Ricardo Energy & Environment

Potential Biomass Prices in Ireland

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Summary

Overview

The price that solid biomass will be available at in Ireland is a key assumption underpinning the formulation of heat incentive tariffs. As part of efforts to ensure that the RHI in Ireland is designed to meet the target for renewable heat at least cost, SEAI have sought advice from Ricardo Energy and Environment on the price and availability of biomass resources for use in the heat sector in Ireland.

This summary highlights key information gathered, and important considerations around biomass supply chains, energy security, infrastructure, and sustainability which need to be taken into account when setting a price to use in analysis of the tariff. It is important that the price reflects as accurately as possible the price that biomass developers will see in the market place as schemes become operational, as if the assumed price in the tariff analysis is lower than is actually seen in the market place then uptake is likely to be lower than forecast as switching to biomass will not be an attractive option. This in turn could mean that Ireland's 2020 targets for renewable heat use under the Renewable Heat Directive are not met. Conversely, if the assumed price is higher than is seen in the market place, then operators will potentially be over subsidised.

The price ranges recommended for consideration are based on prices for wood pellets rather than wood chips, which are typically available at a lower cost. This approach is adopted as there will be a number of potential biomass users for whom a variety of site specific factors will mean that use of wood chips will not be an option, or for whom a local supply of wood chips is not available. It is considered that the price assumption used should not exclude these users, as this could restrict uptake under the scheme, and as discussed above lead to heat targets not being met.

All prices quoted in the report are exclusive of VAT and are on a net calorific (lower heating) value basis.

The price of wood pellets in Ireland varies depending on the size of delivery, but for a bulk, blown delivery of a minimum of 3t is in the range of 5 to 5.3 c/kWh and for larger deliveries can drop to 4.6 c/kWh. An analysis of the prices of imported biomass suggest that imported pellets could currently be delivered within Ireland for between 4.6 to 5 c/kWh. A price of 5 c/kWh could therefore be considered an appropriate price for 2017. The price of chips is lower (at about 3 c/kWh) but as indicated above, there will be a number of potential users for whom use of chips rather than pellets will not be a realistic option, and it is not considered that this should be used as a general price in the analysis.

However, the proposed RHI is unlikely to be operational for several months, and potential applicants to the scheme will be considering the biomass price which they will face in the initial years of operation. By 2018/2019, most market analysts consider that the price of pellets which has fallen over the last couple of years, due to oversupply, will begin to rise again. **An appropriate price to be used for analysis for the period over which the proposed RHI is likely to become operational is considered to be 5.5 to 6.5 c/kWh**.

In the short terms it is likely that at least some of the additional demand generated by the proposed RHI will need to me met by imported pellets and the lower end of this price range **(5.5 c/kWh)** is therefore based on the estimated price of imported pellets in 2019 given forecasts of future CIF prices for pellets. The potential risk of using this price in the analysis is that the availability of biomass at this price may be limited. This is because this price may not be high enough to incentivise investment at Irish ports to develop the additional infrastructure required to deal with large scale biomass imports, meaning that supply of imported pellets may be restricted. Similarly this price may not provide sufficient incentive for additional domestic supply biomass supply chains to be developed and bring additional supply to the market. Finally the impact that meeting potential sustainability requirements may have on the price or availability of imported biomass is currently not known, but if significant could mean that some international biomass would not be available at this price. If supply is not sufficient to meet demand then it is likely that the market price would rise.

A price at the top end of this range (of 6.5 c/kWh) could help to overcome these risks, and ensure that adequate supplies of sustainable biomass are available to support the levels of uptake which are

desired to help meet renewable heat targets. Provided that the benefit of the higher price accrues to biomass suppliers rather than operator, then a higher price should help to ensure that the investment in necessary infrastructure for large scale imported supply happens, thus mitigating the risk that quantities of imported pellets could be limited by a lack of appropriate infrastructure. A higher price should also be sufficient to encourage more rapid and fuller development of domestic supply chains, by incentivising their development. This would help mitigate against the risk of being overly dependent on international supplies and fluctuations in the international market and in foreign exchange rates. This could be particularly important, if as suggested by some modelling of international biomass resources, the international biomass market tighten in the future, as more countries look to exploit biomass as a way of decarbonising their economies.

The main evidence used in developing this recommendation is summarised below. Full details of all the information gathered is given in the main body of the report, with a summary of all price data in Section 5.

Price used in current RHI Analysis

In the modelling analysis undertaken by Element Energy for DCCAE for the RHI in 2016, an import price at the high end of a range published by Ofgem in UK's Reformed and Refocused RHI Impact Assessment was used. This was due to the uncertainty on the availability of sustainably solid biomass imports for Ireland, The Sterling value was taken as 5.0 p/kWh which translates into a 6.9 c/kWh at average 2015 €/£ foreign exchange rates. Due to the substantial change in the €/£ exchange rate since 2015, this would translate into only 5.7 c/kWh at the average exchange rate for 2017[1].

Current UK and Irish Prices

Data from the UK shows a relatively wide range of current market prices for wood pellets, ranging from 4 to 4.6 p/kWh, i.e. between the central (4 p/kWh) and high (5p/kWh) range published in OFGEM's RHI Impact assessment. This is 4.6 to 5.2 c/kWh at current exchange rates. Another recent survey of pellet prices to commercial consumers in the UK also found a wide price range (of 3.7 to 5.4 p/kWh) with an average price of 4.4 p/kWh. This is equivalent to 5.1 c/kWh. Current market prices in Ireland are also within this range at 4.6 c/kWh to 5.3 c/kWh, with the lower prices associated with larger deliveries. Prices for wood chips, which not all potential sites would be able to utilise, are lower, at around 2.9 to 3.1 c/kWh.

Price of potential additional domestic biomass supply

An initial analysis of the price at which future domestic biomass supplies in Ireland could be developed suggests that an initial tranche of biomass with lower production costs could be supplied at prices similar to current market prices. The analysis suggests that biomass resources with higher production costs (such as some forestry resources and energy crops) could be delivered as pellets in prices in the range of 4.5 to 7.1 c/kWh. There is some uncertainly in these prices as the development of detailed data on the cost of pelletisation, storage and distribution in Ireland was not within the scope of this study, so data from the literature (for the UK for 2010) has been used. However, they illustrate the approximate prices at which additional domestic biomass could be delivered, and, and allow the price of domestic supply to be set in context against prices for imported biomass.

Price of imported biomass

Information on the current spot prices of pellets at Rotterdam and in the Baltic suggests that these could be delivered to customers in Ireland at prices of 4.6 and 5 c/kWh respectively, rising to 5.2 to 5.5 c/kWh by 2019. The lower prices reflect estimates based on the CIF[2] price at Rotterdam and the higher price is an estimate based on the CIF price for the Baltic market. There is some uncertainty in these values. Firstly the CIF price is a spot price, and prices under bilateral contracts negotiated directly between producer and buyer could be lower. Secondly, detailed cost data on shipping costs to Ireland and on the final steps in the supply chain in Ireland are not available. There is typically substantial demand for pellets from the Baltic region from Nordic countries where biomass use is high, although it is possible that if demand were to further increase, pellet production capacity in the region would rise to meet it. Imports to Ireland could come from North America, for which the Rotterdam prices are more representative, although exports from North America are typically in very

[1]Average exchange rate from January to September 2017. Based on monthly exchange rates from Central Bank of Ireland. https://www.centralbank.ie/statistics/interest-rates-exchange-rates/exchange-rates. Accessed 13/10/2017.
[2] CIF is cost, insurance and freight and refers to the price to the purchaser as delivered by the shipper at the port.

large loads (more than 10,000 t) and not all Irish ports may currently have suitable facilities to process such large loads.

Factors to be considered in setting price range

In considering a suitable price to be used for analysis, it is also important to consider factors which could limit the availability of sustainable biomass in Ireland, and whether the risk to supply posed by these factors could be affected by the market price of biomass:

- **Energy security**: a reliance on imported biomass would expose Ireland to fluctuations in international pellet supply and international pellet prices, as well as fluctuations in foreign exchange rates. Incentivising development of domestic biomass resources and domestic biomass supply chains, could help to ensure some diversity of supply, which should help to provide a more stable supply and price for biomass. Such diversity of supply could be particularly important in the longer term, if, as seems possible, international demand rises and the market tightens, leading to a more constrained supply and potentially higher prices for imported biomass. Given the estimated prices for additional supplies of domestic biomass, it is likely that a price at the top end of the range suggested, would be necessary to ensure that this development occurred within the timeframe necessary to support biomass use in the RHI.
- **Infrastructure:** increasing amounts of imported biomass could require further development of appropriate facilities at ports in Ireland, and increased use of either imported or domestic biomass is likely to require development of storage and distribution logistics. Investment to develop such facilities is likely to require the market to consider that the future price of biomass will be sufficient to give a return on such investments. A price at the top end of the price range suggested should be sufficient to incentivise these investments and reduce the risk that supply of biomass is limited by lack of appropriate infrastructure.
- **Sustainability:** If sustainability requirements are set for the RHI on a par with those in the recast of the Renewable Energy Directive, then the GHG criteria could preclude transport of pellets from very long distances and pellets that are not produced using heat and electricity which is itself generated from biomass. The land criteria are likely to require certification of the biomass used to produce pellets to appropriate forestry standards, which could preclude some sources of supply. As the EU is a large market for pellets it is likely that suppliers exporting to the EU will ensure that these standards are met, but in the short term supplies of accredited biomass could be restricted. The potential additional cost for imported biomass of demonstrating sustainability standards are met is not currently known.

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1 Introduction

The price that solid biomass will be available at in Ireland is a key assumption underpinning the formulation of heat incentive tariffs. As part of efforts to ensure that the RHI in Ireland is designed to meet the target for renewable heat at least cost, SEAI have sought advice from Ricardo Energy and Environment on the price and availability of biomass resources for use in the heat sector in Ireland.

This short report summarises information on the current prices of biomass in Ireland, examines information on prices of internationally traded biomass and what price this might be available for in Ireland. It also considers the price that biomass from additional development of Irelands domestic resource might be available at. The report then discusses other aspects associated with the importation of biomass – sustainability requirements and infrastructure requirements.

Finally it recommends a range of prices for consideration in any further analysis of the proposed RHI. All prices quoted in the report are exclusive of VAT and are on a net calorific (lower heating) value basis.

2 Biomass supply

2.1 How is biomass supplied

Biomass boilers within the non-ETS non domestic sector covered by the RHI are most likely to use wood chips or wood pellets[3].

Wood pellets are made from wood which has been dried, chipped, milled, and then moulded into pellets which are uniform in size and shape in a pellet mill. If produced overseas, pellets must then be transported to a port, shipped to Ireland, unloaded into transfer hoppers or storage silos at the dock and then loaded on to trucks for delivery to depots or storage yards from where they may be distributed onwards to customers.

Feedstocks for pellets can also include waste products from sawmills, such as sawdust and wood shavings, which have the advantage that they are already relatively dry. Pellets are much drier than wood chips, and this and their compressed form means that they take up less storage space than wood chips and are easier to transport.

Different grades of pellets are available. Pellets for smaller scale boilers generally need to be of a higher quality to ensure that they do not create too much ash in the boilers. Larger industrial scale boilers, where there is more operational oversight, and other types of end users (e.g. cofiring in power stations) can generally accept lower quality 'industrial' pellets. Quality standards for wood pellets, such as the widely used ENplus quality certification scheme[4], set criteria for the quality of pellets, including a minimum energy content per tonne, although particular brands may have higher energy contents.

Pellets may be supplied bagged (typically in bags of about 15kg) for smaller scale boilers, e.g. in the domestic market, with users typically able to order about a 1t of pellets in bags on pallets. For the larger scale boilers, it is more typical to have bulk delivery of pellets to a storage facility or hopper, with pellets often blown from the lorry to the storage hopper. The minimum tonnage delivered in this way is typically 3 tonnes. Typical deliveries for medium size installations could be around 10 tonnes, but the maximum delivery size can be up to 32 tonnes, if there is enough storage on site.

Wood chips are cheaper than wood pellets (as they require less processing) but require more storage and are bulkier to transport, meaning that delivery is often restricted to a smaller area from the source of supply than for pellets. For example, in the UK most chips transported in the UK are transported over short distances (e.g. 16 km)[5], and in the price analysis in Section 3.1.3, the transport costs for delivery of chips are based on a maximum journey distance of 50km.

The energy content of wood chips (per tonne) will vary depending on how dry the wood chips are, but biomass boilers will specify an upper limit for the moisture content of chips they can take. Sites installing biomass systems will need to make a decision as to whether to use chips or pellets at the design stage as storage requirements and arrangements for feeding the biomass to the boiler, as well as the actual boiler or set up of the boiler will be different for chips and pellets. While the lower cost of wood chips means that there is more of an incentive for larger installations, where fuel costs are a more significant proportion of costs, to use chips, the actual decisions is likely to depend on a number of site-specific factors. These may include:

- How much space is available for storage
- What type of vehicular access is available and whether the location of the site means that it is desirable to limit the number of deliveries
- Planning regulations, and the desire to ensure that e.g. fuel storage are below the size at which planning is required6.
- The requirement for greater operational oversight of chip boilers and chip storage

[3] It is also possible to use logs, but these systems cannot be automated and while they may be used in the domestic sector are not commonly used in the non-domestic sector, although there are some examples. Other potential fuels include straw and other agricultural residues, as well as recovered waste wood.
[4] http://www.enplus-pellets.eu/
[5] Evidence from Angela Duignan of the Forestry Commission quoted in E4Tech, 2010. Biomass prices in the heat and electricity sectors in the UK. Report for Department of Energy and Climate Change.
[6] See for example, Planning and Development Regulations 2008. http://www.irishstatutebook.ie/eli/2008/si/235/made/en/print class 18 9a0

- Concerns about being tied to a single or limited number of local wood chip suppliers, as opposed to being able to source pellets from a wider area and number of fuel suppliers

For some potential users wishing to switch from fossil fuels to biomass, a combination of the factors above will mean that the switch is only feasible for the operator if pellets rather than chips are used. There are several examples in the UK, of larger users opting for pellets rather than chips (Box 2.1). For smaller boilers in commercial rather than industrial sites, pellets are more likely to be used, particularly in urban areas.

Box 2.1 Examples of larger installations using pellets

Tomtatin Distillery in Inverness has installed a 4MW wood pellet fuelled steam boiler, which as displaced the majority of the distillery's heavy fuel oil usage (See: www.brites.eu/portfolio-item/tomatin-distillery/)

Specialist lettuce grower Darnicle Hill nursery in Hertfordshire has a high heat demand and installed a 975 kW pellet boiler to heat the whole nursery. It has a very large 100-tonne pellet store that is topped up at least once per month throughout the year and once per week in the winter. These pellet deliveries are made using a specialist 'artic blower' lorry which can transfer the 26 tonne delivery to the store in 30 minutes. (See: www.forestfuels.co.uk/case-studies/darnicle-hill-nursery-hertfordshire-trusts-forest-fuels-deliver-26-tonnes-wood-pellets-biomass-boiler/)

Poultry farmer Tom Forgrave from Ballymoney in Northern Ireland has installed six 99 kW wood pellet boilers, one for each of his six sheds which together house 110,000 broiler chickens. The pellet boilers replaced a gas canopy brooder system. (See: www.daera-ni.gov.uk/articles/heat-biomass).

To protect the EU from the introduction of plant pests, a phytosanitary certificate is required for wood chips that are imported from outside of the EU. Exact requirements depend on the country of origin, but typically require that the chips have been heat treated or kiln dried and are bark free[7]. Wood chips from other parts of the EU may require a plant passport.

2.2 Potential demand for biomass under the RHI

Existing modelling undertaken to support the design of the RHI suggests that there is a potential for the delivery of up to an additional 1,200 GWh of heat from the installation of new boilers in the non-domestic, non-ETS sector. This would require about 1,500 GWh of biomass fuel. If supplied by wood pellets, this would require about 370,000 tonnes and if by wood chip between 370,000 and 430,000 tonnes (depending on moisture content)[8]. This new biomass demand could be met by additional wood fuels produced in Ireland and/or or by imported biomass, probably in the form of pellets.

2.3 Potential availability of biomass in Ireland

Ireland currently uses biomass from domestic sources as a fuel. There are two major pellet producers, Balcas and Laois, producing a total of around 80,000 tonnes (368 GWh) of pellets from sawmill residues, which is sold as both bagged and bulk supply. Residues from sawmills, and panel board mills are also used in CHP plant and boilers, particularly in the wood processing industry and panel board mills.

The potential biomass resource in Ireland, i.e. what could be available if there was a demand for bioenergy resources, and technologies were available to utilise them, was estimated in previous work by Ricardo for SEAI[9]. As well as waste wood, and sawmill residues, there is the potential to extract additional biomass from the forestry sector. In the longer term, the planting of energy crops such as short rotation willow or Miscanthus could also provide biomass suitable for boilers.

The estimated **potential** solid biomass resource (excluding straw[10]) is shown in

[7] Heat treatment must ensure that a minimum of core temperature of 56^{0}C is achieved for at least 30 minutes; kiln drying is to below 20% moisture content
[8] Assuming an NCV for wood pellets of 4600 kWh/t and a range of moisture contents for chips of 20% to 30% giving NCVs of 3491 to 4086 kWh/t.
[9] Ricardo Energy & Environment, 2016. Bioenergy Supply Curves for Ireland – Update. Report for SEAI.
[10] The straw resource in 2002 is estimated as 1074 GWh. However straw is unlikely to be traded in the same way as wood chips and pellets, as it is extremely bulky to transport, and is hence not considered further in this analysis.

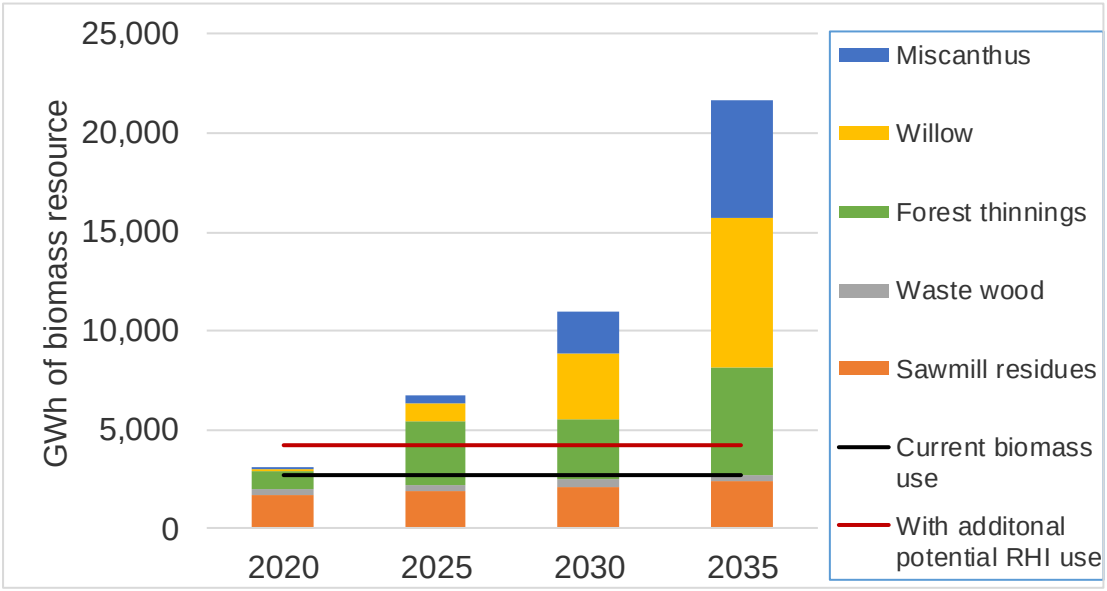
Figure 2-1. It should be noted that considerable development of the relevant biomass supply chains would be necessary to bring these resources to market, and make them available to users.

This shows that in the short term to 2020, the potential resource is mainly comprised of sawmill residues (much of which is already currently utilised) and forest thinnings. The term forest thinnings covers not just small roundwood which is removed from the forest to thin plantations, but also smaller size material which is produced when the forest is finally harvested and is unsuitable for use as sawlogs and residues from final harvesting operations.

In the medium to long term, supply could be expanded with more resource extracted from forests, but the greatest increase in biomass resource could come from the development of energy crops, although these are typically only available at higher costs, and will require substantial development of the supply chain.

It is estimated, based on data from the 2016 energy balance for Ireland, and information from Energy in Ireland 2015, that 2,747 GWh of wood from domestic sources are currently being used for heat and power within Ireland.[11] This accounts for about 90% of the estimated resource that could be available in 2020. In the short term therefore, depending on how quickly the additional demand likely under the proposed RHI ramped up, and whether demand for biomass for other uses (e.g. co-firing at power stations) increases, it is likely that the additional demand created by the proposed RHI would need to be met by some imported biomass as well as domestic resource. In the medium term however (i.e. by 2025), the additional demand could be met by domestic resources, if these were available at suitable prices. The potential production cost of domestic resources and the price at which they might be available to the market are discussed in detail in Section 3.1.3.

Figure 2-1 Potential Solid Biomass Resource in Ireland



2.4 Imported biomass

Pellets have been a growing market in Europe for the past 15-20 years. Europe (EU28) is currently the most significant consumer of pellets, accounting for about 75% of global consumption in 2015 and having about 50% of global pellet production capacity. Within the EU, estimated pellet consumption in 2015 was about 20 million tonnes (Mt), of which about one third (7Mt) were imported, predominantly

[11] Based on quantities of biomass and renewable waste produced domestically and imported in 2016; based on information in Energy in Ireland 1990-2015 (SEAI, 2016), it is assumed that biomass use in food and beverages industry is tallow, and biomass consumed in the cement industry is the renewable portion of solid waste. Non-traded wood consumption in the residential sector (logs for open fires and stoves) have been excluded.

(about 80%) from North America[12]. Within some Member States however, imports are much more significant, e.g. in the UK it is estimated that 95% of pellets consumed in 2016 were imported[13]. This trade includes both pellets for heating, but also of pellets for cofiring in power stations, with particularly large demands for this use in the UK and the Netherlands.

There are several regional 'pellet markets' in Europe, each of which has developed separately and each of which has distinct characteristics. These are:

- the Nordic market, fed by pellets from Sweden, Finland, Estonia, Latvia and Russia;
- the Portuguese ('Iberian') market, where surplus tends to be traded into Amsterdam or Rotterdam;
- the central European market (Germany-Switzerland-Austria);
- the western European market, dominated by imports to the North Sea (and Liverpool).

In the future, it is likely that many countries will become interested in utilising their biomass resource to meet domestic energy demand using low carbon sources. Recent work by Ricardo Energy & Environment for the UK Department for Business, Energy & Industrial Strategy, developed a model that examined global biomass resources and demand for biomass out to 2050 in order to evaluate the potential quantities of biomass that the UK could import to supplement domestic resources[14]. The model considered three future scenarios for global growth and two levels of future biomass demand as forecast by the IEA – one based on current policies and one based on a low carbon future where there is a high bioenergy demand[15].

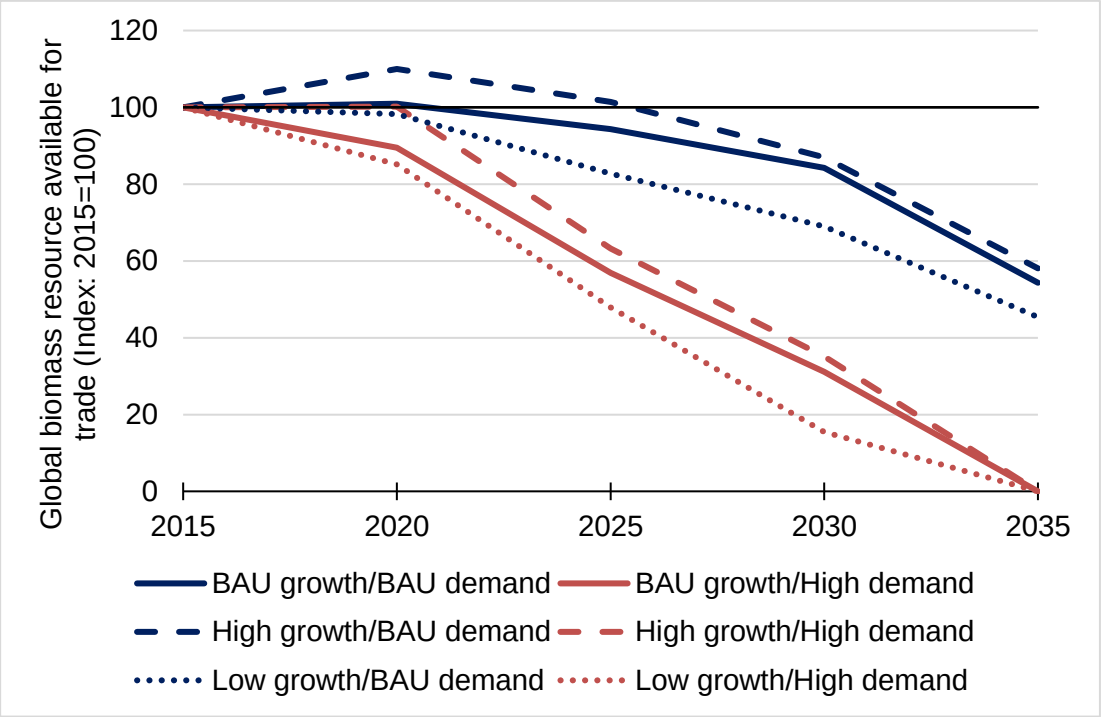
Figure 2-2 shows the trend in the potential quantities of forestry based biomass resource which might be available to trade once producer countries have satisfied domestic demands. The trade in wood pellets in 2015 was estimated to be about 7.7 Mt (35 TWh), which is only a small fraction (3%) of the theoretical global biomass forestry resources estimated by the model as available (1070 TWh) However mobilising this theoretical resource would require substantial development of the supply chains, pellet mills, and infrastructure (e.g. in ports for handling and storage of biomass), which could take several years. Under all future scenarios, the potential biomass resource available for trade is forecast to fall from 2020 onwards as demand increases, and in the case of high biomass demand, declines significantly.

If production of energy crops was to become established worldwide, then this could provide significant quantities of additional biomass which will help to meet global demand (Figure 2-3). Under optimistic assumptions about how rapidly energy crops might become established and expand (the high growth scenario) then quantities of biomass which could potentially be added would rise. However, under more cautions assumptions about the rate of growth that could be expected, then potentially tradeable quantities would still decline substantially if there was a high biomass demand internationally.

However, the scenarios modelled all suggest that in a Business as Usual (BAU) scenario, even if all the potential resources identified are mobilised, then quantities available for export in producer countries are likely to decline. Such a tightening of the market in the future could lead to an increase in prices.

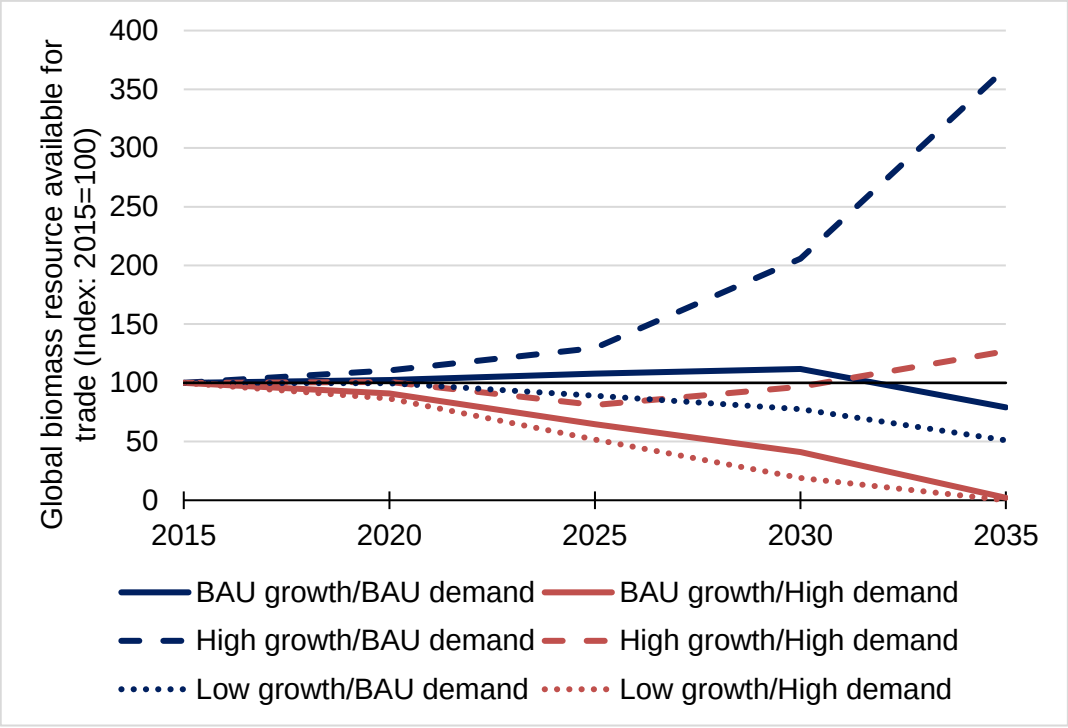
[12] Includes both pellets for the industrial sector (e.g. power plants, industrial CHP and district heating) and pellets for the heating market: the latter account for an estimated 64% of consumption. IEA Bioenergy: Task 40, 2017. Global Wood Pellet Industry and Trade Study 2017.
[13] Estimated production of wood pellets and briquettes in the UK in 2016 was 357 kt, imports were 7,136 kt and exports 21 kt. Forestry Commission, 2016. UK Wood Production and Trade: 2016 provisional figures. Available at https://www.forestry.gov.uk/forestry/beeh-a9zjnu (accessed 25/9/17)
[14] https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model
[15] The scenarios are the BAUI (including new policies) scenario and '450' scenario, where included in the IEA World Energy Outlook (2016). The latter illustrates how the international goal to limit the rise in long term average global temperature by stabilising the atmospheric concentration of greenhouse gases at 450 parts per million (ppm) of CO_2-equivalent might be achieved. In this scenario, use of bioenergy is much higher than under the 'New Policies' scenario,

Figure 2-2 Forecast trend in global forestry biomass resource available for trade



Source: Data from UK and Global Bioenergy Resource Model

Figure 2-3 Forecast trend in global forestry and energy crops resource available for trade



Source: Data from UK and Global Bioenergy Resource Model

3 Price of biomass

Throughout this section of the report, all prices have been converted from price per tonne on a lower heating value basis, using an energy content of 4600 kWh/tonne, which is the minimum required by the ENplus standard. All prices quoted in c/kWh are exclusive of VAT.

3.1 Current and historic pellet prices

3.1.1 Ireland and the UK

The section below discuses current prices found in Ireland and the UK, established through supplier websites for standard loads and telephone interviews for larger bulk deliveries. Current UK prices have been converted using the average exchange rate from January to September 2017 of 0.87 £/€.

Most schemes developed under the proposed RHI are likely to include storage facilities due to the lower cost of bulk delivery. For large bulk deliveries (of the order of 10 tonnes or above) current prices reported in Ireland were about 4.6 c/kWh. Small 'blown' bulk deliveries of 3 t generally in the range of 5 to 5.3 c/kWh, with bulk bags (of about 1 tonne) slightly higher than this again, apart from Laois sawmill, which has its own pelleting plant and advertises pellets at a price of under 4 c/kWh. This range of 5 to 5.3 c/kWh is consistent with SEAI's most recent analysis of commercial fuel prices in July 2017[16], which gives a price for bulk delivery of pellets of 5.2 c/kWh, and indicates that discounts may be available for larger quantities. Within the mainland of the UK prices for large bulk deliveries range from about 4.6 to 5.2 c/kWh depending on the exact size of the load and the delivery distance from depot. Some market intelligence from Northern Ireland suggests that prices there have shown a decline over the last couple of years to 4c/kWh or even lower currently. A recent survey for UK Government reported an average price for deliveries for commercial customers of 5.1 c/kWh, although there was a wider range (4.2 to 6.2 c/kWh)[17].

Bagged pellets are more expensive. Prices for a pallets worth of pellets (which will be about a tonne) in Ireland currently range from 5.4 to 6.7 c/kWh, with SEAI's most recent analysis of commercial fuel prices in July 2017, giving a price of 6.2 c/kWh. It is likely that only a few small boilers (perhaps in the 50kW size range) would use bagged pellets.

Wood chips are generally available at a lower price than pellets, and market data suggests are currently available at between 2.9 to 3.1 c/kWh in Ireland, with SEAI fuel price data giving an average price in July 2017 of 3 c/kWh. As noted in Section 2.1, not all potential users would however be able to utilise wood chip rather than pellets.

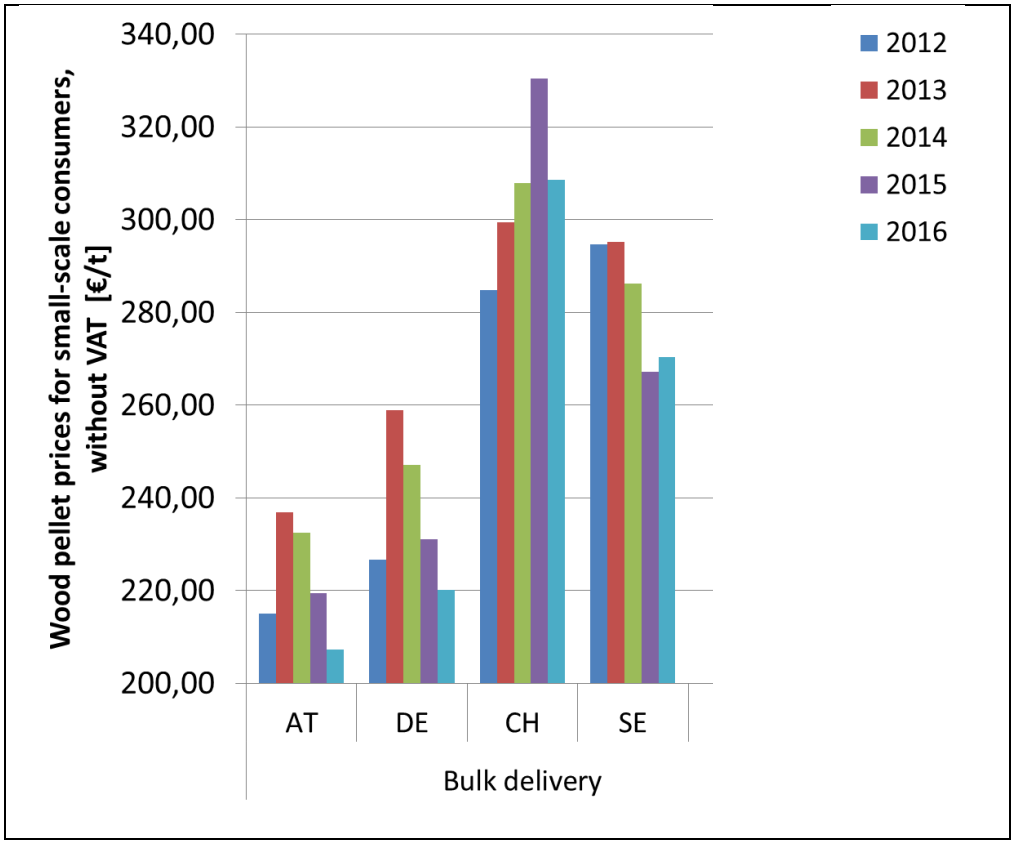
3.1.2 Other EU countries

Prices for residential customers in some key pellet using countries were summarised in a recent study by the IEA Bioenergy Task 40 (**Figure 3-1**). This found pellet prices for residential consumers in Austria, Germany are currently in the range of €205/t to €270/t (4.5 to 5.9 c/kWh), with prices in Switzerland of about €305/t (6.6 c/kWh). Prices have been higher in the past, generally peaked in 2013 and subsequently falling to the 2016. This was considered to be partly due to mild winters and in 2016 due to an oversupply in small-, medium- and industrial pellet markets.

[16] SEAI Commercial/Industrial Fuels Comparison of Energy Costs 01-Jul-17. Available at https://www.seai.ie/resources/publications/Commercial-Fuel-Cost-Comparison.pdf. Accessed 24/9/2017. Values converted from price per tonne using an NCV of 4.6 MWh per tonne; VAT deducted from quoted price at a rate of 13,5%,

[17] https://www.delta-ee.com/delta-ee-blog/can-wood-pellets-set-the-heating-market-alight.html. Accessed 13/10/2017

Figure 3-1 Comparison of wood pellet prices for small-scale consumers in European countries



Note: The price range shown on the graph axis of €200 to €340/t is equivalent to 4.3 to 7.2 c/kWh

Source: Global Wood Pellet Industry and Trade Study 2017, IEA Bioenergy: Task 40: June 2017

3.1.3 Additional domestic biomass supply

The cost of biomass resources in Ireland were estimated in previous work by Ricardo for SEAI[18]. These were costs for the harvested biomass at the point of production, so in the case of forest thinnings at the roadside or in the case of energy crops at the roadside. In order to translate these biomass costs into price of wood chips or pellets delivered to a boiler site, it is necessary to add on costs of collecting the biomass, storing it, chipping it, pelleting it and delivery of the chips or pellets to the final consumer, as well as the margin which the chip or pellet supplier will wish to achieve over costs. An extensive estimation of these additional costs is not within the scope of this work, and is being modelled in detail in work to estimate uptake of technologies. However an approximate estimation of the additional costs involved in processing and delivering the biomass to end users, is useful here in order to allow some comparison with the costs of imported biomass. An estimation has therefore been made using cost data from a bottom-up estimation of biomass costs made to support analysis in the original stages of the RHI in the UK[19]. The values used are shown in Table 3.1 and Table 3.2. As well as cost for the different processing steps, the original methodology also allowed for a margin for pellet and chip suppliers of 20% and 10% respectively; these values were based on evidence that margins for UK chip producers were very low[20], and were lower than those for pellet producers. In Figure 3-2 these margins have been applied to the total cost of biomass and costs incurred up to the point of supply.

[18] Ricardo Energy & Environment, 2016. Bioenergy Supply Curves for Ireland – Update. Report for SEAI.
[19] E4Tech, 2010. Biomass prices in the heat and electricity sectors in the UK. Report for Department of Energy and Climate Change.
[20] Value for chip supplier margin in E4Tech, 2010, was based on views provided by experts in the Forestry Commission in the UK and experts at the Biomass Energy Centre in the UK.

Table 3.1 Estimated additional costs for provision of domestic biomass as chips

	2010 p/kWh	2017 c/kWh[a]
Chipping (if required)	0.2	0.3
Transport to distributors store	0.2	0.3
Storage	0.3	0.4
Transport to final customer	0.5	0.6
Total additional cost (no chipping required)	***1.0***	***1.3***
Total additional cost (chipping required)	***1.2***	***1.5***
Margin for chip supplier (applied to total final cost including cost of biomass)		10%

Source: E4Tech, 2010[21].

Notes: (a) Costs converted at 2010 exchange rate and then inflated to 2017 prices using GDP deflators for Ireland[22]

Table 3.2 Estimated additional costs for provision of domestic biomass as pellets

	2010 p/kWh	2017 c/kWh[a]
Transport of fibre to pellet mill	0.2	0.2
Pellet production	0.9	1.1
Transport to pellet depot and storage at depot	0.3	0.4
Transport to final customer	0.4	0.5
Total additional cost (chipping required)	***1.8***	***2.3***
Margin for pellet supplier (applied to total final cost including cost of biomass)		20%

Source: E4Tech, 2010[21].

Notes: (a) Costs converted at 2010 exchange rate and then inflated to 2017 prices using GDP deflators for Ireland[22]

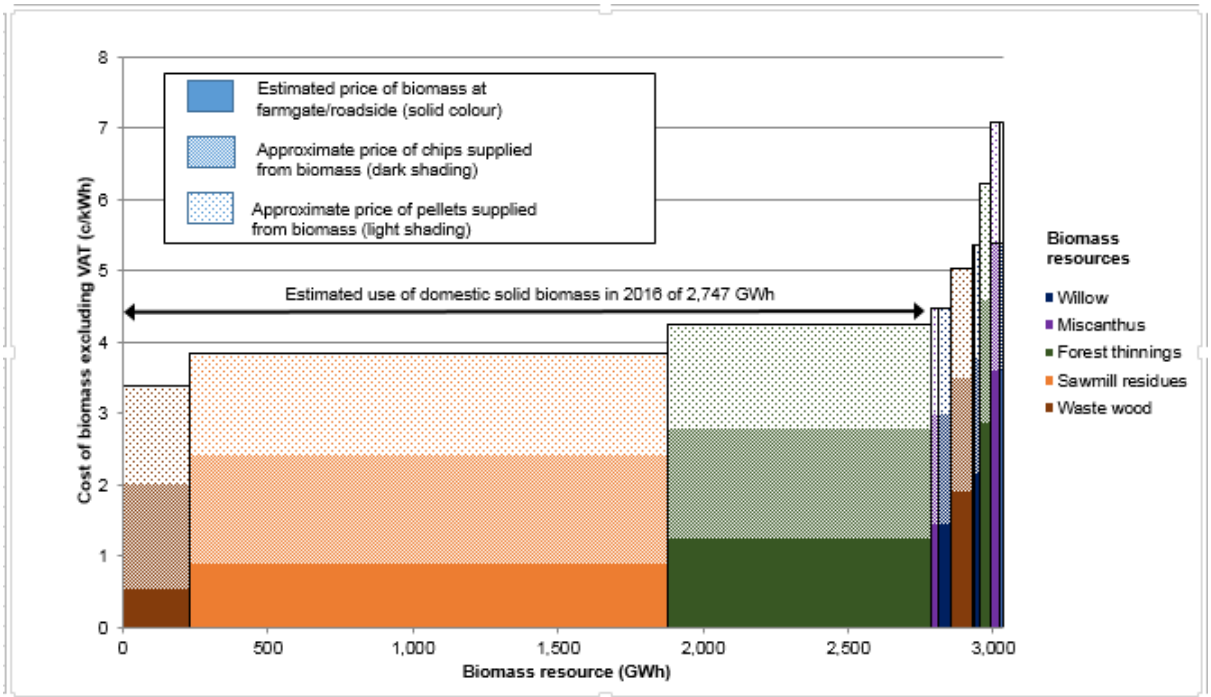
The results are shown in Figure 3-2 for the quantities of biomass resource which could be available in 2020 (excluding straw). As discussed in Section 2.3, it is estimated that 2,747 GWh of wood from domestic sources are currently being used for heat and power within Ireland[23]. This accounts for almost all (98%) of the low cost waste wood, sawmill residue resource and lower cost forest thinnings, shown in Figure 3-2. These resources are already being utilised in boilers or combined heat and power plant, often in the wood processing industry, or being used to produce pellets for other end users. This means if the extra demand generated by the proposed RHI were to be met from domestic sources, then it would need to come from energy crops as willow and Miscanthus and additional forest thinning and waste wood, all of which have a higher resource costs than resources meeting current biomass demand.

[21] E4Tech, 2010[21]. Biomass prices in the heat and electricity sectors in the UK. Report for Department of Energy and Climate Change.
[22] While the cost of diesel at the pump has fallen by about 10% in real terms between 2010 and 2017 (based on data for Ireland in the DG ENER weekly oil bulletin (https://ec.europa.eu/energy/en/data-analysis/weekly-oil-bulletin: accessed 23/10/2017), fuel costs are only between 17% and 30% of haulage costs (http://www.fta.co.uk/policy_and_compliance/fuel_prices_and_economy/fuel_prices/fuel_fractions.html accessed 23/10/2017) meaning the change in diesel price is likely to reduce the estimated transport costs by only about 2 to 3%.
[23] Based on quantities of biomass and renewable waste produced domestically and imported in 2016; based on information in Energy in Ireland 1990-2015 (SEAI, 2016), it is assumed that biomass use in food and beverages industry is tallow, and biomass consumed in the cement industry is the renewable portion of solid waste. Non-traded wood consumption in the residential sector (logs for open fires and stoves) have been excluded.

While it was estimated that forest thinnings might be available at the road side for about 1.2 c/kWh; it is estimated that the price of delivered wood chips from this resource would be approximately 2.8 to 3.1 c/kWh[24], and for delivered pellets about 4.3 c/kWh. Energy crops show similar on-costs for supply as chips (additional costs of 1.5 to 2.1 c/kWh comprising of the costs shown in Table 3.1 and a chip supplier margin of 10% applied to the total final cost) and as pellets (additional costs of 3.0 to 3.5 c/kWh comprising of the costs shown in Table 3.2 and a pellet supplier margin of 20%). This means that energy crops and additional forest thinnings and waste wood, could be available for between 3.3 and 5.5 c/kWh as chips and 4.5 to 7.1 c/kWh as pellets.

As discussed above the analysis underpinning Figure 3-2 is approximate only, but it clearly illustrates how for lower cost biomass resources, the production cost of biomass fibre only accounts for about a third of the delivered cost of pellets. The value of 3.8 c/kWh for pellets produced from sawmill residues corresponds well to the current bulk price of pellets sold by one of Irelands pellet producers (Laois Sawmill).

Figure 3-2 Estimated price of chips and pellets produced from domestically sourced biomass



3.1.4 Prices for Imported Biomass

The prices for delivered pellets generally reflect a mix of both imported and domestically produced pellets. As discussed earlier, pellets could be imported to Ireland from several sources.

Since around 2009 two indices have been established to monitor markets in the Nordic and Baltic and at the Amsterdam-Rotterdam-Antwerp (ARA) port regions. These give an insight into spot prices for pellets and trends with time, but they do not represent the whole picture, which includes bilateral contracts for long periods, annual contracts and local markets in which transport costs are not as significant as in long distance trade. Nevertheless there are some important points:

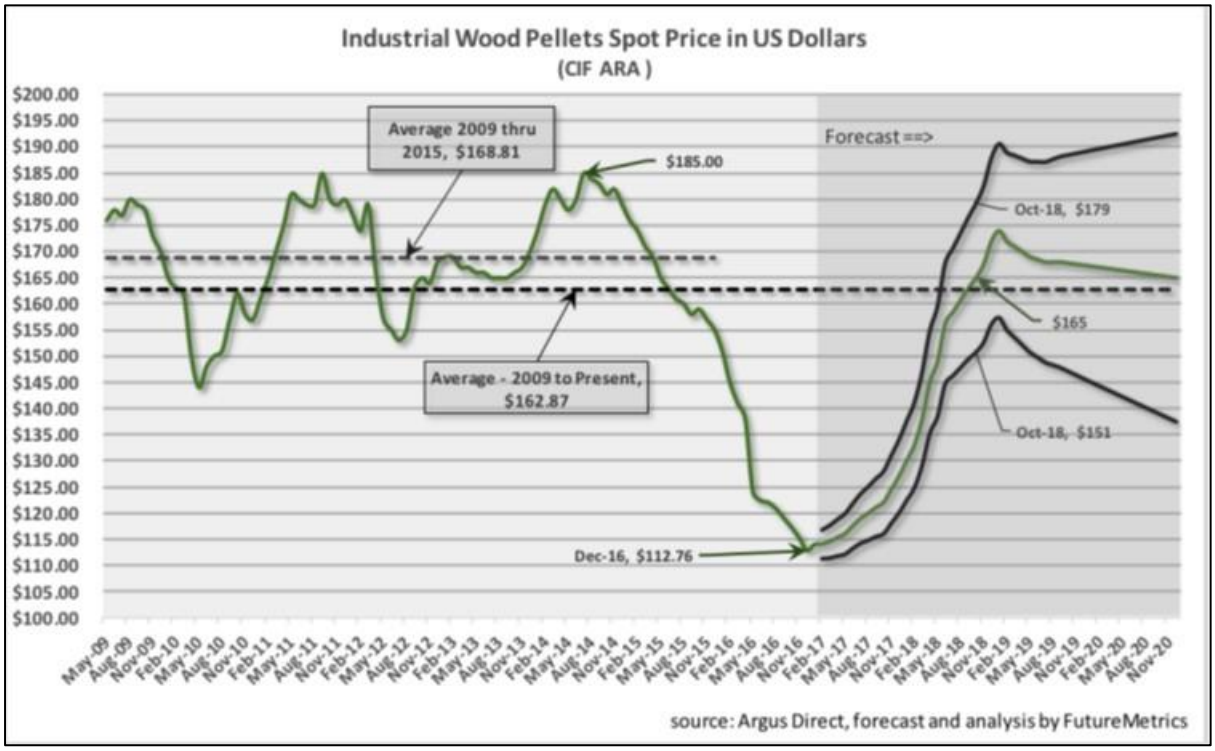
- ARA[25] prices reflect bulk import from North America and from some parts of Europe (e.g. Portugal). Prices for biomass arriving at Irish ports will be of the same order, bearing in mind that these shipments are generally large (>10,000 tonnes). Tariffs and handling costs at the port need to be added to any CIF price.

[24] The variation in prices depends whether thinnings are chipped as part of the harvesting process or require chipping as a separate operation.
[25] ARA is Amsterdam, Rotterdam and Antwerp, referring to these ports. Indices usually quote prices as CIF ARA, meaning the price on arrival at one of these ports. CIF is cost, insurance and freight and refers to a contract in which the seller arranges for the carriage of goods by sea to a port, with all the documentation required for the buyer to obtain the goods from the carrier. The buyer is then responsible for transfer of good at the port and may have to pay destination handling charges and may also have to pay customs entry and duty charges, as well as transport to the final destination.

- The prices quoted for the PIX Nordic are CIF prices for pellets produced in the Baltic or Russia at a Nordic or Baltic port. Shipping from these ports will be in smaller loads than from North America and for some Irish ports this might be more appropriate. Trade in the Baltic is dominated by Latvia, Finland and Russian and CIS pellets.

Figure 3-3 shows the prices of pellets delivered to ARA ports, on a CIF (cost, insurance and freight) basis over the last few years. It should be noted that the very low prices seen in late 2016 of $112/t (€106/t equivalent to 2.3 c/kWh) occurred against a background of warm winter weather and low fossil fuel prices. Argus[26] commented that this price was likely '*brushing the floor production costs for many suppliers' and represented an imbalance of supply and demand'*. Current prices of $148/t (€124/t equivalent to 2.7 c/kWh) are much more typical, and indeed information on forward prices indicates that the price could rise reaching $176/t in 2019 (€158/t equivalent to 3.4 c/kWh)[27].

Figure 3-3 Historic and forecast spot price for wood pellets at Amsterdam, Rotterdam and Antwerp (ARA)



Note: Green line represents historic prices and central forecast going forward; black lines indicate low and high price forecasts.
Source: IEA Bioenergy Task 40: Global Wood Pellet Industry and Trade Study 2017

To allow an approximate estimate of the price of these imported pellets as delivered to an end user in Ireland, information on costs incurred by the pellet supplier in Ireland has been taken from the same bottom-up estimation of biomass costs made to support analysis in the original stages of the RHI in the UK as above[28]. Estimated additional costs are shown in Table 3.3. As with the additional costs of domestic supply, a pellet supplier margin of 20% (as set in the original methodology) has been added, based on the total cost of the pellets and other costs incurred up to the point of supply.

[26] Argus Media April 2016
[27] Historic prices converted to € using historic exchange rate data. Forward prices converted using the average exchange rate for January to September 2017 of $1.11/€
[28] E4Tech, 2010. Biomass prices in the heat and electricity sectors in the UK. Report for Department of Energy and Climate Change. Costs converted at 2010 exchange rate and then inflated to 2017 prices using GDP deflators for Ireland.

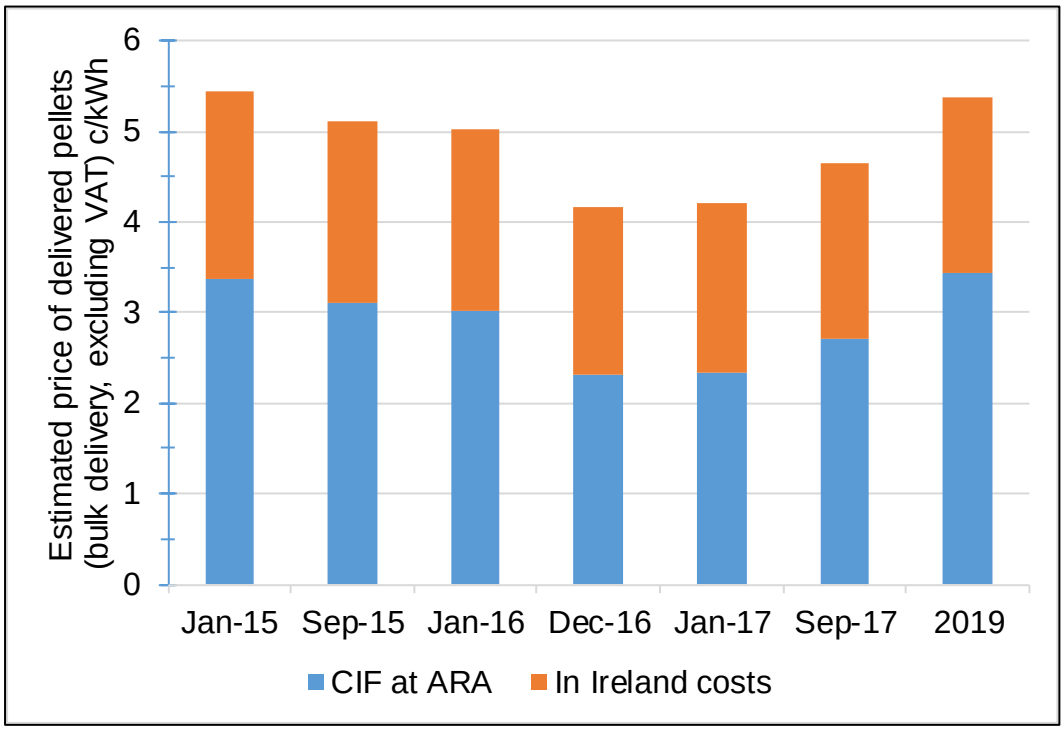
Table 3.3 Estimated additional costs for delivery of imported pellets in Ireland

	2010 p/kWh	2017 c/kWh[a]
Haul from port to store in Ireland and unloading	0.1	0.2
Storage	0.3	0.4
Screening	0.1	0.1
Transport to final customer	0.4	0.5
Total additional cost	***0.9***	***1.2***
Margin for pellet supplier (applied to total final cost)		20%

Source: E4Tech, 2010[28]

The results shown in Figure 3-4 give an estimate of 4.6 c/kWh (for bulk delivery) for CIF prices in September 2017 of $148/t (€124/t equivalent to 2.7 c/kWh). The forecast CIF price for 2019 of $176/t in 2019 (€158/t equivalent to 3.4 c/kWh) would equate to a bulk delivery price to the customer in Ireland of 5.5 c/kWh.

Figure 3-4 Estimated price of delivered pellets based on historic and forecast spot prices (CIF) at ARA

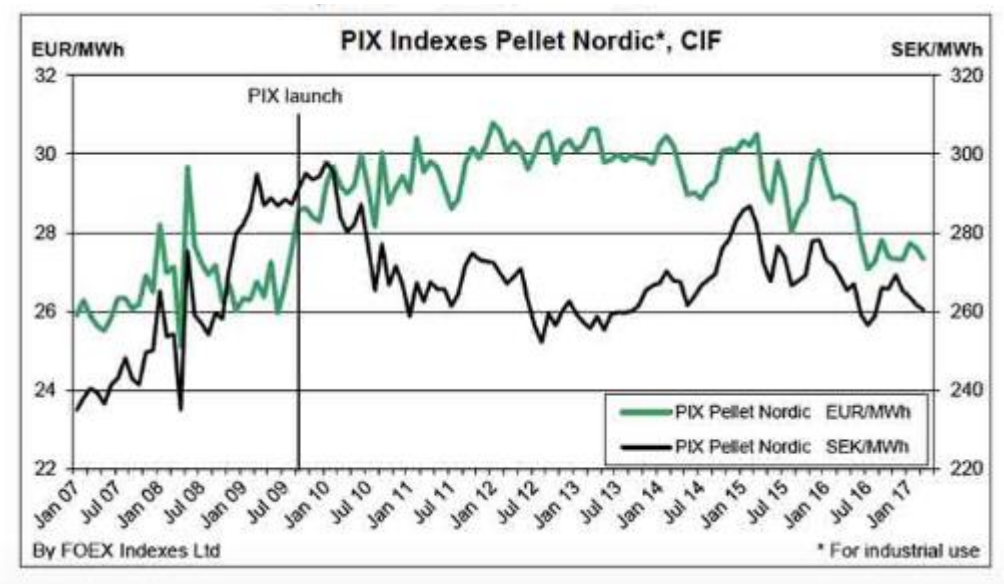


Information on the price of industrial pellets in Nordic countries and the other countries in the Baltic Sea region is available from the FOEX PIX Pellet Nordic Index[29], which gives monthly (CIF) prices for pellets at ports in the region. As shown in Figure 3-5, over the last couple of years prices have shown a downward trend, falling from a price of about €30/MWh (3 c/kWh) to a price in mid September 2017 of €26/MWh (2.6 c/kWh). Assuming a cost for shipping to Ireland of €17/t[30], and costs in Ireland and supplier margin as in the analysis above for pellets imported from North America, gives an estimated price for bulk delivery of 'Baltic' pellets in Ireland based on the September CIF price of 5.0 c/kWh. The higher CIF price of €30//MWh seen historically would, using the same assumptions about shipping and delivery give an estimated price for pellets delivered in Ireland of 5.4 c/kWh. Current forecasts for

[29] http://www.foex.fi/biomass/
[30] Based on spot price for freight from Riga to ARA quoted in Argus Biomass Markets Issue 16-014 of 6 April 2016.

this Index suggest that the future CIF price is likely to be closer to €28/MWh, which equates to an estimated delivered price of 5.2 c/kWh.

Figure 3-5 PIX Pellet Nordic Index



Source: Bioenergy & Bioeconomy Business News and Directory[31]

3.2 Factors that influence pellet prices

Like other solid fuel markets, the pellet market is volatile and prices vary considerably over time. The greatest variations result from changes in demand, which relate to weather (i.e. heat demand) and Government incentives. Supply has increased steadily in Europe to meet demand for pellets and reliability has improved with the introduction of standards and clear specifications.

At present many pellet producers in Europe are not currently producing at full capacity due to oversupply of pellets caused by reduced demand due to mild winters, and a surplus of pellets in the bulk market (see below). It is believed that around 20% of production capacity in Europe is not used at present. This means that there is some capacity to increase pellet production in Europe if there is additional demand in Ireland, and the market price in Ireland is sufficient to support production. Demand in other parts of Europe is also likely to increase however, which could also reduce the oversupply situation, and could result in an increase in prices. This has been seen in the past when extra demand in the heat sector (in places like Italy), resulted in a mismatch between pellet demand and supply, sending prices up for industrial heat pellets.

The bulk market is also affected by demand in the electricity market. Large scale electricity demand has established a trans-Atlantic trade, which is very responsive to changes in the market. This is influenced by large changes, such as when a power station comes on line or a plant closes. For example, when the plan to convert the Langerlo plant in Belgium were shelved, taking demand for 1.6Mt off line, this caused an immediate drop in demand and prices. However, the sector is expecting Lynemouth and MGT to come on line in 2018. These changes in demand have had a significant impact on CIF ARA prices. In December 2016, the CIF ARA price for US pellets was $112/t, a 7 year low. Since then prices have increased to $148/t, presumably as the market adjusted to the new situation and cut production).

Key factors that influence pellet price are:

- **Demand**: Demand for pellets is forecast to increase by 9.5 million tonnes by 2025 (just for heat demand, not electricity), taking it to just under 25 Mt. Most of this demand (around 17-18 million tonnes) is in Europe. The forecast for total industrial pellet demand worldwide is around 42 Mt/y for 2025. This expansion has given investors confidence to invest in pellet supply, but there are times when supply and demand are mismatched, causing fluctuations in

[31] http://www.business.conbio.info/pix-nordic-wood-pellet-index-april-declining-price-in-march/. Accessed 3/10/2017.

spot prices. Pellet suppliers tend to react by encouraging annual contracts for supply. Pellet users react by looking for longer term contracts that iron out the worst of the fluctuations.

- **Weather**: mild winters tend to decrease demand and prices; cold winters tend to increase demand and prices. Cold spells in Europe have created supply crises in the past, accompanied by high prices and poor quality pellets.
- **Oil price**: In their 2017 market outlook, the Wood Pellet Association of Canada (WPAC) commented that the recent low oil price is also thought to have influenced demand for biomass, leading to a decrease in demand[32]. Other wood fuel suppliers[33] have given a similar market commentary. WPAC predicts that this will change in the future, commenting that, based on expected petroleum prices from 2018 onwards, demand in biomass heating markets will resume their traditional growth[34]. The IEA also consider that the oil market is likely to tighten over the medium term (to 2022) and that prices will rise[35], and this is borne out with the most recent IEA market report suggesting that the oil market is beginning to rebalance, that markets are tightening and that prices will rise, albeit very modestly, in the short term[36].
- **Currency fluctuations** can also be important for imported supply from North America. In 2015 and 2016, the strength of the dollar compared to the Euro meant that the price of pellets from North America in Euros rose for European customers. This made selling pellets into the European market difficult for US pellet producers[37].
- **Size of customer demand:** for bulk deliveries, customers requiring large amounts, delivered regularly, may be able to negotiate discounts.

[32] Wood Pellet Association of Canada, 2017. Global pellet market outlook in 2017, https://www.pellet.org/wpac-news/global-pellet-market-outlook-in-2017. Accessed 27/9/2017.
[33] See for example, Forever Fuels. 'Future Prospects for Wood Pellet Prices and Availability'. Available at http://www.forever-fuels.com/future-prospects-wood-pellet-prices-and-availability. Accessed 27/9/2017. Accessed 27/9/2017.
[34] Wood Pellet Association of Canada, 2017. Global pellet market outlook in 2017, https://www.pellet.org/wpac-news/global-pellet-market-outlook-in-2017. Accessed 27/9/2017.
[35] IEA, 2017. 'Oil 2017: Analysis and forecasts to 2022: Executive Summary'. Available at https://www.iea.org/Textbase/npsum/oil2017MRSsum.pdf. Accessed 6/10/2017.
[36] IEA Oil Market Report: 13 September 2017. Available at https://www.iea.org/oilmarketreport/omrpublic/currentreport/#Overview. Accessed 6/10/2017.
[37]Information provided by a biomass supplier, based on their experience of the market over the past year, and confirmed by analysts Hawkins Wright in a recent presentation: http://saee.gov.ua/sites/default/files/Blair_Louisa_NBB17.pdf. Accessed 27/9/2017.

4 Other considerations

4.1 Sustainability requirements

While European legislation does not currently require mandatory sustainability standards for renewable heat, in order to ensure that energy within Ireland is as sustainable as possible, it is likely that some criteria will be introduced with the proposed scheme. This is the case within the UK, where the RHI requires that heat produced must meet sustainability requirements[38]:

- greenhouse gas (GHG) emissions from heat production must be less than 34.8 gCO_2 eq per MJ (equivalent to 125.3 gCO2 per kWh) of heat; these emissions include those associated with producing, processing and transporting the fuel
- wood must not come from areas of high biodiversity or high carbon stock, and must be produced sustainably.

In the UK suppliers of biomass fuels can, if they prove their fuel meets the sustainability criteria register on the Biomass Suppliers List (BSL). RHI participants then only have to provide evidence that they have brought their fuel from an accredited supplier on the BSL to meet the sustainability criteria. BSL suppliers must demonstrate that their BSL registered fuel is 100% from legal sources and at least 70% from sustainable or deemed sustainable sources. Evidence for this can be provided by demonstrating that the fuel is certified under Timber Standard approved schemes: the Programme for the Endorsement of Forest Certification (PEFC) or Forest Stewardship Council certification. If this is not available, then suppliers can provide evidence through a felling licence and UK Forestry Standard compliant management plan (for wood from the UK) or provision of a Risk-Based Regional Assessment (RBRA) to demonstrate that there is a low risk they do not meet the land criteria requirements.[39]

At the EU level, under the proposed recast of the Renewable Energy Directive (RED recast)[40], sustainability requirements will be made mandatory for heat and electricity as well as biofuels, although to avoid excessive administrative burden it is proposed that they will not apply to small biomass installations under 20 MW. Member States may, however, apply them to small sized installations if they wish. The proposed GHG criteria is that heat produced in installations starting operation from 2021 onwards must deliver heat with GHG emissions of 16 g CO_2/ MJ (equivalent to 57.6 gCO2 per kWh) heat delivered.[41] This limit is just under half that currently in place in the UK. In addition, the wood fuel would have to be sustainably produced and not be sourced from areas of high biodiversity or high carbon stock.

Typical savings delivered by biomass fuels contained in Annexes to the proposed RED recast, suggest that the source of heat and power used in wood pellet production has a strong influence on whether wood pellets would meet the GHG criteria. These typical savings indicate that, apart from when wood industry residues are used, it will be necessary for pellet mills to ensure that a biomass fired CHP is used to provide power and process heat for drying to the pellet mill if the criteria are to be met. Transport distances for pellets have a smaller influence on the GHG emissions, but long transport distances (of more than 10,000 km) could prevent the criteria being met for some sources of wood.

In the case of wood chips, as they are less energy dense to transport, distances have a much more significant impact on whether the criteria can be met, and the calculations of typical emissions suggest that regardless of the source of wood chip, longer transport distances (over about 2500 km) would mean that they would not meet the criteria.

As demonstrating compliance with sustainability requirements requires certification system to demonstrate chain of custody and mass balance, it will incur costs (e.g. certification and auditing costs). A 2012 report by IEA bioenergy[42] found that cost of compliance for biomass or biofuels ranges

[38] Fuels which are wastes are exempt from the requirements and some residues are exempt from the land criteria
[39] Biomass Suppliers List: Land Criteria Guidance (Issue 1.1). Available at https://biomass-suppliers-list.service.gov.uk/Content/Documents/BSL%20Land%20Criteria%20Guidance%20-%20V1.1.pdf. Accessed 29/9/2017
[40] COM (2016) 767: Proposal for a Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources (recast)
[41] This is based on achieving an 80% GHG saving compared to the fossil fuel standard for heat of 80 g CO_2/MJ and is proposed to rise to an 85% saving for plant beginning operation in 2025 onwards, which is equivalent to 12g CO2/MJ.
[42] IEA Bioenergy, 2012. Strategic Inter-Task Study (Task 40/43/38): Monitoring Sustainability Certification of Bioenergy: Task 2: Survey on governance and certification of sustainable biomass and bioenergy

from 0.02 to 18 $/ton (equivalent to 0.3 c/kWh) but stated “It is unclear whether the large range in estimated costs stems from differences in which specific costs were included or from actual differences in costs of certification across regions or schemes. Respondents indicated that the most significant costs associated with pursuing certification were those for the services of the certifier and auditors, due to the extra administration and fees paid to the certification body.” It should be noted that the prices for biomass supply in the UK included in this report already include the costs of meeting the sustainability requirements.

4.2 Infrastructure requirements for imports

Biomass imports to Ireland will require facilities at ports and infrastructure for storage and onward transport. Port infrastructure will need to include berths with appropriate handling equipment, port storage and hoppers or blowers to load inland transport. It will require a workforce that understands the handling of pellets (which can disintegrate if not handled appropriately), explosion and fire hazard suppression systems and dust management. We have discussed Irish ports below and provided examples of investment in the UK to demonstrate what needs to be introduced and the investment required for large scale import.

Wood chips can also be imported. Their trade is well-known for paper and pulp requirements. In this case phytosanitary regulations should be adhered to; like pellets port handling and infrastructure will be required.

Trade in wood pellets has been likened to coal. In fact, as indicated above, pellets are not as dense as coal and are more prone to handling issues (e.g. dust), so do require different handling. However, in the UK a number of the ports that traditionally handled coal have been converted to handle pellets, mainly because the forwarding infrastructure is there and often grabs and conveyor belts used for coal can initially be used for pellets. There is one important difference, however, and that is that pellets must be stored under cover. In the UK concrete silos, metal silos and ‘domes’ have been used to store pellets. In their most sophisticated form the domes come with monitoring equipment to understand changes that indicate that there is a fire or explosion hazard in the pellets.

Ports need to be able to handle ships of a particular size to import pellets. In general shipping is of varying size depending on quantities and the port of origin. Most pellet trade from North American now comes in loads of 25,000 or more, in handysize (25,000t), handyman (up to 35,000) or panamax vessels (that can transport 50,000-80,000t). Trade within Europe is usually in smaller vessels, particularly from the Baltic where ports do not have the facilities for large vessels. Key ports in the Baltic include Vyborg, St Petersburg, Riga and Liepaja. These ports can handle small Baltic coasters up to 4,000 tons to large bulk carriers up to 50,000 tons. The available literature implies that these Baltic ports need investment in biomass facilities[43] and Baltic trade is sometimes referred to as ‘unreliable’, but all these ports have successfully acted as hubs for export across the Baltic and beyond. Latvian trade is already established with Irish suppliers; and we have heard from large scale users in the UK that their shipments from Russia arrive reliably into the UK. However the same may not be true of small scale shipments, and it has been reported that there are handling issues at some Russian ports that may hold up small scale supplies.[44]

4.2.1 Shipping of biomass pellets and chips

As indicated above, biomass can be shipped in dry bulk carriers, such as those designed for coal, iron ore and other biomass commodities such as grain. It is important to consider the issues that arise from deterioration both because of poor handling and natural degradation in shipping. The latter must be monitored during passage due to fire and asphyxiation hazards (particularly due to carbon monoxide)[45].

In 2009 the IEA reported that obstacles to competitive maritime shipping biomass included; shipping demand for other products, reliability of biomass supply from plants, port inadequacies, lack of back-haul, and characteristics of biomass requiring specialty shipping[46]. Freight prices are dependent on:

[43] See, for example, Proskurina et al. (2017) Logistical, economic, environmental and regulatory conditions for future wood pellet transportation by sear to Europe: The case of Northwest Russian Seaports Renewable and Sustainable Energy Reviews 56 (2016) 38–50
[44] Proskurina et al. (2017) Logistical, economic, environmental and regulatory conditions for future wood pellet transportation by sear to Europe: The case of Northwest Russian Seaports Renewable and Sustainable Energy Reviews 56 (2016) 38–50
[45] High levels of CO, CO_2 and methane have been reported. See http://www.ieabioenergy.com/wp-content/uploads/2013/10/Health-and-Safety-Aspects-of-Solid-Biomass-Storage-Transportation-and-Feeding.pdf and Gauthier et al in Ann Occup Hyg 56 (7) 755-763, where a death in Ireland is included.
[46] Bradley et al (2009) World Biofuel maritime shipping study, for IEA bioenergy Task 40

demand for shipping; charter rate; bunker prices; duration of voyage; exchange rates. Handling costs at ports and port fees are on top of this.

The IEA report indicated that typical unloading facilities for dry bulk cargo include cranes and grabs that load the cargo into large hoppers that are fixed to high capacity travelling cranes to feed railway wagons, trucks or conveyor belts. At some ports there is pneumatic handling equipment, suitable for free flowing materials such as pellets, grain, soybeans, soy meal, rape etc. The report recommended that gentle pellet loading, storage and transportation systems are essential to minimizing the amount of dust or fines generated during handling.

4.2.2 Irish ports

In 2016 Irish ports handled 50 million tonnes of goods[47], including around 16 million tonnes of dry bulk goods. These are busy ports. A summary of three key ports where pellets might be imported is provided in Table 4.1. One issue is quay space and unloading and storage facilities for biomass imports, as while this can be done using grabs and other equipment that already exist, ideally specialist hoppers or blower and covered conveyor belts for unloading and transporting pellets to purpose built covered silos or straight to onward transport are desirable, both to preserve the quality of the pellets and most importantly to minimise potential hazards. Although all three ports are currently undergoing long term investment upgrades it is not clear if these upgrades will include facilities for biomass, as this cargo is not mentioned in annual reports or forward plans.

There is no indication that any of these ports have facilities to handle large scale import of biomass to Ireland. Investment is required if large scale pellet import is to happen. Further investigation is required with port owners to understand if current investment plans consider biomass and if there is room for routine biomass imports. It is also important to understand infrastructure needs for forwarding the pellets beyond the ports. Storage at port can only be temporary, as the use of port land for storage will be expensive.

Table 4.1 Characteristics of three key ports in Ireland

Port	Trade	Plans
Dublin	Handles 50% of Ireland's trade, mainly with Europe and UK	Masterplan 2012 to 2040, a € 600M 10 year capital expenditure programme approved in Dec 2016. The Masterplan plan is to double port volumes over 30 years. It will provide an additional 16.1 ha of port lands, redevelop 720m of quay walls and develop a new inland port facility[48]
Shannon Foynes	Ireland's largest dry bulk port, handling trade outside of Europe. Can take ships up to 200,000dwt.	Vision 2041 aims to increase trade from 10 to 20M/y. This includes investment of €123M on port infrastructure and €325M on upgrading road and rail infrastructure. Work includes construction of deep water port at Foynes Island. [49, 50]
Cork	Includes dry bulk facilities. Trades mainly with Europe	Port is undergoing a €800 million Euro investment to improve its handling facilities for larger vessels. Key issue for Cork is onward transport.

4.2.3 UK ports: investment for biomass imports

The nature of investment required for large scale import of biomass pellets can be seen in the UK. Table 4.2 below summarises investment made in the UK and in Rotterdam to handle biomass. At the very least appropriate off loading and storage facilities are required, to ensure that the pellets do not deteriorate in handling and to keep dust levels down. Stevedore companies at UK ports train staff to handle pellets and about the potential hazards from pellets, such as carbon monoxide, fire and explosion risks. Expensive covered conveyor belts have been installed in some ports, but other ports use grab unloaders. As pellets must be stored indoors most ports now have silos or domes for short term storage. Within the UK, initial small scale imports of biomass when the Renewables Obligation

[47] http://www.cso.ie/en/releasesandpublications/er/spt/statisticsofporttraffic2016/
[48] http://www.dublinport.ie/wp-content/uploads/2016/08/Dublin-Port-Annual-Report-2016.pdf
[49] 2016 annual report http://www.sfpc.ie/download/SFPC%20Annual%20Report%202016%20(web).pdf
[50] Shannon Foynes Economic Impact Assessment 2016.
http://www.sfpc.ie/download/SFPC%20Economic%20Impact%20Assessment%20August%202016.pdf

and subsequently the RHI, began were handled with existing equipment. As the scale of imports grew, and confidence grew that imports of biomass were likely to continue at a more significant scale in the long term, ports began to invest in facilities for storing and handling biomass.

Table 4.2 Investments made in UK ports and at Rotterdam for Biomass Imports

Port	Facilities/Investment for biomass
Immingham	Upgraded to take panama vessels, including new terminal. Investment in travelling belt ship loader with an extending conveyor with spark detection (over 1km covered conveyors), unloading blowers, 4 storage domes (100,000t capacity) and road and rail loading facilities. [51]
Tyne	Investing £300m in import facilities, wood pellet storage and rail loading. £35m investment in extending the quay; £13m in specialist handling and storage equipment including "Eco-hoppers" for storage (three 36m high silos and 1300m of enclosed conveyors are under construction at the Port) [52]. Investment includes a 70,000-metric ton covered storage facility, a rail car loading silo, and two state-of-the-art mobile pellet hoppers, which effectively eliminate the fugitive dust created when pellet vessels are unloaded [53]
Peel Ports, Liverpool	Investment of £100m to handle biomass imports for Drax. Once complete the terminal is expected to be able to handle 10 train loads of pellets per day (up to 40 percent of the total wood pellets consumed by Drax each year). In addition to rail loading capability, the port facility will also feature 100,000 metric tons of pellet storage capacity.
Rotterdam	Handles 500,000t/y biomass, mainly in Handysize and Handymax, although they have put in facilities for Panamax. This is unloaded using grab cranes (like those used for coal). The port has invested in storage and management of explosion and fire hazard using a combination of cameras and heat sensors for monitoring. Rotterdam prides itself on being an intermodal hub, so that onward movement of goods is effective via shipping, rail and waterways right across Europe.

[51] http://biomassmagazine.com/articles/12092/new-u-k-port-facility-to-provide-pellets-to-drax/
[52] http://www.portoftyne.co.uk/news/port-of-tyne/further-investment-at-port-of-tyne/
[53] http://biomassmagazine.com/articles/9210/preparing-for-a-pellet-tide

5 Recommendations for Price Range to consider

In the modelling analysis undertaken by Element Energy for DCCAE for the RHI, due to the uncertainty on the availability of sustainably solid biomass imports for Ireland, an import price at the high end of a range published by Ofgem in UK's Reformed and Refocused RHI Impact Assessment was used. The Sterling value was taken as 5.0 p/kWh which translates into a 6.9 c/kWh at average 2015 €/£ foreign exchange rates. Due to the substantial change in the €/£ exchange rate since 2015, this would translate into only 5.7 c/kWh at the average exchange rate for 2017 (to September).

Evidence from a number of sources on current market prices for biomass, prices for imported biomass and the potential costs of additional domestic supply is summarised in Table 5.1.

Data from the UK on current prices found a relatively wide range of current market prices for wood pellets, ranging from 4 to 4.6 p/kWh, i.e. between the central (4 p/kWh) and high (5p/kWh) range published in OFGEM's RHI Impact assessment. This is 4.6 to 5.2 c/kWh at current exchange rates. Another recent survey of pellet prices to commercial consumers in the UK also found a wide price range (of 3.7 to 5.4 p/kWh) with an average price of 4.4 p/kWh. This is equivalent to 5.1 c/kWh. Current market prices in Ireland are also within this range at 4.6 c/kWh to 5.3 c/kWh, with the lower prices associated with larger deliveries. Prices for wood chips, which not all potential sites would be able to utilise, are lower, at around 2.9 to 3.1 c/kWh.

An initial analysis of the price at which future domestic biomass supplies in Ireland could be developed suggests that an initial tranche of biomass with lower production costs could be supplied at prices similar to current market prices. The analysis suggests that biomass resources with higher production costs (such as some forestry resources and energy crops) could be delivered as pellets in prices in the range of 4.5 to 7.1 c/kWh. There is some uncertainly in these prices as the development of detailed data on the cost of pelletisation, storage and distribution in Ireland was not within the scope of this study, so data from the literature (for the UK for 2010) has been used. However, they illustrate the approximate prices at which additional domestic biomass could be delivered, and, and allow the price of domestic supply to be set in context against prices for imported biomass.

Information on the current spot prices of pellets at Rotterdam and in the Baltic suggests that these could be delivered to customers in Ireland at prices of 4.6 and 5 c/kWh respectively, rising to 5.2 to 5.5 c/kWh by 2019. The lower prices reflect estimates based on the CIF[54] price at Rotterdam and the higher price is an estimate based on the CIF price for the Baltic market. There is some uncertainty in these values. Firstly the CIF price is a spot price, and prices under bilateral contracts negotiated directly between producer and buyer could be lower. Secondly, detailed cost data on shipping costs to Ireland and on the final steps in the supply chain in Ireland are not available. There is typically substantial demand for pellets from the Baltic region from Nordic countries where biomass use is high, although it is possible that if demand were to further increase, pellet production capacity in the region would rise to meet it. Imports to Ireland could come from North America, for which the Rotterdam prices are more representative, although exports from North America are typically in very large loads (more than 10,000 t) and not all Irish ports may currently have suitable facilities to process such large loads.

In considering a suitable price to be used for analysis, it is also important to consider factors which could limit the availability of sustainable biomass in Ireland, and whether the risk to supply posed by these factors could be affected by the market price of biomass:

- **Energy security**: a reliance on imported biomass would expose Ireland to fluctuations in international pellet supply and international pellet prices, as well as fluctuations in foreign exchange rates. Incentivising development of domestic biomass resources and domestic biomass supply chains, could help to ensure some diversity of supply, which should help to provide a more stable supply and price for biomass. Such diversity of supply could be particularly important in the longer term, if, as seems possible, international demand rises and the market tightens, leading to a more constrained supply and potentially higher prices for imported biomass. Given the estimated prices for additional supplies of domestic biomass, it is likely that a price at the top end of the range suggested, would be necessary to ensure that this development occurred within the timeframe necessary to support biomass use in the RHI.

[54] CIF is cost, insurance and freight and refers to the price to the purchaser as delivered by the shipper at the port.

- **Infrastructure:** increasing amounts of imported biomass could require further development of appropriate facilities at ports in Ireland, and increased use of either imported or domestic biomass is likely to require development of storage and distribution logistics. Investment to develop such facilities is likely to require the market to consider that the future price of biomass will be sufficient to give a return on such investments. A price at the top end of the price range suggested should be sufficient to incentivise these investments and reduce the risk that supply of biomass is limited by lack of appropriate infrastructure.
- **Sustainability:** If sustainability requirements are set for the RHI on a par with those in the recast of the Renewable Energy Directive, then the GHG criteria could preclude transport of pellets from very long distances and pellets that are not produced using heat and electricity which is itself generated from biomass. The land criteria are likely to require certification of the biomass used to produce pellets to appropriate forestry standards, which could preclude some sources of supply. As the EU is a large market for pellets it is likely that suppliers exporting to the EU will ensure that these standards are met, but in the short term supplies of accredited biomass could be restricted. The potential additional cost for imported biomass of demonstrating sustainability standards are met is not currently known.

The available data suggests that the price used in the initial analysis of 6.9 c/kWh is high compared to current market prices and current prices for imported biomass. The current price of wood pellets in Ireland is currently about 5 c/kWh, and an analysis of the prices of imported biomass suggest that imported pellets could be delivered within Ireland for this price range. A price of 5c/kWh could therefore be considered an appropriate price for 2017. The price of chips is lower (at about 3 c/kWh) but as indicated above, there will be a number of potential users for whom use of chips rather than pellets will not be a realistic option, and it is not considered that this should be used as a general price in the analysis.

However, the proposed RHI is unlikely to be operational for several months, and potential applicants to the scheme will be considering the biomass price which they will face in the initial years of operation. By 2018/2019, most market analysts consider that the price of pellets which has fallen over the last couple of years, due to oversupply, will begin to rise again. **An appropriate price to be used for analysis for the period over which the proposed RHI is likely to become operational is considered to be 5.5 to 6.5 c/kWh**.

In the short terms it is likely that at least some of the additional demand generated by the proposed RHI will need to me met by imported pellets and the lower end of this price range **(5.5 c/kWh)** is therefore based on the estimated price of imported pellets in 2019 given forecasts of future CIF prices for pellets. The potential risk of using this price in the analysis is that the availability of biomass at this price may be limited. This is because this price may not be high enough to incentivise investment at Irish ports to develop the additional infrastructure required to deal with large scale biomass imports, meaning that supply of imported pellets may be restricted. Similarly this price may not provide sufficient incentive for additional domestic supply biomass supply chains to be developed and bring additional supply to the market. Finally the impact that meeting potential sustainability requirements may have on the price or availability of imported biomass is currently not known, but if significant could mean that some international biomass would not be available at this price. If supply is not sufficient to meet demand then it is likely that the market price would rise.

A price at the top end of this range (of 6.5 c/kWh) could help to overcome these risks, and ensure that adequate supplies of sustainable biomass are available to support the levels of uptake which are desired to help meet renewable heat targets. Provided that the benefit of the higher price accrues to biomass suppliers rather than operator, then a higher price should help to ensure that the investment in necessary infrastructure for large scale imported supply happens, thus mitigating the risk that quantities of imported pellets could be limited by a lack of appropriate infrastructure. A higher price should also be sufficient to encourage more rapid and fuller development of domestic supply chains, by incentivising their development. This would help mitigate against the risk of being overly dependent on international supplies and fluctuations in the international market and in foreign exchange rates. This could be particularly important, if as suggested by some modelling of international biomass resources, the international biomass market tighten in the future, as more countries look to exploit biomass as a way of decarbonising their economies.

Table 5.1 Summary of price data

Type	Market	Basis	€/tonne (as delivered, excl VAT)	c/kWh (excl VAT and based on NCV[55])	Additional notes and commentary
Current market prices					
Pellets	Ireland	>10t	210	4.6	
		3t (blown delivery)	230 to 275	5.0 to 5.3	Price in SEAI report on commercial fuel prices in July 2017 is 5.2 c/kWh
		~ 1t (bulk bags)	>275	>5.3	Exception is Laois Sawmill which has its own pellet plant and is offering bulk bags at 4 c/kWh
	UK (mainland)	10 t or above	210 to 240	4.6 to 5.2	Likely to vary depending on size of load and distance from depot
	UK (Northern Ireland)	~ 10 t	~185 or below	~4 or below	Market intelligence suggest prices have fallen from those currently seen in mainland UK over the last couple of years
	Europe	Bulk delivery, 2016	205 to 270	4.5 to 5.9	Range of prices in Austria, Sweden and Denmark. Prices in Switzerland were higher (6.6 c/kWh). Prices have fallen to these levels from a peak in 2013
Chips	Ireland	>10t	115 to 125	3.3 to 3.6	Price in SEAI report on commercial fuel prices in July 2017 is 3.5 c/kWh
Extra domestic supply					
Pellets	Bulk delivery to customer in Ireland	Forestry resources	195	4.3	Based on forestry resources available at lower cost
		Energy crops	205 to 325	4.5 to 7.1	Also additional higher cost forestry resources and waste wood.
Chips		Forestry resources	100 to 110	2.8 to 3.1	Based on forestry resources available at lower cost
		Energy crops	105 to 200	3.0 to 5.7	Also additional higher cost forestry resources and waste wood.

[55] Assumed NCV of 4600 kWh/tonne for pellets which is the minimum NCV required by the ENplus standard, and 3500 kWh/tonne for wood chips at 30% moisture.

Table 5.1 Summary of price data (continued)

Type	Market	Basis	€/tonne (as delivered, excl VAT)	c/kWh (excl VAT and based on NCV[56])	Additional notes and commentary
Current imported biomass					
Pellets	Bulk delivery to customer in Ireland	Current Rotterdam market	214	4.6	Based on CIF price at ARA of $148/t (€124/t)
		Current Baltic Market	229	5.0	Based on CIF price in Baltic/Nordic region of €26/MWh (€120/t)
Future imported biomass (2019 price)					
Pellets	Bulk delivery to customer in Ireland	Future Rotterdam market	254	5.5	Based on forward price estimate for ARA market of €176/t in 2019
		Future Baltic market	240	5.2	Based on forward price estimate for Baltic/Nordic market of €28/MWh (€129/t) in 2019

[56] Assumed NCV of 4600 kWh/tonne for pellets which is the minimum NCV required by the ENplus standard, and 3500 kWh/tonne for wood chips at 30% moisture.

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