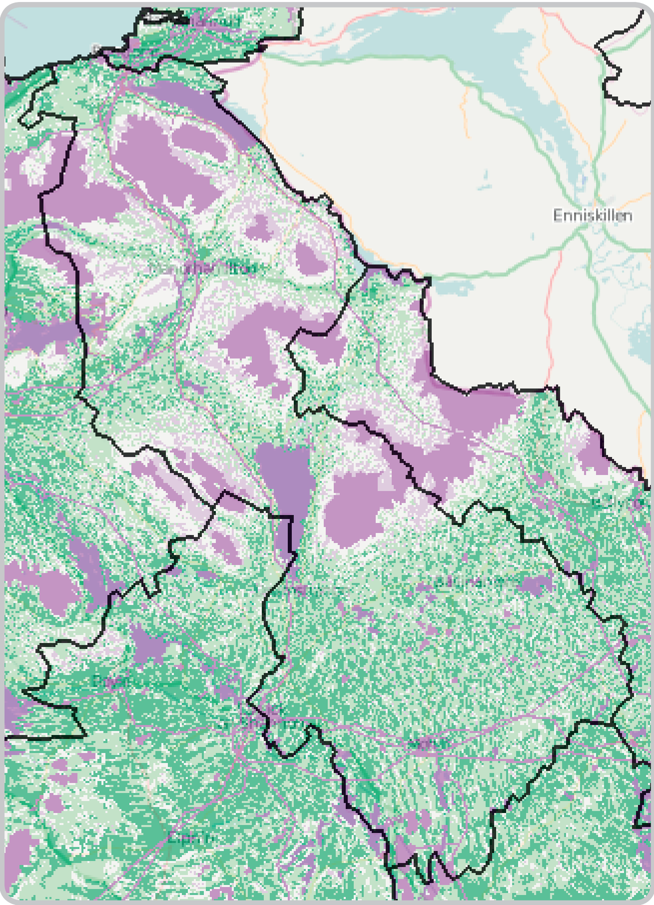


Figure 26: SRC Willow suitability in County Mayo

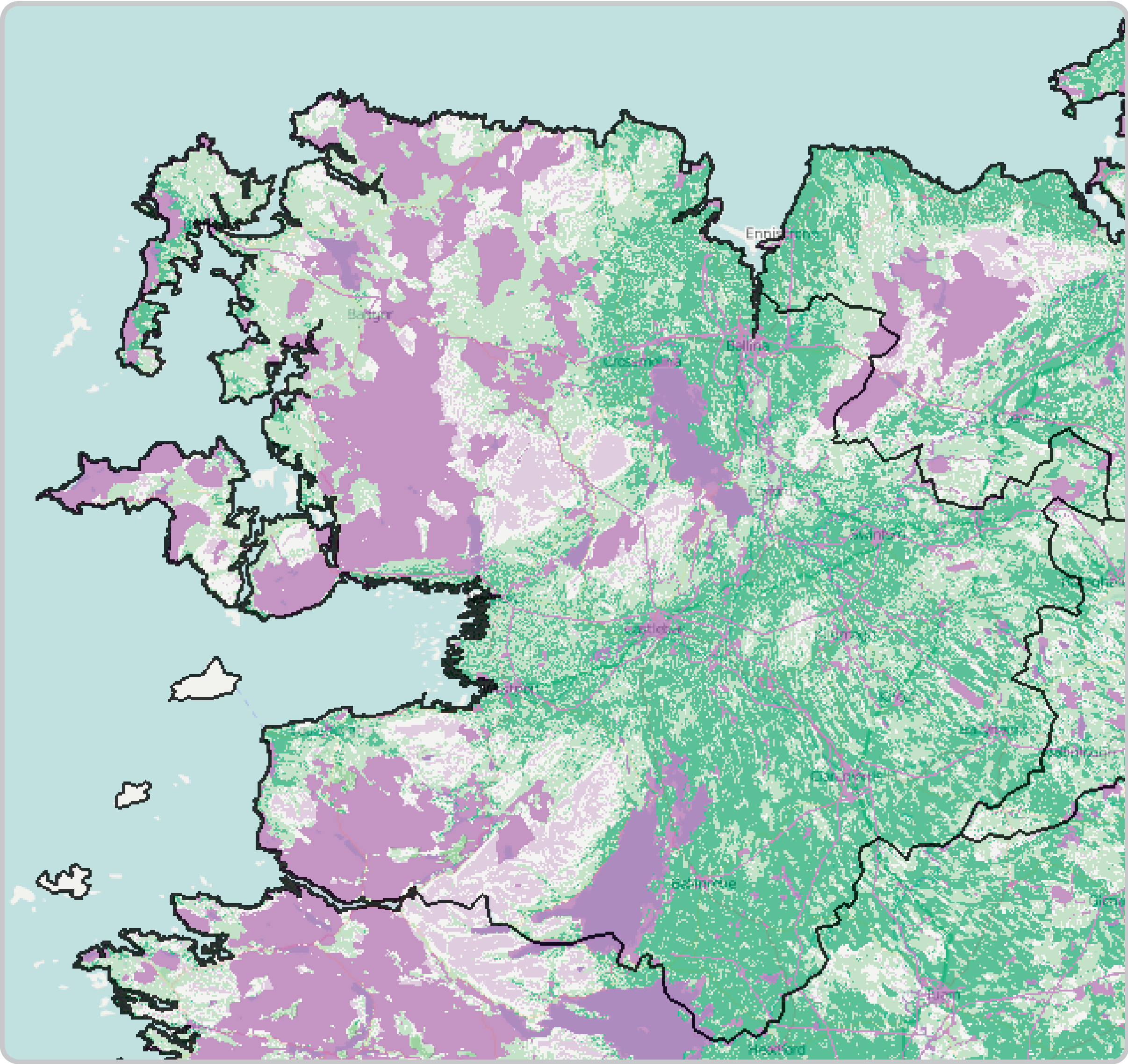


Figure 27: SRC Willow suitability in County Roscommon

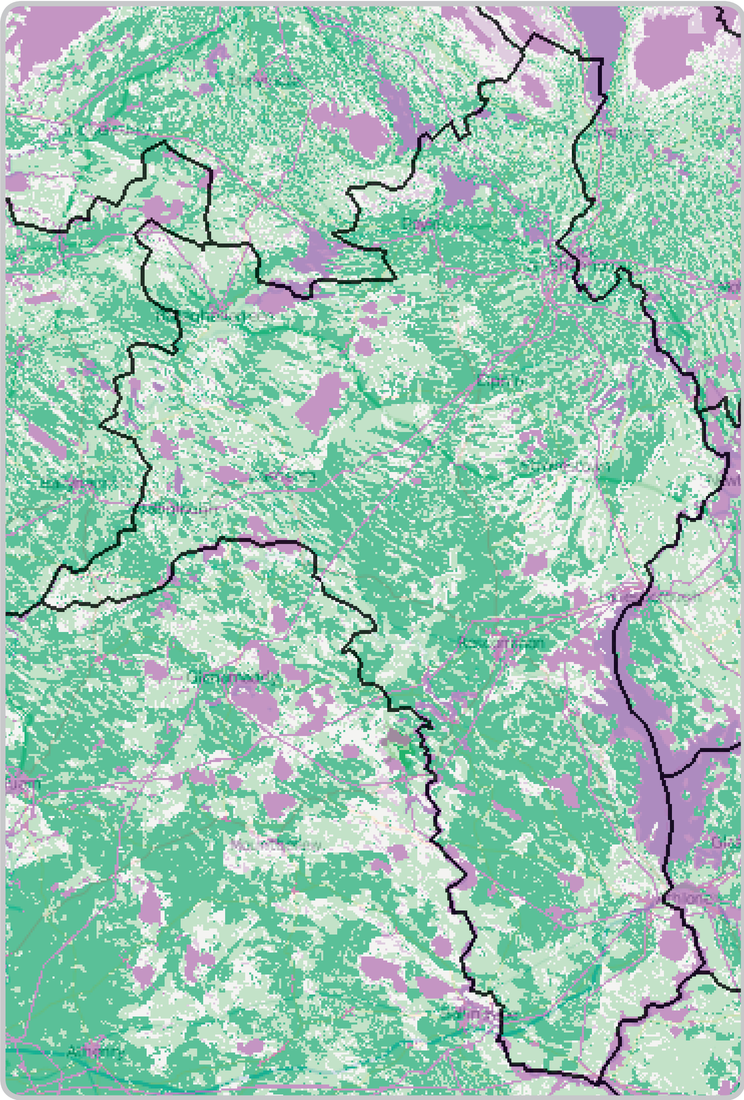
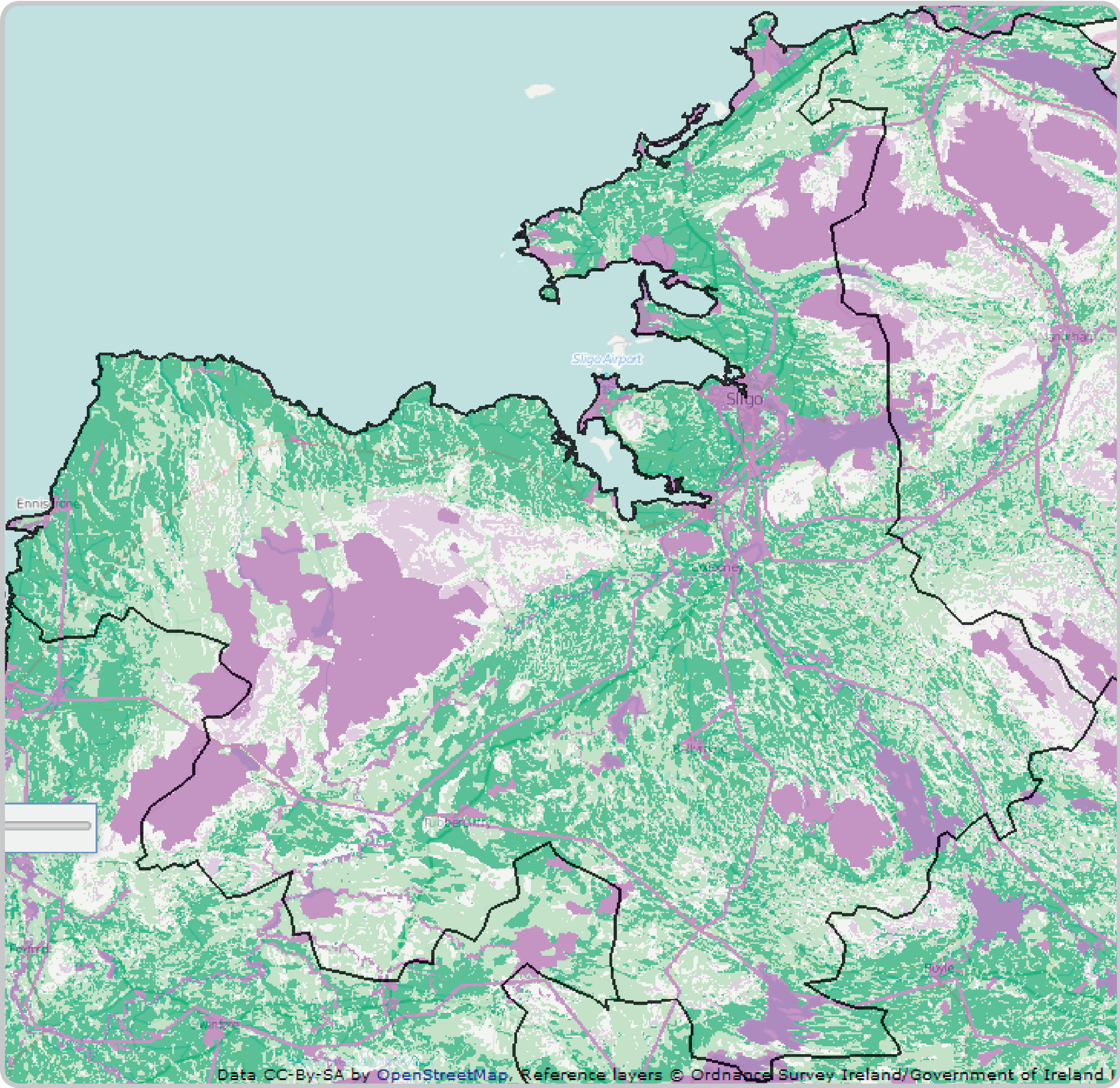


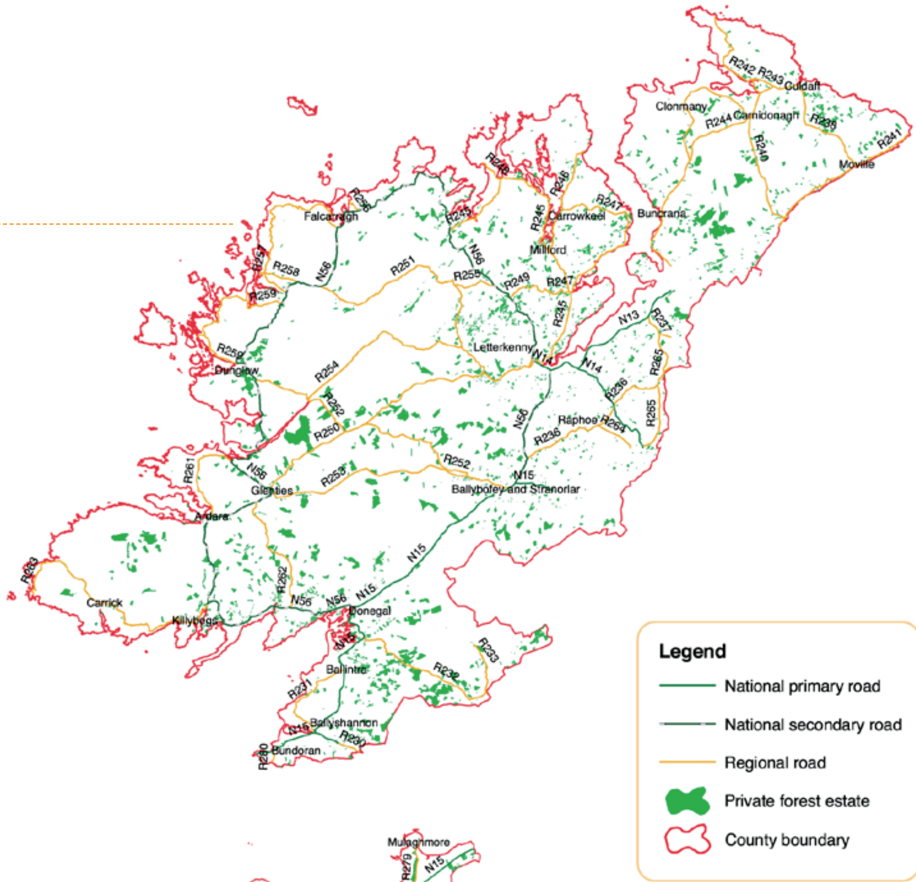
Figure 28: SRC Willow suitability in County Sligo.



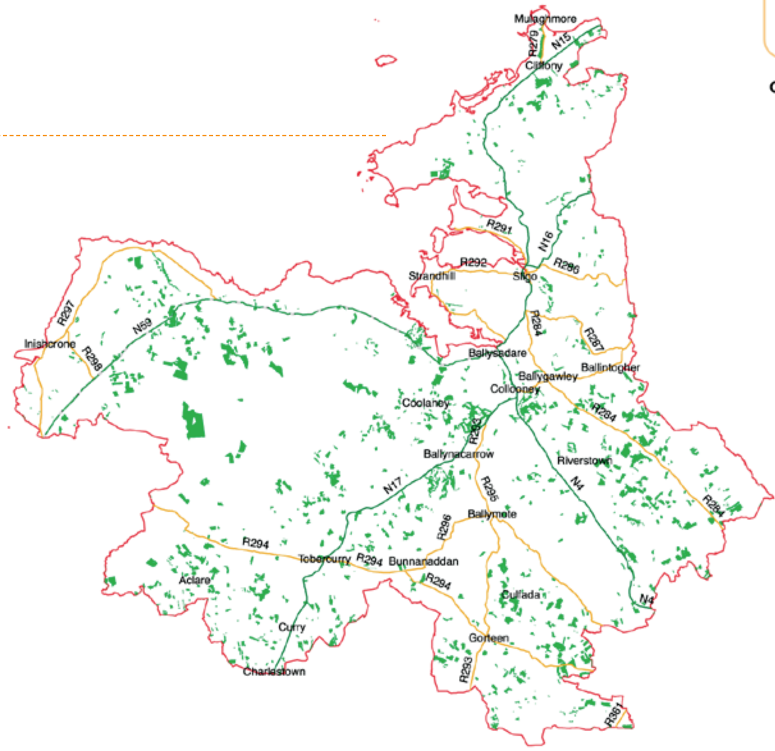
Private Sector Forestry – County Maps

10

Donegal



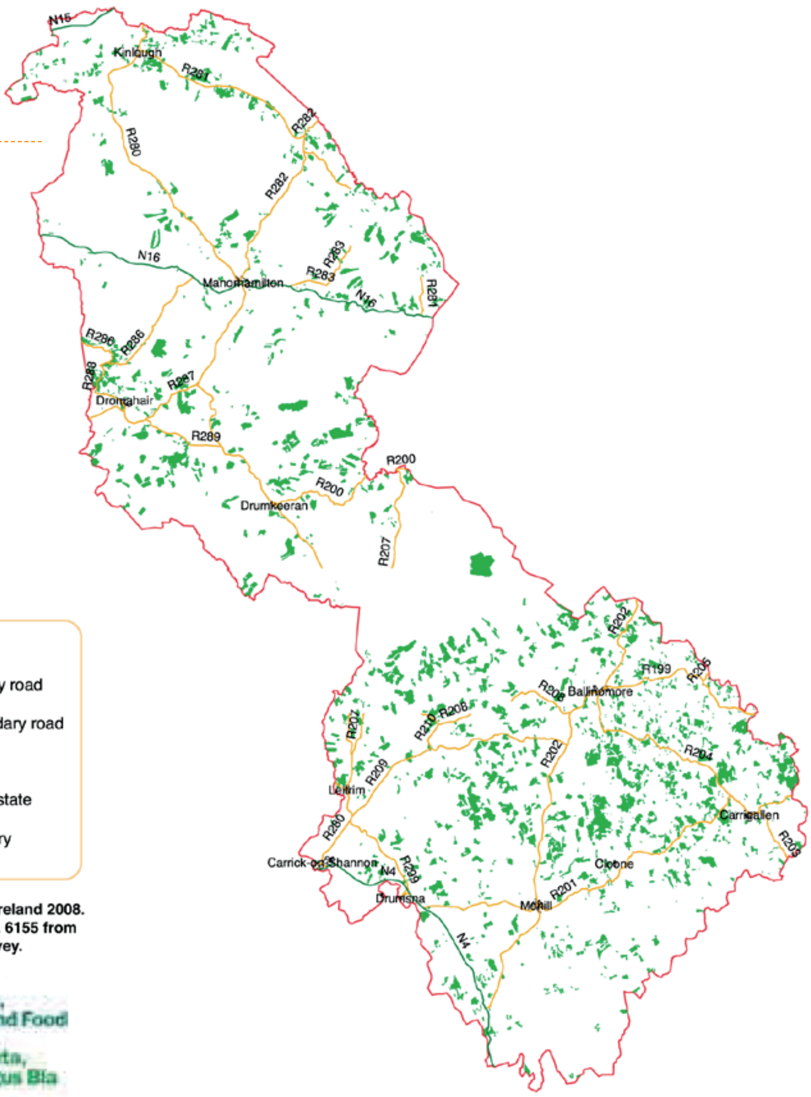
Sligo



Department of Agriculture, Fisheries and Food
An Roinn Talmhaíochta, Iascaigh agus Bia

Forest Service

Leitrim



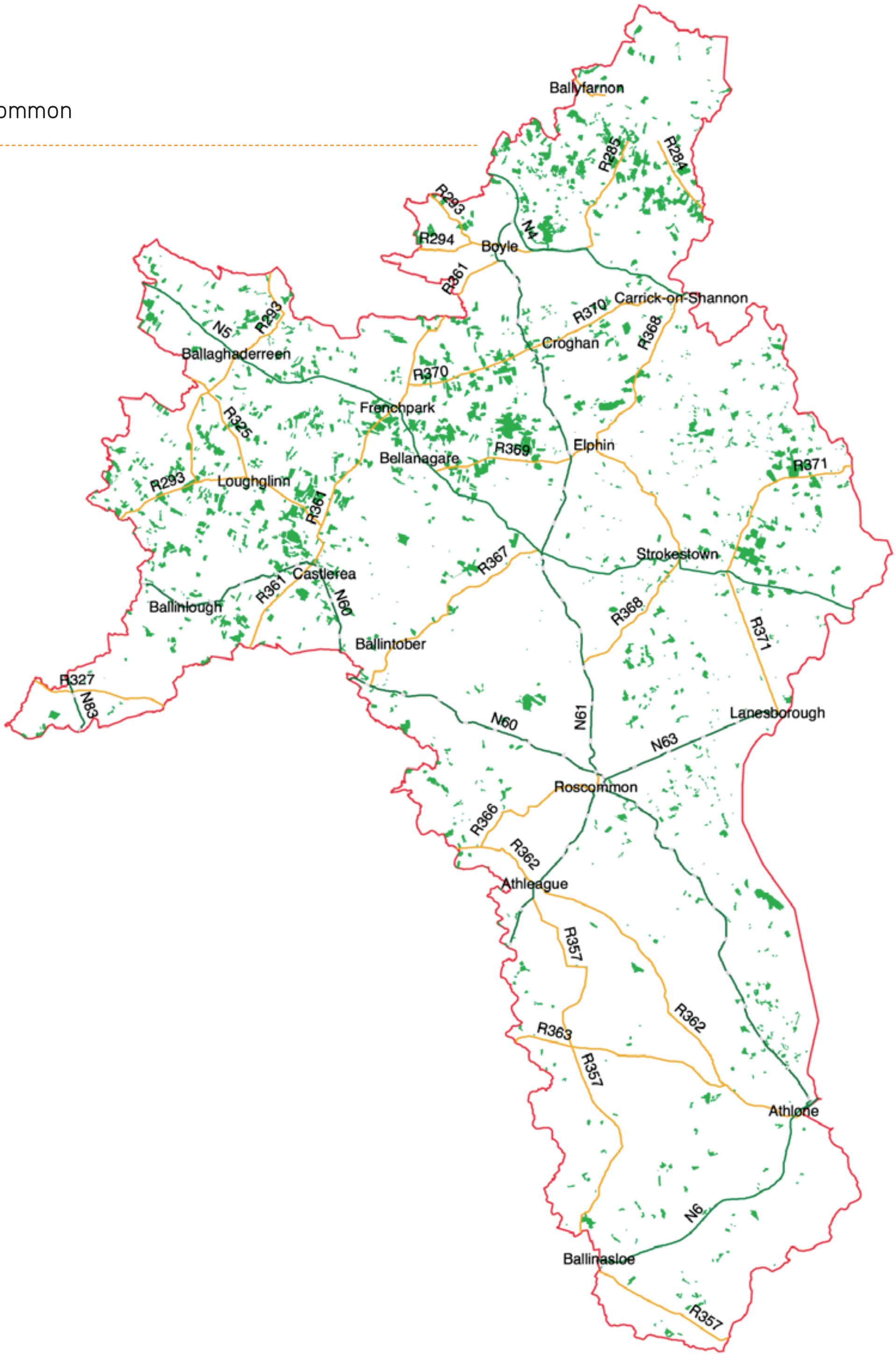
Legend

- National primary road
- National secondary road
- Regional road
- Private forest estate
- County boundary

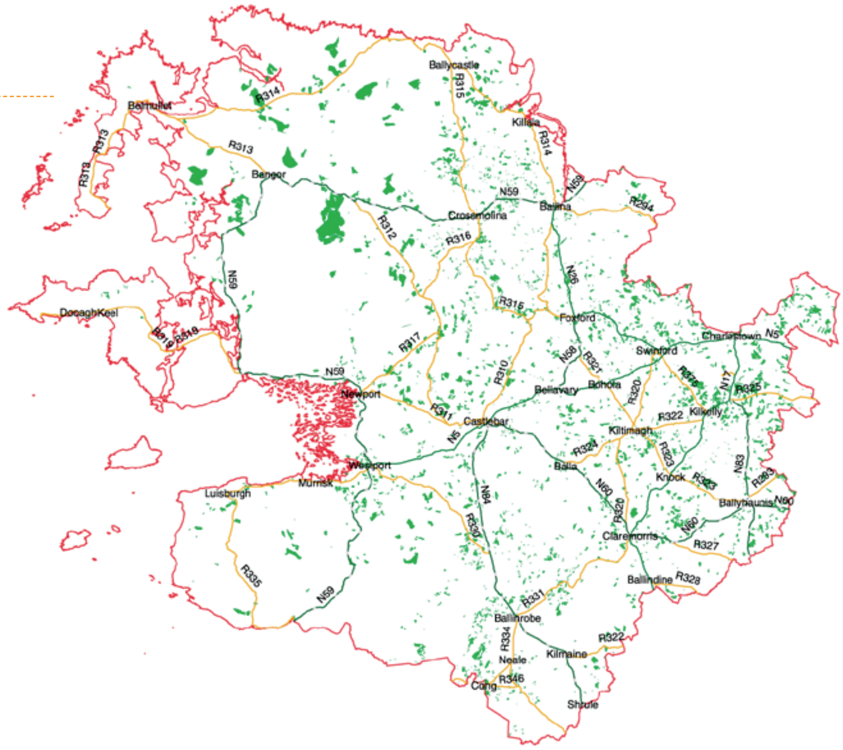
Department of Agriculture, Fisheries and Food
An Roinn Talmhaíochta, Iascaigh agus Bia

Forest Service

Roscommon


Ballyfarnon
R285
R284
R293
R294
Boyle
N4
R361
Carrick-on-Shannon
R370
Croghan
R368
N5
R293
Ballaghaderreen
R370
Frenchpark
R325
Elphin
R369
Bellanagare
R371
R293
Loughglinn
R361
Strokestown
R367
Castlerea
R361
N60
Ballinlough
R368
Ballintober
R371
R327
N83
Lanesborough
N60
N61
N63
Roscommon
R366
R362
Athleague
R357
R362
R363
R357
Athlone
N6
Ballinasloe
R357

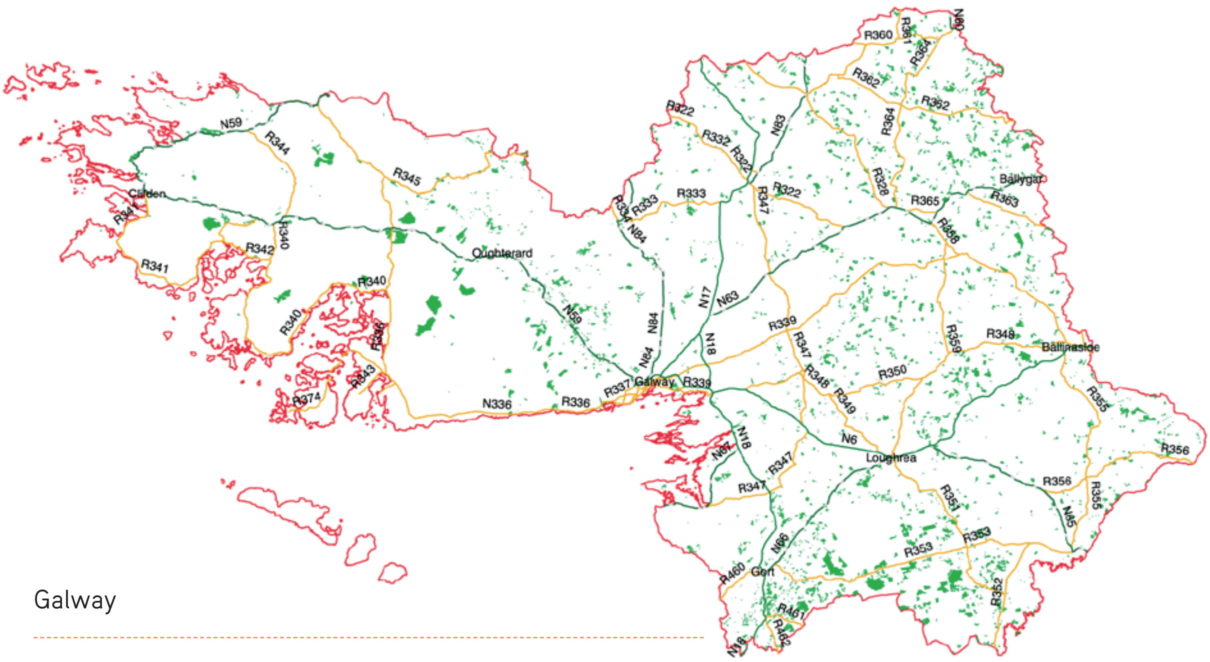
Mayo



Legend
- National primary road
- National secondary road
- Regional road
- Private forest estate
- County boundary

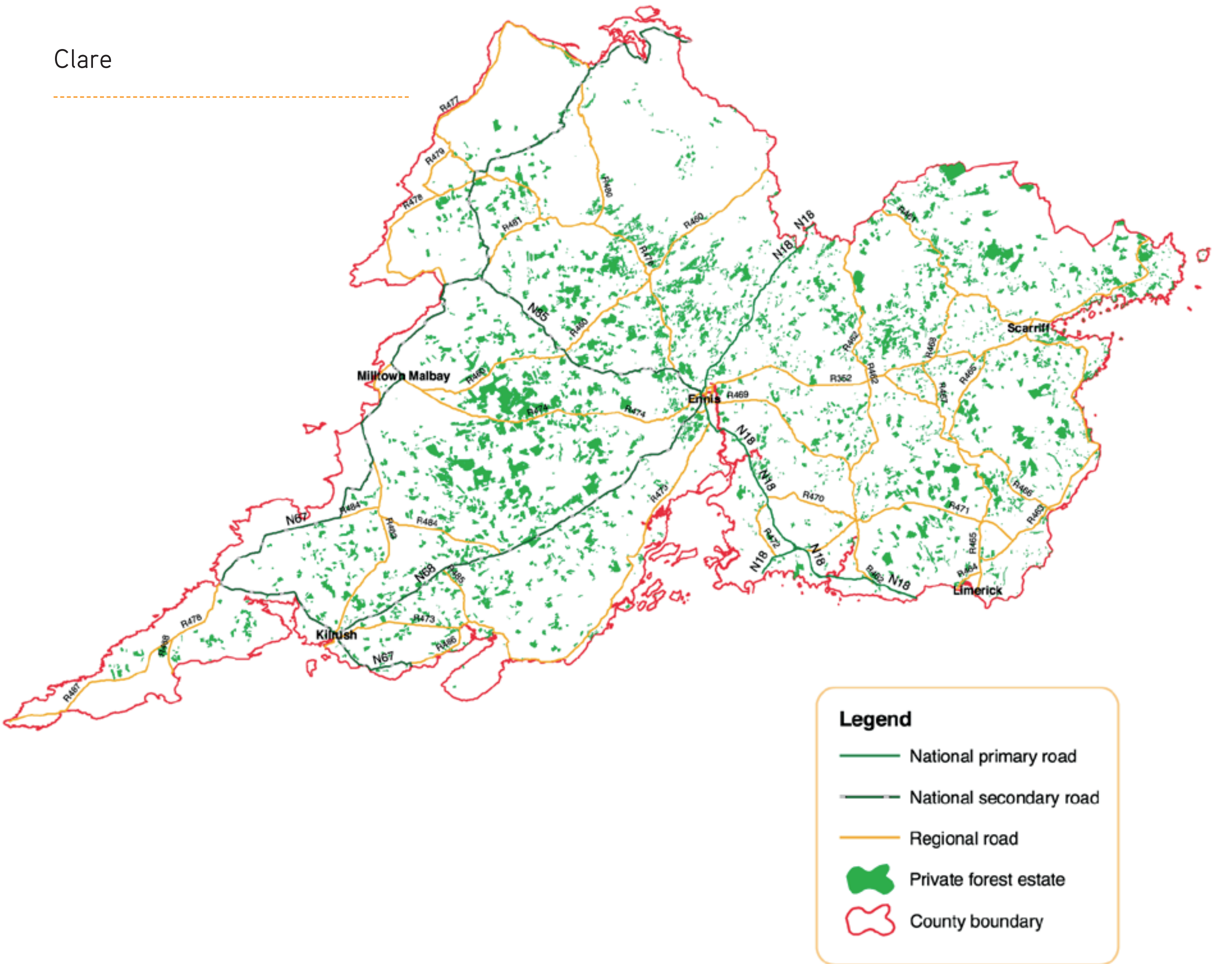
Department of Agriculture, Fisheries and Food
An Roinn Talmhaíochta, Iascaigh agus Bia

Forest Service



Galway

Clare



Department of Agriculture, Fisheries and Food
An Roinn Talmhaíochta, Iascaigh agus Bia

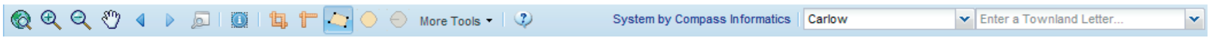
Forest Service

Bioenergy GIS Methodology: A Users Guide

11

The following methods apply to the SEAI bioenergy GIS (http://maps.seai.ie/bioenergy).

Most actions start with the toolbar, which is located above the map window:



11.1 Existing bioenergy crops – county level

1. On the toolbar, click **More Tools**
2. Select **suitability stats by county** (a new window opens titled **Select counties**)
3. In the **available column**, click on a county of interest
4. Click the **right arrow** (the county moves to the **Selected column**)
    a. Note – if there is more than one county in the Selected column, the data returned is the summed data for all the selected counties (not individual county information)
5. Click the **Get Statistics** button (The Generated Bioenergy Statistics by County window opens)
6. Click on the **Existing Output** tab within the new window to see existing bioenergy crop output for that county.

11.2 Bioenergy crop potential – county level

1. Follow steps 1. – 5. Of section 11.1
2. Click on the **Modelled Output** tab within the new window to see the bioenergy crop potential for the selected county(ies)

11.3 Existing and potential bioenergy crops – selected area.

There are three separate tools that can be used to select an area on the map and return the current and potential bioenergy crop output.

11.3.1 Define a polygon (best for detailed areas or unusual shapes)

1. On the toolbar, click the **Crop Area Tool (polygon)** 
2. In the **map window**, **click** to start drawing the polygon
3. **Move** the cursor, **and click** again to create a corner of the polygon – continue except for the last point.
4. **Double click** the last point to complete the polygon and start the analysis
5. A new window opens with the results.
6. Click on the **Existing Output** tab to view production of energy crops within the polygon defined area.
7. Click on the **Modelled Output** tab to view the bioenergy crop potential for the polygon

11.3.2 Define a free-form circle area

1. On the toolbar, click the **Crop Area Tool (circle)** 
2. In the **map window**, **click** (for circle centre) and drag out to desired circle size.
3. A new window opens with the results.
4. Click on the **Existing Output** tab to view production of energy crops within the polygon defined area.
5. Click on the **Modelled Output** tab to view the bioenergy crop potential for the circle

11.3.3 Define a circle with set radius

1. On the toolbar, click the **Crop Radii Tool** 
2. **Click** a spot on the **map window** (this will become the centre of the circle)
3. A new window opens in the top right of the map window – Circle options.
4. Use the **dropdown arrow** to select one of the pre-set circle radii.
5. The size of the circle drawn on the map changes according to the radii selected.
6. When happy with the circle radii, click the **Run** button in the Circle options window.
7. A new window opens with the results
8. Click on the **Existing Output** tab to view production of energy crops within the polygon defined area.
9. Click on the **Modelled Output** tab to view the bioenergy crop potential for the circle.

11.4 Bioenergy crops (existing) – calculation tool

The bioenergy crop calculation tool (for existing bioenergy) enables calculation, for land under production, of:

- the expected yield (in tonnes)
- the amount of energy delivered to a processor or end-user (in toe)
- the amount of energy output in a usable form (in toe)
- the amount of energy output in a usable form (in kWh)
- the cost of the output energy (in either toe or c/kWh)
- the expected tonnes of carbon dioxide emissions saved by production of the bioenergy

The full crop calculation spreadsheet is available in the crop calculation tool, however by default only a few columns are shown. The calculation tool includes sections for:

- Crop yield
- Harvesting costs and losses
- Transport costs (on a per-km basis) and losses.
- Storage costs and losses
- Processing costs and losses
- Conversion to energy costs and efficiency
- Assessment of carbon dioxide savings.

Some specific assumptions that impact the selected values include:

SRC Willow:

- Harvested at 50% MC
- Chipped and converted in commercial scale biomass boiler
- Yield is averaged over production phase (i.e. not per harvest)
- Assume site is in full production.

Miscanthus:

- Harvested at 20% MC
- Baled at harvesting
- Converted in a boiler
- Only planted on high yield land
- Site is in full production.
- Yield is averaged over production phase (i.e. not per harvest)

Oil Seed Rape:

- Rape seed crushed to produce PPO
- PPO converted to biodiesel
- Biodiesel used in 33% efficient car engine
- Production of 356L biodiesel per tonne rapeseed
- Calorific value of biodiesel is 32.9 MJ/L

Wheat & Barley:

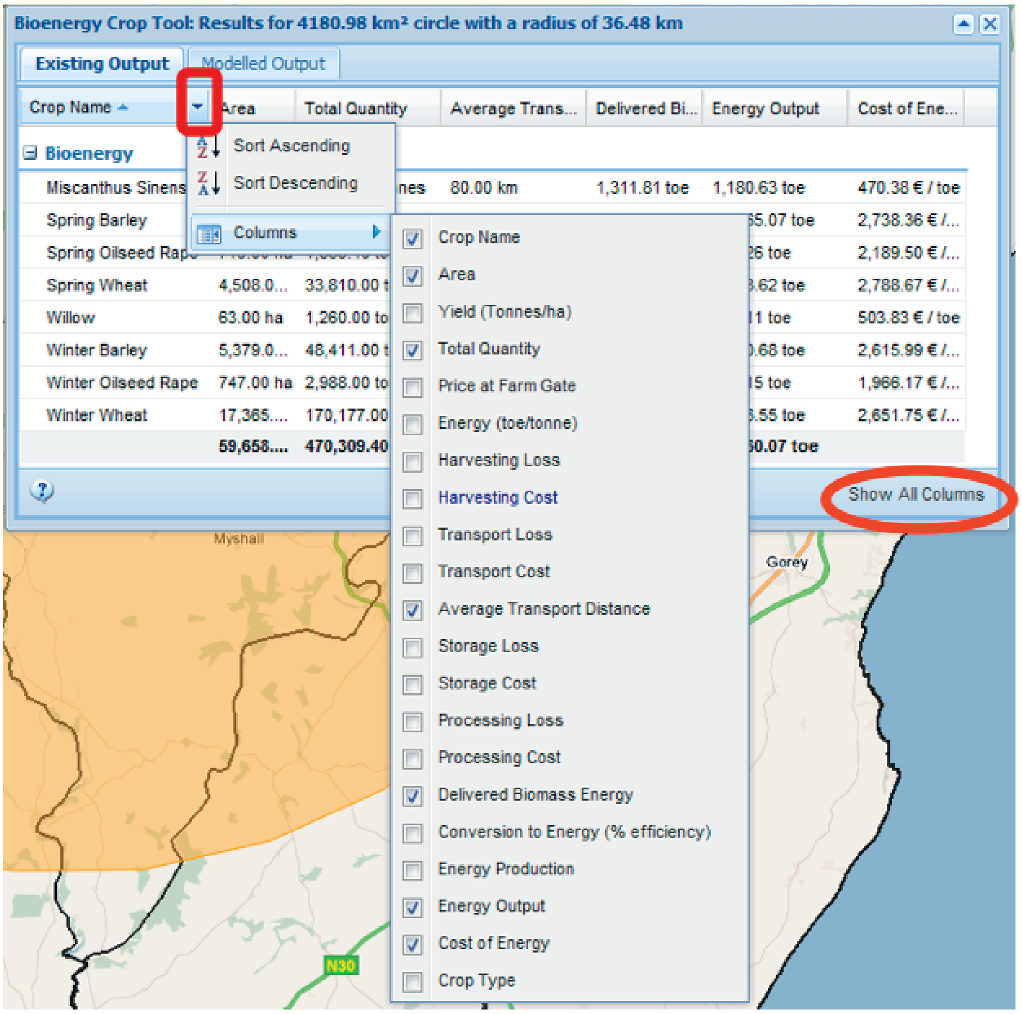
- Cereals used to make Bioethanol
- Bioethanol converted in 30% efficient car engine
- 355L Bioethanol per tonne grain
- Calorific value of Bioethanol is 21.2 MJ/L

11.4.1 View calculation tool columns not shown by default

There are two ways to view the additional columns.

1. Click on the **Show All Columns** button in the bottom right of the results table (as shown by the light red oval in Figure 29). The table will expand to show all columns
2. Select which columns to display using tick boxes.
    a. Place cursor over any of the table headings – a dropdown arrow will appear (as shown by the dark red rectangle in Figure 29).
    b. Click the drop down arrow – three choices appear (note that the table can be sorted by any column in the table)
    c. Click the columns option
    d. A list of possible columns appears. Tick the boxes of the columns to be displayed
    e. Click back in the table to view the updated table.

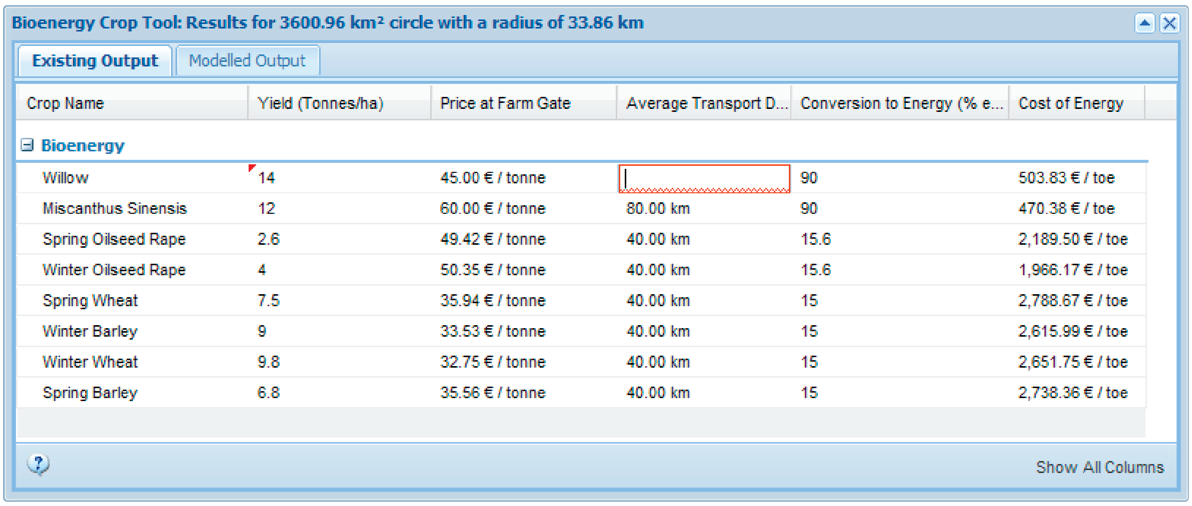
Figure 29: Bioenergy crop tool results table demonstrating how to show additional columns.



11.4.2 Modify values in the calculation table

The user is able to modify any of the values within the table by clicking on the value and typing over it, as shown in Figure 30.

Figure 30: Modifying calculation tool values



11.4.3. The calculations

The calculations that are run within the table are:

1. **Total quantity** (TQ) (tonnes) of material
   a. TQ = # hectares (ha) * yield (tonnes/ha)

2. **Delivered energy content** (DEC) (toe). This assess what enters the processing facility, taking into account losses en-route in:
   a. harvesting (H);
   b. transportation (T);
   c. storage (S) and
   d. pre-processing (PP).

   Note that all losses are entered into the table as a percentage of the initial material, hence in the calculation (which assesses what remains after losses) the factor (1 – H), etc., is used.

   e. The energy content (EC) is defined in tonnes of oil equivalent per tonne of material (toe/tonne)

   DEC = TQ * EC * (1-H) * (1-T) * (1-S) * (1-PP)

3. Usable **energy output** (EO) (toe) – the amount of energy delivered in a usable format, takes account of energy delivered to the processing facility and the conversion efficiency (CE) of the processing facility:
   a. EO = DEC * CE
4. Usable **energy output** (EOk) (kWh)
   a. EOk = EO * 11630
5. **Cost per toe of usable energy delivered** (CE). This sums the costs of each section of the supply chain, and then divides by the amount of usable energy delivered. Individual costs include:
   a. Cost at the farm gate (CFG)
   b. Harvesting cost per tonne (HC)
   c. Transport cost per km, * distance travelled (TC)
   d. Storage cost per tonne (SC)
   e. Pre-processing cost per tonne (PPC)
   f. Cost of producing the energy (PC)

   Then the equation used becomes:

   CE = [CFG * TQ + HC*(TQ*(1-H)) + TC*(TQ*(1-H)) + SC*(TQ*(1-H)*(1-T) + PPC*(TQ*(1-H)*(1-T)*(1-S)) + PC*DEC]/EO

6. **Cost per kWh of usable energy** delivered (CEk).

   CEk = CE *100/11630

7. **Tonnes of carbon dioxide abated** (TCO_2). This depends on what form of fossil fuel energy is being replaced. Necessarily a number of assumptions have been made to enable this calculation. Also, no account of the carbon implications of the bioenergy vs. Fossil fuel supply chains has been made. It should be taken as a very rough guideline only. The assumptions made regarding fossil fuels being replaced, and the carbon intensity (CI) of these fossil fuels, are:

Bioenergy crop	Final energy carrier	Displaces fossil fuel type	Carbon intensity of fossil fuel type (kg/kWh)
Miscanthus	Solid biomass	Burning oil	0.29207
SRC Willow	Solid biomass	Burning oil	0.29207
Oil Seed Rape	Biodiesel	Diesel	0.1478
Wheat	Bioethanol	Petrol	0.1868
Barley	Bioethanol	Petrol	0.1868

The equation used is:

TCO2 = CI * EOk/1000

11.5 Bioenergy crops (potential) – calculation tool

Only the potential total energy (toe) and total value of energy crop production can be calculated using this tool.

11.5.1 Potential total energy (toe)

The total energy potential (TEP), if all available land in a selected area was planted with the given energy crop, is calculated as follows:

TEP_{crop} = Total potential production (TPP) (tonnes) * energy density (toe/tonne)

$= \sum (hectares_{suitability}\ x * yield_{suitability\ x})$ * energy density (toe/tonne)

Where $hectares_{suitability\ x}$ = number of hectares of land, in selected area, that has suitability x for that energy crop (where x = unavailable; unsuitable; low; medium or high).

And $yield_{suitability\ x}$ = tonnes per hectare, for the given energy crop, on land that has suitability x.

Note if the interest is in potential production from less than the full range of land suitabilities, it is possible to manually enter 0 in either the number of hectares, or yield per hectare, for suitabilities that aren't of interest. See Figure 30 for an example of changing table data.

11.5.2 Total value of energy crop production

The total value (TV) of potential energy crop production in a selected area is given by:

TV = Total potential production (tonnes) * Energy crop value (€/tonne)

Note if the interest is in total potential value from less than the full range of land suitabilities, it is possible to manually enter 0 in either the number of hectares, or yield per hectare, for suitabilities that aren't of interest. See Figure 30 for an example of changing table data.

RASLRES

For further information contact:

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

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

www.wdc.ie

www.raslres.eu

Northern Periphery Programme 2007–2013

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

European Union
European Regional Development Fund