Forest-based biomass and modern bioenergy

Moving to net zero

A COFORD paper

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Published by the Department of Agriculture, Food and the Marine, Agriculture House, Kildare Street, Dublin 2, Ireland.

ISBN 978-1-902696-98-0

Citation: COFORD, 2024. Forest-based biomass and modern bioenergy Moving to net zero - A COFORD paper. COFORD, Kildare St. Dublin 2.
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Front cover image background. Photo courtesy of Eugene Hendrick.

Front cover image foreground. Biomass-fuelled combined heat and power plant at Mid Cork Pallets and Packaging, Macroom, Co Cork. Photo courtesy of Noel Gavigan.

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Abstract

Global carbon dioxide emissions arising from human activities rose again in 2022 to reach some 40.7 billion tonnes. The inevitable consequence has been a worldwide rise in atmospheric carbon dioxide concentrations, to some 421 parts per million in 2023, or about 51% above the pre-industrial level (around 278 ppm in 1750). Increases in carbon dioxide levels, allied to similar increases in methane and nitrous oxide emissions and levels, will, according to the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), result in a level of warming that will cause severe impacts on human well-being and biodiversity. As a result, the imperative is to rapidly and radically reduce emissions, while at the same time bolstering carbon dioxide removal from the atmosphere.

The agreed global approach under the Paris Agreement is to limit global warming to 1.5 °C, or at most 2 °C, compared to pre-industrial levels and to achieve a balance between emissions and removals in the second half of the century. Models used by the IPCC and similar approaches employed by the International Energy Agency (IEA) say that net zero greenhouse gas emissions by 2050, or shortly thereafter, will be needed to reach the temperature goals. Both approaches rely on deep and permanent cuts in emissions. In addition, and increasingly (as remaining carbon budget shrink) on carbon dioxide removal (CDR) from activities such as afforestation and forest management, and on bioenergy, and bioenergy with carbon capture and storage (BECCS), in order to move to net zero. The IEA roadmap foresees a contribution of around 18% from modern bioenergy to total global energy needs by 2050.

The EU's *Fit for 55* package aims to achieve carbon neutrality by mid-century with a strong focus on reducing emissions in industry and across all other sectors. The interim 2030 target is for a 55% reduction in emissions, compared with 2005 levels, with an EU-wide 40% reduction in emissions under the Effort Sharing Regulation (ESR), which covers agriculture, transport, residential and other sectors, and excludes emissions covered under the Emissions Trading System Directive (ETS). Ireland's target is a 42% reduction. Analysis shows that complying with the new target through existing and planned domestic measures will be extremely challenging, given the trends over the period 2021-2023 and related projections of greenhouse gas emissions. For example, the EPA report *Ireland's Provisional Greenhouse Gas Emissions 1990-2023* shows ESR emissions decreased by 10.1% or 4.82 Mt CO_2eq[1] on 2005 levels, but well short of the ESR 42% reduction commitment.

While the projections do not include some of the newest measures outlined in the 2024 Climate Action Plan, there is every risk that these and the more well-defined measures included in the EPA's projections will not deliver the sought-after reductions in greenhouse gas emission levels. Prudent policy should therefore better enable sustainable, feasible and cost-effective energy carriers such as woody biomass and associated technologies.

Difficulties in achieving ESR targets at the EU and member state levels have resulted in plans to extend the coverage of the ETS (it currently covers about 40% of overall emissions in the EU) to close to 70% of emissions by 2028. If the trend towards increased ETS coverage further continues (there is provision in Article 30 of the new ETS directive to explore the inclusion of removals), it could be envisaged that, in the early years of the coming decade, most if not all sectors will have a price put on emissions (and removals from land use, land use change and forestry). This should lead to lower mitigation costs, and provide incentives for the expanded use of bioenergy and BECCS.

Land use, land use change and forestry (LULUCF) is currently accounted as a carbon sink in the accounting system under the current LULUCF regulation, and will contribute an estimated 2.68 Mt CO_2eq/yr to national compliance targets over the five years 2021-2026. Biomass harvest is debited in the LULUCF sector, and this provides an incentive for its use in industrial heating and power, where the emission is accounted as zero in order to avoid double counting. Post 2025, the LULUCF regulation and the accounting framework will change, with a wider range of land uses being included, and new base lines being used for the forest estate. The net result will see the LULUCF sector being accounted as an emission, with estimates at national level in excess of 7 Mt CO_2eq/yr.

[1]Mt is million tonnes

Forest-based biomass in Ireland arises from sustainably managed forests, where felling is a licensed activity, with the aim of maintaining forest resources and safeguarding biodiversity. In this framework, carbon dioxide emissions from woodfuels are recaptured over time, resulting in a net reduction in emissions compared with fossil fuels. A suite of sustainability criteria, greenhouse gas savings thresholds and the cascade principle also apply to forest-based biomass under the Renewable Energy Directive. Application of this and a broad range of other measures provides market assurance that the use of sustainably sourced forest-based biomass will not result in damage to biodiversity, cause deforestation or diminution of forest carbon stocks and sinks, and instead will result in a net climate benefit.

Roundwood for energy use can be regarded as a residual assortment, which remains for harvest after sawnwood and wood-based panel manufacture have had their raw material requirements fulfilled. Displacement of harvest from solid wood products to forest-based biomass is not foreseen in terms of the development of modern bioenergy.

The aim in combustion of woodfuels is to oxidise all carbonaceous material to release and capture energy as heat and/or power. When combustion is incomplete, human health can be adversely impacted by particulate matter and other emissions. Most particulate emissions from woodfuel arise from the residential use of wet firewood, combusted in inefficient or inappropriate stoves. The extension of the national Solid Fuel Regulations to woodfuels from 2022, which stipulate a maximum moisture content of 25%, if well enforced, will result in cleaner combustion and air quality benefits. Commercial and industrial scale combustion is covered under a number of EU Directives and for larger installations is regulated by the EPA.

Production of indigenous biomass in Ireland for primary energy purposes has increased steadily over the past three decades, from around 4-5 petajoules per year (PJ/yr) over the 1990s, to 10.5 PJ by 2022. Indigenously sourced forest-based biomass is estimated to have accounted for 9.7 PJ, or 93% of the 2022 biomass supply. Hence the great bulk of woody biomass is sourced within Ireland. Forest-based biomass provided 1.5% of the total primary energy supply in 2021, or some 13.2% of the 69.1 PJ that renewable energy accounted for in the same year.

Most of the indigenous supply of forest-based biomass (53%) is used for process heat in industry (mainly in the forest products sector), with power generation (29%), residential (11%) and commercial uses (7%) forming the balance. In terms of final consumption, bioenergy (which includes biomass and renewable wastes, liquid biofuels, and biogas and landfill gas) accounted for just under one third of the renewable energy contribution to gross final consumption in 2021. Over 80% of delivered energy from forest-based biomass was as heat. This reflects the need to concentrate policy and resources on efficient uses of biomass, and to phase out power-only uses. It can be argued that the focus on electrification in climate action plans neglects to realise the potential expansion of other renewables, particularly bioenergy for heat. This is in the context that heat has been shown to be a difficult mode to decarbonise, despite high levels of ambition to reduce levels of heat use in the residential sector, which is the largest user of heat.

Turning to the supply of forest-based biomass and woody biomass in general, The All Ireland Roundwood Production Forecast 2021-2040, which is updated every five years, includes a separate annual forecast of forest-based biomass that is potentially available for wood energy in the Republic of Ireland out to 2040. An updated forecast of forest-based biomass, undertaken in conjunction with this report, showed that forest-based biomass supply has the potential to increase from the current 1.5 million green tonnes/yr (9.5 PJ/yr) at present to 2.5 million green tonnes (15-16 PJ) by the middle of the coming decade. Building on that level of increase would necessitate substantial increases from the current level of afforestation, up to and beyond 8,000 ha/yr, allied to a reintroduction of short-rotation coppice measures to reach an energy contribution of 20 PJ by mid-century.

Research indicates that perennial woody crops (forests and willow for example) provide for higher long-term carbon sequestration and material substitution effects. Land use support polices should consider these findings in deciding what alternatives merit support over the long term.

With regard to the relative prices for commercial heating fuels, the Sustainable Energy Authority of Ireland (SEAI) estimates a current (April 2024) woodchip price of just under 6 cent per kilowatt hour (c/kWh). This is around the same price as natural gas, about half the cost of oil at 12 c/kWh, and about a quarter of the cheapest electricity price at 22 c/kW. Natural gas price trends are particularly important, as gas is now the fossil fuel of choice for energy generation. In that regard the IEA medium term outlook is that natural gas prices will remain above their historical averages at a wholesale price centred around 5 c/kWh. This compares with wholesale prices over the previous decade, averaging 1.5-2.0 c/kWh and never exceeding 3 c/kWh. Hence the main woodfuel for large industrial and commercial applications - woodchip - is likely to remain competitive with fossil fuel alternatives, especially as it is not subject to carbon tax.

Potential future uses of expanded woody biomass supply include efficient heating, especially as a dispatchable fuel in district heating, and in combined heat and power. Another future use is for BECCS and biochar, in the context of providing energy services and permanent removals of atmospheric carbon in geologic storage and in recalcitrant land-based carbon pools. Use at scale is necessary to realise the full potential of indigenous biomass and to drive competitiveness in energy pricing.


MUS-MAX
KESLA

Executive summary

Introduction

This paper complements and rounds out an earlier series of COFORD statements on the role of forests and forest products in climate change mitigation. It aims to highlight the role that modern bioenergy plays in climate change mitigation and security of energy supply. It also sets out a series of recommendations around future policies to support an expanded role of forest-based biomass. The paper is accompanied by a stand-alone analysis of the potential future forest-based biomass supply.

Modern bioenergy in the context of this paper refers to efficient and low particulate emission biomass combustion, biorefining and other conversion technologies, based on sustainable supply chains, leading to quantifiable reductions in carbon dioxide emissions compared to fossil sources, and/or removals of carbon dioxide from the atmosphere.

Global carbon dioxide emission trends

According to the Global Carbon Project emissions from fossil and net land use, land-use change and forestry carbon dioxide emissions returned to an upward trajectory in 2022, reaching a total of 40.7 billion tonnes. The inevitable consequence of rising carbon dioxide emissions is a corresponding rise in atmospheric concentrations of carbon dioxide, reaching some 421 parts per million in 2023, or about 51% above the pre-industrial level (around 278 ppm in 1750). About half the potential increase is mitigated by the land and ocean carbon sinks.

Modern bioenergy frameworks

Both the Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report (AR6) and the International Energy Agency (IEA) in its Net Zero by 2050 (NZE) roadmap for the energy sector, refer to the reducing window available to meet the 1.5 °C temperature rise constraint.

Climate models referenced in the IPCCs sixth assessment report (AR6) outline that reaching net zero greenhouse emissions by 2050 will be needed to hold the rise to 1.5 °C. To stay within that limit the IEA roadmap foresees a contribution of around 18% from modern bioenergy to total global energy needs by 2050. In practice this means greatly expanded permanent forest cover, allied to the use of other carbon dioxide removal technologies such as bioenergy with carbon capture and storage (BECCS) and biochar.

Trade-offs - forest management and carbon balances

There are trade-offs between harvest and maintaining forest carbon stocks, in relation to net climate benefit. In Ireland, most forests are grown for wood production. In terms of harvest for bioenergy, it is necessary to look at impacts on carbon stocks and sinks at the regional and country levels.

Misleading conclusions on the climate effects of forest bioenergy can be drawn by studies that focus on emissions at the point of combustion, consider only carbon balances of individual forest stands, emphasize short-term mitigation contributions over long-term benefits, or disregard system-level interactions that influence the climate effects of forest bioenergy. Instead, the climate implications of policies that promote bioenergy should be assessed at the landscape level, and use a full life cycle approach that includes supply chain emissions, changes in land carbon stocks and other variables influenced by the policies studied. The bioenergy system should be compared with reference scenarios (counterfactuals) that describe the most likely alternative land use(s) and energy sources that would be displaced by the bioenergy system, and the probable alternative fates for the biomass being utilized.

Also, forest-based biomass arises from a tightly coupled carbon cycle from forest to atmosphere to forest. This differs from fossil fuel, which is a one-way flux to the atmosphere from oil and gas reservoirs, which have stored carbon over many millions of years.

Forests are rarely harvested solely for bioenergy products. For most, early forest harvest is towards higher-paying sawlog and pulpwood assortments, which are used to manufacture sawnwood and wood-based panels. Sawlog assortments typically generate a value per cubic metre that is four to five times the value of energy wood. Growers and wood processors will benefit from early thinning interventions for bioenergy as it increases the proportionate yield of sawlog material and makes it occur sooner, compared with no-thinning options. Increasing the yield of sawlogs has the beneficial impact of storing carbon for longer when wood is used in the built environment as long-lived harvested wood products.

Sustainability of forest-based biomass

Sustainability is essential in deploying all forms of biomass. Acting sustainably means meeting the needs of the present without compromising the ability of future generations to meet their own needs, while maintaining or enhancing forest ecosystem services. The concept encompasses three broad pillars: the environmental, economic, and social dimensions of forest-based biomass harvest and use.

Cascade use of forest products

Cascade use of wood harvest endeavours to direct most harvest to long-lived wood products and on through reuse, recycling and ultimately energy recovery in order to maximise displacement of high embodied carbon materials and of fossil fuels. The principle is enshrined in the Renewable Energy Directive (RED III), which means that policy should endeavour to support the movement of wood harvest through multi stages of use, except where absence of markets dictates a primary energy use.

Policy and regulatory frameworks

Uses of wood for energy intersect with a number of interrelated policy areas, from greenhouse gas emission reduction policies and frameworks at national and EU levels, to interrelated national and EU renewable energy policies, to air quality legislation and of course to forest policy itself.

The starting point for the policy frameworks is the overarching goal to limit global warming to 1.5 °C to be achieved by having net-zero greenhouse gas emissions by 2050, as set out under the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement, and drawing on the scientific evidence provided in the IPCC assessment reports. This extremely ambitious target, deemed necessary to avoid the potentially calamitous effects of climate change, requires transformation of economies and societies, as well as land use and land use practice.

The net zero goal is reflected in both EU and national legislation, which set out 2030 milestone targets on the pathway to 2050. Generally, national emission reduction targets are the more onerous.

The EU Fit for 55 package and target compliance trends

Fit for 55 is the EU's overarching climate policy framework. It aims "to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are in line with the climate goals agreed by the Council and the European Parliament and the target of reducing net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels".

Effort sharing regulation

The fundamental policy instrument under Fit for 55 is the Effort Sharing Regulation (ESR), which covers mainly transport, buildings, agriculture, small industrial installations, waste treatment, energy supply and product use, or about 60% of greenhouse gas emissions (the balance is covered under the Emissions Trading Directive (ETS) for large industrial installations, and the Land Use, Land-use Change and Forestry Regulation (LULUCF sector). The ESR is interlinked with the Emissions Trading Scheme and the LULUCF regulation, as allowances and credits from those mechanisms can be used by member states to contribute to compliance with annual ESR limits.

The EU's overall ESR target for the period 2021-2030 has set the level of ambition at 40%, based on the *Fit for 55* paradigm. Ireland's new target is a 42% reduction on 2005 levels by 2030.

The ESR covers agriculture, transport, residential and other sectors, but excludes emissions covered under the Emissions Trading System Directive (ETS). Analysis presented here and by the Environment Protection Agency (EPA) show that complying with the new target through existing and planned domestic measures will be extremely challenging, given the trends over the period 2021-2023 and related projections of greenhouse gas emissions. For example, the EPA report *Ireland's Provisional Greenhouse Gas Emissions 1990-2023* shows ESR emissions in 2023 have decreased by 10.1% or 4.82 Mt CO_2eq on 2005 levels, but well short of the ESR 42% reduction commitment. Similar conclusions on national targets are outlined in the EPA emission projections as outlined in *Ireland's Greenhouse Gas Emissions Projections 2023-2050*. Overall, it is very unlikely that Ireland will meet national or EU greenhouse gas emission targets in 2030 with the current policy mix and levels of implementation.

Emissions trading directive

The Emissions Trading Directive covers about 40% of overall emissions in the EU and is the main policy tool used to reduce reductions. Sectoral coverage is projected to increase to about 70% of emissions by 2028.

If the trend towards increased ETS coverage continues, and there is provision in Article 30 of the new ETS directive to explore the inclusion of removals, it could be envisaged in the early years of the coming decade, most if not all sectors will have a price put on emissions (and removals from LULUCF). This could, over time, remove the need for direct subsidies for renewables, allowing virtually economy-wide ETS coverage and full fungibility of credits across sectors, which should lead to lower mitigation costs and the wider development of carbon markets.

New levels of ambition under the ETS directive, agreed in 2023, increases the overall target for emission reductions to 62% by 2030, compared to 2005 levels.

Emissions from biomass combustion in installations that come under the ETS are accounted as zero, having already been accounted as emissions in the LULUCF sector. This provides an incentive to switch to biomass or increase the level of use in installations already using it. Sectors such as industrial heating processes which require high temperature steam are well-suited to such fuel-switching. Biomass is not a good fit to power generation only, given that efficiency levels in conventional power generation rarely exceed 35%.

Emissions from fossil fuel use in heating buildings, road transport and certain industrial sectors currently fall outside the scope of the ETS. From 2027 it is planned that a new emissions trading instrument – ETS 2 will cover those sectors. The incentive to switch from fossil fuels in the heating sector, across residential commercial and industrial scales, could present opportunities for modern bioenergy, given strong promotion and engagement at the national level.

Renewable Energy Directive

The Renewable Energy Directive, now in its third iteration - RED III - aims to increase the deployment of renewable energy across transport, heating and electricity in the EU, and sets out mandatory renewable energy targets for the EU and Member States to be achieved by 2030. It also sets out sustainability and greenhouse gas saving criteria that forest-based biomass must meet to qualify as renewable energy.

The overall RES (renewable energy share) target at EU level up to 2020 was a minimum 20% of gross final energy consumption (GFC), which was met and exceeded. Ireland achieved 13.5% RES against a target of 16%. Most of the RES contribution (59%) came from wind for electricity generation. Bioenergy contributed 32%, with forest-based biomass at an estimated 13-14% of total renewables.

At the broader EU level, it is worth noting that many Member States have successfully displaced a large proportion of fossil fuel through forest-based biomass use and other biofuels, to the extent that in 2022 biofuels (mainly solid biomass) remained the largest renewable energy source representing 40% of the total renewable energy supply across Europe in 2022. Sweden had the highest overall share of energy from renewables in the EU in 2022 at 66%, while Ireland had the lowest at 13%. In the case of Sweden, biomass contributed by far the largest share of renewables, at 59%.

Ireland's poor performance in renewable energy deployment in the period up to and including 2022 points to a need to critically examine the potential to deploy all available and feasible sources of renewable energy, and to promote the full spectrum of options, including biomass, and biofuels in general.

RED III increases the EU's overall renewable energy target to 42.5% by 2030, with a possible top-up to 45%. Ireland's 2030 target has been set at 43% of total energy consumption by 2030.

It also includes stricter sustainability criteria for the inclusion of bioenergy/biomass in renewable energy policies and measures at member state level, particularly in relation to the use of the cascade principle. Forest-based biomass derived from industrial roundwood can only be supported where Member States have demonstrated that the roundwood is directed in the first instance to the manufacture of solid wood products, and on fulfilment and in the absence of those markets, biomass its use for energy purposes can be supported and counted towards RES targets.

In Ireland, standing sawnwood prices can be 4-5 times, and up to 10 times, the price of energy wood. Pulpwood prices for the manufacture of wood-based panels also typically command higher standing prices than energy assortments. Furthermore, as referred to in the forest-based biomass forecast (published with this report), Coillte has ringfenced a proportion of its pulpwood-sized assortments for wood-based panel manufacture.

Forest-based biomass emissions in the energy sector and in the ETS will remain accounted as zero, with new text added to the ETS to conform with the RED III criteria, while its use in the energy sector will continue to be counted towards renewable energy targets, as long as it meets the sustainability, carbon savings and cascade use criteria.

Energy Efficiency Directive

The Energy Efficiency Directive (EED) is a further element of the *Fit for 55* package. The EU's policy paradigm is energy efficiency first, in other words reductions in energy use take precedence over renewables deployment. Applying the energy efficiency first principle to the use of forest-based biomass means that energy services provided by biomass should consist of heat only or combined heat and power plants, and the use of efficient appliances in residential heating. Low efficiency uses such as power only, and inefficient stoves and open fires should be phased out over time.

In 2023, the revised EED set out a target for the EU Member States to collectively reduce energy consumption by at least 11.7% compared to the reference scenario, so that final energy consumption is no more than 31,945 PJ (763 million tonnes of oil equivalent (M toe)) in 2030. Ireland's final energy consumption in 2022 was 504 PJ, or about 1.34% of the EU's total consumption of over 37,700 PJ in the same year. Ireland's indicative 2030 targets as submitted earlier this year in the National Energy and Climate Plan (NECP) is a final energy consumption of 437.6 PJ, and a primary energy consumption of 472.9 PJ. Based on the 2022 level, and by the government's own admission, these are extremely challenging targets, given current demographics and the rate of growth of the economy. The target applies irrespective of whether fossil or renewable energy generation is considered.

National climate policies and measures

The Climate Action and Low Carbon Development (Amendment) Act 2021 and the associated carbon budgets_set out an overall target reduction in greenhouse gas emissions of 51% by 2030, relative to 2018 levels. The Climate Change Advisory Council has proposed three economy-wide carbon budgets, for 2021-2025, 2026-2030 and 2031-2035. The LULUCF sector is included in the 2018 baseline, and will be used in estimating compliance with the budgets, as and when the modalities for including the sector are finally agreed at national level.

The latest EPA estimates in *Ireland's Provisional Greenhouse Gas Emissions 1990-2023* shows that over the period 2021-23 emissions were 188.43 Mt CO_2eq or 63.9% of the first five-year carbon budget of 295 Mt CO_2eq. So, a remaining budget of 36.1% to cover the years 2024 and 2025. Staying within budget will require 8.3% annual emissions reductions over both years, or about 5 Mt CO_2eq/yr. Based on current trends it is very likely that the carbon budget for the period 2021-2025 and the subsequent 5-year period will be exceeded by a significant margin.

The Climate Action Plan 2024 is the third annual update to the plan. It seeks to implement the carbon budgets and sectoral emissions ceilings, in order to meet the legally binding 51% reduction in greenhouse gas emissions by 2030 and reach net zero no later than 2050, as set out in the climate act.

The Climate Action Plan 2023 refers to bioenergy (including a target for production of up to 5.7 TWh of biomethane by 2030), with solid biomass referenced in relation to heating in the industry sector, where it is envisaged as playing an enhanced role in displacing fossil fuels.

The Support Scheme for Renewable Heat (SSRH) is the measure that supports biomass and other renewable energy sources in commercial heating. It is also referenced in the plan and is set to continue until 2025, as far as new applicants are concerned, while payments will continue to accrue for scheme members over a 15-year period from the official date of commencement of the project. The latest update indicates steady but slow uptake. SEAI states that there are (unlisted) major perception barriers in relation to the scheme. IrBEA has publicly raised concerns around the slow progress of the scheme and the level of administrative burden involved in securing approvals.

In addition to outlining the high-level the energy policy frameworks and targets, and the compliance trends, it is it is useful to examine current and projected future implementation of the main measures in the Climate Action Plan and energy policy more generally. The objective here is to examine the likelihood of the measures delivering the foreseen emission reductions, in the context of informing policy of where an expanded emphasis on the role of forest-based biomass, particularly in heating, might best contribute to sectoral targets.

The considerable progress made in reaching RES-E targets, at both national level and across the EU, allied to international trends towards electrification of energy supply across all modes, has focused EU and national renewable energy policies in that direction. Electrification is central to three of the five main decarbonisation measures outlined in Climate Action Plan 2023 and in the accompanying Annex of Actions. Afforestation and agriculture are the other measures.

Electrification of energy supply

Probably the most significant measure in the Climate Action Plan framework is the ambition to have 80% of electricity supply from renewable sources by 2030, stated as requiring 22 gigawatts (GW) in installed renewable generation capacity. This is to be achieved by a major expansion of wind energy, both onshore and offshore, and solar energy in order to decarbonise the electricity sector, as well as enabling the electrification of other technologies.

Achieving the RES-E target, and by implication national and EU legally-binding greenhouse gas reductions, will depend on successful bidders achieving the planning consents and finance needed for project completion. It will also require substantial upgrading of the transmission gird to cater for intermittent supply from wind and solar.

In relation to the current adequacy of power supply, the Eirgrid/SONI 2022-2031 Generation Capacity Statement (GCS) points out: “There is no question that the current outlook, based on the best information available, is serious. It is likely that in the coming years we will experience system alerts and will need to work proactively to mitigate the risk of more serious impacts…”

Given these considerations, and in order to spread risk and diversify the technology mix, it can be argued that a strengthened and more broadly recognised role for biomass in decarbonising heating should be included in the national policy system. This would be in line with the insights and recommendations from the SEAI 2022 heat study report (*Sustainable Bioenergy for Heat*) and similar recommendations advanced in the Renewable Energy Ireland report *40 by 30*, which outlined a pathway to 40% renewable heat by 2030 across a range of technologies, including those mobilising modern bioenergy.

Retrofitting and heat pumps

Aligned to renewable electricity is the policy around retrofitting of residential and commercial buildings to increase energy efficiency of existing buildings and putting in place policies to deliver zero-emission new builds to meet the sectoral emission ceilings. Under the climate action plan process, The National Retrofit Plan, run by SEAI, is the core measure, and aims to make substantial progress in decarbonising residential heating, with an overall 2030 target to upgrade some 500,000 homes to a building energy rating (BER) of B2/cost optimal equivalent standard, allied to the installation of 400,000 heat pumps.

Given the current completion rate, and the impact of cost-of-living increases and construction inflation which are likely to continue for a number of years, and other constraining factors identified in the SEAI reports, it is difficult to see the retrofit completion target being achieved.

In relation to the heat pump installation target of 400,000 units by 2030, the level of achievement over the period 2019-2023, as outlined in the SEAI *National Retrofit Plan Full Year Report 2023*, was just under 10,600. There is no reference to the potential use of modern residential heating using woodfuels such as pellets, briquettes or dry firewood in ecodesign stoves and boilers as a further way to decarbonise heating.

Given the foregoing, and despite the availability of generous grant aid, allied to efforts by SEAI to promote and improve its effectiveness, it is unlikely that the National Retrofit Plan will deliver the projected 2030 emission savings of 2 million tonnes CO_2 per annum in residential heating relative to 2018. Again, it can be argued that a programme of biomass-based systems, such as district heating to decarbonise residential and other forms of heating would add to current efforts, contribute to the achievement of greenhouse gas emission targets and as well to the security of energy supply.

Transport

Transport and fleet electrification policies form another pillar of the annual climate action plans. The measures are about providing new infrastructure and incentives to expand public transport, and incentives for switching to electric vehicles (EVs). The end of 2030 target is for 845,000 private EVs and 95,000 commercial EVs; with all new car registrations to be electric for subsequent years. If achieved, the target would be equivalent to one-third of the current fleet of 2.8 million vehicles.

According to SEAI, in May 2024 there were over 121,000 EVs on the road in Ireland. Sales increased to some 23,000 EVs in 2023, up 45% on the previous year. However, a recent blog from SEAI records a steep drop in sales over the first quarter of 2024.

Based on the current number of EVs on the road, and assuming a further 10,000 will be sold in 2025, the distance to the overall EV target (private and commercial combined) is some 809,000. It is very difficult, therefore to see the target being achieved. An optimistic outcome could suggest say half the target being achieved, which would reduce the projected greenhouse gas emission savings of 4.74 Mt CO_2 eq/yr by 2030 by a commensurate amount.

The IEA 2023 bioenergy report also notes that ethanol from lignocellulosic feedstocks, such as woody biomass, is among a number of emerging biofuel pathways not yet fully developed, and that still need to be demonstrated at full scale. These so-called called second generation biofuels can be more expensive to produce, due to the need for feedstock pretreatment. However, the raw materials themselves, originating in the main from waste, tend to be cheaper, can be available in significant quantities, and generally result in higher greenhouse gas emission savings compared with first generation fuels.

Afforestation

This section should be read in the conjunction with the discussion on afforestation in the section on the EU LULUCF regulation.

Afforestation is the primary climate change mitigation measure identified in the Climate Action Plan, but as demonstrated in the COFORD climate change statements, forest management and harvested wood products also have a strong role in addressing climate change. As outlined in this paper modern bioenergy also has role to play if new and existing measures are developed and promoted, and effectively implemented.

With regard to the afforestation target levels of 8,000 ha/year, DAFM data show that the area afforested over 2021, 2022 and 2023 (the opening three years of first carbon budget period) was 5,940 ha, leaving a significant distance to target. Nevertheless, based on the Teagasc Marginal Abatement Cost Curve (MACC) 2023 analysis, afforestation allied to reduced deforestation, seems to remain the most direct route to medium to long term increases in the forest sink in Ireland. Continued and stronger promotion of the financial and wood supply benefits of retaining forest crops closer to optimum rotation ages should also be supported as a short-term option. While a move to continuous cover forestry systems is feasible on part of the forest estate, it requires a high level of expertise that is not likely to emerge over most of the forest estate.

Policy supports for agriculture, such ACRES, matter as far as the uptake of afforestation is concerned, and if they remain at present levels it is difficult to see an uptick in afforestation to the levels envisaged in the Climate Action Plan. While ACRES has climate change mitigation objectives, the level of carbon sequestered and its permanence are not assured. Overall, these policy choices are likely to make the attainment of the 2030 emission reduction ever more difficult and expensive to achieve, with likely increasing burdens post 2030, in light of the Teagasc MACC 2023 projections up to the mid-century point.

Efficiency improvements in agriculture through the adoption of greenhouse gas efficient farming practices

Based on the EPA greenhouse gas inventory, agriculture accounted for 38% of Ireland’s total emissions in 2023. The contribution could rise to 44% by 2030, depending on emissions trends in the sector itself and the level of emission reductions in other sectors.

The EPA’s *Ireland’s Greenhouse Gas Emissions Projections 2023-2050* model the impact of additional measures such as cattle diet modification and management practices. These are outlined in Climate Action Plan 2024, the Teagasc greenhouse gas and ammonia MACCs and AgClimatise. Depending on the level of implementation, the models suggest that these measures could reduce emissions to 19.1 Mt CO_2 eq by 2030, which is an 18% reduction on 2022, compared with the sectoral target of 25% by 2030, as set out in the carbon budget process.

The COFORD statements on forests and wood products and their importance in climate change mitigation, found that “land use and changes from grassland to forestry have not resulted in a significant reduction in agricultural emissions. In general animal herd sizes have not declined as land has transferred to forestry and this will create challenges for carbon neutrality in the land-use sector”.

Forest-related EU and national policies

Land use, landuse change and forestry - LULUCF

The LULUCF regulation (EU 2018/841) covers the period up to the end of 2025. It takes into account age class effects in older forests and provides a direct incentive for afforestation. These treatments, allied to national policies to conserve and expand forest cover, and sustainable forest management, have allowed Ireland to generate credits which will contribute to compliance with national targets under the ESR up to and including 2025. The current EPA estimate is for an accountable sink of 2.68 Mt CO_2eq/yr over the five years 2021-2025.

Post 2025, the accounting rules are substantially different, which. allied to the inclusion of soil carbon on agricultural land will make the LULUCF sector as a whole a substantial source of emissions. This will in effect remove the availability of an amount of credits from the LULUCF sector to aid in compliance with national targets. Ireland will be one of five member states with an emissions baseline, based on high levels of emissions from drained organic soils, mainly in grassland.

Overall, it could be argued that the new LULUCF regulation is more favourable for countries with high levels of forest cover, which offer more flexibility and a greater scope for forest management activities to increase or stabilise the sink. Also given the composition of the forest estate in Ireland, which is overwhelming commercially managed forest, harvest levels are driven by financial considerations, albeit within a licensing framework.

The Teagasc Marginal Abatement Cost Curve (MACC) 2023 report provides a further insight into the possible scale of climate-smart activities and removals across five LULUCF measures in the context of the LULUCF framework post 2025: afforestation, reduced deforestation, extending forest rotations, replanting of former afforested peats with birch, and agroforestry.

The technical level of removals from the forestry measures in the MACC is estimated as 36 Mt CO_2 over the period 2021-2050. Afforestation makes by far the largest contribution, at some 26 Mt CO_2, based on afforestation targets of 4,500 ha/yr from 2023-2025, and rising to 8,000 ha/yr by 2030. As the report points out, the rates of afforestation post 2021 have been well below target, and were just over 1,650 ha in 2023. Extending rotations was estimated to have the possibility of increasing the sink by 4.5 Mt CO_2 over the period 2021 to 2030. Due to age class effects the MACC estimates that this category of forest becomes a net emission of some 4.3 Mt CO_2 over the period 2031-2050. The report points out the difficulties that the new accounting approach in the LULUCF regulation post 2025 poses in relation to generation of compliance units, especially as the forecast for the LULUCF sector as a whole (which includes grassland and cropland) is for a source of 10.4-10.5 Mt CO_2/yr over the 5-year period from 2026-2030.

EU certification framework for permanent carbon removals – towards an EU regulation

The overall aim of the regulation, - CRCF for short - is to develop a voluntary EU certification framework for permanent carbon removals, carbon farming and carbon storage in products, which would complement emission reductions and existing policies at encouraging removals, all in the context of moving towards net zero emissions by 2050. The intention is that the regulation will facilitate and speed up the deployment of high-quality carbon removals and soil emission reductions, while combatting greenwashing and harmonising conditions in carbon removal markets.

An advanced draft of the regulation was agreed by the European Parliament in April 2024, and now awaits Council approval and publication as law.

The regulation proposes the accreditation of third-party certification bodies who will act to verify the level of removals and conformance with the conditions of the regulation. If certified, units, corresponding to 1 tonne of carbon dioxide, can be registered and traded. Removals generated under the CRCF will be recorded in a common and transparent electronic EU-wide registry. Pending that development, certification schemes under the framework must provide public registries based on automated and interoperable systems.

Given the likely timeframes for the development of certification methodologies and registries, the development of geologic storage infrastructure, and a more general move to a greater use of wood in construction, any significant removal impacts of the regulation are more likely to begin towards the end of the current decade, and through into the 2030s and beyond.

Possible inclusion of carbon removals in the ETS has been a long-running debate in the EU. To date the strong focus across all policy instruments has been on emission reductions, where the ETS has proven to be highly effective. However, there is an increasing realisation among policy makers that enhanced removals will be needed in the attempt to reach net zero by mid-century. The new ETS and the post-LULUCF regulation have actions to explore the use of permanent carbon removals in emission trading and in the scope of LULUCF. The outcomes of these processes, and the general post 2030 policy framework are likely to provide a clearer picture on the use of carbon removals in terms of compliance at the national level, in the ETS, and in carbon markets, at both the EU level and internationally.

Ireland's forest strategy

The current forest strategy covers the period up to 2030 and has the overarching objective to "expand the national forest estate on both public and private land in a manner that will deliver lasting benefits for climate change, biodiversity, water quality, wood production, economic development, employment and quality of life".

The implementation plan for the strategy includes a goal to support "the use of sustainable wood products from Irish forests, as alternatives to carbon intensive products, to reduce the embodied carbon in our built environment, and by products including biomass to substitute fossil fuels."

In terms of expansion of the forest estate, a key requirement in relation to biomass supply is the aim to achieve a forest cover of 18%, as stated in the strategy. Although the target is not time bound, achieving such a level of forest cover by 2050 is needed to close in on carbon neutrality by 2050, and given the likelihood that hard-to-decarbonise sectors, including agriculture and transport will continue to be sources of emissions.

EU forest strategy

The European Commission's Forest Strategy for 2030 was published in July 2021 as part of the European Green Deal initiative, and "sets a vision and concrete actions to improve the quantity and quality of EU forests and strengthen their protection, restoration and resilience". It aims to adapt Europe's forests to new conditions, weather extremes and high uncertainty brought about by climate change. Such adaptation it is argued, is a precondition for forests to continue delivering their socio-economic functions, and to ensure vibrant rural areas with thriving populations.

Regarding forests and bioenergy, the strategy states that "Wood based bioenergy is currently the main source of renewable energy, supplying 60% of EU's renewable energy use. To meet the at least 55% emission reduction target by 2030, Member States will need to significantly increase the share of renewable sources in their energy mix. Bioenergy will continue to have a notable role to play in this mix if biomass is produced sustainably and used efficiently, in line with the cascading principle and taking into account the Union's carbon sink and biodiversity objectives as well as the overall availability of wood within sustainability boundaries in 2030 perspective".

Regulation (EU) 2016/2031 – plant passporting

The regulation, which came into force in December 2019, aims to modernise the Union's plant health regime, by providing more effective measures for the protection of plants from destructive pests, and to ensure safe trade, as well as mitigating the impacts of climate change on the health of forests.

The basic principle is to certify that coniferous woodfuels being placed on the market with bark attached, or from *Castanea* species with bark and *Platanus* species with or without bark, come from areas which are free from specified organisms. This requirement is met by having a plant passport accompanying the specified woodfuels when they come to market. The passport also allows traceability back to source in the event of the detection of a specified organism in or on the woodfuel. Plant passports are issued by Professional Operators who have been authorised to do so by the Department of Agriculture, Food and the Marine.

EU Regulation on deforestation-free products

The overall aim of Regulation (EU 2023/1115) is to bring down greenhouse gas emissions and biodiversity loss from deforestation and forest degradation. This is to achieved by promoting the consumption of deforestation-free products and thereby reducing the EU's impact on global deforestation and forest degradation,

The Regulation was published in June 2023, and replaces the EU Timber Regulation (EUTR). It will enter into force on the 30 December 2024. Under the Regulation, any operator or trader who places certain commodities on the EU market, or exports them, must be able to prove that the products have not originated from recently deforested land or have contributed to forest degradation.

Air quality

Good air quality is essential for human health. While air quality in Ireland is generally good and compares favourably with many European countries, localised issues impact negatively on air quality.

For woodfuel, the main air quality issue is residential use of unsuitable wet wood, often in open fires or unsuitable multi-fuel stoves, which leads to incomplete and inefficient combustion and the generation of harmful particulate matter. The Woodfuel Quality Assurance (WFQA) scheme, run by the Irish Bioenergy Association (IrBEA), and the Solid Fuel Regulations, aim at reducing the use of unsuitable woodfuels in residential combustion. However, more consumer education around proper wood combustion is needed, allied to stringent regulation enforcement by Local Authorities who are charged with policing the regulations. Replacing inefficient and polluting open fires and multi-fuel stoves by modern Ecodesign appliances is also necessary to capture the full benefits from the banning of wet woodfuels in residential combustion.

The CAFÉ (Cleaner Air for Europe) Directive and the National Emission Reduction Commitments Directive (NEC) set out legally-binding pollutant concentration and emission reduction commitments (ERCs) across the EU and at specific member state level, respectively.

Air quality monitoring results from the EPA show that fine particulate matter (PM2.5) mainly from residential burning of solid fuel, and nitrogen dioxide (NO2) mainly from road transport, remain the main threats to air quality. Levels detected in EPA monitoring were within current EU legal limits, but exceeded World Health Organisation (WHO) Air Quality Guidelines (AQGs) for health in 2021. It is essential therefore that woodfuels are correctly specified and combusted in clean and efficient appliances and plant, in accordance with the modern bioenergy paradigm.

In order to address emissions from residential solid fuel combustion, the current policy is to favour electrification of heating in new builds and retrofits, allied to the October 2022 updating of the Solid Fuel Regulations.

The regulations, as they stand, do not fully cover the quality requirements for the main woodfuels as set out in ISO EN I.S. 17225 *Solid biofuels — Fuel specifications and classes*. This is the internationally agreed standard and covers all the main woodfuels in terms of quality requirements related to moisture content, fuel sizes, levels of fines and other parameters that impact on combustion efficiency and the generation of pollutants.

Emission limit values for plant and appliances are set out in three EU Directives, which are listed and described in the body of the report.

In relation to the overall policy mix around reducing particulate and other emissions from solid fuel combustion, the approach, in effect, is to phase out solid fuel heating. All new builds must now achieve Nearly Zero Energy Buildings (NZEB) ratings under Part L of the Buildings Regulations, in line with the requirement in the Energy Performance in Buildings Directive (EPBD). Reaching NZEB is made easier by eschewing the installation of chimney vents for solid fuel heating, with the result that almost all new builds now rely on electrical heat pumps for heating. A policy that seems to favour one source of heating over all others, with little published information on relative costs or greenhouse gas savings, is open to question.

A similar approach to effectively exclude bioenergy as a heating option is taken with the deep retrofitting measure under SEAI grant aid.

In relation to new housing schemes, and town and city heating in general, more consideration should be given to group or district heating systems. District heating can afford greater efficiencies and lower levelised costs of energy may be achievable compared to individual home heating. In addition, the use of a wider range of energy sources, rather than electricity alone would serve to provide wider choice, reduce incremental ratcheting up of electricity demand on an already extended grid, may be more advantageous for local communities, and contribute to security of energy supply.

Also, it is highly unlikely, given that over 20% of households use woodfuels either as their main source of heating, or for supplementary heating, that all residential heating will move to an electrical mode, given costs and inconvenience. Therefore, consideration should be given to supports for switching out inefficient, polluting appliances for modern efficient and clean burning stoves and boilers. This can result in an 8-9 times reduction in the emission factor for $PM_{2.5}$, as established over a number of research studies, which compared advanced/ecolabelled stoves and boilers with open fires and conventional stoves. Allied to a sufficient level of home insulation, such a measure is likely to result in substantial reductions in pollutant levels, more efficient use of woodfuels, as well as lower heating and carbon abatement costs.

Biomass use and supply, costs and potential

Primary energy supply is a useful indicator for forest-based biomass, as it relates directly to the supply level of the material at assumed moisture contents and calorific values. Gross final consumption or GFC, on the other hand, is estimated from energy commodities delivered for consumption, while also including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity and heat in distribution. GFC is the metric that is used for targets set under the renewable energy directive.

Use of indigenous biomass for primary energy purposes has increased steadily over the past three decades, from around 4-5 PJ/yr over the 1990s, to 10.5 PJ by 2022 (SEAI annual energy balances). Indigenously sourced forest-based biomass is estimated to have accounted for 9.7 PJ, or 93% of the 2022 biomass supply, against a total energy supply of 595.9 PJ.

The supply figure accords closely with a 2023 forest-based biomass forecast figure of 9.6 PJ which was estimated in the sensitivity analysis of forest-based biomass production, but not included in Table 2. This close match between forecasted supply and biomass production provides additional confidence that the forecasted increases in the availability of forest-based biomass over and above current production levels can be realised, especially as the forecast is based on the existing forest estate.

Most of the indigenous supply of forest-based biomass (53%) is used for process heat in industry (mainly in the forest products sector), with power generation (29%), residential (11%) and commercial uses (7%) forming the balance.

Bioenergy (which includes biomass and renewable wastes, liquid biofuels, and biogas and landfill gas) accounted for just under one third of the renewable energy contribution to GFC in 2021. Wind was the largest and fastest growing contributor at 58.4%. Forest-based biomass contributed some 8.7 PJ or 13.1% of the total renewables (66.7 PJ) in 2021, against an overall GFC of 491.5 PJ. Over 80% of delivered energy from forest-based biomass was as heat, reflecting the low efficiency of biomass used for power.

In terms of the RES-H, forest-based biomass accounted for almost 52% of the heat-based GFC figure in 2021 (SEAI personal communication 2023), despite a 10-fold increase in the deployment and use of heat-pump technology over the period 2005-2020. Forest-based biomass therefore remains an important component of renewable heat, and is likely to remain so.

Security of energy supply and the potential role of biomass

Security of supply and how Ireland's primary energy requirements are met are closely linked. Ireland still imports most of its energy, with oil and gas by far the largest imports, along with significant quantities of coal. Import dependency in 2022 dependency was close to 82%. This is despite considerable strides over the same period in the deployment of indigenous renewable capacity, particularly in wind-powered electricity generation,

While it has been shown that bioenergy overall, and forest-based biomass comprise a small component of overall energy supply, it is worth noting that bioenergy is almost a mirror image of overall energy supply, with 90% of all biomass coming from indigenous sources in 2022, of which by far the greatest share was from forest-based biomass.

On overall security of supply, the rationale for continued investment in natural gas infrastructure and deployment can be called into question, especially for heating. Gas now provides about one third of primary energy requirements (*Energy in Ireland 2022*), through a gas grid that extends to all cities and most major towns, through 15,000 km of pipeline. However, the events of early 2021 have highlighted the supply and cost-spike risks inherent in international gas markets, the need for secure supplies and large-scale storage, and in general a more in-depth and risk-based approach to future energy policy.

In more general terms, it can be argued that the focus on electrification in the climate action plans neglects to realise the potential expansion of other renewables, particularly bioenergy for heat. This is in the context that heat has been shown to be a difficult mode to decarbonise, despite high levels of ambition to reduce levels of heat use in the residential sector, which is the largest user of heat.

In the context of supply, biomass is a good match to heat provision across residential, commercial and industrial sectors. Levels of availability are well established, and biomass can be stored and used on demand. It also bears repeating that modern combustion appliances and plants supplying heat typically run at efficiencies of 80-90% plus. Further deployment of biomass in heating would contribute to security of energy supply, given that currently 90% of biomass used in Ireland comes from indigenous sources. In addition, the establishment, management, supply and use of biomass resources entails the highest levels of employment of all renewables.

All heating providers at scale will look to price, and the level and security of supply. Price increasingly has to factor-in carbon and the continuation of carbon pricing is essential for the reducing dependence on fossil energy across all modes. As pointed out in the discussion on the Emissions Trading Directive, it is planned to extend emissions trading to transport and heat from 2027, which should provide for a more assured policy framework to 2030 and beyond.

Determining the future level of forest-based biomass from existing forest areas, and its security of the supply, is essential to develop a coherent biomass policy framework. This also applies to the potential for the development of other woody biomass sources, such as bespoke willow coppice for energy. These aspects are now summarised.

Biomass availability

The All Ireland Roundwood Production Forecast 2021-2040, which is updated every five years, includes a separate annual forecast of forest-based biomass that is potentially available for wood energy in the Republic of Ireland out to 2040. The forecast is based solely on existing forests and makes no assumptions on future rates of afforestation. Harvest is based upon a number of inputs, mainly the modelled growth of the national forest estate, using a series of empirical forest growth and yield models. It includes current and forecasted future levels of demand from the sawmilling and wood-based panels sectors, which are ring-fenced and not included in the forest-based biomass estimates. It also includes assumptions on the level of residues arising from sawmilling, how these residues are then used, and the level of use of harvesting residues arising at the forest level.

To get a clearer picture of current and future resource availability, and how this could translate into forest-based biomass and its energy potential, sensitivity analyses were undertaken around the forecast. The approach is set out in the full body of this report, and in more detail in the sensitivity report.

All of the analyses assumed the deployment of existing, proven technologies, using sustainable levels of additional harvest, and use expert judgement to select the most realistic options.

The work also involved allocating the harvest, denominated in cubic metres by the forecast engine and then converted to green tonnes at specified moisture contents for the specific powergen/industrial heating, commercial, and residential heating end uses. Proportionate allocation to the end uses was based on current and foreseen levels of use.

What the results show is that the level of supply of forest-based biomass has the potential to increase from the current level of supply of c. 9.5 PJ/yr at present ((Table ES 1) to 15-16 PJ by the middle of the coming decade. Thereafter, there is a decline to ca 14 PJ/yr by 2040. County based forecasts are provided in the full sensitivity analysis that accompanies this report.

Table ES 1. Forecasted availability of forest-based biomass 2024-2040 in green tonnes across harvesting and processing streams (COFORD, 2024 (Unpublished)[2]).

Year	Green tonnes 000							Energy PJ
	Roundwood 7 – 13 cm	Downgrade + Wood Residues	Specified biomass harvest	Harvest 50% SBH (60 t/ha)	20% thinning increase	20% whole tree thinning	Total	
2024	175	1,018	86	77	55	82	1,493	9.5
2025	207	1,047	95	77	54	82	1,562	9.9
2026	244	1,035	145	80	57	86	1,647	10.4
2027	246	1,122	164	80	48	72	1,731	11.0
2028	213	1,125	153	83	39	59	1,673	10.6
2029	255	1,235	145	77	35	53	1,800	11.4
2030	317	1,404	146	63	31	46	2,007	12.7
2031	355	1,555	91	93	32	47	2,173	14.0
2032	441	1,695	98	88	31	46	2,399	15.5
2033	346	1,669	86	82	26	38	2,248	14.5
2034	443	1,631	96	98	27	40	2,335	15.1
2035	378	1,897	96	89	27	41	2,528	16.3
2036	244	1,785	55	126	29	44	2,283	14.7
2037	221	1,796	47	130	32	48	2,274	14.7
2038	177	1,788	32	63	27	41	2,128	13.7
2039	160	1,794	35	75	31	46	2,142	13.8
2040	151	1,790	45	69	37	55	2,147	13.9
Totals	4,574	25,386	1,616	1,449	617	926	34,567	221.7

Given the scenarios chosen and the conservative approach taken in the overall forecasting approach, these estimates are regarded as realisable amounts of forest-based biomass for energy purposes over the period to 2040.

Supplementing overall biomass supply depends on the level of afforestation and management practices in the existing forest estate. Given the time frame of say a decade and half to harvest from afforestation to first harvest, and the current low level of planting, options around short rotation forestry and biomass coppice merit reconsideration. The previous willow coppice scheme ceased in 2015 due to a low level of applications, in turn influenced by weak and low price-paying markets for willow chip.

While there are potential barriers to the reintroduction of a biomass coppice scheme, an imperative to develop large scale biomass heat markets could provide the necessary policy incentive. Potential supply from a renewed willow biomass scheme has been estimated here using the SEAI's heat study supply scenario, adjusted to allow for the time taken to introduce a new grant-aid scheme and for material to flow. The analysis also takes into account the current supply of willow coppice of some 16-17,000 tonnes/yr. Taking these factors into account, and combining the resulting estimated supply with the forest-based biomass stream, Table ES 2 shows that by 2040 the potential availability of biomass from forests and coppice could be close to 20 PJ/yr. The underlying assumption is an annual average level of willow coppice establishment of 2,100 ha over the period to 2040. There is also potential to reactivate a short rotation forestry measure, although very few applications were received previously, which could be used in conjunction with conventional forestry and coppice to reach a desired level of supply, say 20 PJ/yr by 2040. On current (2022) levels of primary energy supply (596 PJ/year) forest and willow-based biomass would account for 3.3% of total energy supply. While this is a relatively small contribution to energy supply, it is likely to grow in importance if overall levels of energy use decline, somewhere in line with the targets in the energy efficiency directive. Furthermore, if and when biomass use is linked with BECCS it could deliver a significant level

[2]COFORD (2024), Unpublished. Sensitivity Analysis of Wood Fibre Potentially Available for Wood Energy. COFORD, Kildare st. Dublin.

of removals. For example, 5 PJ of forest-based biomass linked with BECCS could provide a net removal of around 0.5 Mt CO_2/yr. BECCS is further outlined below.

Table ES 2. Forecasted (forest-based biomass) and potential (willow coppice) woody biomass availability 2024-2040 (SEAI, 2022[3]).

Year	Forest-based biomass	Willow coppice	Total
	PJ		
2024	9.5	0.1	9.5
2025	9.9	0.1	10.0
2026	10.4	0.1	10.5
2027	11.0	0.2	11.2
2028	10.6	0.3	10.9
2029	11.4	0.4	11.9
2030	12.7	0.6	13.3
2031	14.0	0.8	14.9
2032	15.5	1.1	16.6
2033	14.5	1.5	16.0
2034	15.1	2.0	17.0
2035	16.3	2.5	18.8
2036	14.7	3.0	17.8
2037	14.7	3.7	18.3
2038	13.7	4.4	18.1
2039	13.8	5.1	18.9
2040	13.9	5.9	19.8

The feasibility of introducing a new willow scheme relies heavily on the development of a sustainable heat market having the ability to pay in the region of €150/tonne (2023 prices) for willow chip. This in turn depends on continuation of an SSRH scheme allied to a widescale roll-out of district heating, over the coming decades and a strong and effective promotional campaign. There are also challenges in securing agricultural land with the capacity to grow willow at the required productivity level, and with a capacity to facilitate harvesting during the winter months. Willow is not suitable for most marginal agricultural land.

Under the previous willow scheme, which ran from 2007-2014, some 3,300 ha of coppice was established, with a peak of 900 ha being established in 2008. Some of the areas established have since reverted to agriculture, due to an overall lack of an economic price for willow chip and overdependence on a lower price paying power market. Therefore, a key requirement in reducing the risks to state and private investment in short rotation coppice/short rotation forestry is the need to develop sustainable heat and combined heat and power markets for sustainable biomass, through measures such as the SSRH and a district heating support model.

However, there is technical potential for a gradual expansion in willow coppice. As a land use, it compares favourably with grassland for anaerobic digestion (AD) in terms of energy yield. As outlined in the SEAI's *SBH* report, willow can provide up to 45 MWh/ha/yr, about a third more than a red clover/ryegrass mix for silage for AD (30 MWh/ha/yr). The higher energy density, combined with lower upstream emissions from the cultivation of willow, points to overall greenhouse gas savings achieved from a willow coppice being greater than from the silage pathway, on like-for-like basis. Given the ever-tightening constraints on land use and land-use change, greenhouse gas savings and costs, such as those outlined, should be taken into account in policy choices.

[3]Sustainable Energy Authority of Ireland (2022). Sustainable Bioenergy for Heat National Heat Study - Spatial Assessment of Resources and Evaluation of Costs and Greenhouse Gas Impacts. Available at: https://www.seai.ie/publications/Sustainable-Bioenergy-for-Heat.pdf.

Fuel and heating costs

On prices, *SBH* indicated that forestry thinnings are available at under 2 cent per kilowatt hour (c/kWh), excluding conversion and processing costs. Based on the current heat market, woodchip, as delivered, is trading in the region of €150/tonne at a moisture content of 30%, which is equivalent to just over 4 c/kWh. Thus, the SEAI estimate, even allowing for conversion, processing and transport, is below current market prices. Perennial energy crops and biogas from anaerobic digestion of grass silage/slurry feedstock (again excluding conversion and processing costs), are costed 2.3-2.6 c/kWh and 5.3-5.5 c/kWh respectively in *SBH*.

SEAI's latest (1 April 2024) quarterly update shows that for residential (domestic) heating, delivered energy costs were lowest for bulk delivered softwood firewood at 9 c/kWh (at 25% moisture content). Pellets and kerosene (home heating oil) had similar delivered costs of 11-13 c/kWh. Bottled gas and wood briquettes were relatively expensive at 21-22 c/kWh. Average gas costs were 16 c/kWh for typical use ranges, while the comparable figure for electricity being 38 c/kWh.

Fuel poverty generally goes hand-in-hand with the use of the cheapest fuels, combustion in inefficient appliances and low levels of house insulation Many such homes are in receipt of the government's means-tested fuel allowance scheme. However, given the types of appliances in use, the efficiency of this measure could be considerably improved, and levels of pollution reduced, if a carefully considered appliance/open fire replacement scheme were introduced using Ecodesign replacement appliances

Turning to prices for commercial heating fuels, SEAI estimates a current (April 2024) woodchip price of just under 6 c/kWh, or around the same price of natural gas (for installations with installed capacity of approximately 2-22 MW heat), about half the cost of oil at 12 c/kWh, and about a quarter of the cheapest electricity price at 22 c/kW.

Fuel price trends are available through SEAI's quarterly and biannual commercial and domestic fuel prices, which provide a time series stretching back to 2007. Prices as delivered for the main commercial fuels (including electricity) and wood pellets and woodchip show that woodchip has been the cheapest fuel, as delivered, over most of the time series, with only commercial gas being cheaper on occasion

Energy prices, particularly fossil fuels, after a period of relative stability prior to late 2021, have increased in volatility, and are consequently more difficult to predict.

Fuel costs are of course just one element of expenditure that a project investor will consider when deciding on the nature of a heat energy service. Capital and other costs such as carbon tax (for installations outside of the ETS) will also be taken into account, in order to arrive at a levelised cost over the project horizon. In addition, other factors such as carbon emission savings and security of fuel or electricity supply will normally be included in the decision-making process. Most commercial investors will look to horizons of five years or less, as they seek to estimate the time taken to pay back an investment.

Prospective uses of biomass

Over half of forest-based biomass is currently used in industrial heating, mainly in the wood processing sector. However, the forecasted increase in the availability of woody biomass offers an opportunity to consider the policy mix to best support greenhouse gas emission reductions from forest-based biomass use, aligned with affordable and sustainable energy, and security of supply.

A key policy goal at national and EU levels is to move towards carbon neutrality by mid-century. Based on GHG projections, forests and soil carbon – the LULUCF sector – will be a net source of emissions in Ireland for at least another decade. This will add, not detract to the difficulty of achieving the carbon neutrality goal. On the other hand, emissions from difficult to decarbonise sectors are likely to require a significant level of balancing removals, emissions, which could be in the region of 10 M t CO_2 eq/yr, to arrive at a level close to net zero by 2050.

The potential contribution from BECCS - bioenergy with carbon capture and storage - and biochar to these goals are now explored further.

The overall argument is that support policies for new industrial and district heating and CHP installations, should consider the scales of operation, and the feasibility of aligning measures with BECCS/biochar pathways for gaseous and solid carbon removals.

Most of the integrated assessment models (IAMs) which examine pathways to net zero by 2050, as referenced by the IPCC in their assessment and special reports, make use of negative emissions (also referred to as carbon dioxide removals (CDR)) to balance out emissions and reach the global net zero target at some time during this century. Among the technologies BECCS and biochar/soil carbon are the two biomass energy CDRs which can provide substantial removals, while also providing renewable energy services. The earlier calculation showed that for every 5 PJ of forest-based biomass combusted, approximately 0.5 Mt CO_2 is potentially available for BECCS, and what is effectively a permanent removal of CO_2 from the atmosphere, assuming sustainable forest management.

On scale of installation, *Carbon Capture Utilisation and Storage* (*CCUS*), part of the SEAI heat study, states that carbon capture technology is likely to be limited to installations with emissions above 0.1 Mt CO_2/yr and which are included within the EU emissions trading scheme. Assuming this threshold, and using IPCC specific emission factors for wood combustion, as well as average annual utilisation rates it would take a biomass plant with an estimated installed capacity of around 35 MW to reach the threshold. Such installations could be either stand-alone heat or CHP, and would provide an annual energy service in the region of 0.2 TWh.

The annual forest-based biomass supply for one such installation would be close to 1 PJ/yr, or about 95,000 tonnes at 45% moisture content. As Table ES 2 shows, there is a biomass supply available for several such plants. The energy service provided would depend on plant configuration (for example district heating only or CHP) and resultant efficiency, but is likely to be around 0.8 PJ/yr. Plants of this size could bring economies of scale to biomass supply, without being oversized or overly reliant on imports.

At the policy level, and among civil society, there may be concerns that the deployment of CDR technologies, such as BECCS, would deter emission abatement and undermine efforts to achieve net zero. However, the 2023 Climate Action Plan, as pointed out, contains a wide range of decarbonisation measures, which enshrine an emission-reduction first approach. More recently, the 2024 Climate Action Plan envisages some role for carbon removal technologies involving extraction, storage, and utilisation of biogenic carbon dioxide, during the second carbon budget period (post 2025). It refers to biochar and BECCS as potentially promising avenues capable of addressing part of the gap in residual unallocated emissions. Given the high probability of emission reductions being well below target at the end of 2025 and 2030, the role of removals in general, and those based on biochar and BECCS, merits serious policy consideration. Any examination should also include the technical and economic feasibility of new biomass-based heat and CHP plants as outlined, in order to scale up potential removals.

In terms of the 2023 Climate Action Plan, it includes a target of up to 0.7 TWh of district heating by 2025 and 2.5 TWh by 2030. The main fuels envisaged are renewable gases (biomethane) from agriculture-based supply chains. It is unclear whether the fuels would be delivered through existing gas networks, which are overwhelmingly fossil-fuel based. Were this to be the case it could of course, lead to an extension of the use of fossil gas in heating. It is worth considering, therefore, the extent that these targets could be partly met by forest-based biomass, which is the most commonly used fuel for district heating throughout Europe. It is also worth considering to what extent these installations could be readied for potential BECCS.

Conclusions and recommendations

Biomass and bioenergy policy

Bioenergy accounted for almost one third of the renewable energy contribution to gross final energy consumption in Ireland in 2022, while forest-based biomass provided over half of the renewable heat supply. There is considerable scope to expand these contributions from bioenergy, including forest-based/woody biomass, over the coming decades to contribute to climate goals, security of energy supply and balanced regional development. In considering current levels of use and expansion, it is a requirement that bioenergy supply, both indigenous and imported, is sourced from sustainable sources and supply chains. Scarce biomass needs to be used in an efficient manner, and in a way that does not damage air quality.

Biomass is suitable for a wide range of energy uses, from power to heat, to transport and aviation fuels. It can also be used as a replacement for oil in the manufacture of cellulose-based products, such a packaging and clothing fabrics.

A number of policies and measures at national and EU level deal with bioenergy in general and forest-biomass in particular. There is however no overarching strategy or policy covering bioenergy, and its role in substituting for fossil-based fuels and addressing renewable energy targets. This tends to lead to an uncoordinated mix of policies and measures, a lack of clarity of objectives, and a lack of confidence among companies and investors when considering bioenergy as a substitute for oil and gas. For example, the SSRH measure has no defined targets, and the timeframe only extends to 2025, which does not provide a sufficient level of confidence needed for supply side investment, or for fuel switching from gas or oil. While there is potential for a doubling in supply of woody biomass to 2040, and the role of forest-based biomass is referenced in the forest strategy, there is no policy around willow or other additional supplies of biomass. Targets do exist for biomethane, but how these are to be achieved is unclear, especially at the supply side. Land is a limited resource, and there are potentially conflicting demands for afforestation, silage for anaerobic digestion, and willow coppice, along with many other potential uses. Decisions made by the land owner will be influenced by tradition, markets and, to a greater or lesser extent, by government subsidies. Markets are also influenced by policy measures in the energy sector. To develop and sustain a viable indigenous bioenergy sector, therefore, market development and investor assurance are essential.

As far as the bioenergy and biomass contribution to national and EU policies is concerned it is essential to have an evidence base around supply, costs, sustainability and technical feasibility of bioenergy to inform national policies and the climate action plan processes. It is also essential to raise the level of ambition around sustainable bioenergy and biomass in the context of contributing to climate, energy and development goals, and as well to provide confidence to specifiers and investors.

A summary of recommendations follows. Readers are referred to the main body of the text where specific arguments are for each recommendation.

1. ***A national bioenergy strategy be developed to set out the general aims for bioenergy use into the future, and a level of ambition for deployment in the context of climate and energy goals, security of energy supply, sustainability and balanced regional development.***

2. ***The support scheme for renewable heat (SSRH) should be extended to the ETS sector as announced, with an extended timeframe to 2035 in climate action plans, with ambitious greenhouse gas reduction targets*** and

3. ***Be driven by a concerted and sustained promotion of the scheme by SEAI, working with public and private sector specifiers and relevant industry groups, and commensurate with effort in other sustainable heating systems.***

4. ***A separate target for solid biomass should be included in the district heating action in the Climate Action Plan, in line with the target for biomethane.***

5. ***Based on the findings of the feasibility assessment of carbon capture and storage, the technical and economic feasibility of integrating new large-scale district heating, and industrial heating with BECCS, should be investigated. The goal being to generate renewable heat (and power) allied to negative emissions, taking into account the need for economies of scale and locations convenient for transport of compressed carbon dioxide to geological storage.***

6. ***Compliance checking of solid fuels, including woodfuels, should be rigorously enforced by local authorities as set out in the Solid Fuel Regulations. This should be based on the provision of sufficient budgeted resources, in order to deliver foreseen improvements in air quality and provide consumers with clean and efficient home-heating woodfuels.***

7. ***Consideration be given to a targeted capital grant scheme for efficient and clean burning wood pellet and wood log gasification stoves and boilers, with provision for an affordable level of building insulation.***

8. ***Policy should also enable energy clustering of new or existing residences, and provision of heating services to apartment buildings, with a focus on the displacement of oil heating and non-mains gas heating.***

9. ***The code of practice outlined in the IrBEA good practice guidance note Specified biomass harvesting - good practice guidance for energy assortment harvesting at clearfell should be referenced in the Department of Agriculture, Food and the Marine Standards for Felling and Reforestation, in order to provide clear guidance to certifiers and foresters on sustainable residue harvesting methods.***

10. ***Teagasc and DAFM should continue to promote early thinning interventions, where appropriate, in order to improve stand quality and accelerate the growth of sawlog assortments and returns to owners. Where small roundwood for board manufacture and other solid wood products are not economically available, advise on harvesting and stacking practices that recover a high proportion of biomass and promote drying to specified moisture contents. DAFM knowledge transfers schemes should include modules on the importance of thinning, biomass harvesting and wood for energy.***

11. ***Independent verification of compliance of biomass, used in qualifying installations with the greenhouse gas savings and sustainability criteria under the renewable energy directive, should be progressed and achieved as a matter of urgency.***

12. ***Innovation and research funding should be provided to support continuous improvement in woodfuel quality and efficiency of production. Funding should also be provided to track the development of innovative wood-based second-generation biofuels, green hydrogen and for biorefining in conjunction with biofuel production.***

13. ***State and industry bodies should resource the promotion of the use of modern bioenergy and woodfuels as cost-effective, sustainable, and part of the transition to better air quality, which contributes to a balanced regional development through local supply chains and overall security of energy supply.***

14. ***Wider government policy should reflect the beneficial outcomes to climate mitigation of burning sustainable biomass and its impacts on displacing fossil-based heating fuels.***

Introduction, aim and definition

A series of COFORD statements[4] on forests and wood products, and their importance in climate change mitigation were published in 2021. The objective was to highlight the role that factors such as expansion of forest cover, management of forest resources, and wood product use play in removing carbon dioxide from the atmosphere. Impacts of climate change on forests and how these can be addressed through adaptation measures were also highlighted. The statements included policy recommendations around afforestation, forest management and measures in the built environment to encourage a greater penetration of wood construction across all types of buildings. This paper rounds out the role of forests and forest products in climate change mitigation and adaptation by outlining the role that modern bioenergy can play in reducing dependence on fossil fuels and consequent unabated carbon dioxide emissions. It also highlights the potential of modern bioenergy as a pathway to negative emissions.

Modern bioenergy in the context of this paper refers to efficient and low particulate emission biomass combustion, biorefining and other conversion technologies, based on sustainable supply chains, leading to quantifiable reductions in carbon dioxide emissions compared to fossil sources, and/or removals of carbon dioxide from the atmosphere.

Science and policy interfaces

Climate science

Since the publication of the COFORD statements, the Global Carbon Project has published *Carbon Budget 2022*[5], and the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) have issued key reports. These are now briefly summarised.

At the global level, fossil carbon dioxide emissions returned to an upward trajectory in 2021 after the impact of COVID 19 in decreasing economic activity and associated emissions (Figure 1). When combined with net emissions from land use, land-use change and forestry (LULUCF), where deforestation is the major contributor on the emissions side, the estimated global emission in 2022 was 40.7 billion tonnes of carbon dioxide[6]. The total net carbon dioxide emission at the global level in 2021 works out at an annual carbon dioxide emission of 5 tonnes per person. When, the full basket of greenhouse gases[7] (GHGs) is considered, the range is from less than one tonne per annum in the least developed countries, to 30 tonnes per annum and more in parts of the developed world. In Ireland in 2021, average GHG emissions per capita were 12.3 tonnes of CO_2 eq[8].

[4] COFORD (2022). Forests and wood products, and their importance in climate change mitigation: A series of COFORD statements. COFORD, Kildare st. Dublin.

[5] Readers are also referred to the 2023 GPC carbon budget which forecasts a continuing upward increase in global fossil carbon dioxide emissions of 1.1% in 2023 relative to 2022.

[6] Friedlingstein, P., O'Sullivan, M., Jones, M.W., Andrew, R.M., Bakker, D.C.E., Hauck, J., Landschützer, P., Le Quéré, C., Luijkx, I.T., Peters, G.P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J.G., Ciais, P., Jackson, R.B., Alin, S.R., Anthoni, P. and Barbero, L. 2023. Global Carbon Budget 2023. Earth System Science Data, [online] 15(12), pp.5301–5369. doi:https://doi.org/10.5194/essd-15-5301-2023.

[7] Principally carbon dioxide, methane and nitrous oxide.

[8] CO_2 eq means carbon dioxide equivalents and is used to express combined amounts of the main greenhouse gases: carbon dioxide, methane and nitrous oxide, based on their relative global warming potentials.

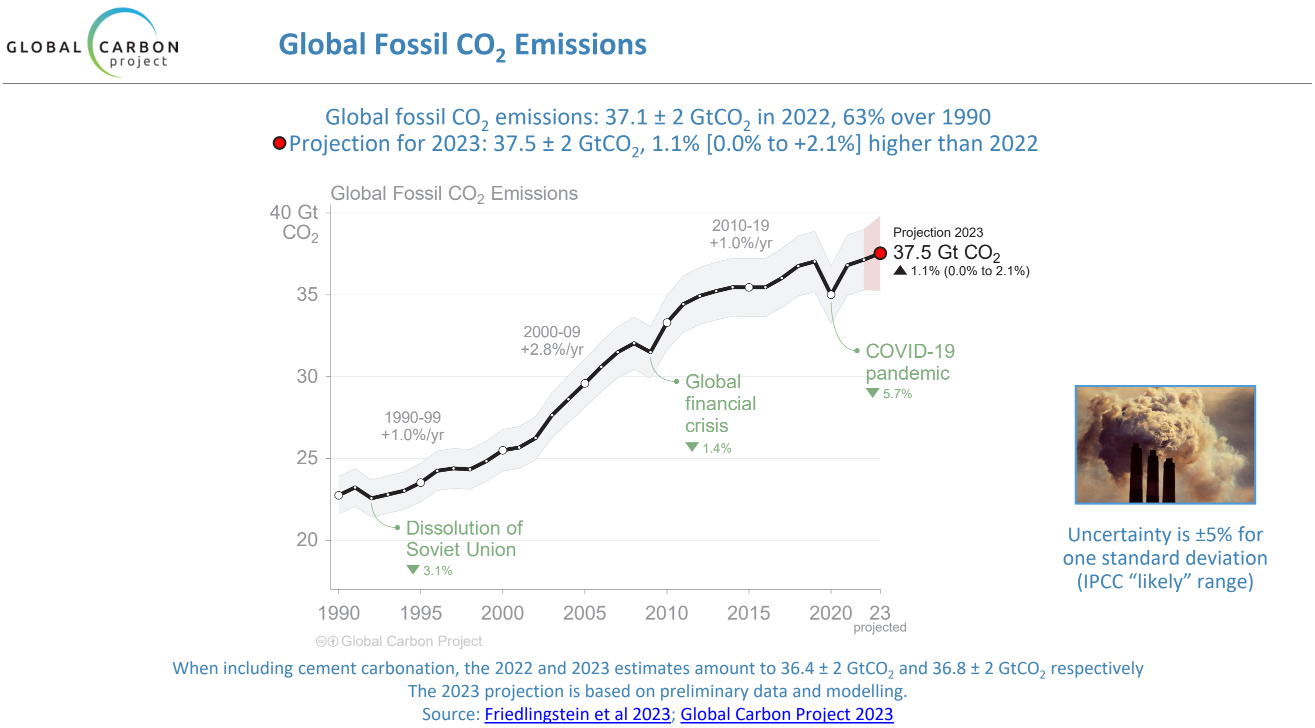
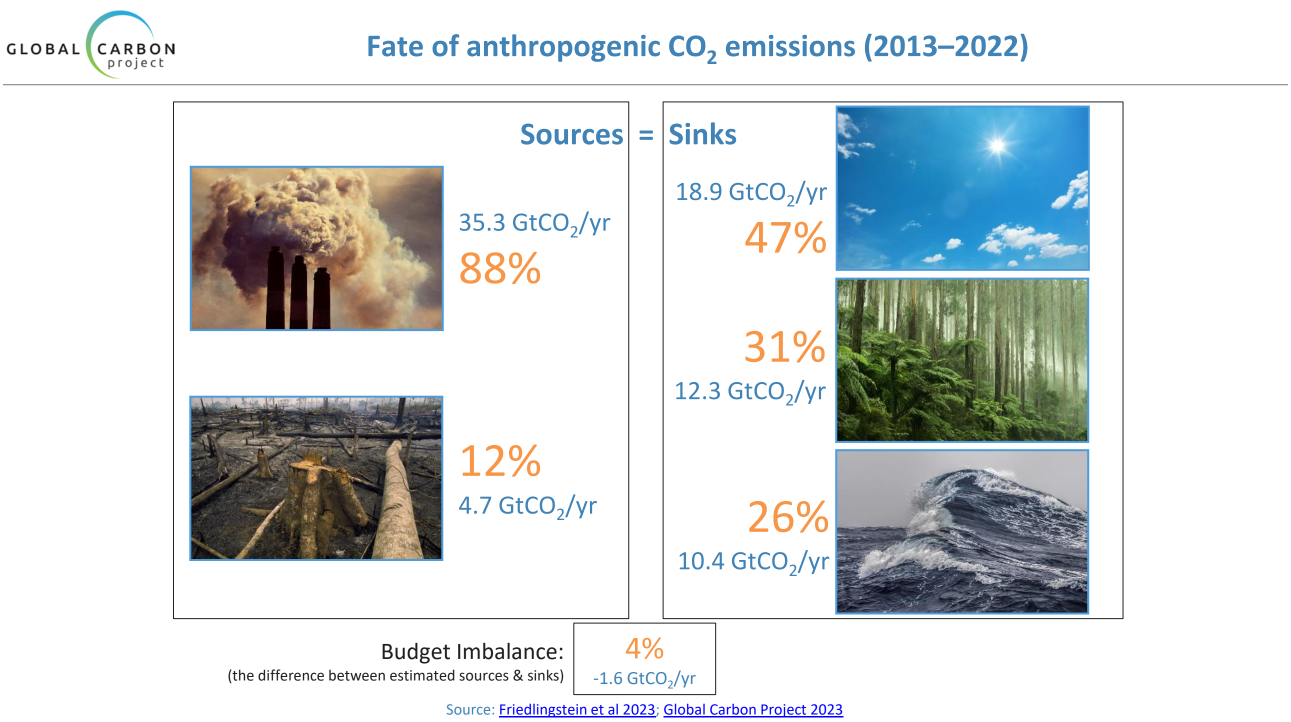


Figure 1. Trend in global fossil carbon dioxide emissions 1990-2022, and projected emissions for 2023 (source Global Carbon Project, 2023[9]).

By far the largest share of CO_2 emissions globally (88%) comes from fossil fuel combustion and cement manufacture (these estimates do not include methane and nitrous oxide emissions which are compiled in separate GCP publications). Land and ocean sinks take up about half of carbon dioxide emissions, the remainder (average 18.9 billion tonnes/yr) end up in the atmosphere where they can remain for 300 to 1,000 years (Figure 2). Fossil fuel and cement manufacturing emissions can be substantially reduced through a range of measures, including electrification and substitution by sustainable bioenergy and solid wood products.



[9] Global Carbon Project (2023). Global Carbon Budget 2022 [Powerpoint Presentation]. [online] Available at: GCP - Carbon Budget (globalcarbonproject.org)

Figure 2. Where carbon dioxide emissions arise and are stored at the global level (source Global Carbon Project[10]).

The inevitable consequence of rising carbon dioxide emissions is a corresponding rise in atmospheric concentrations of carbon dioxide, reaching some 421 parts per million in 2023, or about 51% above the pre-industrial level (around 278 ppm in 1750, see Figure 3). About half the potential increase is mitigated by the land and ocean carbon sinks.

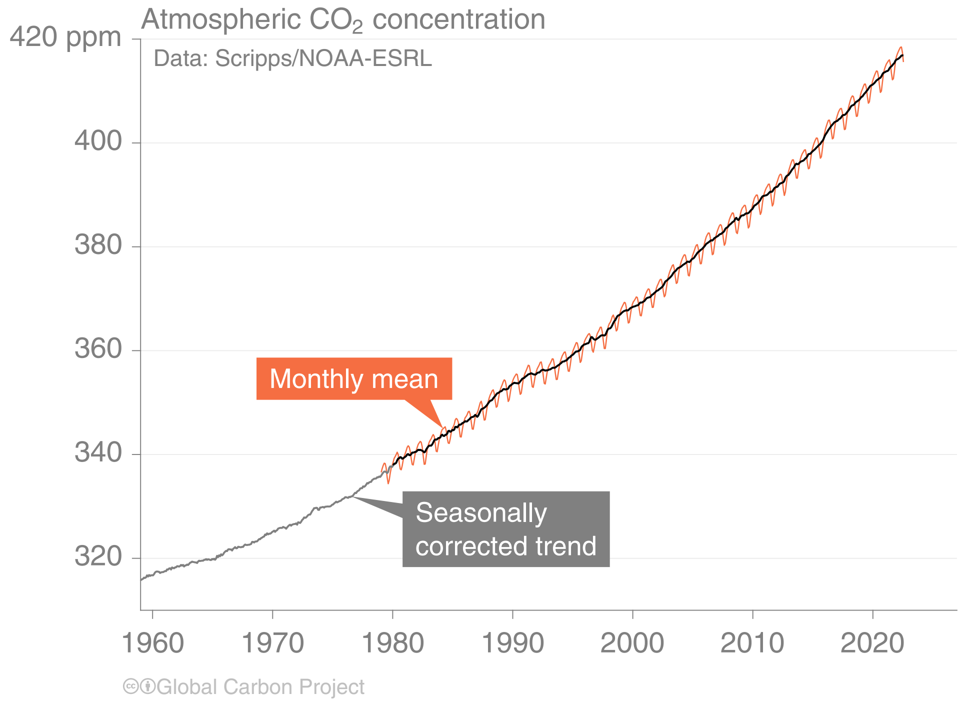


Figure 3. Atmospheric carbon dioxide concentrations over the six decades since 1960 (source Global Carbon Project[11]).

Net negative carbon dioxide

Both the IPCC, in its *Sixth Assessment Report*[12] (AR6) and the IEA in its *Net Zero by 2050* (NZE) roadmap for the energy sector, take account of the reducing window available for compliance with the Paris Agreement goals. To meet the 1.5 °C temperature rise constraint, net zero carbon emissions by 2050 is required, with a need for an expanded bioenergy contribution.

The Paris Agreement sets out a global framework to reduce the impacts of dangerous climate change by limiting global warming to well below 2° C and pursuing efforts to limit it to 1.5 °C above pre-industrial levels. Climate models referenced in AR6 outline that reaching net zero greenhouse emissions by 2050 will be needed to hold the rise to 1.5 °C. AR6 also states that net zero implies net negative carbon dioxide emissions. In practice this means greatly expanded permanent forest cover, allied to the use of carbon removal technologies such as bioenergy with carbon capture and storage (BECCS) and biochar application to, and storage in soil (Box 1).

Box 1. Extract from IPCC Working Group III [mitigation] contribution to the Sixth Assessment Report [AR6], Summary for Policymakers, on the necessity for carbon dioxide removal (CDR) and net negative emissions to constrain temperature increases in line with the Paris Agreement. Leading letters and numbers refer to Section C of the summary report, which deals with system transformations to limit global warming, identifies emission pathways and alternative mitigation portfolios consistent with limiting global warming to different levels, and assesses specific mitigation options at the sectoral and system level.

[10] Global Carbon Project (2023). Global Carbon Budget 2023. [Powerpoint Presentation] [online] Available at: https://globalcarbonbudget.org/carbonbudget2023/)

[11] Global Carbon Project (2022). Global Carbon Budget 2022 [Powerpoint Presentation]. [online] Available at: GCP - Carbon Budget (globalcarbonproject.org)www.globalcarbonproject.org/.

[12] IPCC (2021). Sixth Assessment Report — IPCC. [online] Available at: https://www.ipcc.ch/assessment-report/ar6/.

C.11 The deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved. The scale and timing of deployment will depend on the trajectories of gross emission reductions in different sectors. Upscaling the deployment of CDR depends on developing effective approaches to address feasibility and sustainability constraints especially at large scales.

C.11.1 CDR refers to anthropogenic activities that remove CO_2 from the atmosphere and store it durably in geological, terrestrial, or ocean reservoirs, or in products. CDR methods vary in terms of their maturity, removal process, timescale of carbon storage, storage medium, mitigation potential, cost, co-benefits, impacts and risks, and governance requirements…

C.11.3 The removal and storage of CO_2 through vegetation and soil management can be reversed by human or natural disturbances; it is also prone to climate change impacts. In comparison, CO_2 stored in geological and ocean reservoirs (via BECCS, DACCS [direct air carbon capture and storage], ocean alkalinisation) and as carbon in biochar is less prone to reversal.

C.11.4 In addition to deep, rapid, and sustained emission reductions CDR can fulfil three different complementary roles globally or at country level: lowering net CO_2 or net GHG emissions in the near-term; counterbalancing 'hard-to-abate' residual emissions (e.g., emissions from agriculture, aviation, shipping, industrial processes) in order to help reach net zero CO_2 or net zero GHG emissions in the mid-term; achieving net negative CO_2 or GHG emissions in the long-term if deployed at levels exceeding annual residual emissions.

International Energy Agency Net Zero Emissions 2050 roadmap

The IEA NZE 2050[13] roadmap is built on a number of overarching principles, namely that the uptake of all the available technologies and emissions reduction options is dictated by costs, technology maturity, policy preferences, and market and country conditions.

Overall, the IEA roadmap provides a useful framing for general policy considerations and analysis in relation to the development and deployment of renewable energy measures. For modern bioenergy, the roadmap foresees a contribution of around 18% to total global energy needs by 2050 (Figure 4). The 2023 update[14] of the roadmap states: *The NZE Scenario projects increasing use of low-emissions energy sources in place of unabated fossil fuels. Between 2022 and 2030, low-emissions sources increase by over 110 EJ, equivalent to the current total energy supply of the United States and Japan combined. Over the remainder of this decade, the increase in low-emissions energy sources is led by modern bioenergy in its solid, liquid and gaseous forms*.

Notably the roadmap assumes a phasing out of traditional biomass for cooking, a necessity in many developing countries, through displacement by modern stoves. It also foresees a greatly reduced use of food crops for bioenergy, with a shift to dedicated short-rotation woody crops, grown on cropland, pasture land or marginal lands not suited to food crops, which the roadmap says can produce twice as much bioenergy per hectare as many conventional bioenergy crops. Forestry (including residues) and short rotation biomass are forecast to contribute 56% to bioenergy supply.

[13] International Energy Agency (2021). Net Zero by 2050 A Roadmap for the Global Energy Sector. [online] Available at: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

[14] International Energy Agency (2023). Net Zero Roadmap a Global Pathway to Keep the 1.5 °C Goal in Reach. [online] Available at: https://iea.blob.core.windows.net/assets/9a698da4-4002-4e53-8ef3-631d8971bf84/NetZeroRoadmap_AGlobalPathwaytoKeepthe1.5CGoalinReach-2023Update.pdf.

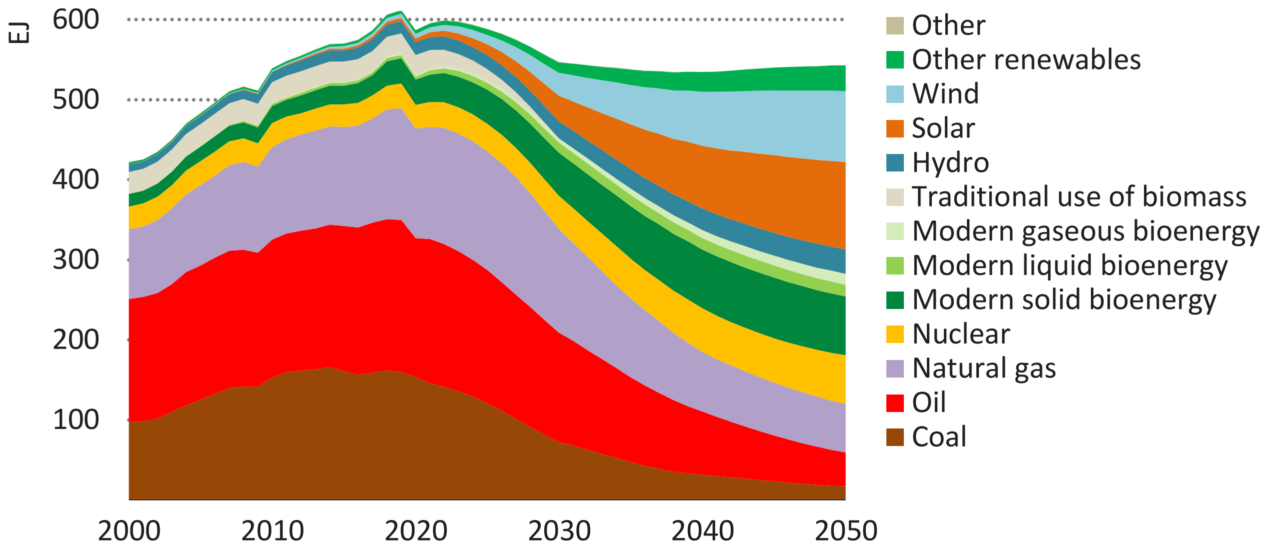


Figure 4. Evolution of total energy supply[15] from 2000-2050 as foreseen in the IEA NZE roadmap (EJ is exojoule and is 1000 (10^3) petajoules (PJ). Ireland's total primary energy supply in 2021 was 0.6 EJ (IEA, 2021[16]).

Policies and measures, as the IEA points out, are dictated by costs, policy preferences and market and country conditions, with EU policy playing a strong role in Member States.

Forest-based biomass and climate change mitigation – why it makes scientific sense

There are trade-offs between harvest and maintaining forest carbon stocks, in relation to net climate benefit. In Ireland most forests are grown for wood production, with harvest income and government supports providing the main incentives for landowners to consider afforestation in the first place. Income from roundwood sales covers the cost of reforestation after harvest, thereby closing the production cycle. In forests worked under a continuous cover system, a similar argument can be made that income from wood sales pays for the cost of interventions and generates a return to the owner. In both types of silviculture, early thinning to remove smaller and poor-quality stems makes economic sense, and is necessary to select potential final crop trees.

At harvest, carbon is removed from the forest and, depending on what growth stage the forest is at, there will be less uptake of carbon than if the forest was left unharvested. This is sometimes referred to as foregone carbon sequestration. In assessing the impact of harvest, it is necessary to look at impacts on carbon stocks and sinks at the regional and country levels.

In relation to system boundaries Cowie et al[17] point out:

Misleading conclusions on the climate effects of forest bioenergy can be produced by studies that focus on emissions at the point of combustion, or consider only carbon balances of individual forest stands, or emphasize short-term mitigation contributions over long-term benefits, or disregard system-level interactions that influence the climate effects of forest bioenergy. Payback time calculations are influenced by subjective methodology choices and do not reflect the contribution of bioenergy within a portfolio of mitigation measures, so it is neither possible nor appropriate to declare a generic value for the maximum acceptable payback time for specific forest bioenergy options.

[15] The IEA clarifies that the terms total primary energy supply (TPES) or total primary energy demand (TPED) have been renamed as total energy supply (TES) in accordance with the International Recommendations for Energy Statistics (IEA, 2020).

[16] International Energy Agency (2021). Net Zero by 2050 A Roadmap for the Global Energy Sector. [online] Available at: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

[17] Cowie, A.L., Berndes, G., Bentsen, N.S., Brandão, M., Cherubini, F., Egnell, G., George, B., Gustavsson, L., Hanewinkel, M., Harris, Z.M., Johnsson, F., Junginger, M., Kline, K.L., Koponen, K., Koppejan, J., Kraxner, F., Lamers, P., Majer, S., Marland, E. and Nabuurs, G. (2021). Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy. GCB Bioenergy, 13(8), pp.1210–1231. doi:https://doi.org/10.1111/gcbb.12844.

To answer the key question 'what are the climate implications of policies that promote bioenergy?' assessment should be made at the landscape level, and use a full life cycle approach that includes supply chain emissions, changes in land carbon stocks and other variables influenced by the policies studied. Effects on land cover, land management and the wood products and energy sectors need to be considered, including indirect impacts at international level. The bioenergy system should be compared with reference scenarios (counterfactuals) that describe the most likely alternative land use(s) and energy sources that would be displaced by the bioenergy system, and the probable alternative fates for the biomass being utilized (Figure 5). A no-harvest counterfactual is not realistic in most current circumstances, but markets that pay for carbon sequestration and other ecosystem services could change incentives for harvest in future.

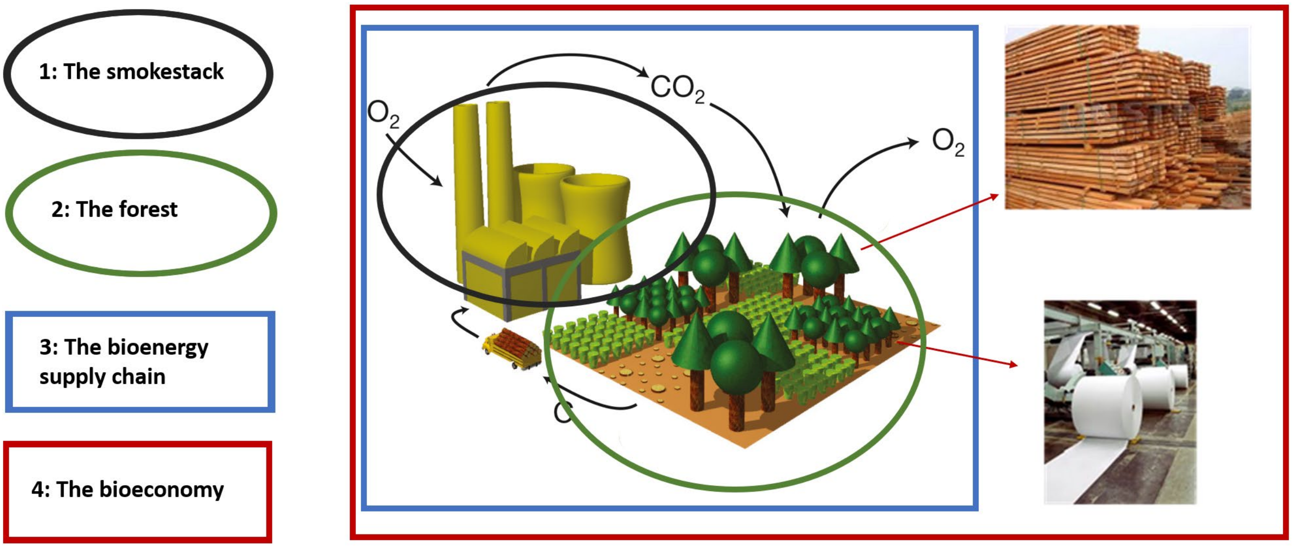


Figure 5. Alternative system boundaries that have been applied in studies assessing climate effects of forest-based bioenergy. Option 1 (black) considers only the stack emissions; Option 2 (green) considers only the forest carbon stock; Option 3 (blue) considers the bioenergy supply chain; Option 4 (red) covers the whole bioeconomy, including wood products in addition to biomass (Cowie et al., 2021[18]).

Cowie et al. argue that biomass for bioenergy should be considered as one component of the bioeconomy (Option 4). Studies should assess the effects of increasing biomass demand for bioenergy on carbon stocks of the whole forest, and include the broader indirect impacts on emissions (potentially positive or negative) due to policy- and market-driven influences on land use, use of wood products and GHG-intensive construction materials and fossil fuel use, outside the bioenergy supply chain.

More recently, a study examined the impacts of biomass harvest for pellet manufacture in the south-east region of the US on local carbon stocks over a 19-year period. It concluded that the impact was that carbon stocks increased as a direct result of increased levels of management. As the harvest resulted in no net emissions to the atmosphere, it concluded that the wood pellet industry in the study context and period had met the overall condition of forest carbon neutrality[19].

It is also important to point out that wood biomass arises from a tightly coupled carbon cycle from forest to atmosphere to forest. This differs from fossil fuel, which is a one-way flux to the atmosphere from oil and gas reservoirs, which have stored carbon and kept it away from the atmosphere over many millions of years. (Figure 6).

[18] Cowie, A.L., Berndes, G., Bentsen, N.S., Brandão, M., Cherubini, F., Egnell, G., George, B., Gustavsson, L., Hanewinkel, M., Harris, Z.M., Johnsson, F., Junginger, M., Kline, K.L., Koponen, K., Koppejan, J., Kraxner, F., Lamers, P., Majer, S., Marland, E. and Nabuurs, G. (2021). Applying a science-based systems perspective to dispel misconceptions about climate effects of forest bioenergy. GCB Bioenergy, 13(8), pp.1210–1231. doi:https://doi.org/10.1111/gcbb.12844.

[19] Aguilar, F.X., Sudekum, H., McGarvey, R., Knapp, B., Domke, G. and Brandeis, C. (2022). Impacts of the US southeast wood pellet industry on local forest carbon stocks. Scientific Reports, 12(1). doi:https://doi.org/10.1038/s41598-022-23870-x.

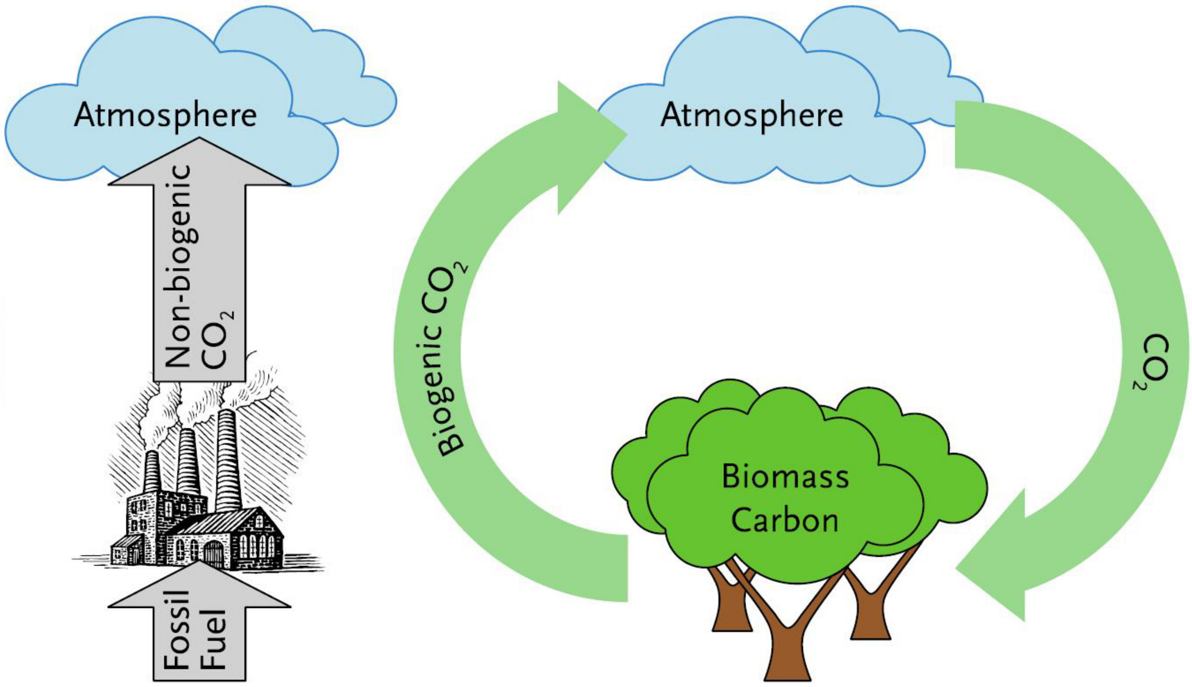


Figure 6. Illustrative unidirectional (non-biogenic) and circular (biogenic) carbon dioxide pathways from fuel combustion[20].

In summary, forests are rarely harvested solely for bioenergy products, as this would not make any economic or environmental sense (apart from some coppice-based systems). The reality is that the objective of most early forest harvest is towards higher-paying sawlog and pulpwood assortments, which are used to manufacture sawnwood and wood-based panels. Sawlog assortments typically generate a value per cubic metre that is a minimum of four to five times the value of energy wood. Growers and wood processors will benefit from early thinning interventions for bioenergy as it increases the proportionate yield of sawlog material and makes it occur sooner, compared with no-thinning options. This applies equally to conifer and broadleaved forests and silviculture.

Forest-based biomass and sustainable development

Sustainability[21] is key in deploying forest-based biomass, while forest-based biomass also contributes to sustainable development. Acting sustainably, for the purposes of this paper, means meeting the needs of the present without compromising the ability of future generations to meet their own needs.

The concept encompasses three broad pillars: the environmental, economic, and social dimensions of forest-based biomass harvest and use. These are now outlined.

Environmental sustainability includes the extent that biomass harvest has an overall positive impact on reducing greenhouse gas emissions, to what extent it contributes to emissions of local air pollutants, how it impacts on biodiversity, land and water use, and so on. Environmental sustainability, in the Irish context, is assured through compliance with requirements of the Renewable Energy Directive (RED II), and the expanded sustainability and greenhouse gas savings criteria of the recently agreed RED III. It is also assured through the Solid Fuel Regulations of the Department of the Environment, Climate and Communications. For fuel suppliers, environmental sustainability is ensured through membership of the Woodfuel Quality Assurance Scheme (WFQA) of the Irish Bioenergy Association (IrBEA), and by way of the forest licensing and guidelines of the Department of Agriculture, Food and the Marine (DAFM). In this context, harvesting of forest residues, if carried out according to IrBEA's good practice guidance[22], is compatible with environmental sustainability, as well as providing one of the fastest ways for forest-based biomass to balance greenhouse gas emissions from displaced fossil fuels (Figure 7).

[20] Kofman P and Hendrick E. 2021. Wood as a Fuel.

[21] IEA Bioenergy (2022). IEA Bioenergy Report 2023. [online] Available at: https://www.ieabioenergyreview.org/.

[22] Gavigan N, Hendrick E. (2023). Specified biomass harvesting: Good practice guidance for energy assortment harvesting at clearfell. Irish Bioenergy Association, Dublin

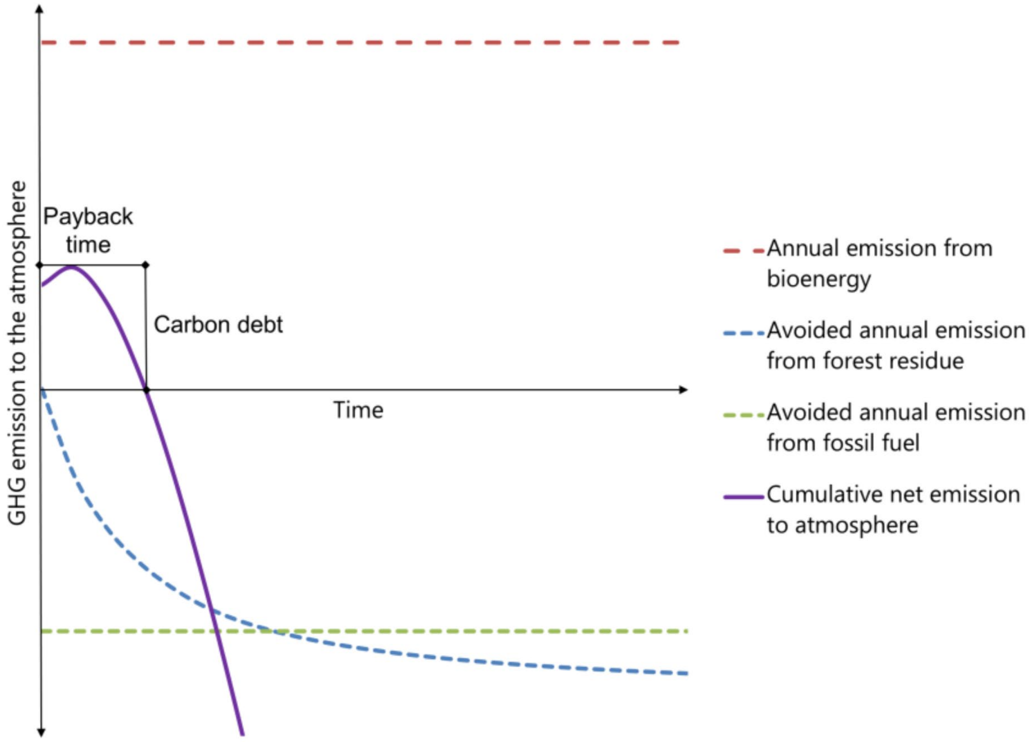


Figure 7. Illustrative example of carbon debt and payback time arising from the use of forest residues for energy, showing a rapid payback time of greenhouse gas emissions from biomass combustion, as decay and fossil fuel emissions are avoided[23].

<u>Economic sustainability</u> encompasses the supply of sufficient quantities of biomass, when and where they are needed, at reasonable prices. Forest-based biomass has been regarded as a relatively low-cost energy vector, though gas and oil prices before the price rises from mid-2021 were quite competitive. Being price-competitive with other (fossil or renewable) energy carriers is a challenge for bioenergy, though forest residues are generally a low-cost option compared with fossil fuels.

Policy instruments, such as carbon taxes, are probably the most important driver of the switch from fossil energy to renewables, and where deployed provide a significant advantage for the economic sustainability of forest-based biomass as a replacement for fossil fuels.

Policy development for forest-based biomass should also include careful analysis of supply v demand dynamics. Creating an unsustainable demand for biomass feedstocks can increase the risk of reducing forest productivity and deplete soil nutrient capital. It can also lead to excessive removal of deadwood and in extreme cases to land-use change, with negative consequences for biodiversity and the soil carbon stock. Again, it is essential to carefully manage the mobilisation of biomass to safeguard the environment, while biomass - being a limited resource - should be used efficiently and wisely in order to optimise its climate change mitigation potential.

<u>Social sustainability</u> deals with how harvest of forest-based biomass affects people, their health and wellbeing, and their ability to make a decent living. The 17 Sustainable Development Goals (SDGs), which all United Nations Member States have adopted and aim to achieve by 2030, balance the three dimensions of sustainability - environmental, economic, and social - and aim for a just transition to a sustainable future. Expanding the use of forest-based biomass has beneficial effects socially through increased levels of employment in harvesting, transporting and at the combustion stage.

Cascade use of wood harvest

Much research has shown that the most climate-advantageous way to use forest carbon is to maximise displacement of fossil-based materials and fuels. The principle is now enshrined in RED III. It means that

[23] Madsen K, Bentsen N.S. (2018). Carbon Debt Payback Time for a Biomass Fired CHP Plant - A Case Study from Northern Europe. Energies 11: 807-819.

policy should endeavour to support the movement of wood harvest through multi stages of use, thereby maximising fossil carbon displacement (Figure 8). For some assortments, such as sawmill and harvesting residues, there may be no market other than energy. It makes sense to use this material to displace fossil fuels as it would otherwise return to the atmosphere through microbial oxidation, without providing an energy service, and through fossil fuel displacement, contributing to climate change mitigation. Other situations arise where there may be no local market for small dimension thinnings, and it may be economically and environmentally more advantageous to direct this material to energy use.

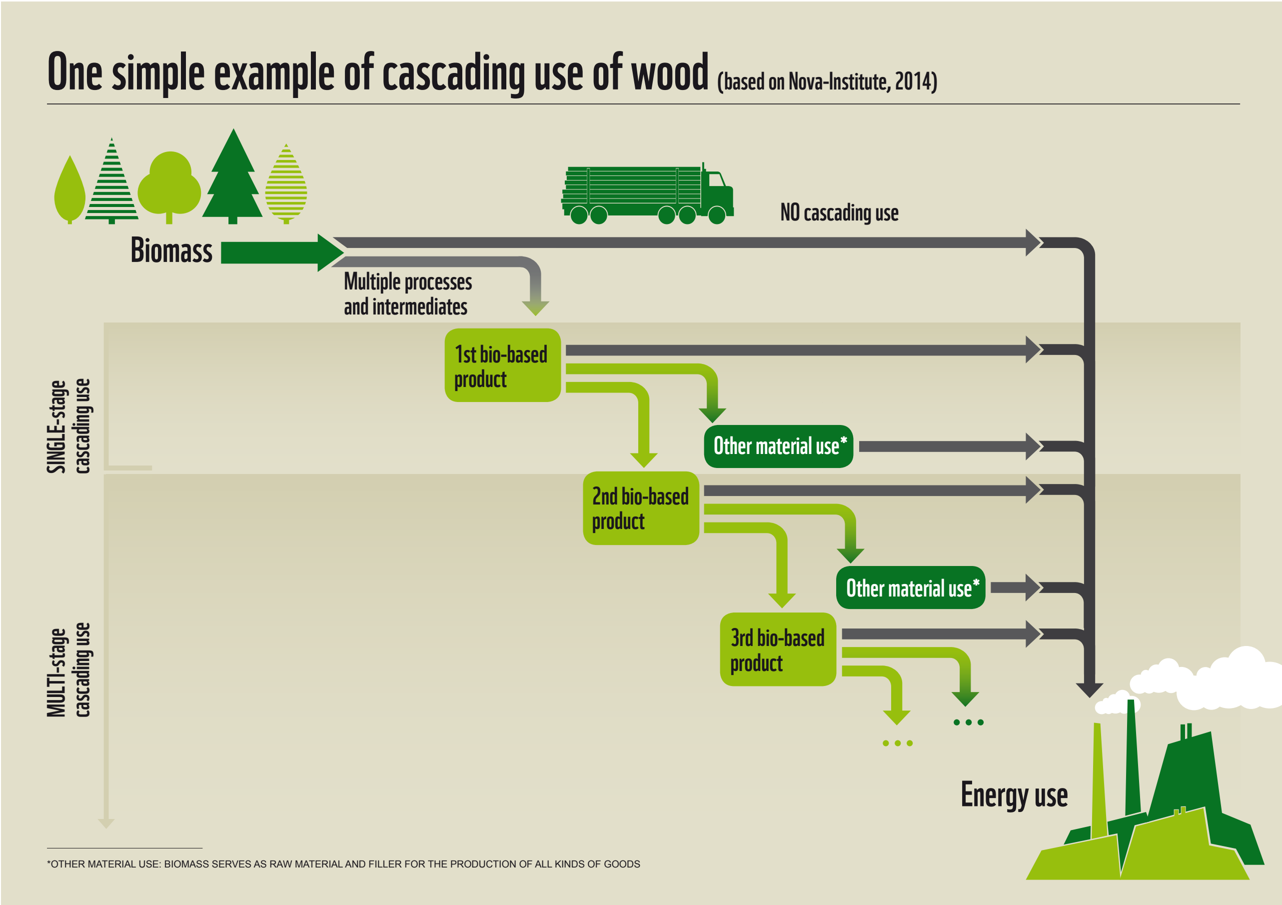


Figure 8. Illustrative example of cascade use of forest biomass, an underlying principle of climate change mitigation from wood harvest. In some instances, due to distance to market or wood quality considerations, cascade use may not be possible. However, in all foreseeable cases sawlog will be directed to sawnwood production (WWF[24]).

[24] WWF. Cascading use of wood. Source: Infographic_One_simple_example_of_cascading_use_of_wood.pdf (wwf.de)

EU and national policy frameworks

What follows is an overview of national and EU policies (often intertwined), which impinge on the current and future use of forest-based biomass in the context of modern bioenergy. Uses of wood for energy intersect with a number of interrelated policy areas, from greenhouse gas emission reduction policies and frameworks at national and EU levels, to interrelated national and EU renewable energy policies, to air quality legislation and of course to forest policy itself.

The objective here, particularly in relation to the Climate Action Plan, is to outline the policies and measures, leading to current and possible future roles for forest-based biomass across the main policy areas outlined.

The starting point for the policy frameworks is the overarching goal to limit global warming to 1.5 °C to be achieved by having net-zero greenhouse gas emissions by 2050, as set out under the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement, and drawing on the scientific evidence provided in the IPCC assessment reports referred to earlier. This extremely ambitious target, deemed necessary to avoid the potentially calamitous effects of climate change, requires transformation of economies and societies, as well as land use and land use practice.

The net zero goal is reflected in both EU and national legislation, which set out 2030 milestone targets on the pathway to 2050. Generally, the national legislation emission reduction targets are the more onerous. Different base years are used in the EU and national frameworks, which can lead to confusion when reference is made to percentage reductions in the absence of a base year. Helpfully, Environmental Protection Agency (EPA) projections and greenhouse gas emission reports refer to both actual greenhouse gas emission levels, as well as percentages in relation to compliance with the targets and carbon budgets, set out in the two frameworks.

For comparison and interpretation purposes, greenhouse gas emissions are commonly expressed in grammes or metric tonnes of carbon dioxide equivalent (CO_2 eq). This means that methane and nitrous oxide emissions are expressed relative to carbon dioxide in terms of global warming potential[25], using factors agreed by the IPCC for greenhouse gas inventories. Carbon dioxide equivalents are commonly expressed as million metric tonnes of carbon dioxide equivalents, or mega tonnes, abbreviated as Mt CO_2 eq[26] or more simply as Mt CO_2.

Fit for 55 and the EU climate change policy landscape

At the EU level, the *Fit for 55* package[27] (tabled in July 2021) is the overarching climate policy framework. It aims "to revise and update EU legislation and to put in place new initiatives with the aim of ensuring that EU policies are into line with the climate goals agreed by the Council and the European Parliament and the target of reducing net greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels".

Most of the separate legislative proposals under the *Fit for 55* package have been agreed, including the revised Renewable Energy Directive (RED III), which is of direct relevance to forest-based biomass use.

The relevant parts of *Fit for 55* are now considered in terms of current and future use of forest-based biomass, and its potential contribution to displacing greenhouse gas emissions from fossil fuel use.

The Effort Sharing Regulation

The fundamental policy instrument under *Fit for 55* is the Effort Sharing Regulation (ESR), which covers mainly transport, buildings, agriculture, small industrial installations, waste treatment, energy supply and product use, or about 60% of greenhouse gas emissions (the balance is covered under the Emissions Trading Directive (ETS) for large industrial installations, and the Land Use, Land-use Change and Forestry Regulation (LULUCF sector)). The ESR is interlinked with the ETS and the LULUCF regulation, as

[25] United States Environmental Protection Agency (2023). Understanding Global Warming Potentials | US EPA. [online] US EPA. Available at: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials.

[26] Mt is million tonnes

[27] European Council (2022). Fit for 55. [online] www.consilium.europa.eu. Available at: https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition/.

allowances and credits from those mechanisms can be used by member states to contribute to compliance with annual ESR limits.

The EU's overall ESR target for the period 2021-2030 was originally set as a 29% reduction in emissions on 2005 levels, with Ireland's target being 30%. The revised ESR has set the level of ambition at 40%, based on the *Fit for 55* paradigm[28]. Ireland's new target is a 42% reduction on 2005 levels by 2030.

Complying with the new target through domestic measures will be extremely challenging, given the trends over the period 2021 and 2022, with the EPA's *Ireland's Provisional Greenhouse Gas Emissions 1990-2023*[29] report showing ESR emissions decreased by 10.1% or 4.82 Mt CO2eq on 2005 levels, but well short of the ESR 42% reduction commitment. The latest EPA's greenhouse gas projections for the ESR[30] forecast that cumulative emissions, taking into account additional measures and flexibilities, will exceed the agreed allocation by some 17.7 Mt CO_2 eq over the 2021-2030 period, which will represent a 25% reduction in emissions on 2005. While a range of substantial decarbonisation measures have been included in climate action plans, there is every risk, as discussed in later sections, that these will not deliver the sought-after reductions in greenhouse gas emission levels.

The Emissions Trading Directive – putting a price on carbon

The Emissions Trading Directive (commonly abbreviated to ETS – Emissions Trading System) is the EU's main policy tool to reduce greenhouse gas emissions. It currently covers about 40% of overall emissions. Sectoral coverage is projected to increase to close to 70% of emissions by 2028, subject to certain conditions, under the new revised directive, which has now been agreed at EU level. Despite some earlier difficulties with the level of free allocation of allowances and a consequent low carbon price (thereby reducing the incentive to cut emissions), the ETS has become an effective instrument in quickly reducing greenhouse gas emissions. The auction price for ETS allowances (EUA) has been running at €56-71/t CO_2 eq over April- May 2024[31].

If the trend towards increased ETS coverage continues, it could be envisaged that by the early years of the coming decade, most if not all sectors will have a price put on emissions (and removals from LULUCF). This could, over time, remove the need for direct subsidies for renewables, allowing virtually economy-wide ETS coverage and full fungibility of credits across sectors, leading to lower mitigation costs. Food security and energy costs may require special consideration, but there is a clear policy trend towards wider coverage by the ETS. The period to the end of the decade and the success or otherwise of the expanded sectoral coverage under the new directive will be a good indicator of post 2030 policy.

In Ireland, the emission reduction utility of the ETS is reflected in the fact that since 2005, emissions in the ETS sector have decreased by 35.7% or 10.25 Mt CO_2 eq, whereas emissions under the ESR decreased by just 10.1% or 4.82 Mt CO_2 eq, well short of Ireland's 42% reduction commitment out to 2030. Within the ETS, and due to their size, electricity generation and cement production have had the highest levels of emission reductions [32].

The ETS works by putting a limit on overall emissions from installations that come within its scope. The limit is reduced each year. Within the limit, companies can buy and sell emission allowances through the ETS markets as needed. It is a cap-and-trade approach, enshrining the polluter pays principle. According to economic theory, it gives companies the flexibility to cut emissions in the most cost-effective way, and that emission reductions take place where it is cheapest to do so. As a result, most emission reductions across the EU have taken place in the power sector, where deployment of renewables has been moving apace.

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[28] Proportionately higher levels of emission reductions in the ETS sector are expected to close the gap to the 55% target.

[29] Environmental Protection Agency (2024). Ireland's Provisional Greenhouse Gas Emissions 1990-2023. [online] www.epa.ie. Available at: EPA-Provisional-GHG-Report-Jul24-v6.pdf

[30] Environment Protection Agency (2024). Ireland's Greenhouse Gas Emissions Projections 2023-2050. [online] www.epa.ie. Available at: EPA-GHG-Projections-Report-2022-2050-May24--v2.pdf

[31] EEX EUA (n.d.). EEX EUA Primary Auction Spot - Download. [online] Available at: https://www.eex.com/en/market-data/environmental-markets/eua-primary-auction-spot-download.

[32] Environmental Protection Agency (2024). Ireland's Provisional Greenhouse Gas Emissions 1990-2023. [online] www.epa.ie. Available at: EPA-Provisional-GHG-Report-Jul24-v6.pdf

New levels of ambition under the ETS directive, agreed in 2023, increases the overall target for emission reductions to 62% by 2030, compared to 2005 levels. This will be achieved by an annual 4.3% decrease in the allowance cap each year, reducing the level of allowances on the market, with the intention of increasing the price of carbon, and further encouraging companies to switch to renewables to reduce compliance costs. Emissions from biomass combustion, are accounted as zero, having already been accounted as emission in the LULUCF sector, (provided the biomass meets the sustainability and greenhouse gas savings criteria under REDIII). This provides an incentive to switch to biomass or increase the level of use in installations already using it. Sectors such as industrial heating processes which require high temperature steam are well-suited to such fuel-switching. As the main reduction in fossil fuel use is foreseen in power generation, most switching from fossil fuel in installations currently under the ETS is likely to be to wind- and solar-derived electricity generation. In any event, biomass is not a good fit to power generation only, given the low levels of efficiency in conventional power generation.

Given the success of the ETS in driving emission reductions in large industrial installations, compared with the slower progress in reducing emissions from fossil fuels use in heating buildings, road transport and certain industrial sectors outside the scope of the ETS, it is planned that the new directive will extend to cover those sectors from 2027 or 2028, depending on energy prices (the proposed new instrument is called ETS 2). Countries such as Ireland, which already put a price on fossil fuels through a carbon tax, can apply for a derogation under ETS 2. This is subject to certain pricing considerations, with the intention to avoid what would in effect be double taxation. The derogation would apply until 2030.

The implementation of ETS 2 will require additional rules and modalities, and it remains to be seen if it will deliver the level of emission reductions envisaged in the *Fit for 55* targets. Transport fuels, and to a lesser extent heating fuels, tend to be price inelastic and if the carbon price increases too rapidly, it could engender strong consumer resistance. Overall though, from the climate perspective, the new measure makes sense, and the incentive to switch from fossil fuels in the heating sector, across residential commercial and industrial scales, could present opportunities for modern bioenergy, given strong promotion and engagement at a member state level.

The Renewable Energy Directive

The Renewable Energy Directive, now in its third iteration - RED III - aims to increase the deployment of renewable energy across transport, heating and electricity in the EU, and sets out mandatory renewable energy targets for the EU and Member States to be achieved by 2030. It also sets out sustainability and greenhouse gas saving criteria that forest-based biomass must meet to qualify as renewable energy, in order to contribute to renewable energy and greenhouse gas emission reduction targets.

The overall RES (renewable energy share) target at EU level up to 2020 was a minimum 20% of gross final energy consumption (GFC[33]), which was met and exceeded. Ireland achieved 13.5% RES against a target of 16%. Most of the RES contribution (59%) came from wind for electricity generation. Bioenergy contributed 32%, with forest-based biomass at an estimated 13-14% of total renewables (about 2% of total GFC).

Two voluntary renewable energy targets were elected by Ireland under RED: an electricity (RES-E) target of 40%, and a heat (RES-H) target of 12%. RES-E reached 39.1% at the end of 2020, just below target and a considerable increase on the 7% share that existed in 2005.

RES-H, which is dominated by biomass and the use of renewable wastes in industry, was at 6.3%, or just over half of the 2020 target. By far the largest users of heat energy are the residential and industrial sectors (Figure 9).

[33] GFC is defined as energy commodities delivered for energy purposes to industry, transport, households, services, agriculture, forestry and fisheries, including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity and heat in distribution.

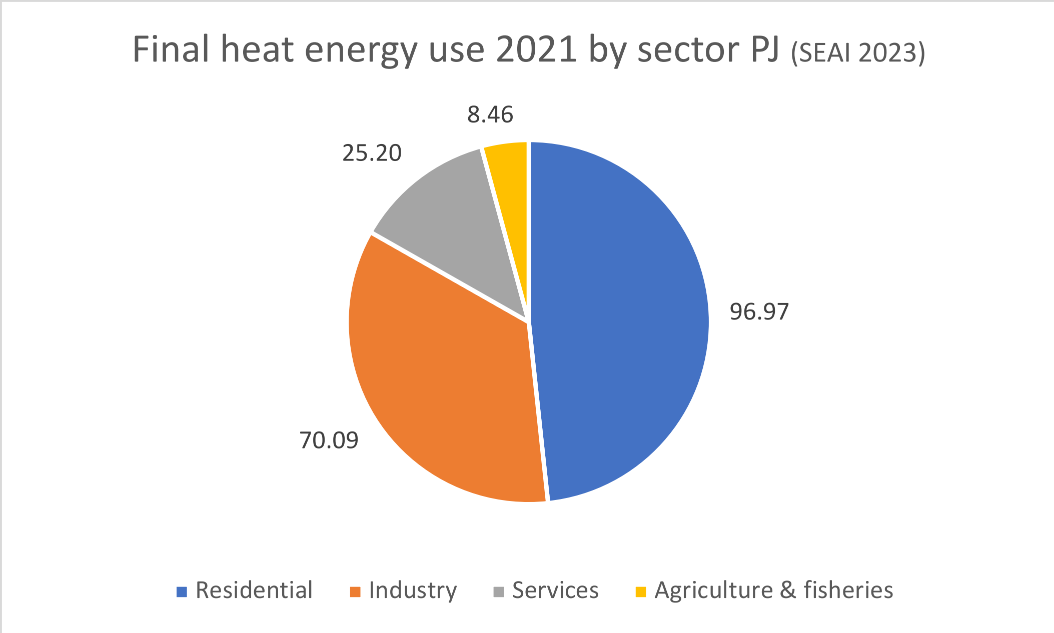

Figure 9. Final heat energy use in Ireland in 2021 by sector (SEAI, 2022).

The background to the RES-H underachievement is that after the economic crash in 2008 overall heat energy use declined, which also coincided with a period of higher oil prices. Over the subsequent period to 2014 renewable heat increased by 38%, and by 81% as a proportion of overall heat use. Following the return to economic growth after 2014, and over the period up to 2030, renewable heat showed a further increase of 16%, but overall heat use rose by a similar level so that the level of RES-H was virtually unchanged at around 6.3%[34].

At the broader EU level, it is worth noting that many Member States have successfully displaced a large proportion of fossil fuel through forest-based biomass use and other biofuels. As a result, in 2022 biofuels (mainly solid biomass) were the largest renewable energy source representing 40% of the total renewable energy supply across Europe in 2022. Sweden had the highest overall share of energy from renewables in the EU in 2022 at 66%, while Ireland had the lowest at 13%[35]. In the case of Sweden, biomass contributed by far the largest share of renewables at 59%[36]. Sweden leads the way in renewable energy deployment and in reaching greenhouse gas emission goals. This is due to a to a number of factors, not least of which is a continuing commitment to policies inaugurated as a result of the energy crises of the 1970s, and a range of tax and support measures that provide the incentives and the assurances for investments in renewables.

Ireland's poor performance in renewable energy deployment, in the period up to and including 2022, points to a need to critically examine the potential to deploy all available and feasible sources of renewable energy, and to promote the full spectrum of options, including biomass, and biofuels in general. Also, the high levels of renewable deployment in Sweden and in other Member States point to a need for the general thrust of policy measures and supports to be maintained over several decades. Such an approach contributes to supply chain and know-how development, drives down costs, and encourages private sector capital investment.

New RES targets were introduced under RED II for the period from 2021-2030. The overall RES target was raised to a minimum of 32% by 2030, with Ireland's target rising to 34.1%. RED II also introduced and updated sustainability and greenhouse gas saving criteria across the full range of biofuels, including forest-based biomass. Installations must demonstrate that the criteria have been fulfilled by maintaining sustainability records of all consignments of biomass, applying a mass balance, and have all such information that is submitted to

[34] Sustainable Energy Authority of Ireland (2022). ENERGY IN IRELAND 2022 Report. [online] Available at: https://www.seai.ie/publications/Energy-in-Ireland-2022.pdf.

[35] EUROSTAT (2024). Share of energy from renewable sources. [online] Available at: https://ec.europa.eu/eurostat/databrowser/view/nrg_ind_ren/default/table?lang=en&category=nrg.nrg_quant.nrg_quanta.nrg_ind_share.

[36] Swedish Energy Agency. 2023. Energy in Sweden – Facts and Figures. [online] Available at: https://www.energimyndigheten.se/en/news/2023/energy-in-sweden---facts-and-figures-2023/

the competent authority independently audited[37]. These requirements must be met so that the energy generated can be counted towards compliance with RED targets. However, no verification system was in place in Ireland during 2021, with the result that 8% of renewable energy was not counted towards renewable energy targets[38]. The Sustainable Energy Authority of Ireland (SEAI) reports that a verification procedure is being developed for operators of biomass installations.

Following the need to address the “hardships and global energy market disruption caused by Russia’s invasion of Ukraine” and to further accelerate renewable deployment, RED III, the third iteration of the renewable energy directive was agreed in principle at the end of March 2023. The target is to increase the EU’s overall renewable energy target to 42.5% by 2030, with a possible top-up to 45%. The target is to increase the EU’s overall renewable energy target to 42.5% by 2030. Based on previous allocations, Ireland’s overall target is 43% set out in Ireland’s updated National Energy and Climate Plan (NECP) which was submitted to the European Commission in 2024.

RED III includes stricter sustainability criteria for the inclusion of bioenergy/biomass in renewable energy policies and measures at member state level, particularly in relation to the use of the cascade principle. Forest-based biomass derived from industrial roundwood can only be supported where Member States have demonstrated that the roundwood is directed in the first instance to the manufacture of solid wood products, and on fulfilment of those markets, biomass for energy purposes can be supported and counted towards RES targets.

In Ireland, standing sawnwood prices can be 4-5 times, and up to 10 times, the price of energy wood. Pulpwood prices for the manufacture of wood-based panels also typically command higher standing prices than energy assortments. Furthermore, as referred to in the preamble to the forest-based biomass forecast (set to be published with this report), Coillte has ringfenced a proportion of its pulpwood-sized assortments for wood-based panel manufacture. Hence, roundwood for energy use can be regarded as a residual assortment, which remains for harvest after sawnwood and wood-based panel manufacture have had their raw material requirements fulfilled.

Under RED III, the current requirements for third party certification of biomass supply chains for installations over a certain size will continue. The overall thermal threshold for the application of the sustainability criteria is reduced from 20 MW to 7.5 MW. The demonstration of biomass sustainability is therefore extended to more installations. Also, Member States will not be allowed to grant new or renewed support for electricity-only installations using forest biomass (with certain exceptions).

Forest-based biomass emissions in the energy sector and in the ETS will remain accounted as zero, with new text added to the ETS to conform with the RED III criteria. The use of forest-based biomass in the energy sector will continue to be counted towards renewable energy targets, as long as it meets the sustainability, carbon savings and cascade use criteria.

Energy Efficiency Directive

The Energy Efficiency Directive (EED) is a further element of the *Fit for 55* package. The EU’s policy paradigm is energy efficiency first[39], in other words reductions in energy use take precedence over renewables deployment. It includes a series of measures in the buildings, industry, and transport sectors, for example better insulated buildings, more efficient use of heat, increased use of public transport. Applying the energy efficiency first principle to the use of forest-based biomass means that energy services provided by biomass should consist of heat only or combined heat and power plants, and the use of efficient appliances in residential heating. It also means that low efficiency uses such as power only, and inefficient stoves and open fires, should be phased out over time.

[37] Irishstatutebook.ie. (2022). SI 350 of 2022 European Union (Renewable Energy) Regulations (2) [online] Available at: https://www.irishstatutebook.ie/eli/2022/si/350/.

[38] Sustainable Energy Authority of Ireland (2022). ENERGY IN IRELAND 2022 Report. [online] Available at: https://www.seai.ie/publications/Energy-in-Ireland-2022.pdf.

[39] As defined in Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action, energy efficiency first means taking utmost account in energy planning, and in policy and investment decisions, of alternative cost-efficient energy efficiency measures to make energy demand and energy supply more efficient, in particular by means of cost-effective end-use energy savings, demand response initiatives and more efficient conversion, transmission and distribution of energy, whilst still achieving the objectives of those decisions.

The reduction target is set using 'reference scenario' projections of energy use to 2030, based on the policies and measures that were in place and/or planned up to 2020. In 2023, the revised Energy Efficiency Directive[40] set out a target for the EU Member States to collectively reduce energy consumption by at least 11.7% compared to the reference scenario, so that final energy consumption is no more than 31,945 PJ (763 million tonne of oil equivalent (M toe)) in 2030.

Ireland's final energy consumption in 2022 was 504 PJ, or about 1.34% of the EU's total consumption of over 37,700 PJ in the same year. Ireland's indicative 2030 targets as submitted earlier this year in the National Energy and Climate Plan (NECP) is a final energy consumption of 437.6 PJ, and a primary energy consumption of 472.9 PJ. Based on the 2022 level, and by the government's own admission, these are extremely challenging targets, given current demographics and the rate of growth of the economy. The target applies irrespective of whether fossil or renewable energy generation is considered.

National climate change policies and measures

Climate Action and Low Carbon Development (Amendment) Act 2021 and carbon budgets

The act sets out an overall target reduction in greenhouse gas emissions of 51% by 2030, relative to 2018 levels. Under the legislation, the Climate Change Advisory Council has proposed three economy-wide carbon budgets[41], for 2021-2025, 2026-2030 and 2031-2035, "to assist the State in achieving its national climate objectives and greenhouse gas emissions targets agreed by the European Union"[42]. Any deficits in a budgetary period must be made up in the following period, in order to achieve compliance with the reduction target. The LULUCF sector is included in the 2018 baseline, and will be used in estimating compliance with the budgets, as and when the modalities for including the sector are agreed at national level.

The budgets as proposed were adopted by the Oireachtas and signed into law in April 2022 as follows:

- 2021-2025: 295 Mt CO_2 eq
- 2026-2030: 200 Mt CO_2 eq
- 2031-2035: 151 Mt CO_2 eq.

The EPA publication *Ireland's Provisional Greenhouse Gas Emissions 1990-2023*[43] reports that emissions, including LULUCF, over the period 2021-2023 were 188.43 Mt CO_2eq or 63.9% of the first five-year carbon budget of 295 Mt CO_2eq. So, a remaining budget of 36.1% to cover the years 2024 and 2025. Staying within budget will require 8.3% annual emissions reductions over both years, or about 5 Mt CO_2eq/yr. Based on current trends it is very likely that the carbon budget for the period 2021-2025 and the subsequent 5-year period will be exceeded by a significant margin.

Climate Action Plans

The Climate Action Plan 2024 is the third annual update to the plan, which was first issued in 2019. It is the second plan to be prepared under the Climate Action and Low Carbon Development At 2021 and follows the introduction of economy-wide carbon budgets and sectoral emissions ceilings.

The plan seeks to implement the carbon budgets and sectoral emissions ceilings, as agreed by the Oireachtas, in order to meet the legally binding 51% reduction in greenhouse gas emissions by 2030 and reach net zero no later than 2050, as set out in the climate act.

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[40] Council directive 2023/1791/EC on energy efficiency and amending Regulation (EU) 2023/955 (recast). (2023) Official Journal L231. [online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023L1791

[41] A carbon budget sets a limit of the amount of greenhouse gases that may be emitted during a specified period, and is normally expressed in tonnes of CO_2 eq.

[42] www.climatecouncil.ie. (n.d.). Carbon Budgets | Climate Change Advisory Council. [online] Available at: https://www.climatecouncil.ie/carbonbudgets/.

[43] Environmental Protection Agency (2024). Ireland's Provisional Greenhouse Gas Emissions 1990-2023. [online] www.epa.ie. Available at: EPA-Provisional-GHG-Report-Jul24-v6.pdf

The Climate Action Plan 2023 refers to bioenergy (including a target for production of up to 5.7 TWh of biomethane by 2030), with solid biomass referenced in relation to heating in the industry sector, where it is envisaged as playing an enhanced role in displacing fossil fuels.

The Support Scheme for Renewable Heat (SSRH)[44] is the measure that supports biomass and other renewable energy sources in commercial heating. It is also referenced in the plan and is set to continue until 2025, as far as new applicants are concerned. Payments will continue to accrue for scheme members over a 15-year period from the official date of commencement of the project. The latest update on the biomass element of SSRH (heat pumps are also eligible for support) indicate steady but slow uptake, with 35 projects in receipt of funding across the agriculture sector, hotels and nursing homes. Only one third of offers have progressed to investment. SEAI states that there are (unlisted) major perception barriers in relation to the scheme. Total estimated CO_2 abatement per annum from funded projects is estimated at 25,000 t/yr. IrBEA has publicly raised concerns around the slow progress of the scheme and the level of administrative burden involved in securing approvals.

In addition to outlining the high-level energy policy frameworks and targets, and the compliance trends, it is useful to examine current and projected future implementation of the main measures in the Climate Action Plan and energy policy more generally. The objective is to examine the likelihood of the measures delivering the foreseen emission reductions, in the context of informing policy of where an expanded emphasis on the role of forest-based biomass, particularly in heating, might best contribute to sectoral targets. These observations inform the final sections of the report, which draw conclusions and set out a number policy-related recommendations around forest-based biomass.

The considerable progress made in reaching RES-E targets, as outlined earlier, at both national level and across the EU, allied to international trends towards electrification of energy supply across all modes, has focused EU and national renewable energy policies in that direction. Electrification is central to three of the five main decarbonisation measures outlined in Climate Action Plan 2023 and in the accompanying Annex of Actions. Afforestation and agriculture are the other measures. The five measures are now outlined, with a summary and a general commentary on progress to date.

Renewable electricity generation

Probably the most significant measure in the Climate Action Plan framework is the ambition to have 80% of electricity supply from renewable sources by 2030, stated as requiring 22 gigawatts (GW) in installed renewable generation capacity. This is to be achieved by a major expansion of wind energy, both onshore and offshore, and solar energy, in order to decarbonise the electricity sector, as well as enabling the electrification of other technologies.

In July 2022, the Government committed additional resources to facilitate the bringing on stream of 5,500 megawatts (MW) of solar generation and 7,000 MW of off-shore wind generation by 2030. The aim of which is to support an increased need for renewable electricity capacity, and to further accelerate the reduction of overall economy-wide emissions.

Electricity policy resides with the Department of Environment, Climate and Communications (DECC). EirGrid, the state-owned electric power transmission operator, and the Commission for Regulation of Utilities (CRU) are responsible for grid capacity and transmission, adequacy of supply, and the design, operation and regulation of the wholesale and retail electricity markets.

According to the Eirgrid/SONI *2022-2031 Generation Capacity Statement* (GCS), installed renewable capacity in the Republic of Ireland at the end of 2022 was an estimated 5.054 GW[45]. The GCS estimates that successful bids under the Renewable Energy Support Scheme (RESS) and the Offshore Renewable Electricity Support Scheme (ORESS) have the potential to increase that level to 12.623 GW by 2030, and to 14.962 GW in the

[44] The Minister for the Environment, Climate and Communication announced on the 1 March 2023 that the SSRH would maintain the maximum support for biomass applications at €3.5 million over 15 years, while also stating that the intention is to expand the scheme to the Emission Trading Scheme sector, comprising of large industry and large fossil fuel users, subject to State Aid approval. The announcement stated that the SSRH has provided 15-year biomass support tariffs to 90 installations, with 30 installations commissioned and already receiving regular payments. The total committed support amounted to €35 million over 15 years and is anticipated to provide 90 GWh (0.32 PJ) of renewable heat annually.

[45] Eirgrid/Soni (2022). Ireland Capacity Outlook 2022-2031 [online] Available at: EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

following year. Figure 10, taken from GCS 2022-2031, illustrates the current and assumed future level of renewable power in the grid. The GCS report foresees no expansion in biomass-based electricity provision, with Edenderry assumed to close post 2030. Wind and solar, in line with the climate action plans, are foreseen as the main renewables underpinning decarbonisation of the grid and as supporting increased levels of electrification of heat and transport.

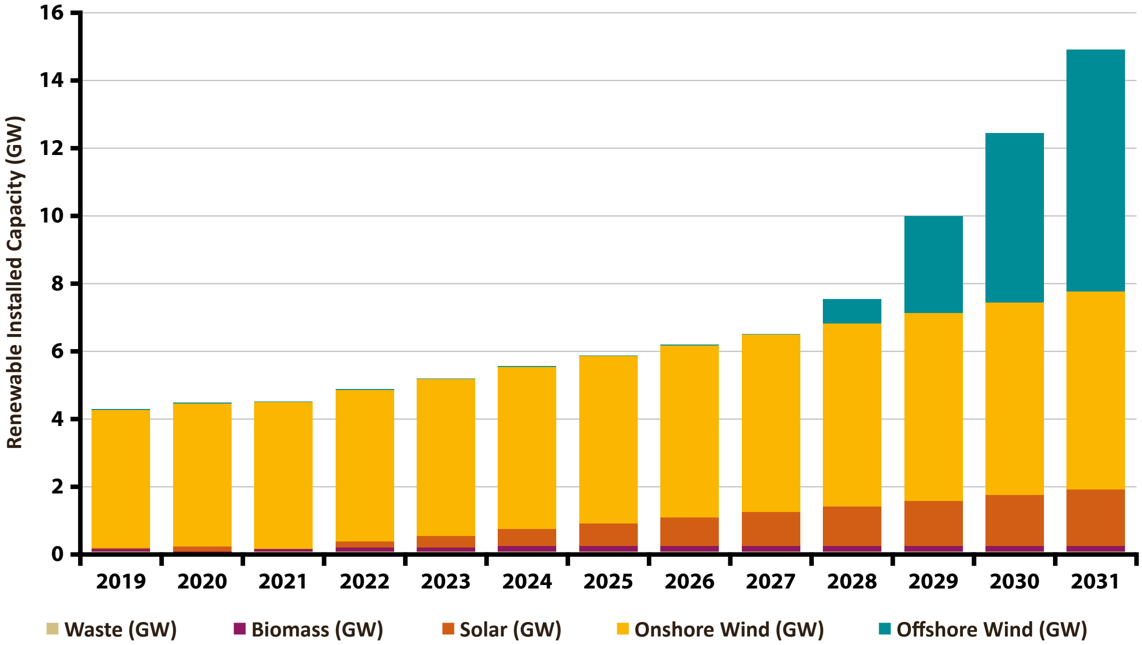

Figure 10. Projected levels of installed renewable energy capacity by source, 2019-2031, (Eirgrid/SONI, 2022[46]).

Climate Action Plan 2023 has raised the RES-E level of ambition to 80% by 2030. GCS 2023-2032 is scheduled to update the renewable assumptions based on the higher target.

Achieving the RES-E target, and by implication national and EU legally-binding greenhouse gas reductions, will depend on successful bidders achieving the planning consents and finance needed for project completion. It will also require substantial upgrading of the transmission gird to cater for intermittent supply from wind and solar.

In relation to the current adequacy of power supply, the statement points out: "There is no question that the current outlook, based on the best information available, is serious. It is likely that in the coming years we will experience system alerts and will need to work proactively to mitigate the risk of more serious impacts… A balanced portfolio of new capacity is required and this includes the need for new cleaner gas fired generation plant which are renewable gas ready, especially at times when the wind and solar generation is low … Furthermore, by 2030 there will be significant new additional load from the heat and transport sectors as they are electrified, in line with government targets set out in the Climate Action Plan 2021".

Given these considerations, and in order to spread risk and diversify the technology mix, it can be argued that a strengthened and more broadly recognised role for biomass in decarbonising heating should be included in the national policy system. This would be in line with the insights and recommendations from the SEAI 2022 heat study report *Sustainable Bioenergy for Heat* (*SBH*) and similar recommendations advanced in the Renewable Energy Ireland report *40 by 30*[47], which outlined a pathway to 40% renewable heat by 2030 across a range of technologies, including those mobilising modern bioenergy.

Overall, current and forecast supplies of biomass are tight (see below) and are unlikely to make any substantial direct contribution to increasing levels of renewable electricity, albeit there may be a renewed

[46] Eirgrid/Soni (2022). Ireland Capacity Outlook 2022-2031 [online] Available at: EirGrid_SONI_Ireland_Capacity_Outlook_2022-2031.pdf

[47] Renewable Energy Ireland (2021). 40 by 30: A 40% Renewable Heat Vision by 2030 Delivering 7% CO_2 Abatement per Year. [online] Available at: https://renewableenergyireland.ie/wp-content/uploads/2021/05/Renewable-Energy-Ireland_Renewable-Heat-Plan_-Final.pdf

role for biomass-based combined heat and power (CHP). Indeed, power-only use of biomass is not supported under the proposed RED III Directive, given the efficiency range of biomass for power is rarely above 35%.

Almost all policy and financial analysis therefore point to directing biomass towards high efficiency uses such as CHP and stand-alone heating. The main energy contributions, depending on the policy framework, and the pricing of biomass and bioenergy relative to fossil fuels such as gas and oil, is judged to be in the heating sector. Efficient and clean heating, from modern biomass systems, across residential, commercial, and industrial users is likely to have the largest decarbonisation contribution. These aspects are explored in greater depth below.

Retrofitting of residential and commercial buildings

Retrofitting to increase energy efficiency of existing buildings and putting in place policies to deliver zero-emission new builds to meet the sectoral emission ceilings.

Under the climate action plan process, The National Retrofit Plan, run by SEAI, is the core measure, and aims to make substantial progress in decarbonising residential heating. It has an overall 2030 target to upgrade some 500,000 homes to a building energy rating (BER) of B2/cost optimal equivalent standard, allied to the installation of 400,000 heat pumps.

The energy upgrade target aggregates deep retrofitting with less intensive individual energy upgrades, for items such as attic and wall insulation, to arrive at an equivalent (in terms of carbon savings) B2-rated total. For example, the interim targets for the period 2019-2025 envisage a total of 185,000 home energy upgrades, of which 85,000 will be to a "B2/cost optimal level". This is equated[48] to 120,000 deep retrofits. To date, over the period 2019 to the end of Q1 2023, some 94,700 properties have had some form of an energy upgrade (which includes solar panels), of which 22,000 have been to B2 or higher[49].

Recent trends show an acceleration in both applications for scheme and property upgrades completed. Total upgrades over the first half of 2023 totalled some 22,000, which was 2.5 times the level over the same period in 2022[50], while the number of new applications was 31,600, an increase of 41% on the same period in 2022. These trends are very encouraging, and based on completions to date as outlined, the total number of upgrades achieved by the end of 2025 is likely to meet the target, provided some 32,000 upgrades are achieved per year from here on. The B2 or better target is however very challenging as the level achieved in 2022, some 8,500 homes, would need to increase to 22,000/yr from here to end of 2025 to meet the target. Post 2025, and assuming the targets up to the end of 2025 are achieved, the annual completion rate needed to reach the 500,000 target by 2030 stretches to 75,000 B2-equivalent home upgrades. Given the current completion rate, and the impact of cost-of-living increases and construction inflation which are likely to continue for a number of years, and other constraining factors identified in the SEAI reports, it is difficult to see the completion target being achieved. The *Report on the Accounts of the Public Services 2022*[51] reaches a similar conclusion and estimates that emissions savings from SEAI residential retrofit programmes, following an examination of a number of measures, will be somewhere in the region of less than half those projected in the Climate Action Plan.

In relation to the heat pump installation target of 400,000 units by 2030, the level of achievement over the period 2019-2023, as outlined in the SEAI *National Retrofit Plan Full Year Report 2023*[52], was just under 10,600[53]. As the report states: "Also, while the number of heat pumps supported in 2023 was up 65%

[48] Sustainable Energy Authority of Ireland (2022). National Retrofit Plan Quarterly Progress Report Full Year 2022. [online] Available at: https://www.seai.ie/publications/SEAI-Retrofit-Annual-Report-2022.pdf.

[49] It can be difficult to disentangle the data in the SEAI reports in relation to overall targets. For example, the extent that solar PV and heat pump installations count towards the overall total of energy upgrades, and how the latter metric relates to retrofitting.

[50] The total includes about 9,000 solar PV installations, see https://www.seai.ie/publications/SEAI-Retrofit-Quarterly-Report-Q2-2023.pdf

[51] Office of the Comptroller and Auditor General, (2022). Report on the Accounts of the Public Services 20222. [online] Available at: 8. Performance of certain residential retrofit schemes (audit.gov.ie)

[52] Sustainable Energy Authority of Ireland (2023). National Retrofit Plan – Full Year Report 2023. [online] Available at: https://www.seai.ie/sites/default/files/publications/SEAI-Retrofit-Full-Year-Report-2023.pdf

[53] Local Authorities also carry out heat pump installations but the levels of installation are not available in the SEAI report. They are likely to be a small fraction of the those installed under the SEAI grant scheme.

on the 2022 figure this number will need to dramatically increase in the coming years. The focus of the National Retrofit Plan is the decarbonisation of our residential housing stock and to do this we simply have to stop burning fossil fuels, oil, gas or solid fuels like coal and turf". There is no reference to the potential use of modern residential heating using woodfuels such as pellets, briquettes or dry firewood in ecodesign stoves and boilers, as a further way to decarbonise heating. This is a questionable omission given that a doubling of the 2023 rate of c. 3,800 heat pump installations to 7,600, the total level of installation by 2030 comes to some 64,000 units, representing 16% of the target. Under this likely outcome, it would seem necessary to seek other sustainable and cost-effective scenarios to address decarbonisation of residential heating. In relation to costs, according to the SEAI report, most heat pumps cost in the region of €15,000, exclusive of installation and controls. An equivalent pellet boiler would cost in the region of €8,000. Even allowing for the high coefficient of performance of heat pumps, and fuel costs, recent analysis by IrBEA shows that pellet boilers provide for a considerably lower levelised cost of heat and cost per tonne of carbon abated[54].

Greenhouse gas emission savings achieved through retrofit and energy upgrades depend not only on the volume of installations but also on performance. Recent work carried out by the Building in a Climate Emergency Group at UCD and funded by SEAI has shown that across new builds and retrofits, NZEB[55] buildings underperform by one BER rating[56,57]. The research group also found that heat pumps had an average coefficient of performance (COP)[58] in use of 2.5, compared to rated performances of 3 and above.

In common with many studies dating back over several decades[59], the study also revealed a rebound or comfort take-back effect, whereby following retrofitting some home owners significantly increased the level of heating and hence energy consumption above what modelled savings predicted. This phenomenon has been shown to occur also in district heating and other forms of biomass heating, and is not specific to retrofitting as such, but it needs to be factored-in and addressed in the modelling and operation of schemes.

Finally, the carbon intensity of electricity supply is an important factor in determining the level of greenhouse gas savings from the use electrical heating systems. Data from the SEAI *Energy in Ireland* 2023[60] report show that in 2022 the carbon intensity of the electricity grid was 332 grams CO_2/kWh, down from 347 grams CO_2/kWh in 2021, due to a decrease in the share of oil and coal in the generation mix. While the decline in intensity is likely to continue, given the plans for a greatly expanded renewable energy fleet, the current net level of carbon emissions from heat pumps at a COP of 2.5 and a grid carbon intensity of say 325 g CO_2/kWh works out at 128 g CO_2/kWh. Assuming an average annual heating usage of 3000 kilowatt hours (kWh) for a well-insulated home gives an estimated emission of c. 380 kg CO_2/yr. Wood-fuelled systems, on the other hand have rated CO_2 emissions of zero.

Given the foregoing, and despite the availability of generous grant aid, allied to efforts by SEAI to promote and improve its effectiveness, it is unlikely that the National Retrofit Plan will deliver the projected 2030 emission savings of 2 million tonnes CO_2 per annum in residential heating relative to 2018.

It can be argued that a programme of biomass-based systems, such as district heating to decarbonise residential and other forms of heating would add to current efforts, contribute to the achievement of greenhouse gas emission targets and as well to the security of energy supply.

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[54] Personal communication, Noel Gavigan, Irish Bioenergy Association.

[55] NZEB means net zero energy building – one with a level of energy performance such that the low level of supplementary heating required will be covered by energy from renewable sources.

[56] Sustainable Energy Authority of Ireland (n.d.) Accelerating transformative research to deliver Ireland's energy revolution. [online] Available at: https://www.seai.ie/documents/research-projects/RDD-000358-Policy-Brief-Nzeb_101.pdf

[57] In common with the COFORD statements on forests and wood products and their role in climate change mitigation, work by the UCD group has also highlighted the importance of taking embodied as well as operational (mainly heating and cooling) emissions into account when assessing the greenhouse gas impacts of construction.

[58] The COP of a heat pumps is the ratio of useful heating provided to work (energy) required. Higher COPs equate to higher efficiency, lower energy (power) consumption and thus lower operating costs (Wiki).

[59] See for example https://www.sciencedirect.com/science/article/abs/pii/S0301421500000239 and work at TUD at https://arrow.tudublin.ie/cgi/viewcontent.cgi?article=1089&context=engschcivart.

[60] Sustainable Energy Authority of Ireland (2023). ENERGY IN IRELAND 2023 Report. [online] Available at: https://www.seai.ie/publications/Energy-in-Ireland-2023.pdf.

Transport

Policies and measures in transport are focussed on providing new infrastructure and incentives to expand public transport, and incentives for switching to electric vehicles (EVs). The EV target is 845,000 private EVs and 95,000 commercial EVs; by 2030 with all new car registrations to be electric for subsequent years.[61] If achieved, the target would be equivalent to one-third of the current fleet of 2.8 million vehicles.

According to SEAI, in May 2024 there were over 121,000 EVs on the road in Ireland. Sales increased to some 23,000 EVs in 2023, up 45% on the previous year. However, a recent communication from SEAI[62] records a steep drop in sales over the first quarter of 2024. It attributes the decline to a number of factors including the overall decline in new car sales, the reduction in the grant from €5,000 to €3,500, and low trade-in values for EVs. The communication also points to a number of advantages of EV's over petrol/diesel equivalents, including running costs and lower carbon dioxide emissions[63].

Based on the current number of EVs on the road, and assuming a further 10,000 will be sold in 2025, the distance to the overall EV target (private and commercial combined) is some 809,000. With 6 years remaining (2025 to the end of 2030) of the target period, it would require average annual EV sales to reach 135,000. Given the overall new car market (excluding commercial vehicles) in 2023 was c. 160,000 it is very difficult to see the target being achieved. An optimistic outcome could suggest half the target being achieved, which would reduce the projected greenhouse gas emission savings of 4.74 Mt CO_2 eq/yr by 2030 by a commensurate amount.

All this could change if imported Chinese EVs come to market at price levels below €30,000, as some forecasts indicate. However, in June 2024 the European Commission, following a period of anti-subsidy investigation, announced it intended to impose additional import duties of up to 38% on Chinese EV imports from July. Exactly what impact the additional tariffs (which range from 17-38%) will have on prices and sales is unclear.

As well as the move to electrical vehicles and investment in public transport, measures to support biofuel blends based on ethanol and biodiesel are part of the policy mix to reduce the level of fossil fuels used in transport. Since the 1 July 2023, petrol for sale must be E10 compliant, which entails a 10% blend of ethanol by volume. An increase in the level of biodiesel blend from 7% to 12% (B12) is also in the offing.

Most ethanol is produced from industrial-scale fermentation of maize and sugarcane feedstocks. It is one of a range of established biofuels, which also include biodiesel derived from tallow and other fats, biomethane from upgrading of biogas, and increasingly HVO (hydrogenated vegetable oil)[64].

The IEA 2023 bioenergy report also notes that ethanol from lignocellulosic feedstocks, such as woody biomass, is among a number of emerging biofuel pathways not yet fully developed, and that still need to be demonstrated at full scale. These so-called called second generation biofuels can be more expensive to produce, due to the need for feedstock pretreatment[65]. However, the raw materials themselves, originating in the main from waste, tend to be cheaper, can be available in significant quantities, and generally result in higher greenhouse gas emission savings compared with first generation fuels. Their use also avoids concerns raised in the food versus fuel debate, which came into prominence again following the Russian invasion of Ukraine and the implications for grain production from the Ukraine breadbasket [66].

Research and development on the production of second-generation biofuels from woody material continues, with costs of production remaining a key issue remaining a stumbling block to large-scale production.

[61] EVs include plug-in hybrids, but exclude petrol or diesel hybrids.

[62] Sustainable Energy Authority of Ireland (2024). Why have EV sales dropped in 2024? [online] Available at: https://www.seai.ie/blog/ev-sales-drop-2024/.

[63] Although EV's have no tailpipe emissions, they are powered by electricity that comes with embodied carbon dioxide emissions, and there are embodied emissions in battery manufacture, and issues concerning the supply chain for some of the transition metals used.

[64] IEA Bioenergy (2022). IEA Bioenergy Report 2023. [online] Available at: https://www.ieabioenergyreview.org/./

[65] Moodley, P. 2021. Sustainable biofuels: opportunities and challenges. In Sustainable Biofuels - Opportunities and Challenges p1-20. Applied Biotechnology Reviews, Academic Press. https://www.sciencedirect.com/science/article/abs/pii/B9780128202975000037?via%3Dihub

[66] A useful outline of recent developments in food versus fuel debate can be found at https://www.ifpri.org/blog/food-versus-fuel-v20-biofuel-policies-and-current-food-crisis

Afforestation

This section should be read in the conjunction with the discussion on afforestation in the section on the EU LULUCF regulation.

Afforestation is the primary climate change mitigation measure identified in the Climate Action Plan (target of 8,000 ha/yr)), but as demonstrated in the COFORD climate change statements, forest management and harvested wood products (HWP) also have a strong role in addressing climate change. As outlined in this paper, modern bioenergy also has a role to play if new and existing measures are developed and promoted, and effectively implemented.

Carbon stock changes in forest lands and HWP are accounted in the national greenhouse gas inventory under the LULUCF sector[67]. Costs and effectiveness in reducing emissions can therefore be readily determined, according with the "what cannot be measured cannot be managed" paradigm. Thus, investment in well-resourced research and expertise to achieve accurate estimates of LULUCF fluxes is a necessary component of a national system for climate change mitigation.

The policy in the Climate Action Plan 2023 is for an expansion of the annual afforestation rate of approximately 2,000 ha/yr to 8,000 ha/yr over the period 2021-2025. This provides for 28,000[68] ha of new forest over the first budget period of the carbon budget. DAFM data show that the area afforested over 2021, 2022 and 2023 (the opening three years of first carbon budget period) was 5,940 ha, leaving a significant distance to target. DAFM data show that the area afforested over 2021, 2022 and 2023 (the opening three years of first carbon budget period) was 5,940 ha, leaving a significant distance to target.

Nevertheless, based on the Teagasc Marginal Abatement Cost Curve (MACC) 2023 analysis, afforestation allied to reduced deforestation, seems to remain the most direct route to medium to long term increases in the forest sink in Ireland. Continued and stronger promotion of the financial and wood supply benefits of retaining forest crops closer to optimum rotation ages should also be supported as a short-term option. While a move to continuous cover forestry systems is feasible on part of the forest estate, it requires a high level of expertise that is not likely to emerge over most of the forest estate.

In relation to afforestation, it has become a hard sell in recent years due to a number of reasons. Land values continue to increase making investment in afforestation less attractive. Dairy expansion has increased demand for land and the implications of a possible change to the derogation under the Nitrates Directive also increases competition for land. As well as these developments, there are growing land rental and leasing markets. These trends, when allied to a perception that obtaining permission for afforestation is over-burdensome, make it difficult to raise levels of afforestation to the levels envisaged in the Climate Action Plan. While it is too soon to gauge the impact of the new afforestation supports under the new Forestry Programme (2023-2027), the early signs are not hopeful. This contrasts with the success of ACRES - the new agri-environment climate scheme under Ireland's Common Agriculture Policy Strategic Plan 2023-2027 - in attracting 55,000 farmers to join up. It is referenced[69] as a farmer-friendly scheme to help address biodiversity decline while delivering an income support for up to 50,000 [now 55,000] farm families in Ireland.

These policy dichotomies matter as far as the uptake of afforestation is concerned, and if they remain it is difficult to see an uptick in afforestation to the levels envisaged in the Climate Action Plan. While ACRES has climate change mitigation objectives, the level of carbon sequestered, and its permanence, are not assured. Overall, these policy choices are likely to make the attainment of the 2030 emission reduction targets ever more difficult and expensive to achieve, with likely increasing burdens post 2030.

Levels of afforestation and reforestation after felling, as well species composition and forest management regimes also impact on the level of forest-based biomass available for bioenergy uses. One of the main

[67] COFORD (2022). Forests and wood products, and their importance in climate change mitigation: A series of COFORD statements. COFORD, Dublin, Ireland.

[68] Department of the Environment, Climate and Communications (2022). Climate Action Plan 2023. [online] Available at: https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/

[69] Department of Agriculture, Food and the Marine (2022). Agri-Climate Rural Environment Scheme (ACRES). [online] Available at: https://www.gov.ie/en/service/f5a48-agri-climate-rural-environment-scheme-acres/.

arguments in this paper is that the full range of cost effective and sustainable mitigation options available from the forest sector need to be mobilised, including use of wood products and forest-based biomass. Current and future supply levels of forest-based and other woody biomass are outlined under woody biomass supply.

Efficiency improvements in agriculture

Here the aim is the adoption of greenhouse gas efficient farming practices. Agriculture sector emissions include methane emissions from enteric fermentation, manure management and nitrogenous fertiliser use. Fuel combustion from agriculture, forestry and fishing is also included. Based on the EPA greenhouse gas inventory, agriculture contributed 38% of Ireland's total emissions in 2023. The contribution could rise to 44% by 2030, depending on emissions trends in the sector itself and the level of emission reductions in other sectors.

The EPA's 2024 greenhouse gas emission projections[70] estimate that total emissions from agriculture are projected to decrease by only 1% over the period 2022-2030 (from 23.4 to 23.1 Mt CO_2eq /yr), assuming existing measures are implemented in full.

The EPA projections also model the impact of additional measures such as cattle diet modification and management practices. These are outlined in the Climate Action Plan 2024, the Teagasc greenhouse gas and ammonia MACCs and DAFM's roadmap to climate neutrality (AgClimatise). Depending on the level of implementation, the models suggest the measures could reduce emissions to 19.1 Mt CO_2 eq by 2030, which is an 18% reduction on 2022, compared with the sectoral target of 25% by 2030, as set out in the carbon budget process.

The EPA projections for the agriculture sector do not include diversification measures in agriculture, which are outlined in the Teagasc MACC and Climate Action Plan 24. While these indicate potential savings of 1.5 Mt CO_2 eq/yr by 2030, the report states that "Further information is needed to model an implementation pathway for these measures as they imply a reduction in herd numbers which will affect the quantification of all of the other proposed measures". Be that as it may, the *COFORD statements on forests and wood products and their importance in climate change mitigation*, found that "land use and changes from grassland to forestry have not resulted in a significant reduction in agricultural emissions. In general animal herd sizes have not declined as land has transferred to forestry and this will create challenges for carbon neutrality in the land-use sector".

Forest-related EU and national policies

Land use, land-use change and forestry – regulations and impacts

The LULUCF regulations are closely linked with the ESR. Regulation EU 2018/841 applies for the period 2021-25. The accounting framework takes into account age class effects in older forests and provides a direct incentive for afforestation. These treatments, allied to national policies to conserve and expand forest cover, and sustainable forest management, have allowed Ireland to generate credits which will contribute to compliance with national targets under the ESR up to and including 2025. The current estimate is for a sink of 2.68 Mt CO_2 eq/yr over the five years 2021-2025.

Post 2025 the LULUCF accounting rules in the recently agreed Regulation EU 2023/839 are substantially different. For 2026–2030, binding annual targets for net greenhouse gas removals are to set for each Member State in the sector, determined by a linear reduction in emissions[71], starting from 2022 (based on the average emissions for the years 2021-2023) and out to 2030. The 2030 target is the average net emissions/removals over the baseline period 2016-2018, less a fixed national target of 0.626 Mt CO_2. The 2023 LULUCF values have yet to be finalised, so the 2022 starting point is not yet determined.

The Climate Action Plan 2024 estimates that a carbon budget of 24.8 Mt CO_2 eq will be available to Ireland over the period 2026-2029, or an average of 6.1 Mt CO_2 eq/yr over the four years. The 2022 LULUCF emissions were estimated as 7.31 Mt CO_2 eq, while the EPA with existing measures scenario projects that

[70] Environmental Protection Agency (2024). Ireland's Provisional Greenhouse Gas Emissions 1990-2023. [online] www.epa.ie. Available at: EPA-Provisional-GHG-Report-Jul24-v6.pdf

[71] For most member states the trajectory will be for a linear increase in removals from 2022.

LULUCF emissions will increase by 54% from the 2018 baseline by 2030. Given current trends, and notwithstanding inventory uncertainties, it will therefore be extremely challenging to remain within the LULUCF 2026-2029 emissions budget, or to attain the 2030 target. The challenge arises from not just a declining forest sink[72] over the period up to 2030 and beyond, but the low level of implementation to date of measures at scale for rewetting of harvested peatlands (given the timescales to turn sources to sinks) or to reduce emissions from grasslands located on peaty soils.

The overall aim of the new LULUCF regulation is for the sector to be a net sink of 310 Mt CO_2/yr by 2030 at the EU level, and thereby contribute to the overall EU target of a 55% reduction in net greenhouse gas emissions compared with 1990 levels. By far the largest element of the sink is forest land (Figure 11). Other categories such as cropland and grassland are currently net emission sources at the EU level. If the net sink target is not achieved, the flexibility measures outlined in the regulation will not be made available.

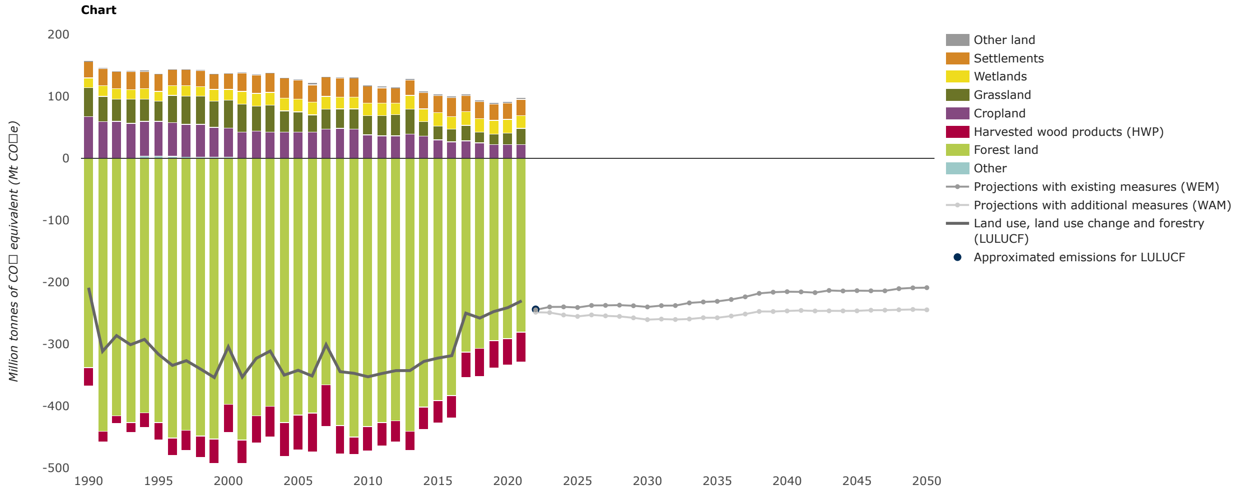

Figure 11. Historic trends in LULUCF sector emissions and removals in the EU, by main land- use category, with the 2030 sink target of -310 Mt CO_2 eq. (EEA, 2023[73]).

A recent paper with authors from the EU's Joint Research Centre casts doubts on the achievement of the 310 Mt CO_2/yr sink by 2030, stating: "Our findings indicate that on the EU level, the recent decrease in increment and the increase in harvest and mortality are causing a rapid drop in the forest sink"[74]. The drop in the forest sink does not, of course, mean that carbon stocks are declining in the EU, it simply means that forest stocks are increasing at a declining rate. One could argue, on the assumption of sustainable forest management, that an increase in harvest is an indicator of an increased contribution from the forest sector to the EU's circular economy.

Overall, it could be argued that the new LULUCF regulation is more favourable for countries with high levels of forest cover, which offer more flexibility and a greater scope for forest management activities to increase or stabilise the sink. Also given the composition of the forest estate in Ireland, which is overwhelming commercially managed forest, harvest levels are driven by financial considerations. Thus, the forest estate may not be as amenable to climate-smart forest management measures around enhancing sink effects, as is the case in some member states.

The Teagasc MACC 2023[75] report provides a further insight into the possible scale of climate-smart activities and removals across five LULUCF measures in the context of the LULUCF framework post 2025. These are afforestation, reduced deforestation, extending the age of forest rotations, replanting of former afforested peats

[72] DAFM, FERS. 2019. Ireland's National Forestry Accounting Plan 2021-2025. DAFM, Kildare Street, Dublin.

[73] European Environment Agency (2024). EU emissions and removals of the LULUCF sector by main land use category. [online] Available at: EU emissions and removals of the LULUCF sector by main land use category | European Environment Agency's home page (europa.eu)

[74] Korosuo, A., Pilli, R., Abad Viñas, R. et al. (2023) The role of forests in the EU climate policy: are we on the right track?. Carbon Balance Manage 18, 15. https://doi.org/10.1186/s13021-023-00234-0

[75] Lanigan G, Black K et al. (2023) MACC 2023: An Updated Analysis of the Greenhouse Gas Abatement Potential of the Irish Agriculture and Land-Use Sectors between 2021 and 2030. Teagasc, Oak Park, Carlow.

with birch, and agroforestry. The technical level of removals from the measures is estimated as 36 Mt CO_2 over the period 2021-2050. Afforestation makes by far the largest contribution, at some 26 Mt CO_2, based on afforestation targets of 4,500 ha/yr from 2023-2025, and rising to 8,000 ha/yr by 2030. As the report points out, the rates of afforestation post 2021 have been well below target, and were just over 1,600 ha in 2023. Extending rotations were estimated to have the possibility of increasing the sink by 4.5 Mt CO_2 over the period 2021 to 2030. However, due to age class effects the estimate was that this category of forest would become a net emission of some 4.3 Mt CO_2 over the period 2031-2050 as these forests are harvested. The report provides commentary around the difficulties of implementing extended rotation policy, including implications on the timing of future wood, delayed income streams for forest owners, among other factors. The commentary also points out the difficulties that the new accounting approach in the LULUCF regulation post 2025 poses in relation to generation of compliance units, especially as the forecast for the LULUCF sector as a whole (which includes grassland and cropland) is for a source of 10.4-10.5 Mt CO_2/yr over the 5-year period from 2026-2030.

These considerations also focus attention on a more fundamental question: is it better to leave more carbon in the forest, and reduce the harvest for energy and reduce the manufacture of solid wood products. In the short term this might seem an attractive option, but it would come with costs around incentives for retention and a constraint on the growth in wood product manufacture, and the contribution of forest-based biomass to fossil fuel displacement. While there are a range of scientific and policy views on the matter, the IPCC's Fourth Assessment Report[76] (FAR) concluded:

In the long-term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fiber or energy from the forest, will generate the largest sustained mitigation benefit. Most mitigation activities require up-front investment with benefits and co-benefits typically accruing for many years to decades.

Subsequent IPCC assessment reports (including the most recent *Sixth Assessment Report* (AR6) - see earlier), take a more nuanced view of bioenergy expansion, referring to the influence of feedstock, land management practice, climatic region, the context of existing land management, and the timing, scale and speed of deployment due to its potential impact of food production and environmental quality. In terms of the scale of bioenergy deployment envisaged in AR6 for pathways limiting warming to 1.5° C, with no or limited overshoot, models foresee increases in global forest cover of about 322 million ha by 2050, and a cropland area to supply biomass for bioenergy (including BECCS) of around 19 million ha in 2100. Such levels of land-use change are extremely unlikely given current trends, and therefore concerns around the impacts of expansion of cropland-based biomass are unlikely to materialise at the scales envisaged. So, in general the conclusions in the Fourth Assessment Report seem to remain valid in the case of harvest and use of forest-based biomass for energy.

It is also necessary to bear in mind that perverse effects can arise if forests are maintained simply as carbon stores. From the climate perspective, one of the more important is the phenomenon of sink saturation[77]. It is generally accepted that the level of carbon uptake in forests declines after a peak age, and in some circumstances can reverse. Carbon stocks are also at greater risk of natural disturbances, such as wildfires, increased incidence of some diseases, and windthrow as forests age, and more especially in the absence of forest management. Additional fire vulnerability also comes from predicted increased temperatures and longer periods of spring and summer droughts, while windthrow risk is likely to increase as a result of stormier and wetter autumns and winters[78] (see COFORD statement on the impacts of climate change on forests).

EU Carbon Removals and Carbon Farming Certification Regulation Framework

The overall aim of the regulation, - CRCF for short - is to develop a voluntary EU certification framework for permanent carbon removals, carbon farming and carbon storage in products, which would complement emission reductions and existing policies at encouraging removals, all in the context of moving towards net zero emissions by 2050. The intention is that the regulation will facilitate and speed up the deployment of

[76] Nabuurs GJ et al. 2007. Forestry. Chapter 9 in Climate change 2007: mitigation of climate change. Working group III contribution to the fourth assessment Report of the Intergovernmental Panel on Climate Change. p541 – 584. Cambridge University Press, Cambridge.

[77] Nabuurs GJ, Lindner M, Verkerk P et al. 2015. First signs of carbon sink saturation in European forest biomass. Nature Climate Change 3, 792–796 . https://doi.org/10.1038/nclimate1853

[78] Environmental Protection Agency (2019). What impact will climate change have on Ireland? [online] Www.epa.ie. Available at: https://www.epa.ie/environment-and-you/climate-change/what-impact-will-climate-change-have-for-ireland.

high-quality carbon removals and soil emission reductions, while combatting greenwashing and harmonising conditions in carbon removal markets.

An advanced draft of the regulation was agreed by the European Parliament in April 2024, and now awaits Council approval and publication as law.

Fundamental to the CRCF is that activities must meet four overarching ‘QU.A.L.ITY’ criteria[79]

1. quantification (against a baseline),
2. additionality,
3. long-term storage, and
4. sustainability

The criteria are essential components of any voluntary carbon removal framework, with corresponding methodologies, tests and eligibility criteria. With a fully operational and transparent registry (as proposed) should ensure that removals certified under the CRCF will have a climate impact, in other words result in removals of carbon dioxide from the atmosphere

The CRCF includes three broad classes of carbon removal, and a soil carbon emission reduction activity:

- permanent carbon removal (storing atmospheric or biogenic carbon for several centuries, which would include direct air capture and BECCS, technologies that use carbon dioxide injection to recover additional hydrocarbons (EHR) are not eligible)
- temporary carbon storage in long-lasting products (such as wood-based construction products) of a duration of at least 35 years and that can be monitored on-site during the entire monitoring period
- temporary carbon storage from carbon farming (e.g. restoring forests and soil, wetland management, seagrass meadows)
- soil emission reduction (from carbon farming), which includes carbon and nitrous oxide reductions from soil management, and activities that must overall reduce the carbon emissions of soils or increase carbon removals from biological matter (examples of activities are wetland management, no tilling and cover crop practices, reduced use of fertilizer combined with soil management practices, etc).

The regulation proposes the accreditation of third-party certification bodies who will act to verify the level of removals and conformance with the conditions of the regulation. If certified, units, corresponding to 1 tonne of carbon dioxide, can be registered and traded. Removals generated under the CRCF will be recorded in a common and transparent electronic EU-wide registry, four years after the entry into force of the regulation. Information on the certification and units publicly available and accessible, including certificates of compliance and summaries of certification audits. Pending that development, certification schemes under the framework must provide public registries based on automated and interoperable systems.

In the meantime, the European Commission has established a carbon removals expert group[80] as part of the CRCF to develop certification methodologies for the different types of removals. This work is likely to take another year or more to conclude.

Given the likely timeframes for the development of certification methodologies and registries, the development of geologic storage infrastructure and a more general move to a greater use of wood in construction, any significant removal impacts of the regulation are more likely to begin towards the end of the current decade, and through into the 2030s and beyond.

[79] The criteria and associated articles are summarised in an European Commission explanatory document on the CRCF at https://climate.ec.europa.eu/document/download/a8abe1c4-a3c6-4c94-be0e-4b76f7fd0308_en?filename=policy_carbon_faq_crcf_regulation_en.pdf

[80] European Commission (2023). 4th EU Carbon Removals Expert Group meeting. [online] Available at: https://climate.ec.europa.eu/news-your-voice/events/4th-eu-carbon-removals-expert-group-meeting-2024-04-15_en.

Possible inclusion of carbon removals in the ETS has been a long-running debate in the EU. To date the strong focus across all policy instruments has been on emission reductions, where the ETS has proven to be highly effective. However, there is an increasing realisation among policy makers that enhanced removals will be needed in the attempt to reach net zero by mid-century. This it seems has provided an impetus for the European Commission being mandated under Article 30 of the new ETS to assess, by 2026, whether permanent carbon removals could be eligible for use in emission trading and, if appropriate, present a legislative proposal and an accompanying impact assessment. Also, under the post-2025 LULUCF regulation, the Commission is to submit a report to the European Parliament and to the Council on the possible benefits and trade-offs of the inclusion of sustainably sourced long-lived carbon storage products in the scope of the regulation.

These reports and the general post 2030 policy framework are likely to provide a clearer picture on the use of carbon removals in terms of compliance at the national level, in the ETS, and in carbon markets, at both the EU level and internationally.

Ireland's forest strategy

The current forest strategy[81] covers the period up to 2030 and has the overarching objective to "expand the national forest estate on both public and private land in a manner that will deliver lasting benefits for climate change, biodiversity, water quality, wood production, economic development, employment and quality of life".

The implementation plan for the strategy includes a goal to support "the use of sustainable wood products from Irish forests, as alternatives to carbon intensive products, to reduce the embodied carbon in our built environment, and by products including biomass to substitute fossil fuels."

In terms of expansion of the forest estate, a key requirement in relation to biomass supply is the aim to achieve a forest cover of 18%, as stated in the strategy. Although the target is not time bound, achieving such a level of forest cover by 2050 is needed to close in on carbon neutrality by 2050, and given the likelihood that hard-to-decarbonise sectors, including agriculture and transport will continue to be sources of emissions. The level of achievement of the afforestation target and implications are discussed under the Climate Action Plan and in Conclusions and recommendations.

EU forest strategy

Forest policy is a Member State competence in the EU. Climate and energy provision aspects of forests, as has been outlined, also come under the EU's environmental and energy policy frameworks.

The European Commission's Forest Strategy for 2030 was published in July 2021 as part of the European Green Deal initiative, and "sets a vision and concrete actions to improve the quantity and quality of EU forests and strengthen their protection, restoration and resilience". It aims to adapt Europe's forests to new conditions, weather extremes and high uncertainty brought about by climate change. Such adaptation it is argued, is a precondition for forests to continue delivering their socio-economic functions, and to ensure vibrant rural areas with thriving populations. As stated forest policy is reserved to member states, and forest policy objectives vary between member states. However, all Member States have embraced the FOREST EUROPE definition of sustainable forest management:

the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems

Regarding forests and bioenergy, the strategy states that "Wood based bioenergy is currently the main source of renewable energy, supplying 60% of EU's renewable energy use. To meet the at least 55% emission reduction target by 2030, Member States will need to significantly increase the share of renewable sources

[81] Department of Agriculture, Food and the Marine (2023). Ireland's Forest Strategy (2023 – 2030). [online] Available at: https://www.gov.ie/en/publication/89785-irelands-forest-strategy-2023-2030/.

in their energy mix. Bioenergy will continue to have a notable role to play in this mix if biomass is produced sustainably and used efficiently, in line with the cascading principle and taking into account the Union's carbon sink and biodiversity objectives as well as the overall availability of wood within sustainability boundaries in 2030 perspective".

In November 2021, the Council adopted conclusions on the strategy, after several rounds of deliberations. Member States welcomed the publication of the strategy and "'its increased ambition for the contribution of forest through their multifunctional role to the European Green Deal and ... 2030 Agenda". They nevertheless stressed the need to strike a balance between the environmental, social and economic aspects of sustainable forest management, as well as the importance of maintaining the diversity of forests and forest management practices in different Member States and regions, respecting their competences in the area. Moreover, the Member States expressed doubts about the added value of developing national strategic plans for forestry, as envisaged in the Commission's communication, and encouraged the use of existing international monitoring and reporting processes. Finally, ministers recommended that the existing Standing Forestry Committee (SFC) remain the main forum for discussion, reinforcing its role in the implementation of the strategy.

Regulation (EU) 2016/2031 on protective measures against pests of plants

The regulation, which came into force in December 2019 aims to modernise the Union's plant health regime, by providing more effective measures for the protection of plants from destructive pests. It also ensures safe trade, as well as mitigating the impacts of climate change on the health of forests.

The basic principle is to certify that coniferous woodfuels being placed on the market with bark attached (or from *Castanea* species with bark and *Platanus* species with or without bark) come from areas which are free from specified organisms. This requirement is met by having a plant passport accompanying the specified woodfuels when they come to market. The passport also allows traceability back to source in the event of the detection of a specified organism in or on the woodfuel. In effect, a plant passport is an official statement to enable the movement within the EU of plants or plant products that attests to their compliance with the plant health requirements for that product. To ensure legibility and visibility, standardised formats for plant passports have been agreed at an EU level. Plant passports are issued by Professional Operators who have been authorised to do so by the Department of Agriculture, Food and the Marine.

EU Regulation on deforestation-free products

The overall aim of Regulation (EU 2023/1115) is to bring down greenhouse gas emissions and biodiversity loss from deforestation and forest degradation. This is to be achieved by promoting the consumption of deforestation-free products and thereby reducing the EU's impact on global deforestation and forest degradation. The main driver of these processes is the expansion of agricultural land that is linked to the production of commodities like cattle, wood, cocoa, soy, palm oil, coffee, rubber, and some of their derived products, such as leather, chocolate, tyres, or furniture.

The Regulation was published in June 2023, and replaces the EU Timber Regulation (EUTR). It will enter into force on the 30 December 2024. Under the Regulation, any operator or trader who places certain commodities (such as those outlined) on the EU market, or exports from it, must be able to prove that the products have not originated from recently deforested land or have contributed to forest degradation.

Further information on the regulation is available from the Department of Agriculture, Food and the Marine and from a dedicated EU website[82].

Air quality and combustion plant legislation

Good air quality is essential for human health. While air quality in Ireland is generally good and compares favourably with many European countries, localised issues impact negatively on air quality[83].

[82] European Commission (2023). Regulation on deforestation-free products. [online] environment.ec.europa.eu. Available at: https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products_en.

[83] Environment Protection Agency (n.d.). Air. [online] www.epa.ie. Available at: https://www.epa.ie/environment-and-you/air/.

When wood is properly combusted, the lignocellulosic and, in certain species, resinous compounds that comprise the wood are almost fully oxidised, and emissions are confined to carbon dioxide and water. Wood combustion also results in small amounts of ash, comprised mainly of potassium and calcium salts, and this must be removed from the combustion chamber and disposed of in landfill or by land-spreading. Depending on the type of woodfuel being combusted (firewood, woodchip, pellets or briquettes), the species, moisture content, combustion appliance and the manner of combustion (particularly during the ignition phase), a number of carbonaceous compounds can be emitted.

For woodfuel, the main air quality issue is residential use of unsuitable wet wood, often in open fires or unsuitable multi-fuel stoves, which leads to incomplete and inefficient combustion and the generation of harmful particulate matter. The WFQA scheme, allied to the Solid Fuel Regulations[84], aim at reducing the use of unsuitable woodfuels in residential combustion. However, more consumer education around proper wood combustion is needed, allied to stringent regulation enforcement by Local Authorities who are charged with policing the regulations. Replacing inefficient and polluting open fires and multi-fuel stoves by modern ecodesign appliances is also necessary to capture the full benefits from the banning of wet woodfuels in residential combustion.

Larger-scale woodfuel use for commercial and industrial heating is tightly controlled, as combustion plants must meet specified emission limit values (ELVs) before being placed on the market, and the larger installations are subject to EPA licensing. A combination of professional operation, woodfuel certification, requirements under the RED Directive and the SEAI's Support Scheme for Renewable Heat (SSRH), are resulting in a modern low-emission combustion fleet in the commercial and industrial sectors.

Overall, the air quality legislative and policy frameworks that operate at EU and national levels aim to reduce air pollution by limiting and reducing the concentration and amount of emissions of specified pollutants. These legally binding thresholds are allied to the Solid Fuel Regulations and ELVs for combustion appliances and plant. Given the importance of air quality in the context of woodfuel combustion, a brief outline of the main measures now follows. Further information is available in the publications cited in this footnote[85].

The CAFÉ (Cleaner Air for Europe) Directive and the National Emission Reduction Commitments Directive (NEC) set out legally-binding pollutant concentration and emission reduction commitments (ERCs) across the EU and at specific member state level, respectively.

In terms of CAFÉ compliance, the EPA, in partnership with Local Authorities, public/semi-state bodies and universities run the national air quality monitoring network, which comprises 114 stations, most of which are in urban areas, principally in Dublin and Cork[86].

The monitoring results show that fine particulate matter ($PM_{2.5}$) mainly from residential burning of solid fuel, and nitrogen dioxide (NO_2) mainly from road transport, remain the main threats to air quality. Levels detected in EPA monitoring were within current EU legal limits[87], but exceeded World Health Organisation (WHO) Air Quality Guidelines (AQGs) for health in 2021. As outlined in the government's Clean Air Strategy[88] there is a commitment to moving towards the WHO four interim targets over the period to 2040. Achieving compliance with these targets will be a major challenge across all sectors, including residential woodfuel use. It is essential therefore that woodfuels are correctly specified and combusted in clean and efficient appliances and plant, in accordance with the modern bioenergy paradigm.

The EPA compliance report[89]on NEC found that Ireland was compliant with the emission reduction commitments for nitrogen oxides and fine particulate matter ($PM_{2.5}$) in 2021, values for which were marginally

[84] Air Pollution Act 1987 (Solid Fuels) Regulations 2022 (S.I. No. 529/2022). Available at: https://www.irishstatutebook.ie/eli/2022/si/529/made/en/print

[85] Kofman P and Hendrick E. 2021. Wood as a Fuel. Wood Fuel Book Partnership. Dublin.

[86] Sonitus Systems (2024). AirQuality.ie. [online] Available at: http://www.airquality.ie.

[87] Environment Protection Agency (n.d.) Air Quality in Ireland Report 2021. [online] Available at: https://www.epa.ie/publications/monitoring--assessment/air/EPA-Air_Quality_in-Ireland-Report_2021_-interactive-pdf.pdf

[88] Department of Environment, Climate and Communications (2023). Clean Air Strategy. [online] Available at: https://www.gov.ie/en/publication/927e0-clean-air-strategy/.

[89] Environment Protection Agency (2023) Irelands Air Pollutant Emissions (1990 -2030) [online] Available at: https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/Ireland's-Air-Pollutant-Report-Final_May2023.pdf

below those in 2020. The main sources of $PM_{2.5}$ emissions were combustion of fossil fuels in residential and commercial settings, and manufacturing industries and construction sectors, which produced 53% and 12% of the annual total emissions, respectively, in 2021. Out to 2030, the forecast, which is based on a with-additional-measures (WAM) scenario, indicates that fine particulate emissions will just about meet the NEC target.

In order to address emissions from residential solid fuel combustion, the current policy is to favour electrification of heating in new builds and retrofits, allied to the October 2022 updating of the of the Solid Fuel Regulations[90]. The regulations, which have been referred to earlier, are now nationwide in scope and include woodfuels and all other solid fuels used in residential heating. Firewood is the main woodfuel of concern from an emissions' perspective, as higher moisture contents lead to inefficient and smoky combustion, and higher levels of unburnt carbonaceous particles being emitted[91].

The intention is that regulations will be revised over time. In that regard, a concern is that the regulations, as they stand, do not fully cover the quality requirements for the main woodfuels as set out in ISO EN I.S. 17225 *Solid biofuels — Fuel specifications and classes*. This is the internationally agreed standard and covers all the main woodfuels in terms of quality requirements related to moisture content, fuel sizes, levels of fines and other parameters that impact on combustion efficiency and the generation pollutants.

It is also a condition of grant aid under the SSRH scheme that woodfuel being supplied for grant aid installations (woodchip and wood pellets) must be certified by an independent body, such as the WFQA, in order to meet the quality requirements of the scheme.

Emission limit values for plant and appliances are set out in the three EU Directives listed in Table 1 (The Ecodesign Directive also sets out minimum efficiency levels. *Wood as a Fuel* and the IrBEA *Biomass Emissions Report* elaborate further on these matters).

Table 1. Directives and regulations pertaining to emission limit values.

EU Directive	Description	Thermal input/output	Regulation
2010/75/EU	Industrial emissions – the IED Directive	>50 MW thermal input	-
2015/2193/EC	Medium combustion plants – the MCP Directive	≥1 MW to <50 MW thermal input	-
2009/125/EC	The Ecodesign Directive	solid fuel local space heaters ≤50 kW thermaloutput	2015/1185 In operation from 1 January 2022
		solid fuel boilers ≤500 kW thermal output	2015/1189 In operation from 1 January 2020

In relation to the overall policy mix around reducing particulate and other emissions from solid fuel combustion, the approach, in effect, is to phase out solid fuel heating. All new builds must now achieve Nearly Zero Energy Buildings (NZEB) ratings under Part L of the Buildings Regulations, in line with the requirement in the Energy Performance in Buildings Directive (EPBD). Reaching NZEB is made easier by eschewing the installation of chimney vents for solid fuel heating, with the result that almost all new builds now rely on electrical heat pumps for heating. There are however a small number of A rated buildings that use modern bioenergy for their heating, and these comply with the Building Regulations, and should be publicised more as an alternative path to compliance. A policy that seems to favour one source of heating over all others, with little published information on relative costs or greenhouse gas savings, is open to question.

[90] The new solid fuels legislation is set out in Statutory Instrument 529/2022, https://www.irishstatutebook.ie/eli/2022/si/529/made/en/print. The regulation restricts the retail, online and commercial sale of smoky fuels, including smoky coal, turf and wet wood. Firewood must be supplied for sale at a moisture content below 25%. All suppliers must register annually with the EPA and display their registration number on fuels supplied for sale. Compliance with the regulation is subject to checking by the Local Authorities.

[91] Schön C, Hartmann H. 2012. Log wood combustion in stoves – Influence on Emissions and Efficiency. In: Proceedings of the 20th European Biomass Conference and Exhibition. Milan. [online] Available at: http://www.tfz.bayern.de/mam/cms08/festbrennstoffe/dateien/cp_log_wood_combustion_in_stoves_%E2%80%93_influence_on_emissions_and_efficiency_-_eu_bc_e_milan_2012.pdf.

It is worth noting that the EPBD broadly defines a NZEB as "[having] very high energy performance, … The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". In effect this permits the use bioenergy sources for heating NZEB buildings.

A similar approach to effectively exclude bioenergy as a heating option is taken with the deep retrofitting measure under SEAI grant aid. Aspects of retrofitting are discussed under the outline of Climate Action Plan measures.

In relation to new housing schemes, and town and city heating in general, more consideration should be given to group or district heating systems. District heating can afford greater efficiencies and lower levelised costs[92] of energy may be achievable compared to individual home heating. In addition, the use of a wider range of energy sources, rather than electricity alone, would serve to provide wider choice, reduce incremental ratcheting up of electricity demand on an already extended grid, may be more advantageous for local communities, and contribute to security of energy supply.

Also, it is highly unlikely, given that over 20% of households use woodfuels either as their main source of heating, or for supplementary heating[93], that all residential heating will move to an electrical mode, given costs and inconvenience. Therefore, consideration should be given to supports for switching out inefficient, polluting appliances for modern efficient and clean burning stoves and boilers. This, according to the emissions inventory guidebook of the European Monitoring and Evaluation Programme/European Environment Agency, can result in an 8-9 times reduction in the emission factor for $PM_{2.5}$, as established over a number of research studies, which compared advanced/ecolabelled stoves and boilers with open fires and conventional stoves[94]. Allied to a sufficient level of home insulation, such a measure is likely to result in substantial reductions in pollutant levels, more efficient use of woodfuels, as well as lower heating and carbon abatement costs.

[92] A good introduction to the concept of levelised costs is provided in the video at https://www.youtube.com/watch?v=mkNUTemjWHA

[93] Central Statistics Office (n.d.) Household Environmental Behaviours - Energy Use Quarter 3 202. [online] Available at: https://www.cso.ie/en/releasesandpublications/er/hebeu/householdenvironmentalbehaviours-energyusequarter32021/ and the 2022 census breakdown of households by main heating type.

[94] EEA. 2019b. EMEP/EEA air pollutant emission inventory guidebook 2019. Chapter 1.A.4.a.i, 1.A.4.b.i, 1.A.4.c.i, 1.A.5.a Small combustion. EEA, Luxembourg. [online] Available at: https://www.eea.europa.eu/publications/emep-eea-guidebook-2019/part-bsectoral-guidance-chapters/1-energy/1-a-combustion/1-a-4-small-combustion/view

Biomass use, supply, costs and potential

Current use of forest-based biomass

There are different ways to express energy use, as outlined in the SEAI national energy balance and accompanying explanatory material. Primary energy supply[95] is a useful indicator for forest-based biomass, as it relates directly to the supply level of the material at assumed moisture contents and calorific values. Gross final consumption or GFC (see footnote 19) is estimated from energy commodities delivered for consumption, while also including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity and heat in distribution. GFC is the metric that is used for targets set under the renewable energy directive.

The energy data presented here come from the SEAI's annual energy balances[96] and energy use publications.

Figure 12 shows that production of indigenous biomass for primary energy purposes has increased steadily over the past three decades, from around 4-5 PJ/yr over the 1990s, to 10.5 PJ by 2022 (SEAI annual energy balances). Indigenously sourced forest-based biomass is estimated to have accounted for 9.7 PJ, or 93% of the 2022 biomass supply, against a total energy supply of 595.9 PJ. Indigenous supply includes a small proportion of biomass arising from the processing of imported sawlog[97]. Imports of energy-destined biomass are excluded.

The supply figure accords closely with a 2023 forest-based biomass forecast figure of 9.6 PJ which was estimated in the sensitivity analysis of forest-based biomass production, but not included in Table 2. Albeit for a year later than the 2002 SEAI data, the annual changes in the forecast sensitivity analysis over the period 2022-2024 are estimated to be no more than 0.3 PJ. This close match between forecasted supply and biomass production provides additional confidence that the forecasted increases in the availability of forest-based biomass over and above current production levels can be realised, especially as the forecast is based on the existing forest estate.

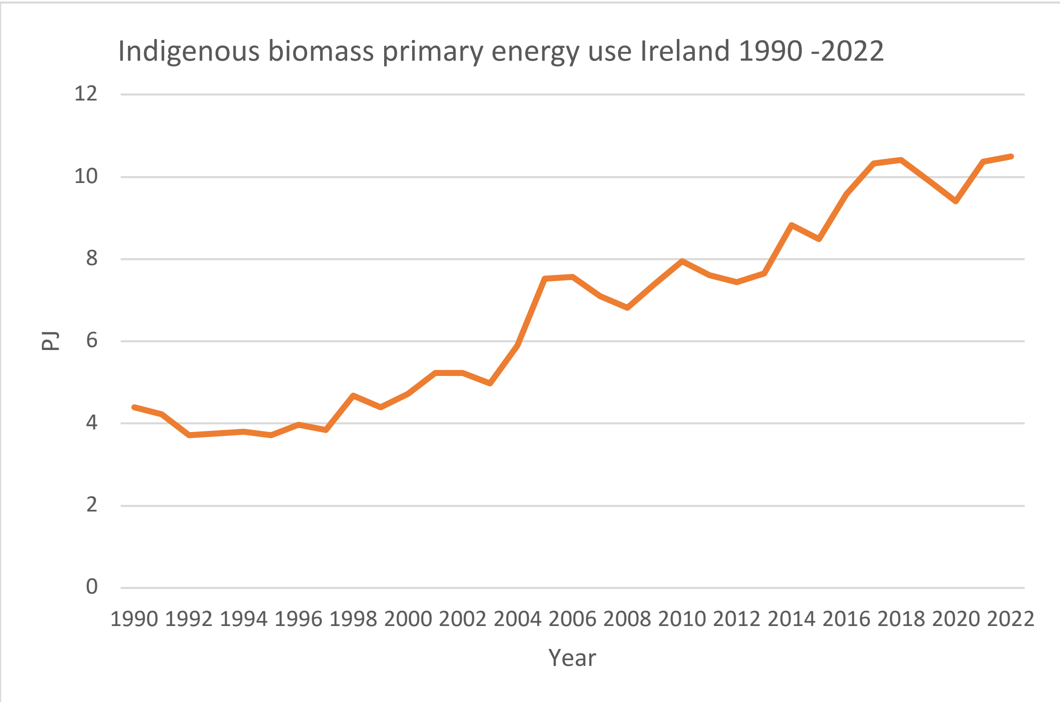

Figure 12. Indigenous biomass primary energy use in Ireland over 1990-2022 (SEAI annual energy balances[98]).

[95] Primary energy includes all energy products not transformed, directly exploited or imported. It mainly includes crude oil, oil shale, natural gas, solid mineral fuels, biomass, solar radiation, hydraulic energy, wind energy, geothermic energy and the energy from uranium fission (INSEE (2016) Primary Energy. [online] Available at: https://www.insee.fr/en/metadonnees/definition/c1189).

[96] Sustainable Energy Authority of Ireland (n.d.). National Energy Balance. [online] Available at: https://www.seai.ie/data-and-insights/seai-statistics/key-publications/national-energy-balance/.

[97] Personal communication. Cathal Ó Cléirigh, SEAI

[98] Sustainable Energy Authority of Ireland (n.d.). National Energy Balance. [online] Available at: https://www.seai.ie/data-and-insights/seai-statistics/key-publications/national-energy-balance/.

Forest-based biomass therefore provided 1.5% of the total primary energy supply in 2021, or some 13.2% of the 69.1 PJ that renewable energy accounted for in the same year.

Most of the indigenous supply of forest-based biomass (53%) is used for process heat in industry (mainly in the forest products sector), with power generation (29%), residential (11%) and commercial uses (7%) forming the balance (Figure 13).

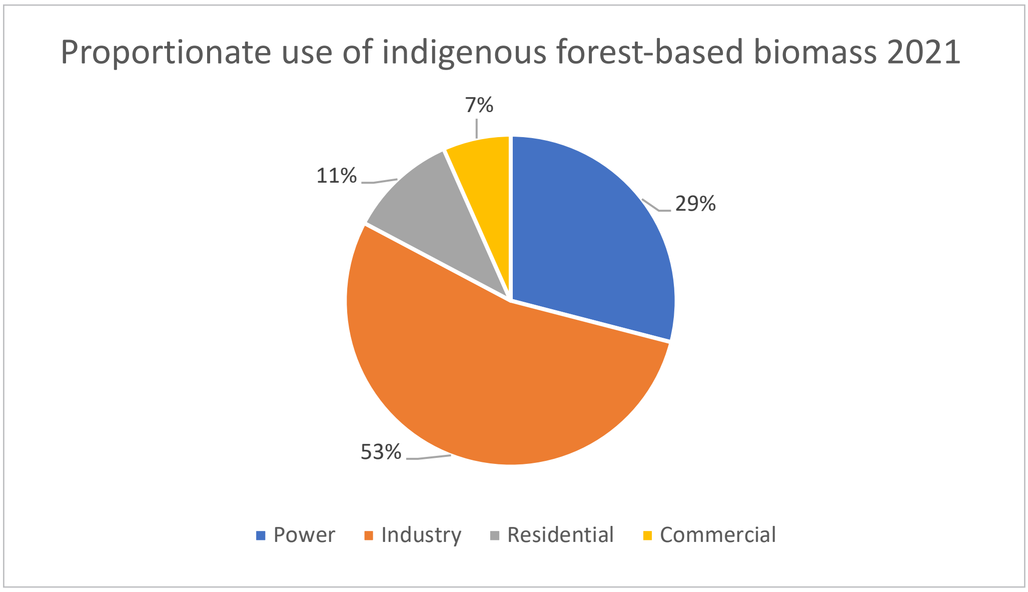

Figure 13. Uses of indigenous forest-based biomass primary energy supply in 2021 (SEAI annual energy balance[99]).

In terms of GFC, bioenergy (which includes biomass and renewable wastes, liquid biofuels, and biogas and landfill gas) accounted for just under one third of the renewable energy contribution to GFC in 2021. Wind was the largest and fastest growing contributor at 58.4%. Forest-based biomass contributed some 8.7 PJ or 13.1% of the total renewables (66.7 PJ) in 2021, against an overall GFC of 491.5 PJ. Over 80% of delivered energy from forest-based biomass was as heat, reflecting the low efficiency of biomass used for power generation (Figure 14).

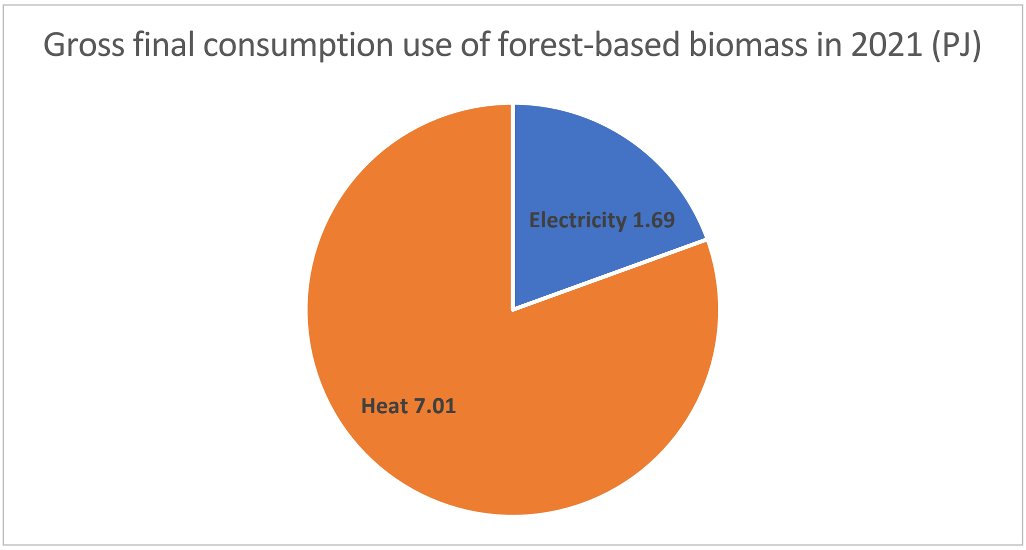

Figure 14. Gross final consumption of forest-based biomass in 2021 in electricity generation and heat (SEAI annual energy balance [100]).

[99] Sustainable Energy Authority of Ireland (n.d.). National Energy Balance. [online] Available at: https://www.seai.ie/data-and-insights/seai-statistics/key-publications/national-energy-balance/.

[100] Sustainable Energy Authority of Ireland (n.d.). National Energy Balance. [online] Available at: https://www.seai.ie/data-and-insights/seai-statistics/key-publications/national-energy-balance/.

In terms of the RES-H, forest-based biomass accounted for almost 52% of the heat-based GFC figure in 2021 (SEAI personal communication 2023), despite a 10-fold increase in the deployment and use of heat-pump technology over the period 2005-2020. Forest-based biomass therefore remains an important component of renewable heat, and is likely to remain so.

The potential future contribution of forest-based biomass is explored in greater depth in the following sections and in the conclusions and recommendations.

Security of energy supply and the potential role of biomass

Security of supply[101] and how Ireland's primary energy requirements are met are closely linked. Ireland still imports most of its energy, with oil and gas by far the largest imports, along with significant quantities of coal. Import dependency[102] reduced in 2016 when it fell to 71% (from over 90% in preceding years) due to the Corrib gas field coming on stream. From 2018, however, the pattern began to reverse, and by 2022 dependency on energy imports was close to 82%[103]. This is despite considerable strides over the same period in the deployment of indigenous renewable capacity, particularly in wind-powered electricity generation,

While it has been shown that bioenergy overall, and forest-based biomass comprise a small component of overall energy supply, it is worth noting that bioenergy is almost a mirror image of overall energy supply. Some 90% of all biomass coming from indigenous sources in 2022, of which by far the greatest share was from forest-based biomass.

The impact of the high level of energy import dependency in Ireland, and indeed across most of Europe, on energy costs was brought into sharp focus as a result of unprecedented increases in gas and electricity prices that arose from mid-2021. The gas price on the Dutch TTF market spiked at over €330/MWh (33 c/kWh) in August 2022, following Russia's invasion of Ukraine in early 2022, and its subsequent curtailment of gas and oil exports to most European countries. While prices as of mid-May 2024 are running at about one tenth of that figure, they are up about 50% compared to the long-term average of €15-20/MWh (1.5-2.0 c/kWh) that prevailed over the period from 2010 to mid-2021[104].

Due to the extent of gas-fired heating, and electricity generation from gas (as a necessary back-up to intermittent wind and solar generation), the high gas prices of 2022, and the earlier parts of 2023, had a disproportionate effect on wholesale electricity prices. This was mainly due to the price clearance mechanism that is used in the EU's regulated electricity markets, where the highest price sets the market price in order to match instantaneous demand and supply. So high-cost gas generation bids tended to set the market price, which resulted in windfall profits for lower bidders, including renewables. A number of mechanisms have been put in place at EU and Member State levels in order to address unearned profits as a result of the perverse effects of the market. More immediate measures have also been instigated, including direct supports in Ireland to consumers who had been impacted by sharply increased energy and electricity prices. For households the Electricity Costs Emergency Benefit Scheme (operated by ESB Networks and electricity suppliers) has been in operation since 2022, while Budget 2024 provided for a lump sum payment of €300 to those in receipt of the fuel allowance. For businesses the Temporary Business Energy Support Scheme (TBESS) was introduced on the 1 September 2022 to support businesses with increases in their electricity or natural gas (energy) costs. Market interventions and reforms, as well as energy supports point to the volatility of energy supply across Europe and beyond. The consequences for households and businesses dependent on affordable fossil fuel, and by extension fossil fuel prices, can be severe. Strategically, the move to renewables, across a wide range of sustainable and price-competitive energy sources and technologies, including modern bioenergy, allied to a reduction in overall energy use, is the EU policy as the pathway to secure and affordable energy.

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101 Defined by the IEA as "the uninterrupted availability of energy sources at an affordable price".

102 The ratio of net energy imports to primary energy.

103 Sustainable Energy Authority of Ireland (2023). ENERGY IN IRELAND 2023 Report. [online] Available at: https://www.seai.ie/publications/Energy-in-Ireland-2023.pdf.

104 Trading Economics (2022). EU Natural Gas | 2021 Data | 2022 Forecast | 2010-2020 Historical | Price | Quote. [online] tradingeconomics.com. Available at: https://tradingeconomics.com/commodity/eu-natural-gas.

New electricity market design rules, consisting of the amending Directive EU/2024/1711 and the amending Regulation EU/2024/1747 entered into force in July 2024.[105].

On overall security of supply, the rationale for continued investment in natural gas infrastructure and deployment can be called into question, especially for heating. On the power-gen side, the gas prices that prevailed over the period prior to 2021, favoured the policy switch away from certain fossil fuels (such as oil, coal and peat) to gas, as a lower carbon dioxide intensity fuel[106]. It also fit well, from a grid management perspective, to its use as backup to intermittent wind and solar. Gas now provides about one third of primary energy requirements (*Energy in Ireland 2023*), through a gas grid that extends to all cities and most major towns, through 15,000 km of pipeline. However, the events of early 2021 have highlighted the supply and cost-spike risks inherent in international gas markets. It also points to the need for secure supplies and large-scale storage, and in general a more in-dept and risk-based approach to future energy policy.

In looking to recent and future energy use patterns, *Energy in Ireland 2022* points out that between 2017 and 2021, over 45,000 new consumers were connected to the gas infrastructure. This generated an estimated 4,000 gigawatt hours per year (GWh/yr) of new gas demand, or the equivalent to the impact of two full years of state-sponsored energy efficiency policies. The report makes the point that new gas connections effectively lock users into fossil fuels for periods averaging 15 years, and states that to stay within legally binding carbon budgets, many of the new gas connections will have to be undone in order to radically reduce fossil fuel use. In order to continue to provide a heat service to those homes, institutions and businesses, the report refers to the potential for district heating systems based on renewable fuels and electrical heating. There is no doubt that district heating is a proven, reliable and cost-effective technology that is widely deployed across central and northern Europe, mainly using locally-available forest-based biomass, with installations often owned and managed by local municipalities and communities.

In relation to the future use of gas, Gas Networks Ireland recently issued a report[107] outlining a potential for indigenous biomethane production of up to 14.8 terawatt-hours per year (TWh/yr) by 2030, which it states would equate to 26% of the annual gas requirement. If 60% of the feedstock is silage-based (with equal amounts of animal slurry), and based on multipliers used in *Sustainable Bioenergy for Heat*, this would equate to an annual area of approximately 220,000 ha of grass/clover sward being devoted to silage production for AD. Given the nature and scale of use of existing silage production as winter feed for livestock, this would entail a radical shift in land use away from beef and single suckler farm enterprises, and would inevitably make afforestation targets even more difficult to achieve. At the same time, the government's own 2030 biomethane target of 5.7 TWh/yr production is of itself highly ambitious and uncertain. To meet the target an estimated total area of 120,000 ha of land would be necessary to grow the silage required, in addition to winter slurry from an estimated 1.3 million cattle.

Recently, the National Biomethane Strategy[108] proposed funding of €40 million for a capital grant scheme for biomethane production plants. It is envisaged the funding will support the roll-out of up to 1 TWh/yr of biomethane production. This would seem to be a more realistic level of production to be achieved by 2030. A key question is the price-paying potential of biomethane for silage feedstock and how this will impact on the viability of supply chains. There is also the question as to which energy mode fits best to biomethane: injection to the gas grid or as a renewable transport fuel.

In more general terms, it can be argued that the focus on electrification in climate action plans neglects to realise the potential expansion of other renewables, particularly bioenergy for heat. This is in the context that heat has been shown to be a difficult mode to decarbonise, despite high levels of ambition to reduce levels of heat use in the residential sector, which is the largest user of heat.

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105 European Commission (2023). Electricity market design. [online] Available at: https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en.

106 While the specific emissions (g CO2 e/MJ) of natural (refinery) gas are about 20% lower than oil, and just less than half that of bituminous coal, its combustion remains a major source of greenhouse gas emissions.

107 Gas Networks Ireland (2023). Available at: https://www.gasnetworks.ie/docs/business/renewable-gas/biomethane-energy-report.pdf.

108 Department of the Environment, Climate and Communications; Department of Agriculture, Food and the Marine (2024). National Biomethane Strategy. [online] Available at: https://www.gov.ie/en/publication/d115e-national-biomethane-strategy.

In the context of supply, biomass is a good match to heat provision across residential, commercial and industrial sectors. Levels of availability are well established, and biomass can be stored and used on demand. It also bears repeating that modern combustion appliances and plants supplying heat typically run at efficiencies of 80-90% plus. In addition, plant and appliance emissions are continually lessening to meet legislative emission limits values. The revised Solid Fuel Regulations also aim to lessen pollution from across the full range of solid fuels.

Further deployment of biomass in heating would contribute to security of energy supply, given that currently 90% of biomass used in Ireland comes from indigenous sources. In addition, the establishment, management, supply and use of biomass resources entails the highest levels of employment of all renewables.

All heating providers at scale will look to price, and the level and security of supply. Price increasingly has to factor-in carbon and the continuation of carbon pricing is essential for reducing dependence on fossil energy across all modes. As pointed out in the discussion on the Emissions Trading Directive, it is planned to extend emissions trading to transport and heat from 2027, which should provide for a more assured policy framework to 2030 and beyond.

Determining the future level of forest-based biomass from existing forest areas, and its security of the supply, is essential to develop a coherent biomass policy framework. This also applies to the potential for the development of other woody biomass sources, such as bespoke willow coppice for energy. These aspects are now outlined based on new analysis carried out in conjunction with this paper[109], and on the SEAI 2022 Heat Study report – *Sustainable Bioenergy for Heat*[110].

Biomass availability

The All Ireland Roundwood Production Forecast 2021-2040[111], which is updated every five years, includes a separate annual forecast of forest-based biomass that is potentially available for wood energy in the Republic of Ireland out to 2040. The forecast is based solely on existing forests and makes no assumptions on future rates of afforestation. Harvest is based upon a number of inputs, mainly the modelled growth of the national forest estate, using a series of empirical forest growth and yield models. It includes current and forecasted future levels of demand from the sawmilling and wood-based panels sectors, which are ring-fenced and not included in the forest-based biomass estimates[112]. It also includes assumptions on the level of residues arising from sawmilling, how these residues are then used, and the level of use of harvesting residues arising at the forest level.

To get a clearer picture of current and future resource availability, and how this could translate into forest-based biomass and its energy potential, sensitivity analyses were undertaken around the forecast, and concerning:

1. levels of first thinning,

2. recovery rates of biomass at thinning – including the level of use of systems that harvest all the above ground biomass (excluding foliage),

3. recovery rates following specified biomass harvesting (SBH) at final felling[113] (this refers to planned harvesting of separately piled tops and branches on clearfell sites in accordance with good practice).

All of the analyses assumed the deployment of existing, proven technologies, using sustainable levels of additional harvest, and use expert judgement to select the most realistic options.

[109] COFORD (2024), Unpublished. Sensitivity Analysis of Wood Fibre Potentially Available for Wood Energy. COFORD, Dublin, Ireland.

[110] SEAI (2022). Sustainable Bioenergy for Heat National Heat Study - Spatial Assessment of Resources and Evaluation of Costs and Greenhouse Gas Impacts. [online] Available at: https://www.seai.ie/publications/Sustainable-Bioenergy-for-Heat.pdf.

[111] COFORD (2021). All Ireland Roundwood Production Forecast 2021-2040. COFORD, Kildare St. Dublin 2.

[112] This methodology is closely aligned with a cascade use of forest harvest.

[113] Gavigan N, Hendrick E. 2023. Specified Biomass Harvesting: Good practice guidance for energy assortment harvesting at clearfell. Irish Bioenergy Association, Dublin.

The work also involved allocating the harvest, denominated in cubic metres by the forecast engine and then converted to green tonnes[114] at specified moisture contents for the specific powergen/industrial heating, commercial, and residential heating end uses. Proportionate allocation to the end uses was based on current and foreseen levels of use, and the calculation of green tonnes took into account end use moisture content requirements. A full outline of the methodologies involved and the underlying data are available in the COFORD report "Sensitivity Analysis of Wood Fibre Potentially Available for Wood Energy".

What the results show is that the level of supply of forest-based biomass has the potential to increase from the current level of supply of c. -9.5 PJ/yr at present to 15-16 PJ by the middle of the coming decade (Table 2). Thereafter, there is a decline to ca 14 PJ by 2040. County based forecasts are provided in Phillips (2023).

Table 2. Forecasted availability of forest-based biomass 2024-2040 in green tonnes across harvesting and processing streams (COFORD, 2024 (Unpublished)[115]).

Year	Green tonnes 000							Energy PJ
	Roundwood 7 – 13 cm	Downgrade + Wood Residues	Specified biomass harvest	Harvest 50% SBH (60 t/ha)	20% thinning increase	20% whole tree thinning	Total	
2024	175	1,018	86	77	55	82	1,493	9.5
2025	207	1,047	95	77	54	82	1,562	9.9
2026	244	1,035	145	80	57	86	1,647	10.4
2027	246	1,122	164	80	48	72	1,731	11.0
2028	213	1,125	153	83	39	59	1,673	10.6
2029	255	1,235	145	77	35	53	1,800	11.4
2030	317	1,404	146	63	31	46	2,007	12.7
2031	355	1,555	91	93	32	47	2,173	14.0
2032	441	1,695	98	88	31	46	2,399	15.5
2033	346	1,669	86	82	26	38	2,248	14.5
2034	443	1,631	96	98	27	40	2,335	15.1
2035	378	1,897	96	89	27	41	2,528	16.3
2036	244	1,785	55	126	29	44	2,283	14.7
2037	221	1,796	47	130	32	48	2,274	14.7
2038	177	1,788	32	63	27	41	2,128	13.7
2039	160	1,794	35	75	31	46	2,142	13.8
2040	151	1,790	45	69	37	55	2,147	13.9
Totals	4,574	25,386	1,616	1,449	617	926	34,567	221.7

Given the scenarios chosen and the conservative approach taken in the overall forecasting approach, these estimates are regarded as realisable amounts of forest-based biomass for energy purposes over the period to 2040. The estimated resource availability closely aligns with the forecasted levels of sawmill residues and thinnings potentially available for heat use by 2030, as outlined in *Sustainable Bioenergy for Hea*t (ca 4 TWh/yr (14.4 PJ) by 2030 across most of the scenarios explored in that report). Additional amounts of sustainable biomass can be secured through a higher extent of thinning, higher intensity of biomass removal in thinning and a higher level of biomass recovery following final felling (SBH). The modelled levels of additional material as presented here are relatively modest, but there is considerable scope to extend supplies from these sources by up to 300-400,000 tonnes/yr, provided there is a secure and profitable market for biomass-based heat.

[114] Green tonne normally refers to the weight of freshly felled ronudwood before any natural or artificial drying has taken place. For the purposes of the sensitivity analysis of forest-based biomass supply it was decided to express forecasted volumes in green tonnes with moisture contents specific to the end uses envisaged. This conversion also facilitated the calculation of energy values. The full methodology is outlined in the sensitivity analysis.

[115] COFORD. 2024, Unpublished. Sensitivity Analysis of Wood Fibre Potentially Available for Wood Energy. COFORD, Kildare st. Dublin 2.

As previously pointed out, the estimates are net of the forecasted resource needed for future levels of sawnwood and panel-board manufacture. (Both product types have, as the COFORD climate change statements point out, significant roles to play in the decarbonisation of the building sector.) Also, harvest of forest-based biomass for energy use has a strong forward linkage to the production of quality sawlog, as the form of thinning practised in Ireland – low thinning – both removes the smaller, poorer-quality trees, and accelerates the diameter growth of the maincrop trees, which go to high-value sawlog assortments.

On the other hand, preferential removal of higher quality trees during thinning, thereby leaving a residual crop of poorer quality stems, or "high-grading" as it is called, is not a sustainable form of forest management. High-grading practices, while they may provide a temporary increase in income, generally lead to lower financial returns over the forest cycle, and degrade the genetic quality of the stand. This is especially important if silvicultural systems such as continuous cover are being practised or considered.

One of the main functions of the work undertaken in conjunction with the *Sustainable Bioenergy for Heat* (*SBH*) report was to quantify the potential bioenergy contribution to the scenarios explored under the SEAI's National Heat Study, in order to reach net-zero emissions in the heat sector by 2050[116]. These included a balanced scenario, summarised as a mix of "policy supports around electrification, alongside use of green hydrogen and biomethane, and implementation of CCS/BECCS in power and industry". On the energy crops side, the assumption was a 50:50 mix of land use conversion to grass silage and willow, enabled by an increase in grassland productivity. How feasible or desirable increases in grassland productivity will be is open to question given the uncertainty around fertiliser prices, and the levels of derogation from the Nitrates Directive application rates that will be available in the future. Compliance may in certain circumstances require the renting or purchase of additional land for slurry spreading (some of which could possibly be diverted to anaerobic digestion). However, the balanced scenario seems a useful framework to examine the potential contribution of additional woody biomass from short rotation coppice coming on stream to support and extend the forest-based resource, and its contribution to renewable energy and decarbonisation. This is especially the case as, according to *SBH*, the scenario accounts for a technology mix that is: "cost effective, feasible to implement and aims to minimise the risk of over-dependence on any single technology".

Supplementing overall biomass supply depends on the level of afforestation and, as shown, management practices in the existing forest estate. Given the time frame of say a decade and half to harvest from afforestation to first harvest, and the current low level of planting, options around short rotation forestry and biomass coppice merit reconsideration. The previous willow coppice scheme ceased in 2015 due to a low level of applications, in turn influenced by weak and low price-paying markets for willow chip.

While there are potential barriers to the reintroduction of a biomass coppice scheme, an imperative to develop large scale biomass heat markets could provide the necessary policy incentive. Potential supply from a renewed willow biomass scheme has been estimated here using the *SBH* supply scenario, adjusted to allow for the time taken to introduce a new grant-aid scheme and for material to flow. The analysis also takes into account the current supply of willow coppice of some 16-17,000 tonnes /yr (at say 50% moisture content, this converts to about 0.1 PJ/yr). Taking these factors into account, and combining the resulting estimated supply with the forest-based biomass stream, Table 3 shows that by 2040 the potential availability of biomass from forests and coppice could be close to 20 PJ/yr. The underlying assumption is an annual average level of willow coppice establishment of 2,100 ha over the period to 2040[117]. There is also potential to reactivate a short rotation forestry measure, which could be used in conjunction with conventional forestry and coppice to reach a desired level of supply, say 20 PJ/yr by 2040. However, state aid rules for forestry may prevent funding for energy crops.

On current (2022) levels of primary energy supply (596 PJ/year) forest and willow-based biomass would account for 3.3% of total energy supply. While this is a relatively small contribution to energy supply, it is likely to grow in importance as overall levels of energy use decline, somewhere in line with the targets in the energy efficiency directive. Furthermore, if and when biomass use is linked with BECCS, it could deliver a significant level of removals. For example, 5 PJ of forest-based biomass linked with BECCS could provide a net removal of around 0.5 Mt CO_2/yr. BECCS is further outlined below.

[116] Sustainable Energy Authority of Ireland (2022). Net-Zero by 2050: Exploring Decarbonisation Pathways for Heating and Cooling in Ireland. [online] Available at: www.seai.ie/publications/Net-Zero-by-2050.pdf

[117] Based on an average fresh weight yield of say 20 tonnes/ha, dried to 40% and allowing for upstream energy inputs, providing 45 MWh heat/ha.

Table 3. Forecasted (forest-based biomass from Table 2) and potential (willow coppice) woody biomass availability 2024-2040, (willow coppice data are from the SEAI, 2022[118]).

Year	Forest-based biomass	Willow coppice	Total
	PJ		
2024	9.5	0.1	9.5
2025	9.9	0.1	10.0
2026	10.4	0.1	10.5
2027	11.0	0.2	11.2
2028	10.6	0.3	10.9
2029	11.4	0.4	11.9
2030	12.7	0.6	13.3
2031	14.0	0.8	14.9
2032	15.5	1.1	16.6
2033	14.5	1.5	16.0
2034	15.1	2.0	17.0
2035	16.3	2.5	18.8
2036	14.7	3.0	17.8
2037	14.7	3.7	18.3
2038	13.7	4.4	18.1
2039	13.8	5.1	18.9
2040	13.9	5.9	19.8

The feasibility of introducing a new willow scheme relies heavily on the development of a sustainable heat market having the ability to pay in the region of €150/tonne (2023 prices) for willow chip. There may also be implications under state aid rules which do not facilitate the funding for forest crops for energy. This in turn depends on continuation of an SSRH scheme allied to a widescale roll-out of district heating, over the coming decades and a strong and effective promotional campaign. There are also challenges in securing agricultural land with the capacity to grow willow at the required productivity level, and with a capacity to facilitate harvesting during the winter months. Willow is not suitable for most marginal agricultural land.

Under the previous willow scheme, which ran from 2007-2014, some 3,300 ha of coppice was established, with a peak of 900 ha being established in 2008. Some of the areas established have since reverted to agriculture, due to an overall lack of an economic price for willow chip and overdependence on a lower price paying power market. Therefore, a key requirement in reducing the risks to state and private investment in short rotation coppice/short rotation forestry is the need to develop sustainable heat and combined heat and power markets for sustainable biomass, through measures such as the SSRH and a district heating support model.

However, there is technical potential for a gradual expansion in willow coppice. As a land use, it compares favourably with grassland for anaerobic digestion (AD)[119] in terms of energy yield. As outlined in *SBH*, willow can provide up to 45 MWh/ha/yr, about a third more than a red clover/ryegrass mix for silage for AD (30 MWh/ha/yr). The higher energy density, combined with lower upstream emissions from the cultivation of willow, points to overall greenhouse gas savings achieved from a willow coppice being greater than from the silage pathway, on like-for-like basis. Given the ever-tightening constraints on land use and land-use change, greenhouse gas savings and costs, such as those outlined, should be taken into account in policy choices.

[118] Sustainable Energy Authority of Ireland (2022). Sustainable Bioenergy for Heat National Heat Study - Spatial Assessment of Resources and Evaluation of Costs and Greenhouse Gas Impacts. [online] Available at: https://www.seai.ie/publications/Sustainable-Bioenergy-for-Heat.pdf.

[119] Sustainable Energy Authority of Ireland (2022). Sustainable Bioenergy for Heat National Heat Study - Spatial Assessment of Resources and Evaluation of Costs and Greenhouse Gas Impacts. [online] Available at: https://www.seai.ie/publications/Sustainable-Bioenergy-for-Heat.pdf.

There is also potential for woody biomass recovery from arboriculture, small areas of woodland and from site clearance operations. Work done in relation to the potential biomass supply from such areas in the Midlands Just Transition region[120], and scaled up to national level, indicate a potential annual supply of somewhere in the region of 200-400,000 green tonnes annually, with an energy value that could reach to up to 3.5 PJ/yr. However, the level and nature of the supply from these sources is highly uncertain.

Fuel and heating costs

On prices, *SBH* indicated that forestry thinnings are available at under 2 cent per kilowatt hour (c/kWh), excluding conversion and processing costs. Based on the current heat market, woodchip, as delivered, is trading in the region of €150/tonne at a moisture content of 30%, which is equivalent to just over 4 c/kWh. Thus, the SEAI estimate, even allowing for conversion, processing and transport, is below current market prices. Perennial energy crops and biogas from anaerobic digestion of grass silage/slurry feedstock (again excluding conversion and processing costs), are costed 2.3-2.6 c/kWh and 5.3-5.5 c/kWh respectively in *SBH*.

SEAI's latest (1 April 2024) quarterly update shows that for residential (domestic) heating, delivered energy costs were lowest for bulk delivered softwood firewood at 9 c/kWh (at 25% moisture content). Pellets and kerosene (home heating oil) had similar delivered costs of 11-13 c/kWh. Bottled gas and wood briquettes were relatively expensive at 21-22 c/kWh. Average gas costs were 16 c/kWh for typical use ranges, while the comparable figure for electricity being 38 c/kWh. Actual heating costs depend of course on appliance efficiency and the level of house insulation. Fuel poverty generally goes hand-in-hand with the use of the cheapest fuels, combustion in inefficient appliances and low levels of house insulation.

Many such homes are in receipt of the government's means-tested fuel allowance scheme. However, given the types of appliances in use, the efficiency of this measure could be considerably improved, and levels of pollution considerably reduced, if a carefully considered appliance/open fire replacement scheme[121] were introduced using Ecodesign replacement appliances. Funding for such a scheme could come from the carbon tax, which has been increased in Budget 2024 by €7.50/t CO_2 emitted, to €56.00/t CO_2. Carbon tax funds are already ring fenced to address fuel poverty and measures such as retrofitting.

Turning to prices for commercial heating fuels, SEAI estimates a current (April 2024) woodchip price of just under 6 c/kWh. This is around the same price of natural gas (for installations with installed capacity of approximately 2-22 MW heat), about half the cost of oil at 12 c/kWh, and about a quarter of the cheapest electricity price at 22 c/kW. Natural gas price trends are particularly important, as gas is now the fossil fuel of choice for energy generation. In that regard the IEA[122] medium term outlook is that natural gas prices will remain above their historical averages at a wholesale price centred around 5 c/kwh[123]. This compares with wholesale prices over the previous decade, averaging 1.5-2.0 c/kWh and never exceeding 3 c/kWh.

Fuel price trends are available through SEAI's quarterly and biannual commercial and domestic fuel prices, which provide a time series stretching back to 2007. Prices as delivered for the main commercial fuels (including electricity) and wood pellets and woodchip show that woodchip has been the cheapest fuel, as delivered, over most of the time series (Figure 15), with only commercial gas being cheaper on occasion. Notwithstanding these data, when projects are at an early stage and fuel types and prices are being considered, larger fossil-fuel suppliers tend to have greater flexibility in price based on a far larger market share and broader customer portfolios, and they can offer competitive prices.

[120] In Press: Bioenergy feedstock supply analysis - Potential bioenergy supply in the National Just Transition Fund's Wider Midlands Region 2024-2040. IrBEA.

[121] See for example the US EPA's Guide to Financing Options for Wood-burning Appliance Changeouts at https://www.epa.gov/system/files/documents/2022-03/finance-optionsupdated2022links.pdf

[122] International Energy Agency (n.d.) Medium-Term Gas Report 2023. [online] Available at: https://iea.blob.core.windows.net/assets/f2cf36a9-fd9b-44e6-8659-c342027ff9ac/Medium-TermGasReport2023-IncludingtheGasMarketReportQ4-2023.pdf

[123] Wholesale prices in February 2024 had dropped to about half of that level, or c 2.5 c/kWh, based on abundant supplies and reduced chances of a cold spell, Nevertheless the price remains volatile.

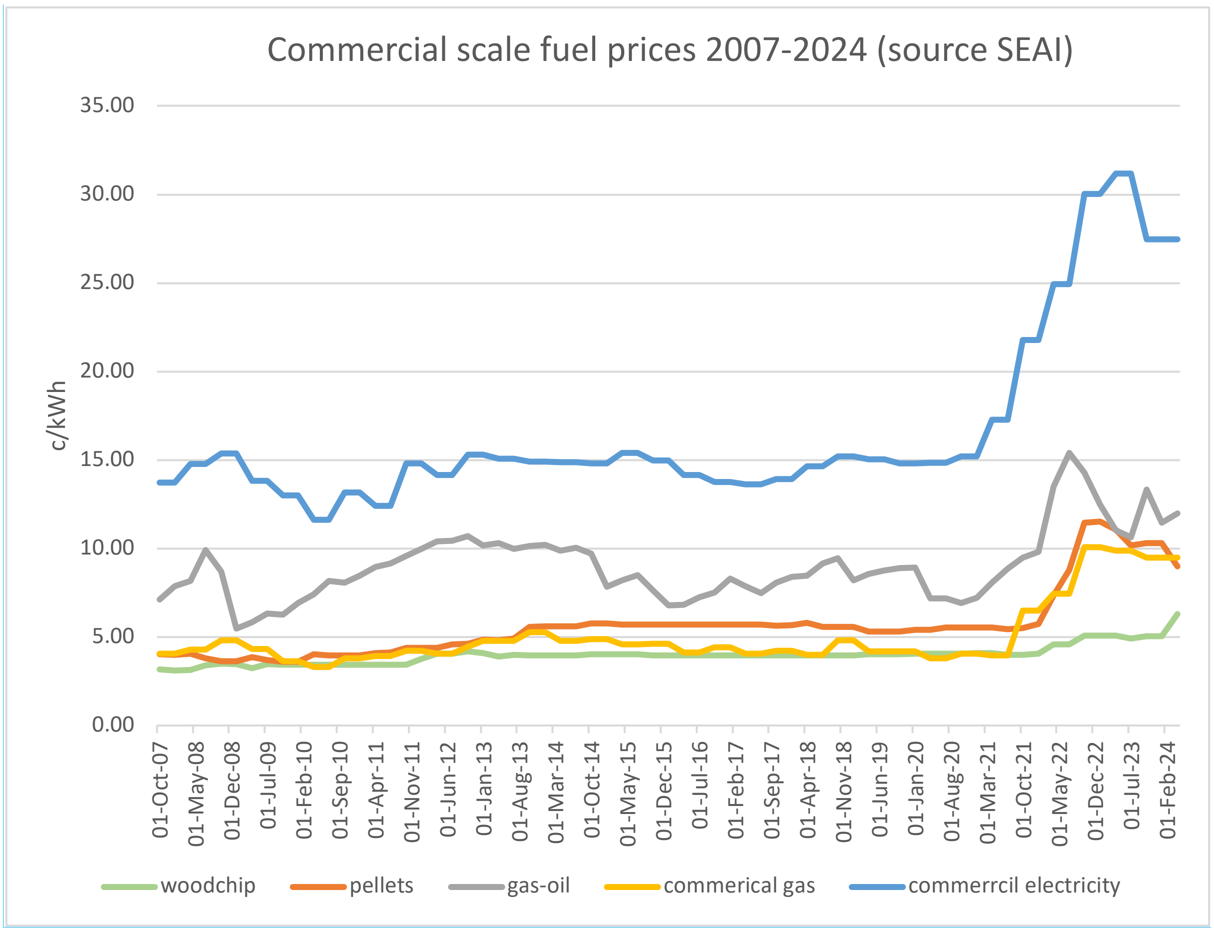

Figure 15. Trends in delivered fuel and electricity prices from October 2007 to April 2024 (SEAI[124]).

Energy prices, particularly fossil fuels, after a period of relative stability prior to late 2021, have increased in volatility, and are consequently more difficult to predict.

Fuel costs are of course just one element of expenditure that a project investor will consider when deciding on the nature of a heat energy service. Capital and other costs such as carbon tax (for installations outside of the ETS) will also be taken into account, in order to arrive at a levelised cost over the project horizon. In addition, other factors such as carbon emission savings and security of fuel or electricity supply will normally be included in the decision-making process. Most commercial investors will look to horizons of five years or less, as they seek to estimate the time taken to pay back an investment based on levelised cost (which is equivalent to the break-even cost). Larger companies will consider how the investment relates to corporate social responsibility (CSR) goals. CSR is likely to have a larger impact on decision-making as the EU's Corporate Sustainability Reporting Directive, agreed in 2023, requires larger companies and small and medium sized enterprises (SMEs) to apply the new rules for the 2024 financial year, for reports to be published in 2025. Public bodies normally take a longer view and may seek to factor in carbon savings to align with national policies.

Prospective uses of biomass

Figure 13 shows that over half of forest-based biomass is currently used in industrial heating, mainly in the wood processing sector. However, the forecasted increase in the availability of woody biomass offers an opportunity to consider the policy mix to best support greenhouse gas emission reductions from forest-based biomass use, aligned with affordable and sustainable energy, and security of supply. As outlined, when dealing with electrification aspects of the Climate Action Plan, there is good evidence to suggest that the use of woody biomass in efficient heating, at large scale, in industry-scale applications and in district heating, is likely to be the most advantageous from a policy perspective.

[124] Sustainable Energy Authority of Ireland (2019). Energy price trends. [online] Available at: https://www.seai.ie/data-and-insights/seai-statistics/prices#comp00005cb739ab0000000838246e.

A key policy goal at national and EU levels is to move towards carbon neutrality by mid-century. Based on GHG projections, forests and soil carbon – the LULUCF sector – will be a net source of emissions in Ireland for at least another decade. This will add, not detract to the difficulty of achieving the carbon neutrality goal. On the other hand, emissions from difficult to decarbonise sectors are likely to require a significant level of balancing removals, emissions, which could be in the region of 10 Mt CO_2 eq/yr, to arrive at a level close to net zero by 2050.

The potential contribution from BECCS and biochar (both referenced earlier) to these goals are now explored further. The overall argument is that support policies for new industrial and district heating, and CHP installations, should consider the scales of operation, and the feasibility of aligning measures with BECCS/ biochar pathways for gaseous and solid carbon removals.

In relation to the earlier discussion on BECCS and biochar, most of the integrated assessment models (IAMs) which examine pathways to net zero by 2050, as referenced by the IPCC in their assessment and special reports, make use of negative emissions (also referred to as carbon dioxide removals (CDR)) to balance out emissions and reach the global net zero target at some time during this century. Afforestation is one of the main CDRs referenced in the IAMs. It and the other main CDRs are illustrated in Figure 16.

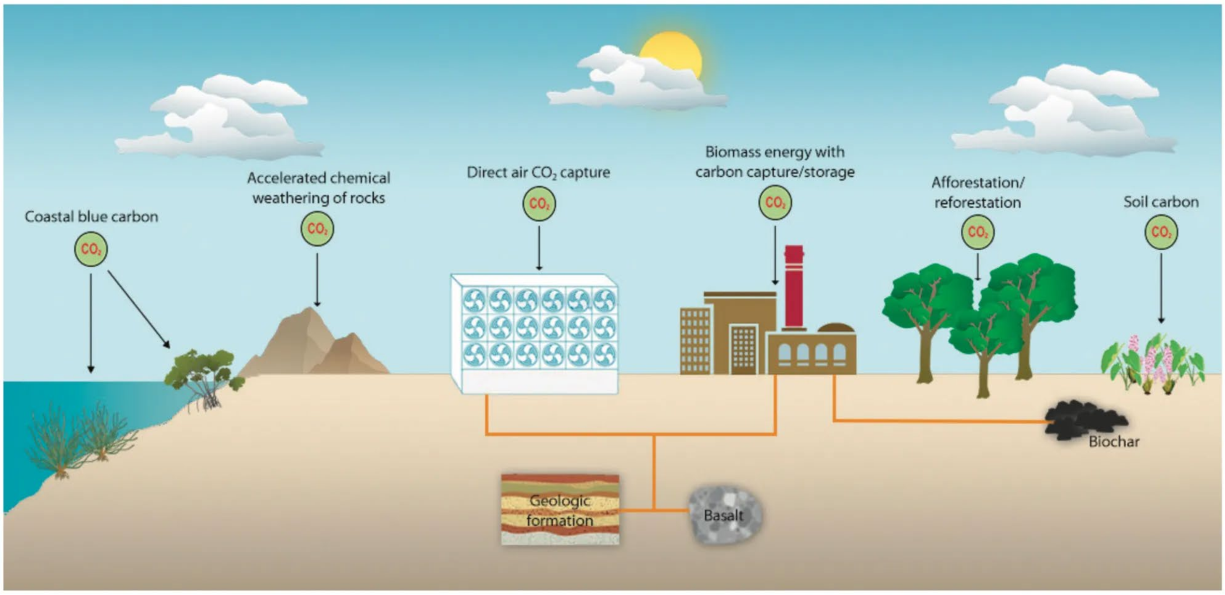

Figure 16. Carbon dioxide removal (CDR) categories (source National Academies of Science[125])

Among the technologies, BECCS and biochar/soil carbon are the two biomass energy CDRs which can provide substantial removals, while also providing renewable energy services. The earlier calculation showed that for every 5 PJ of forest-based biomass combusted, approximately 0.5 Mt CO_2 is potentially available for BECCS. This is effectively a permanent removal of CO_2 from the atmosphere, assuming sustainable forest management.

On scale of installation, *Carbon Capture Utilisation and Storage (CCUS)*, part of the SEAI National Heat Study, states that carbon capture technology is likely to be limited to installations with emissions above 0.1 Mt CO_2/yr and which are included within the EU emissions trading scheme. Assuming this threshold, and using IPCC specific emission factors for wood combustion, as well as average annual utilisation rates, it would take a biomass plant with an estimated installed capacity of around 35 MW to reach the threshold. Such installations could be either stand-alone heat or CHP, and would provide an annual energy service in the region of 0.2 TWh. The annual forest-based biomass supply for one such installation would be close to 1 PJ/ yr, or about 95,000 tonnes at 45% moisture content. As Table 2 shows, there is a biomass supply available for several such plants. The energy service provided would depend on plant configuration (for example district heating only or CHP) and resultant efficiency, but is likely to be around 0.8 PJ/yr. Plants of this size could bring economies of scale to biomass supply, without being oversized or overly reliant on imports.

[125] P. Smith, S.J. Davis, F. Creutzig, et al. (2016) Biophysical and economic limits to negative CO2 emissions Nat Clim Change, 6 (1), pp. 42-50. https://doi.org/10.1038/nclimate2870

Apart from the Edenderry plant (which runs at an efficiency in the low 30 percents, no such installations exist at present in Ireland. Matching this level of heat (and power) to customers' demands in an economic fashion would require energy mapping and consideration of pricing capex and opex, and the availability of government supports. These and other issues are addressed in *A guide to district heating in Ireland*[126], a report from IrBEA.

Overall, the SEAI's *Carbon Capture Utilisation and Storage* identified potential BECCS removals from its balanced scenario[127] of 5.1 Mt CO_2/yr, with a gradual build-up in capacity involving three existing energy-from-waste plants and a new dedicated large-scale biomass-for-power plant. Given the need for efficiency in the use of a limited biomass resource, a stand-alone biomass-for-power plant is questionable, and runs against the thrust of RED III. The SEAI report also identified potential CCS sites and amounts of carbon that could be captured and stored.

Several factors are identified in the SEAI report that are likely to influence the viability of BECCS and CCS:

- Some industrial sectors, cement manufacture and fossil fuel refining for example, have process-based emissions which cannot be decarbonised by low/zero-carbon fuel switching alone, thereby requiring CCUS technology.

- • Infrastructure development will be a key constraint for adopting CCUS at both industrial and power sites, particularly more dispersed sites.

- • Deployment of CCUS and BECCS technologies is most suitable for large point source emitters of carbon. Sites in or near to clusters potentially have easier access to shared infrastructure, which helps to achieve economies of scale infrastructure such as pipelines and shipping.

At the policy level, and among civil society, there may be concerns that the deployment of CDR technologies, such as BECCS, would deter emission abatement and undermine efforts to achieve net zero. However, the 2023 Climate Action Plan, as pointed out, contains a wide range of decarbonisation measures, which enshrine an emission-reduction first approach. More recently, the 2024 Climate Action Plan[128] envisages some role for carbon removal technologies involving extraction, storage, and utilisation of biogenic carbon dioxide, during the second carbon budget period (post 2025). It refers to biochar and BECCS as potentially promising avenues capable of addressing part of the gap in residual unallocated emissions. Given the high probability of emission reductions being well below target at the end of 2025 and 2030, the role of removals in general, and those based on biochar and BECCS, merits serious policy consideration. Any examination should also include the technical and economic feasibility of new biomass-based heat and CHP plants as outlined, in order to scale up potential removals.

As outlined, a key issue for forest-based biomass in any BECCS deployment is the sustainability of the biomass supply chain. A recent report - *The ability of BECCS to generate negative emissions*[129] - issued in conjunction with the new UK *Biomass Strategy 23*[130], did not identify "any significant and insurmountable scientific barriers to the permanent removal of CO_2 from the atmosphere via BECCS with sustainable supply chains when well-regulated." It pointed to "substantial existing regulations that cover the cultivation and harvesting of biomass for bioenergy purposes, in addition to a range of industrial 'best management practices'". These are analogous to the renewable energy directives, which the newly agreed RED III builds upon, with increased regulation of biomass supply such that it has a small negative, neutral or positive impacts on forest carbon stocks.

[126] Gartland, D. Bruton, T. (2016) A guide to District Heating in Ireland. [online] Available at: https://www.seai.ie/publications/2016_RDD_79._Guide_District_Heating_Irl_-_CODEMA.pdf

[127] The balanced scenario aims at a middle ground between these two, accounting for a technology mix that achieves an outcome that is cost-effective, feasible to implement, and aims to minimise the risk of over-dependence on any single technology.

[128] Department of the Environment, Climate and Communications (2023) Climate Action Plan 2024. [online] Available at: https://www.gov.ie/en/publication/79659-climate-action-plan-2024/

[129] Department for Energy Security and Net Zero (2023). The ability of BECCS to generate negative emissions - Task and Finish Group Report. [online] Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1177531/task-finish-group-report-ability-beccs-to-generate-negative-emissions.pdf

[130] Department for Energy Security and Net Zero (2023). Biomass Strategy 2023. [online] Available at: https://www.gov.uk/government/publications/biomass-strategy#:~:text=The%20Biomass%20Strategy%20sets%20out,the%20UK's%20net%20zero%20target.

In terms of the 2023 Climate Action Plan, it includes a target of up to 0.7 TWh of district heating by 2025 and 2.5 TWh by 2030. The main fuels envisaged are renewable gases (biomethane) from agriculture-based supply chains. It is unclear whether the fuels would be delivered through existing gas networks, which are overwhelmingly fossil-fuel based. Were this to be the case, it could of course lead to an extension of the use of fossil gas in heating. Therefore, it is worth considering the extent that these targets could be partly met by forest-based biomass, which is the most commonly used fuel for district heating throughout Europe. It is also worth considering to what extent these installations could be readied for potential BECCS.

In considering the best use of forest-based biomass and other renewable fuels, it is important to decide which is more important, an energy service or carbon removal. Work by Chiquier et al.[131] and others have examined these issues, and merit consideration in terms of policy formulation.

[131] Chiquier S, Piera P, Bui M, Sunnyab N, Mac Dowell N. (2022). A comparative analysis of the efficiency, timing, and permanence of CO_2 removal pathways. Energy Environ. Sci.: 4389-4403

Conclusions and recommendations

Biomass and bioenergy policy

Bioenergy accounted for almost one third of the renewable energy contribution to gross final energy consumption in Ireland in 2022, while forest-based biomass provided over half of the renewable heat supply. There is considerable scope to expand these contributions from bioenergy, including forest-based/woody biomass, over the coming decades to contribute to climate goals, security of energy supply and balanced regional development. In considering current levels of use and expansion, it is a requirement that bioenergy supply, both indigenous and imported, is sourced from sustainable sources and supply chains. Biomass needs to be used in an efficient manner, and in a way that does not damage air quality.

Biomass is suitable for a wide range of energy uses, from power to heat, to transport and aviation fuels. It can also be used as a replacement for oil in the manufacture of cellulose-based products, such a packaging and clothing fabrics.

A number of policies and measures at national and EU level deal with bioenergy in general and forest-biomass in particular. There is however no overarching strategy or policy covering bioenergy, and its role in substituting for fossil-based fuels and addressing renewable energy targets. This tends to lead to an uncoordinated mix of policies and measures, a lack of clarity of objectives, and a lack of confidence among companies and investors when considering bioenergy as a substitute for oil and gas. For example, the SSRH measure has no defined targets, and the timeframe only extends to 2025, which does not provide a sufficient level of confidence needed for supply side investment, or for fuel switching from gas or oil. While there is potential for a doubling in supply of woody biomass to 2040, and the role of forest-based biomass is referenced in the forest strategy, there is no policy around willow or other additional supplies of biomass. Targets do exist for biomethane, but how these are to be achieved is unclear, especially at the supply side. Land is a limited resource, and there are potentially conflicting demands for afforestation, silage for anaerobic digestion, and willow coppice along with many other potential uses. Decisions made by the land owner will be influenced by tradition, markets and, to a greater or lesser extent, by government subsidies. Markets are also influenced by policy measures in the energy sector. To develop and sustain a viable indigenous bioenergy sector, therefore, market development and investor assurance are essential.

As far as the bioenergy and biomass contribution to national and EU policies is concerned it is essential to have an evidence base around supply, costs, sustainability and technical feasibility of bioenergy. This in turn can inform national policies and the Climate Action Plan processes. It is also essential to raise the level of ambition around sustainable bioenergy and biomass in the context of contributing to climate, energy and development goals, and as well to provide confidence to specifiers and investors.

It is recommended therefore, that analogous to processes such as the UK's recent *Biomass Strategy 2023* that:

1. ***A national bioenergy strategy should be developed to set out the general aims for bioenergy use into the future, and a level of ambition for deployment in the context of climate and energy goals, security of energy supply, sustainability and balanced regional development.***

Given the likely timeframe for the development of the strategy, including public engagement, a series of interim targeted recommendations are also made in the context of the preceding analyses and the summaries hereunder.

The climate change mitigation challenge – marshalling bioenergy and biomass

To achieve the Paris Agreement aims to limit global warming to 1.5 °C or 2 °C, deep cuts in greenhouse gas emissions are needed over the quarter century to 2050 and beyond. To date, policies adopted by countries have fallen far short of the emission reductions and removals needed to reach the desired temperature goals. Projections from the IPCC AR6 mitigation report[132] show, based on policies adopted up to 2020, there will

[132] IPCC (2022). Summary for Policymakers. [online] Available at: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf. f

be global emissions overrun ranging from 10-20 billion tonnes of CO_2 eq/yr by 2030, that would preclude achievement of both the 2 °C and 1.5 °C temperature increase limits. In recognising this finding, the EU has upped its goals for emission reductions and removal levels, by revising the relevant climate-change related directives and regulations as part of the *Fit for 55* package[133]. Ireland has also significantly raised its level of ambition under the Climate Action and Low Carbon Development (Amendment) Act 2021, which has an emission reduction target, including LULUCF, of 55% by 2030 on 2018 levels. Under the legislation, sectoral emission targets have been set under the carbon budget mechanism. Decarbonisation measures are set out in the climate action plans, with target levels of greenhouse gas savings in each sector to 2030 (apart from LULUCF pending the completion of the land use review), with indicative levels to 2035. Progress has been made in reducing emissions, but the levels achieved to date are insufficient to stay within the overall carbon budget to 2025, or to comply with the targets set out in the EU's revised Effort Sharing Directive, under *Fit for 55*.

Both the IPCC and the IEA foresee the need to mobilise a mix of technologies to reach net zero carbon emissions by 2050 or shortly thereafter. The models include significant increase in the use of modern bioenergy, including BECCS, based on the level of emission reductions and removals needed to arrive at the net zero target.

At the national level, the main CDR policy approach is the expansion of forest cover, with an afforestation target of 8,000 ha/yr indicated in the Climate Action Plan, and endorsed in the government's recently issued forest strategy[134]. It states that "over the coming decade and beyond, forestry will be the one of the largest land-based climate mitigation measures available to Ireland". Given that afforestation is now running at about 2,000 ha/yr, and the many competing demands on land use, this target will be difficult to achieve. However, it is vitally important that every effort is made at the policy and operational level to move upwards towards the 8,000 ha/yr goal, and if possible well beyond, not only for climate change mitigation but the wider range of economic, social and environmental services that forests in Ireland have been shown to provide.

The analysis around the COFORD climate change mitigation statement estimated that an afforestation programme of 16,000 ha/yr, up to 2050, would be needed to provide a sufficient level of removals to balance out an estimated level of remaining emissions of c. 10 Mt CO_2 eq/yr at mid-century. Given current afforestation trends it is difficult to see such levels being achieved. From a biological carbon perspective, the remaining sink options are BECCS and biochar. There is a strong case therefore to consider the technical, economic and sustainability aspects of BECCS and biochar, in conjunction with new, medium to large scale district heating systems, switched industrial heating, and combined heat and power, possibly using hybrid bioenergy/electricity systems[135].

These summary considerations on climate change mitigation, and the role of bioenergy and forest-based biomass, lead to the following recommendations:

2. ***The support scheme for renewable heat (SSRH) should be extended to the ETS sector as announced, with an extended timeframe to 2035 in climate action plans, with ambitious greenhouse gas reduction targets and***

3. ***Be driven by a concerted and sustained promotion of the scheme by SEAI, working with public and private sector specifiers and relevant industry groups, and commensurate with effort in other sustainable heating systems***

4. ***A separate target for solid biomass should be included in the district heating action in the Climate Action Plan, in line with the target for biomethane.***

[133] The EU's increased level of ambition to reduce greenhouse gas emissions by 555 by 2050 as introduced in July 2021 in the Fit for 55 package, and if fully achieved will likely have some impact on the 2030 levels, though with its current share of global emissions standing at 7.6%, the impact will be relatively small. It requires commensurate increases in ambition among other countries to close the emissions gap.

[134] Department of Agriculture, Food and the Marine (2023). Ireland's Forest Strategy (2023 – 2030). [online] Available at: https://www.gov.ie/en/publication/89785-irelands-forest-strategy-2023-2030.

[135] Rezaei R, Sameti M, Nasiri F .2021. Biomass-fuelled combined heat and power: integration in district heating and thermal-energy storage, Clean Energy 5 (1): 44–56. https://doi.org/10.1093/ce/zkaa031

5. ***Based on the findings of the feasibility assessment[136] of carbon capture and storage, the technical and economic feasibility of integrating new large-scale district heating, and industrial heating with BECCS, should be investigated. The goal being to generate renewable heat (and power) allied to negative emissions, taking into account the need for economies of scale and locations convenient for transport of compressed carbon dioxide to geological storage.***

Air quality and woodfuel use

Residential combustion of solid fuels is regulated at the national level through the Solid Fuel Regulations, and the requirement that new residential solid-fuel combustion appliances for sale must comply with the ecodesign regulations on efficiency and level of emissions. The Solid Fuel Regulations have been through a second heating season, with most suppliers having registered, and having supplied certificates of compliance issued by the Wood Fuel Quality Assurance Scheme and other certification bodies. In order to build confidence in the operation of the scheme, to deliver the air quality improvements foreseen and to provide reassurance to registered woodfuel suppliers and users of woodfuels, it is essential that compliance is widely enforced through the designated local authorities. It is recommended therefore that:

6. ***Compliance checking of solid fuels, including woodfuels, should be rigorously enforced by local authorities as set out in the Solid Fuel Regulations. This should be based on the provision of sufficient budgeted resources, in order to deliver foreseen improvements in air quality and provide consumers with clean and efficient home-heating woodfuels.***

Apart from fuel quality, efficient and clean combustion of woodfuels is determined by the type of appliance, and its maintenance and operation. Ecodesign stoves combined with quality woodfuels can result in up to 9-fold reductions in particulate emissions, while also providing for cost effective and efficient combustion. Given the likelihood of residential woodfuel use continuing at some scale over the coming decade, it is recommended that:

7. ***Consideration be given to a targeted capital grant scheme for efficient and clean burning wood pellet and wood log gasification stoves and boilers, with provision for an affordable level of building insulation.***

8. ***Policy should also enable energy clustering of new or existing residences, and provision of heating services to apartment buildings, with a focus on the displacement of oil heating and non-mains gas heating.***

Supply side

Continuous improvement in forestry practice in the harvesting of forest-based biomass, and in transferring knowledge on good harvest planning and practice among forest owners and foresters is necessary to support sustainable forest-based supply chains. Forest harvesting residues are a valuable source of sustainable forest-based biomass, and when used to displace fossil fuels can rapidly repay carbon debt. The foliage component of residues carries most of the trees nutrient load and must be retained on site to maintain site nutrient capital so that long-term forest productivity is maintained in order to sustain forest resources. To that end it is recommended that:

9. ***The code of practice outlined in the IrBEA good practice guidance note Specified biomass harvesting - good practice guidance for energy assortment harvesting at clearfell - should be referenced in the Department of Agriculture, Food and the Marine Standards for Felling and Reforestation, in order to provide clear guidance to certifiers and foresters on sustainable residue harvesting methods.***

10. ***Teagasc and DAFM should continue to promote early thinning interventions, where appropriate, in order to improve stand quality and accelerate the growth of sawlog assortments and returns to owners. Where small roundwood for board manufacture and other solid wood products are not economically available, advise on harvesting and stacking practices that recover a high proportion of biomass and promote drying to specified moisture contents. DAFM knowledge transfers schemes should include modules on the importance of thinning, biomass harvesting and wood for energy.***

[136] Being undertaken by the Department of Environment, Climate and Communications.

Sustainability - assurance and certification

The Forest Service felling licence system provides good assurance as to the sustainability of indigenously sourced forest-based biomass, and the voluntary WFQA scheme seeks evidence of sustainable supply chains. Separate sustainability criteria are called up in the renewable energy directive, with strengthened criteria being incorporated in the 2023 revision RED III, which has now been officially adopted by the EU. RED III also lowers the threshold whereby biomass fuels used in installations above a certain size, must fulfil sustainability and greenhouse gas saving criteria. This must be independently verified using procedures set down in the directive. As of the end of 2021, a lack of certification resulted in a significant proportion of biomass use not being counted towards renewable energy targets. This situation needs to be addressed in order to comply with the directive and demonstrate that biomass contributes to RES-H and overall RES targets. It is important therefore that:

11. ***Independent verification of compliance of biomass, used in qualifying installations with the greenhouse gas savings and sustainability criteria under the renewable energy directive, should be progressed and achieved as a matter of urgency.***

Continuous quality improvement and innovation

Woodfuels range from firewood, woodchip, densified briquettes and pellets, and derivatives such as biochar, pyrolysis oils and gases, through to green hydrogen production from steam gasification and other technologies. Firewood itself, and other woodfuels, are now well specified and standardised fuels through the work of ISO Technical Committee 238 – Solid Biofuels. The requirement to achieve specified moisture contents for firewood, for example, brings a need for innovation in drying and processing practices. Advancing the development of second-generation biofuels derived from wood residues, sometimes in conjunction with biorefining, has been the subject of much research and innovation, as highlighted by the IEA's 2023 bioenergy report. It outlines that a wide range of wood-derived biofuels are being developed, which have potential for wide-scale use over the coming decades as low carbon substitutes for fossil fuels.

In addition, there is ongoing work across Europe, North America and in developing countries to improve combustion efficiencies of wood-based cookers, stoves and boilers, and to contribute to reductions in air pollution.

For these reasons it is recommended that:

12. ***Innovation and research funding should be provided to support continuous improvement in woodfuel quality and efficiency of production. Funding should also be provided to track the development of innovative wood-based second-generation biofuels, green hydrogen and for biorefining in conjunction with biofuel production.***

Promotion

Promotion of the use of high quality, sustainable and renewable forest-based biomass, as a clean, versatile and cost-effective fuel suitable for use in efficient heat and power uses across the residential, commercial/institutional and industrial sectors, is necessary to provide confidence to project developers, and fuel users. Among the key messages are that woodfuels used in Ireland are from sustainable sources, their efficient use contributes to tackling climate change, improved security of energy supply, and that modern bioenergy is part of the pathway to reducing air pollution. To enable these key messages to be communicated clearly and effectively, it is recommended that:

13. ***State and industry bodies should resource the promotion of the use of modern bioenergy and woodfuels as cost-effective, sustainable, and part of the transition to better air quality, which contributes to a balanced regional development through local supply chains and overall security of energy supply.***

14. ***Wider government policy should reflect the beneficial outcomes to climate mitigation of burning sustainable biomass and its impacts on displacing fossil-based heating fuels.***

Acknowledgements

Eugene Hendrick, former charman of COFORD, was the principal drafter of this report in collaboration with several members of the COFORD climate change group. He wishes to acknowledge their contribution, and technical input from members of the Department of Agriculture, Food and the Marine. Henry Phillips undertook the sensitivity analysis of the All Ireland Roundwood Production Forecast carried out in conjunction with this work.

Thanks are also due to members of the Energy Statistics Team at the Sustainable Energy Authority of Ireland for data on the level of use of forest-based biomass in the energy sector. The Irish Bioenergy Association secretariat and Daniel Reinemann of Bioenergy Europe provided helpful insights on bioenergy policies and measures. Kevin Black of Forest, Environmental Research & Services (FERS) Limited clarified aspects of forest sink estimation and accounting. Pieter D Kofman provided information on the scale and operation of wood-fuelled district heating systems in operation in Denmark and elsewhere.

All comments and policy recommendation are attributable to Eugene Hendrick alone, as are any errors of fact or interpretation.

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