TRANSPORT IN IRELAND: A PATHWAY TO HALVING EMISSIONS

MEETING AMBITIOUS EMISSIONS REDUCTION IN IRELAND'S TRANSPORT SECTOR AND THE ROLE OF SUSTAINABLE BIOENERGY

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Energy · Climate · Marine

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FOREWORD BY IRISH BIOENERGY ASSOCIATION

Ireland's soaring ambition for climate action is very welcome. **Cutting greenhouse gas emissions by 51% by 2030** represents a societal, environmental and economic transition bigger than any country in the modern world has ever voluntarily undertaken. To ensure progress and credibility, the government needs to quickly mobilise a package of substantial climate action policy measures that are palatable to citizens, affordable and clear in their climate benefit. Transport is a significant challenge. Accounting for the largest portion of Ireland's energy related greenhouse gases, the sector is still seeing an upward trend in fossil fuel consumption, conventional vehicle numbers and carbon emissions.

Biofuels are the only measure slowing that trend to date. This is because biofuels represent the lowest cost decarbonisation option for transport, and can be deployed quickly and sustainably in the existing transport system. Biofuels now account for over 5% of Ireland's transport energy, **bringing the same climate benefit as nearly half a million electric cars.** This contribution could be doubled or more with the rapid implementation of the policy interventions detailed in this report, such as the switch to E10 petrol (in an instant bringing the same climate benefit as 50,000 electric cars), B12 diesel and biomethane powered trucks.

Biofuels alone won't bring the revolution, nor will cycling and walking, working from home, urban planning reform, changed driving habits or electric vehicles. **Instead, all of these measures together, applied to the maximum extent possible, will be required if real progress is to be made towards 51%** emissions reductions in just eight years time.

The scale of the challenge necessitates meaningful change at both local and national levels. **At local authority level, spatial and transport planning need to be key considerations.** We need to see the rapid extension, across all regions, of the TenT Network supports for compressed natural gas fuelling stations. Across the EU, and particularly in freight transport, we have seen a major shift towards compressed methane gas. **Bio-methane has strong potential to displace this fuel and do the heavy lifting for transport emissions reductions in this sector by 2030.** An open and honest conversation about transport climate action in Ireland is desperately needed. Over a decade when the conversation has been **narrowly focused on the electrification of transport** as the only decarbonisation solution the conventional vehicle fleet has continued to grow at a considerably higher pace than the electric fleet.

It is now beyond doubt that a wider range of policy measures and interventions is required, that cost and convenience are the number one factors for public acceptance and uptake, and that the current fleet will still be the backbone of Ireland's transport system in eight years' time. There is a palpable risk that several more years will pass without effective transport climate action taking place.

IrBEA thanks our Transport Committee Chairman and IrBEA Executive staff who oversaw the commissioning of this report. IrBEA gratefully acknowledges the sponsorship contributions of Transport Infrastructure Ireland, Ethanol Europe, Green Biofuels Ireland, Green Generation and 3 Counties Energy Agency.

Mr Paddy Phelan
IrBEA PRESIDENT

Mr Seán Finan
IrBEA CEO

BIOFUELS IN TRANSPORT IN IRELAND: DID YOU KNOW?

-84%

In 2020, biofuel delivered an 84% reduction in carbon on a per energy unit basic compared to fossil fuel

Bioliquids made up 5% of total road energy consumption in 2020

Biofuels avoided approx. 520,000 tonnes of CO_2 emissions in 2020

Less than 1% of consumption in road transport were from crop-based fuels. The EU Average is 4%

Sustainable biofuels make up 98% of renewable energy in transport in Ireland. The remainder is renewable electricity (2%)

68% of all the biofuels placed on the market in Ireland were produced from used cooking oil while 15% were from animal fats (Tallow)

33% of raw materials to make biofuels were imported from China

14% of raw materials were sourced from Ireland

SEAI estimate bioenergy potential equals 30% of the energy we use today

All fuel met sustainability requirements in accordance with the Biofuel Obligation Scheme

Glossary of Terms and Bioenergy Explainer here

KEY MESSAGES

SUSTAINABLE BIOFUELS ARE KEY TO DELIVERING EMISSIONS REDUCTION IN TRANSPORT

Transport is Ireland's largest source of energy related emissions with forecasts of continued increases in distances travelled and goods carried in the period to 2030. Emissions must reduce significantly to achieve the ambition targeted in the Climate Action Bill and will require a combination of electric vehicles, sustainable biofuels and behavioural change.

Sustainable bioliquids and bioenergy in general have been a policy blind spot in decarbonisation policy. Sustainable liquid biofuels dilute the carbon content of transport fuels in Ireland, reducing emissions by 520,000 tonnes in 2020. This is similar in effect to replacing 230,000 cars with electric cars. There is scope for increasing the contribution of biofuels.

Sustainable bioliquids are cost competitive. From a policy perspective, the Climate Change Advisory Council estimates the current cost per unit of carbon avoided to be €250 - €350 per tonne of CO_2 for battery electric vehicles and higher for Plug in Hybrids. This will naturally reduce as EVs become more affordable. This compares to our estimates of values between €110 - €280 per tonne of carbon avoided for bioliquids and biomethane.

Renewable energy* in transport should increase from 4% today to 35% in 2030 to deliver government ambition. The increase in bioenergy resource use can be met with existing indigenous resources for biomethane as determined by SEAI , by increasing biofuels blending to E10 and B12 as indicated in the National Energy and Climate Action Plan while HVO expansion will be dependent on new production capacity coming online in Europe.

FIVE CORE POLICY ACTIONS ARE REQUIRED TO DELIVER A 51% REDUCTION IN TRANSPORT EMISSIONS.

These are:

i)	Delivering on the government ambition of over 940,000 electric vehicles in 2030
ii)	Increasing the blend rate of sustainable bioliquids in petrol and diesel (minimum 10% ethanol and 12% biodiesel) as per the Climate Action Plan
iii)	Efficiency and behavioural measures that reduce surface transport fuel consumption by 17% by 2030
iv)	Targeting 5 TWh of indigenous biomethane production for use in heavy transport
v)	Targeting 2 TWh of Hydrotreated Vegetable Oils (HVO) following best practice in Swedish Renewable Transport Policy

Indigenous biomethane is an untapped resource that can reduce emissions in transport by 1 million tonnes while advancing emissions reduction in both agriculture and landuse. A biomethane industry would contribute to rural employment and offer options to farming families to diversify incomes for those in the lower income sectors. Policies that encourage sustainable biomethane production with the displacement of livestock would have limited impact in terms of landuse change.

To avoid negative consequences for carbon emissions and biodiversity, Ireland must continue to adhere to existing sustainability guidelines and promote transparency in the sourcing of all sustainable feedstock.

* This is the unweighted volume in energy terms after efficiency measures and EVs are accounted

INTRODUCTION

RENEWABLE TRANSPORT IS KEY TO CLIMATE AMBITION

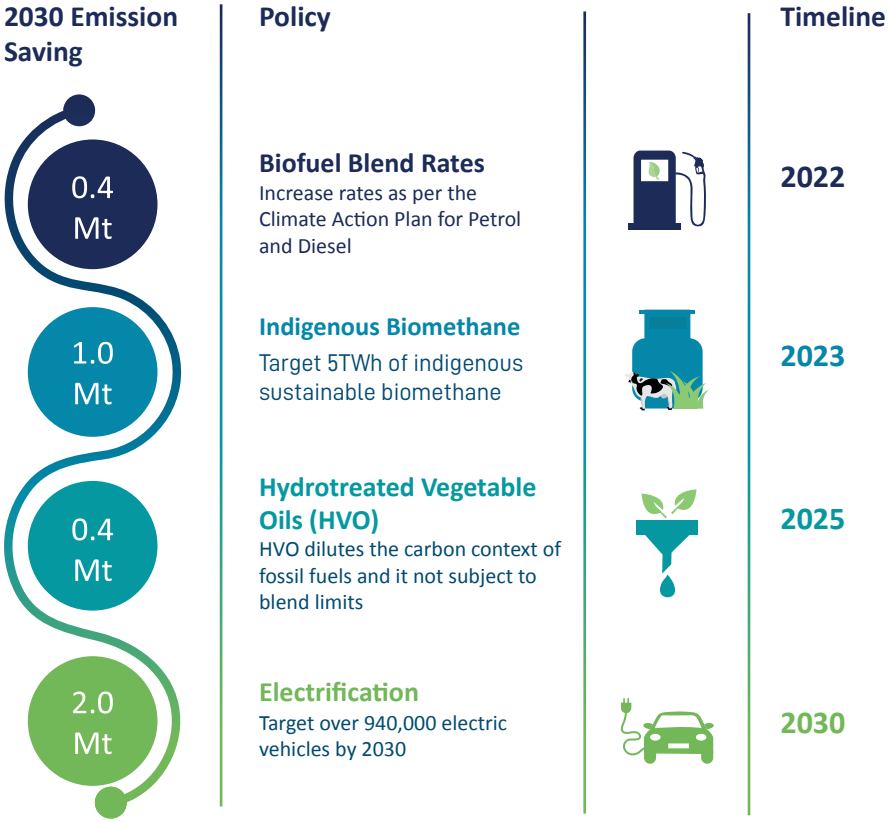
Time is not on our side when it comes to climate action in Ireland. Emissions today are higher than they were 30 years ago, and transport emissions alone have grown by over 130% over the period. This is a defining decade for Ireland as the government has set a target to reduce all greenhouse gas emissions by 51% by 2030 with the Climate Action Bill. Translating ambition into action will require a radical rethinking of the transport sector. Above all, waiting is not an option. Electric vehicle deployment and new infrastructure for public transport and cycling will take time to deliver emissions reduction. There is a need to look at what works today and expand on it as complimentary policy.

This report addresses the decarbonisation of Irish transport with a special emphasis on the role of sustainable biofuels. For transport to play its fair share we examine options to deliver a 51% reduction in transport emissions by 2030.

Renewable Transport has largely been neglected in much of the public discussions on renewable energy. The role of electric vehicles has captured the public imagination and tends to dominate transport policy discourse, but electrification has limited potential in heavier transport while slow passenger vehicle stock turnover and EV sales are at odds with the pressing timelines for emissions reduction. Electrification of transport will play an important role, but alone is not enough to deliver what is required to meet emissions reduction targets.

We find that in the period to 2030, a broad and diverse mixture of policy, technical and behavioural measures are needed to reduce emissions in transport. The deployment of EVs must significantly increase alongside an increase in blending levels of sustainable bioliquids. Ireland must harness its sustainable biomethane resource which can provide multiple benefits to rural Ireland, including diversification of incomes for farming families. At a national level, renewables in transport should increase to 35%, up from the 5% that it is today. An increase in efficiency, behavioural changes and the promotion of active modes of transport are also all required. Key to the success of bioliquids in a zero carbon future is sustained policy support that delivers not only emissions reduction but also promotes transparency and ensures sustainability.

Policy Roadmap

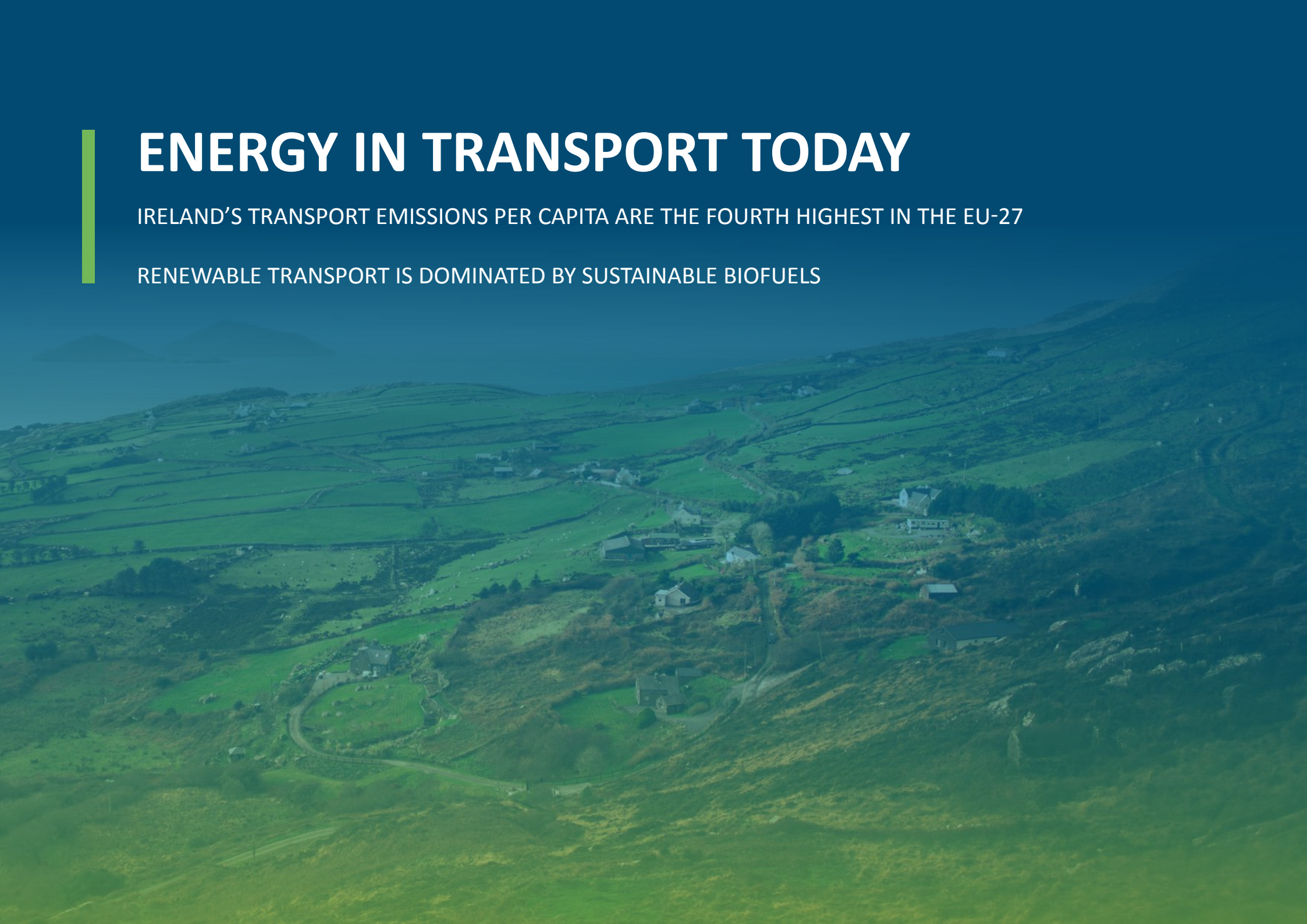


See other Climate Action Plan Measures on page 20

ENERGY IN TRANSPORT TODAY

IRELAND'S TRANSPORT EMISSIONS PER CAPITA ARE THE FOURTH HIGHEST IN THE EU-27

RENEWABLE TRANSPORT IS DOMINATED BY SUSTAINABLE BIOFUELS



POLICY CONTEXT

International Climate Action is gathering momentum

In a 2018 special report, the Intergovernmental Panel on Climate Change detailed that countries must bring carbon dioxide emissions to "net zero" by 2050 to keep global warming to within 1.5 °C of pre-industrial levels. Across the globe, governments are making pledges to reduce emissions and take actions on climate change. In April 2021, the administration of US President Joe Biden has pledged 2050 as its deadline for net zero greenhouse-gas emissions, while China declared 2060 as its target to achieve net zero. The European Union aims to be the first climate neutral continent by 2050 and has proposed a series of measures, including a 55% reduction in greenhouse gases by 2030 and a European Climate Law to enshrine climate neutrality into EU law.

The Climate Bill is a landmark piece of legislation

In Ireland, the Climate Action and Low Carbon Development Bill 2021 aims to achieve a climate neutral economy by no later than 2050 by establishing a legally binding framework with targets and commitments set in law. Importantly, the Bill embeds the process of carbon budgeting into law, Government is required to adopt a series of economy-wide five-year carbon budgets, including sectoral targets for each relevant sector, on a rolling 15-year basis, starting in 2021 with an overlapping objective to achieve a 51% reduction in emissions (relative to 2018) by 2030. It is a landmark piece of legislation as it brings climate thinking into the centre of political decision making. **This level of proposed emissions reduction to 2030 is extraordinarily ambitious and is without an international parallel.**

Transport Policy in Ireland

Ireland has several supportive policies in place than need scaling up to meet future emissions reduction. Ireland already has some of the most generous supports in the world for electric vehicle purchases. EV deployment in Ireland is supported by an SEAI grant, a subsidised charging point, a favourable VRT rate and toll exemptions. The EV fleet is growing though it should be noted that the stock of conventional vehicles may also continue to grow.

From a policy perspective, the Climate Change Advisory Council estimate the cost per unit of carbon avoided to be €250 - 350 per tCO2 for a BEV, rising to between €492 - €681 for a PHEV. This compares to values between 110 - 280€ per tonne for bioliquids. While EV and Biofuels have abatement costs higher than the current carbon tax, both will be needed into the future and a higher level of deployment is required. Meeting the Climate Bill Ambitions will require all the measures in the Climate Action Plan to be met as well as additional measures discussed in this report.

Launch of Climate Bill in Ireland-March 2021-A landmark piece of legislation setting Ireland on course to a climate neutral future.

TRANSPORT | ENERGY AND CO_2 EMISSIONS

IRELAND'S TRANSPORT EMISSIONS PER CAPITA ARE THE FOURTH HIGHEST IN THE EU-27, AND TRANSPORT IS IRELAND'S LARGEST ENERGY SECTOR EMITTER

We drive a remarkable amount in Ireland. Over 35 billion kilometres were driven by private cars in 2018. The transport sector is the largest source of energy-based CO_2 emissions. The transport sector is not only our largest energy demand but is also the most sensitive to economic change. While transport is a key sector globally for the reduction of greenhouse gas emissions, the scale of the challenge is even more pronounced in Ireland as it tends to grow or reduce sharply in response to economic growth or contraction. This is evident over the past three decades where emissions have more than doubled since 1990.

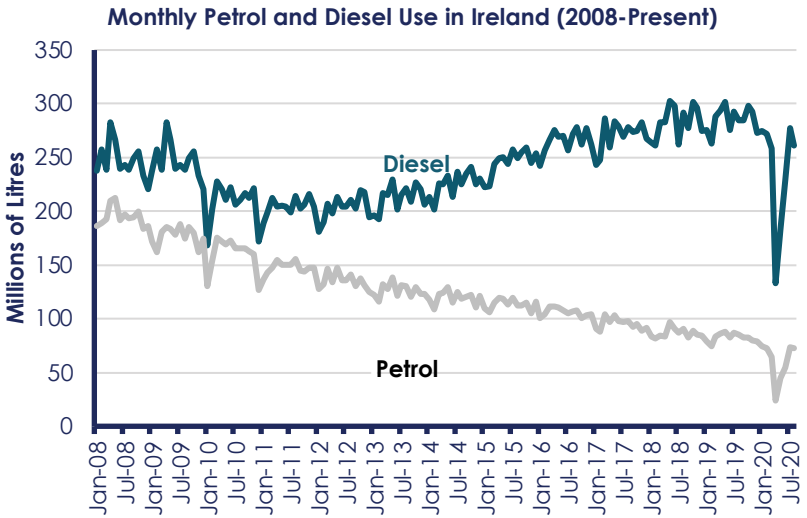
MOST EMISSIONS COME FROM PRIVATE DIESEL CARS WHICH HAVE HIGHER ANNUAL MILEAGE THAN PETROL

Today there are over 1.2 million diesel cars in Ireland and just under 1 million petrol cars. The make-up of the diesel fleet tends to be newer with just under half of diesel cars purchased since 2015. Petrol cars tend to be older with only 25% of the fleet purchased since 2015. In the past, private cars ran mostly on petrol while commercial and heavy vehicles used diesel. From the mid-2000s, the share of diesel private cars began to increase. Changes to annual car taxation in 2008 accelerated this trend. The amount of petrol consumed in Ireland reduced by more than half between 2007 and 2018 due to the shift to diesel cars. Recent measures to contain COVID19 had a marked impact on fuel consumption but have returned to near-normal levels of use as measures are relaxed.

In terms of EU climate action targets to date, Ireland has reached just half (3.1% according to NORA) of its carbon intensity reduction target of 6% for 2020 under the Fuel Quality Directive. Renewable energy in transport reached 5% in 2020 in real terms, though regulatory weightings allow the figure to be reported as 10%. Numeric weightings are applied to certain energy sources to help incentivise the transition to sustainable and renewable transport.

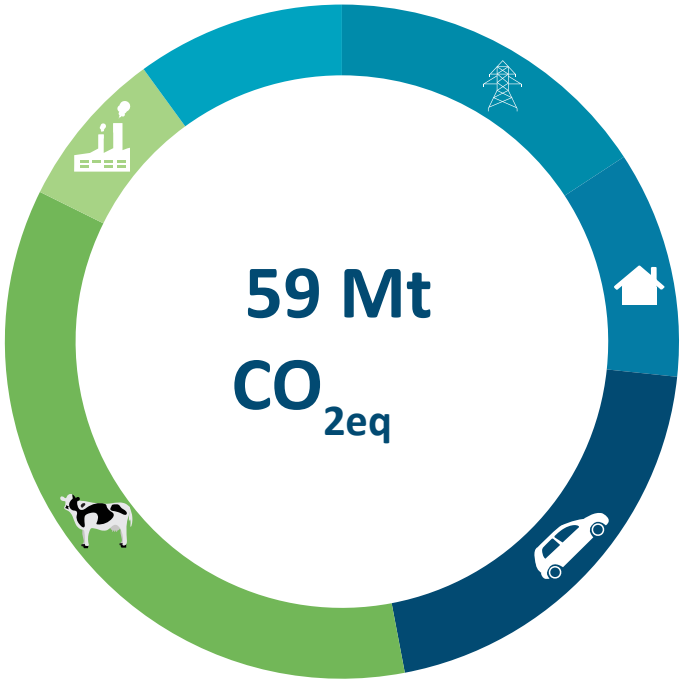
EV DEPLOYMENT IS INCREASING BUT TARGETS WILL BE CHALLENGING TO MEET

According to the Climate Change Advisory Council, the ambition in the Climate Action Plan, particularly in relation to the expansion of the numbers of EVs, will be very challenging. There is a need to develop contingency options to achieve the same level of emissions reduction should the EV targets prove unattainable. The continuation, and expansion of sustainable biofuels in transport can help address this challenge.



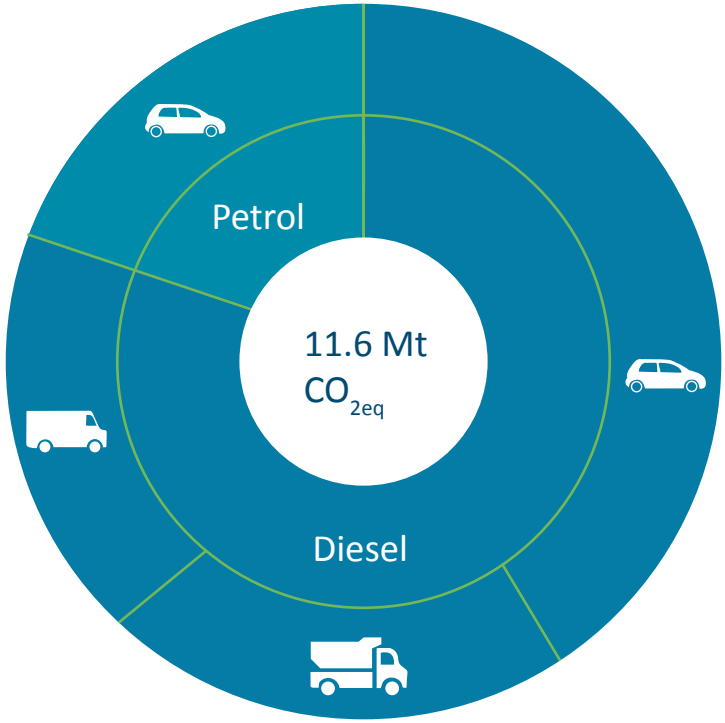
GREENHOUSE GAS EMISSIONS OVERVIEW 2019

Economy Wide |Transport represents 20% of all Greenhouse Gas Emissions



Electricity
Residential
Transport
Agriculture
Manufacturing Combustion
Other

Transport| Diesel is the dominant fuel with passenger cars the largest emitter



Date sourced from https://www.epa.ie/publications/monitoring--assessment/climate-change/air-emissions/greenhouse-gas-emissions-final-2019.php

IRELAND | BIOLIQUIDS IN TRANSPORT

BIOLIQUIDS IN IRISH TRANSPORT DELIVER SIGNIFICANT EMISSIONS REDUCTION

The Biofuels Obligation Scheme was introduced in 2010 and requires suppliers of road transport fuels to include a certain percentage of environmentally sustainable biofuels across their general fuel mix. Since the introduction of the Sustainability Regulations (SI 33 of 2012), companies are also required to demonstrate that the biofuel being placed on the market is sustainable. Biofuel that is not deemed to be sustainable will not be awarded certificates and cannot be counted towards the biofuel obligation.

BIOFUELS DELIVERED 520,000 TONNES OF CO_2 SAVINGS IN 2020; THE EMISSIONS EQUIVALENT TO TAKING 230,000 PETROL CARS OFF THE ROAD

Data reported by the National Oil Reserve Agency (NORA) shows that the average litre of biofuel placed on the market in Ireland in 2020 had a life cycle carbon intensity of c. 14 gCO_{2eq} / MJ, which represents an 83% reduction in comparison to road transport fossil fuel and substituting fossil fuel with biofuel resulted in a reduction of approximately 520,000t of CO_{2eq} emissions. This equates to an overall lifecycle saving of 4.5% in GHG emissions from the road transport sector as a consequence of achieving a biofuel penetration rate of 6.1%, by volume (5.4%, by energy). Figure 1 compares emissions on a per km travelled basis for three different fuel types.

The most important bioliquids are bioethanol (made from sugar and cereal crops) used to replace petrol, and biodiesel (made mainly from vegetable oils and fats) used to replace diesel. To be compliant with European renewable and sustainability regulation, emissions savings from the use of biofuels must produce significant emissions savings.

BIOLIQUIDS AND EVS DELIVERY ON EMISSIONS REDUCTION

Bioliquids placed on the Irish market deliver significant greenhouse gas savings compared to fossil fuels, and, on a kilometre travelled unblended basis, are also comparable with electric vehicles. Naturally one EV will have lower emissions than one regular car with a mix of fuel and biofuel. The emissions from EVs will continue to reduce overtime in line with the decarbonisation of the power sector and both provide an important lever for emissions reduction in the transport sector.

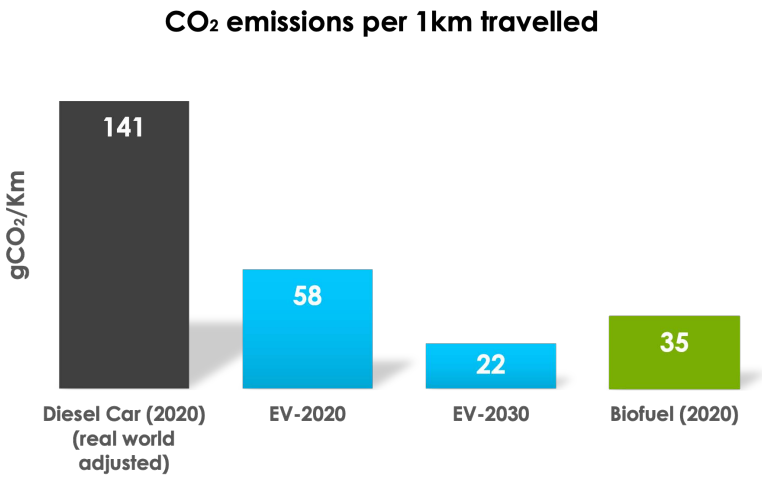


Figure 1: Emissions per Km travelled. Emissions are on a lifecycle basis for fuels

*Based on CSO data for 2020, there were approximately 13,700 battery electric vehicles and 12,500 plug-in hybrids in use in Ireland. This would deliver approximately 16,000 tonnes of CO_2 Savings at a national level

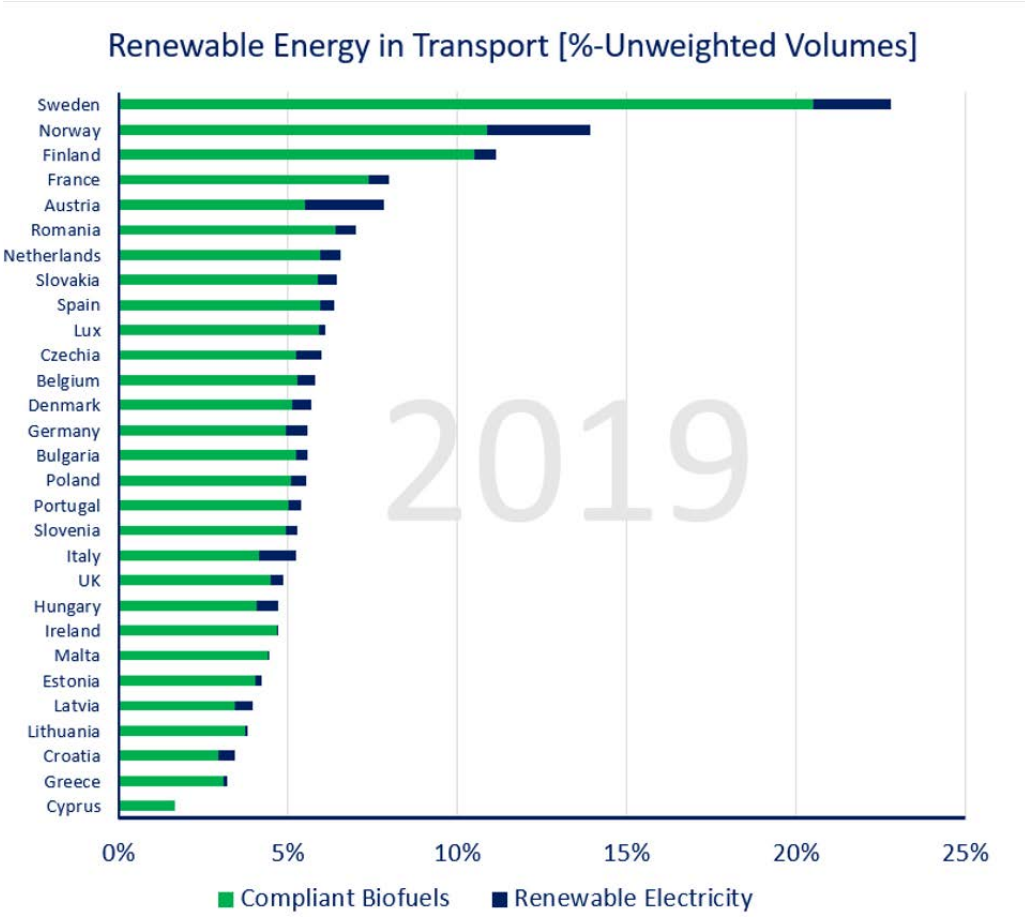
EUROPE | RENEWABLE ENERGY IN TRANSPORT

RENEWABLE TRANSPORT IN IRELAND AND ACROSS THE EU IS DOMINATED BY BIOFUELS

Across Europe, renewable energy in transport is dominated by sustainable liquid biofuels. **For European renewable transport targets, a weighted system is used which allows some fuels to make a higher contribution to the target, however this is not applied to emissions or the national level renewable energy target.** Sweden has the highest share of energy from renewable sources in transport (see Focus on Sweden page 12). In Ireland, renewable transport fuels have grown from a low base to 4% of transport final energy use in 2019. This is almost all from biofuels blended with petrol and diesel. Renewable Electricity remained at just 2% of transport final energy demand in 2019. Most of this was from Luas and DART, but electric vehicles are growing strongly from a low base.

APPROX. 98% OF RENEWABLE ENERGY IN IRISH TRANSPORT IS LIQUID BIOFUEL, HOWEVER, TRANSPARENCY FOR TRACING MUST BE IMPROVED ACROSS EUROPE

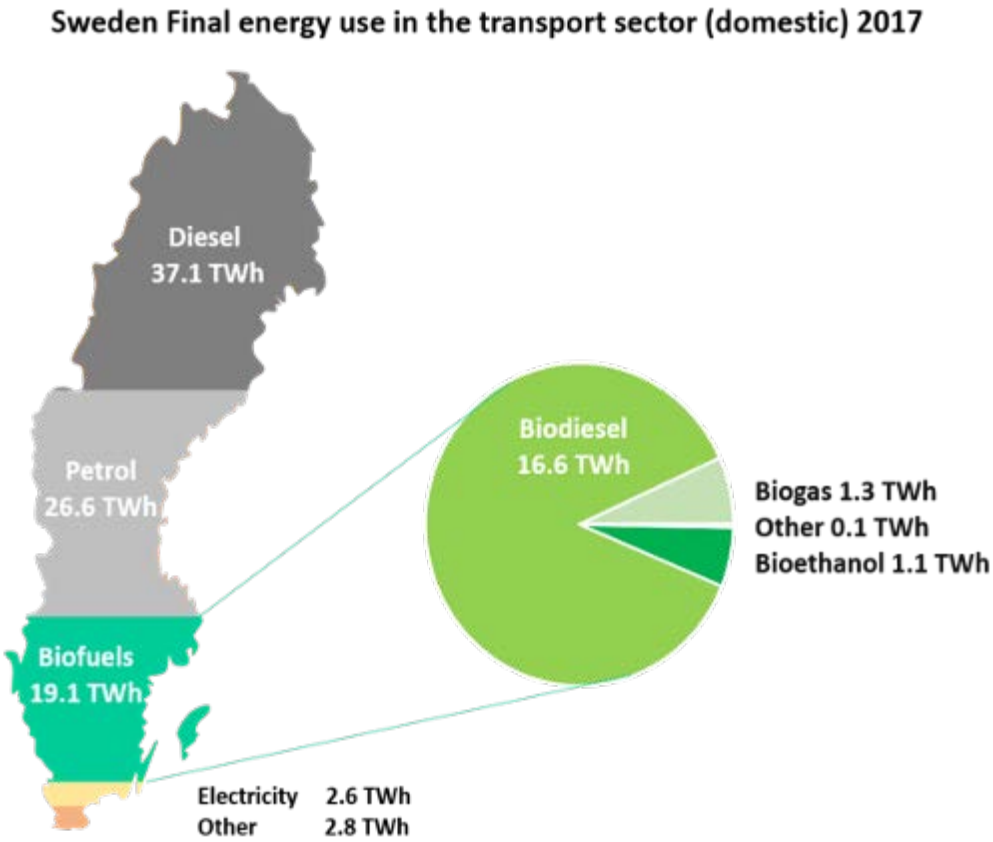
There have been concerns raised at the significant rise in used cooking oil imported into Ireland from China and the reliability of data. European Law limits NORA's ability to investigate compliance with sustainability criteria if a supplier has evidence of compliance with the sustainability criteria. The EC is currently looking at an EU database that will trace every supplier and feedstock that is placed on the market, this is expected to be in place by mid-2021. Additionally, more stringent audit measures being put in place by voluntary schemes which are under the remit of the EC, will ensure it is more difficult for fraudulent feedstocks to make it to the market. Ireland can take a greater role in supervision of the origins of renewable energy and the renewable energy directives allow this.



EXPLAINER: SWEDEN-A LEADER IN RENEWABLE TRANSPORT

TRANSPORT POLICY IN SWEDEN

Sweden is far ahead of its European counterparts in renewable transport (30% national value against a 2020 EU target of 10%) primarily due to its high use and production levels of biofuels. From a policy perspective, Sweden has successfully promoted biofuels with a combination of incentives and long-term climate policy goals. The national target is to reduce emissions from the transport sector by 70% in 2030 compared to 2010 by promoting efficiency, electric vehicles and fuel switching from fossil fuels. In setting these goals, the Swedish government aims to achieve a fossil-free vehicle fleet by using more sustainable biofuels. The expectation is that these goals can be achieved with approximately 50% of passenger cars running on biofuels, 20% on electricity and 80% of urban buses also running on electricity. Sweden already has the largest E85 (85% ethanol fuel blend) flexible-fuel fleet in Europe and the largest ethanol bus fleet in the world. Sweden has recently introduced E10, and other member states like France now have E85 at over one third of forecourts. The promotion of fuel switching was boosted in 2005 when the Swedish government implemented the 'Pump Act'. This meant all major fuel filling stations were obliged to supply renewable fuels, thus increasing their availability. This act led to an increase in sales of flexi-fuel cars as the transition towards biofuels began. In Sweden, liquid fuels are subject to both a carbon and energy tax. However, since 2002, biofuels have been exempt from these taxes with these exemptions most recently extended to 31 December 2021. The goal of these exemptions is to stimulate the use of biofuels and also there production.



THE ROAD TO 2030

DELIVERING A 51% REDUCTION IN TRANSPORT EMISSION REQUIRES A DIVERSE SET OF MEASURES

RENEWABLE ENERGY IN TRANSPORT SHOULD RISE TO 35%

2030 | POLICY MEASURE FROM AMBITION TO ACTION

SIGNIFICANT MEASURES ARE NEEDED TO DELIVER THE AMBITION OF A 51% REDUCTION IN EMISSIONS BY 2030

The Government's 2019 Climate Action plan already proposes significant measures to reduce emissions in transport, however more is now needed to align with the revised 51% reduction ambition in the 2021 Climate Action Bill. The associated emissions reduction from these measures is shown in Figure 2. It is worth noting that the projected growth in emissions by 2030 due to increased transport activity is expected to be offset by emissions savings associated with the increased electric vehicles (940,000) and biofuels blending (10% ethanol and 12% biodiesel).

TO DELIVER A 51% REDUCTION IN TRANSPORT EMISSIONS, A DIVERSE PORTFOLIO OF DECARBONISATION OPTIONS IS NEEDED INCLUDING:

- Delivering on the Government stated ambition of over 940,000 electric vehicles in 2030, avoiding approximately 2 Million Tonnes of CO_2
- Increasing the blend rate of sustainable bioliquids on petrol and diesel (minimum of 10% ethanol and 12% biodiesel) as per the Climate Action Plan avoids an additional 0.4 Million Tonnes noting that early action is key to delivering higher cumulative emissions savings
- Efficiency and behavioural measures* that reduce surface transport fuel consumption by 17% by 2030 as per the climate Action Plan 2019 avoids 4.7 Million Tonnes
- Targeting 5 TWh of indigenous biomethane production for use in heavy transport avoids approximately 1 Million Tonnes
- Targeting 2 TWh of Hydrotreated Vegetable Oils (HVO) avoids approximately 0.4 Million tonnes. Note: Sweden increased the blending of HVO with diesel from 0 TWh in 2011 to 14 TWh in 2018

RENEWABLES IN TRANSPORT RISE FROM 4% TO 35% IN 2030

These options would increase the unweighted volume of renewable fuels in surface transport in Ireland from 4% today to 35% in 2030 and the increase in bioenergy resource can be met with existing indigenous resources from biomethane as published by SEAI, for E10 and B12 as published in the National Energy and Climate Action Plan while the resource for HVO is dependant on new production capacity coming online in Europe and potentially Ireland.

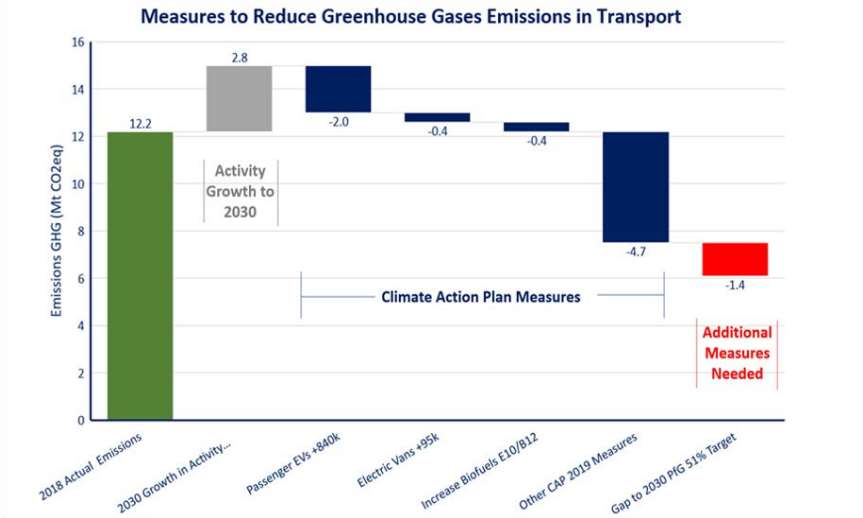
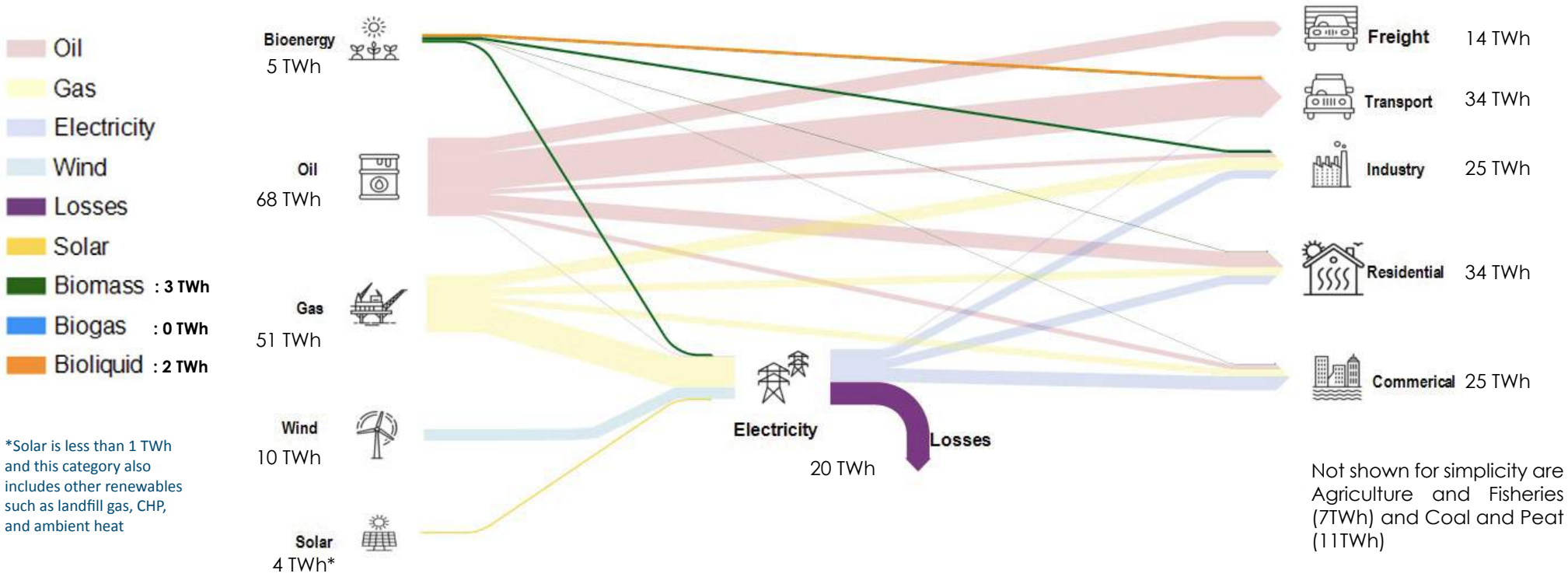


Figure 2-Measures to Achieve a 51% reduction in Transport Emissions

*Other CAP 2019 measures Include CO_2 emissions avoided by up to 10% of short car trips being shifted to walking and cycling are in the range of 0.3Mt Mt while if half of the employees living more than 25 km away work from home, this can avoid up to 0.3 Mt

IRELAND'S ENERGY SYSTEM 2020

157 TWH PRIMARY ENERGY* | Click here to understand how to read these diagrams



*Solar is less than 1 TWh and this category also includes other renewables such as landfill gas, CHP, and ambient heat

Not shown for simplicity are Agriculture and Fisheries (7TWh) and Coal and Peat (11TWh)

OUR ENERGY SYSTEM IS DOMINATED BY FOSSIL FUELS WITH STRONG END USE DEMAND FROM TRANSPORT

Primary Energy*
32 MWh/capita

Energy Emissions
37 Million tonnes

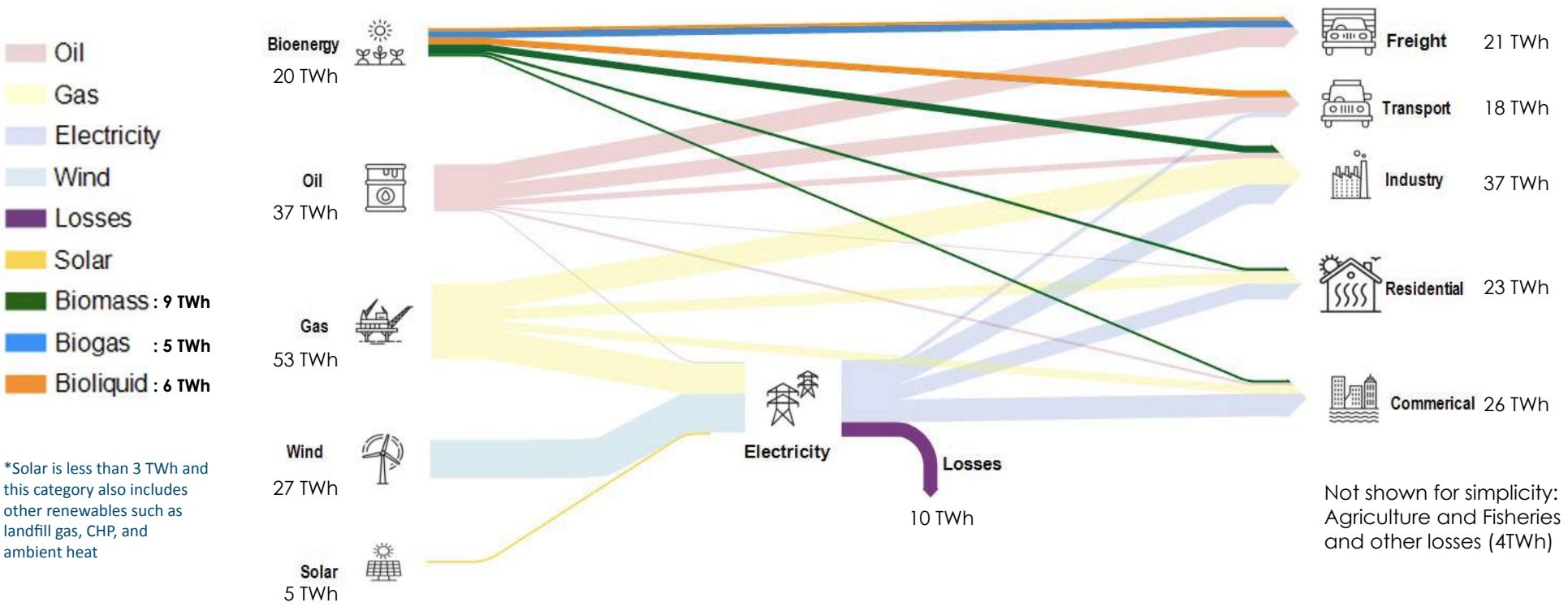
Renewable Energy
12%

Renewable Transport
4%

* Excludes International Aviation and Shipping

IRELAND'S ENERGY SYSTEM 2030

146 TWH PRIMARY ENERGY* | Click here to understand how to read these diagrams



*Solar is less than 3 TWh and this category also includes other renewables such as landfill gas, CHP, and ambient heat

Not shown for simplicity: Agriculture and Fisheries and other losses (4TWh)

SUSTAINABLE BIOFUELS AND ELECTRIFICATION HELP REDUCE OIL USE IN TRANSPORT BY ALMOST 40% IN 2030

Primary Energy*	Energy Emissions	Renewable Energy	Renewable Transport
26 MWh/capita	21 Mt	34%	35%

* Excludes International Aviation and Shipping

SPECIAL FOCUS| HEAVY TRANSPORT IN IRELAND

The freight sector is key to a functioning economy in Ireland and faces different challenges in decarbonisation to the passenger car sector. **It is a sector that is hard to electrify and in the near-term other measures are required.** But there are barriers to investment in new technologies such as high competition, low margins and a high share of small businesses. Additionally, a lack of clear consensus internationally has also slowed progress with European countries often pursuing different measures.

There were approximately 136,000 HGVs in Ireland in 2020 accounting for 15% of transport energy. The fleet relies solely on diesel. Just 57 trucks are powered by Compressed Natural Gas (CNG), the rest are diesels of various vintages. Ireland has a relatively old fleet with approximately 55% of HGVs 6 years old or more meaning they do not meet the 2014 increased Euro VI emissions standards. In fact, 60% of 5t+ HGVs registered in 2020 were used imports, almost exclusively from the UK. Driven by economies of scale, and demand for faster deliveries to homes and businesses, the trend is for increased shares of the largest (12.5t+) and smallest (2-5t) vehicles operating a hub-and-spoke model.

The following additional measures can deliver emissions reductions to 2030 in heavy transport.

Promotion of biomethane and bio CNG - The promotion of CNG to include natural gas in transport is an important step and one that could stimu late indigenous biomethane production. There is an opportunity within the Agriculture sector to advance carbon neutrality while providing multi ple co-benefits to society including biofuels to displace fossil fuels from transport sectors. The penetration of bio CNG is limited by the share of new sales in the market, a lack of industry support, and until recently a lack of refuelling infrastructure.

Eco-Driver Training - An average of 10% fuel saving can be achieved when drivers are given the training and tools to change their driving style.

Increase biofuel Obligation to 20% Increase biodiesel blend rate from 12% to 20% in 2025 could deliver 0.5Mt. A substantial share of HGVs utilise “central fuel storage” meaning they mostly or exclusively refuel from their own bulk supplies. With 20% biodiesel blends marketed as B20 avail able on the market today, many HGV operators are well placed to switch from fossil diesel to this blended product. If tax policy were to be amended such that B20 offered a cost advantage, as with CNG, this would be a low resistance way of increasing the utilisation of biofuels in the existing fleet. This is considered an optional measure.

Policy measures: According to the Climate Change Advisory Council, the removal of the diesel rebate would increase the cost of haulage to better reflect the social cost. This would provide a signal to consumers to reduce their consumption of goods and services that have high levels of embodied carbon, due to distance travelled. The current rebate is guiding us towards the unsustainable consumption of goods and services that have travelled long distances. In the long-term, price signals such as carbon taxes are negated by counteracting rebates. Their removal is necessary for a clear long-term investment signal for decarbonisation.

THE ROAD TO 2050

ELECTRIFICATION LEADS THE WAY AND SUSTAINABLE BIOENERGY FOLLOWS

THE ROLE OF BIOENERGY IN 2050

VARIABLE RENEWABLES WILL BE THE MAIN SOURCE OF ENERGY WITH ALL FORMS OF BIOENERGY PLAYING AN IMPORTANT ROLE IN HARD TO DECARBONISE AREAS

Sustainable Bioenergy becomes a core pilar in decarbonising heavy transport

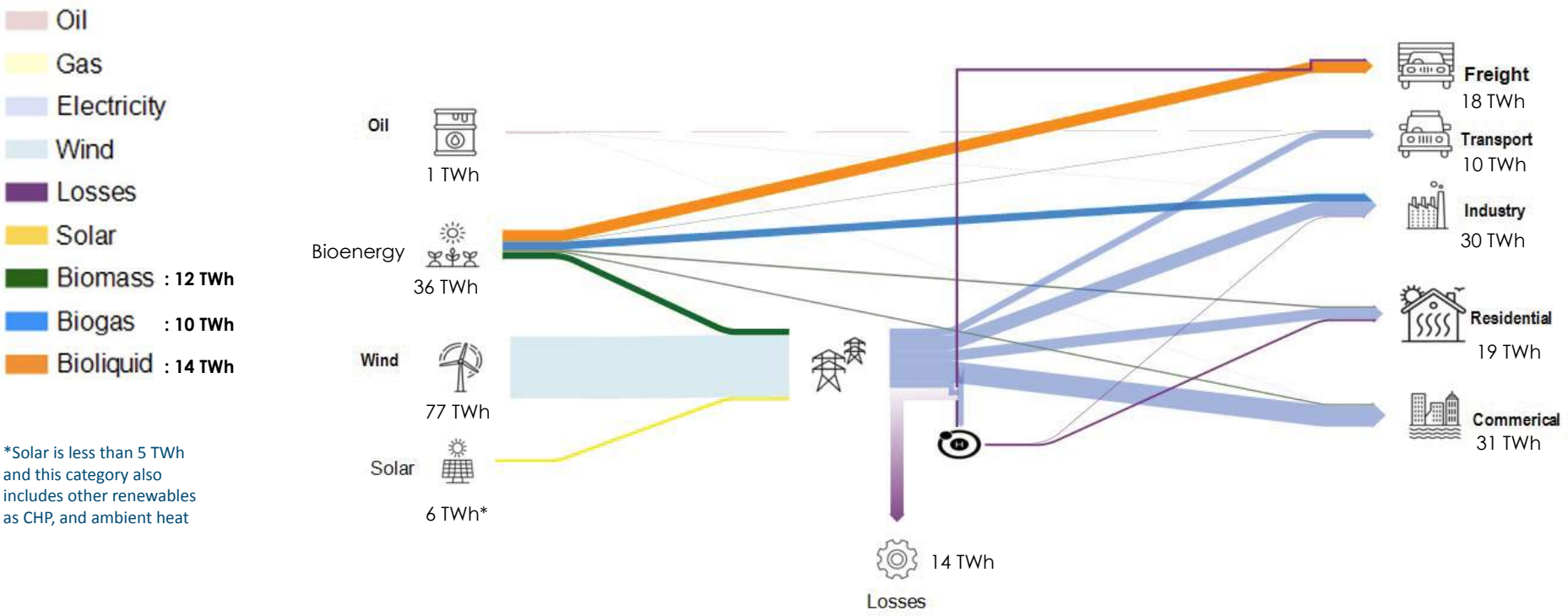
Achieving the ambition of Net Zero for the energy system requires a significant transformation of the entire energy system. In this analysis, we examine a future energy system in Ireland that is compatible with carbon budgets reflecting a 33-50% probability of a 1.5 Degree world consistent with the Paris Climate Agreement. The energy system is almost 100% fossil fuel free with the main modes of transport and heating being predominantly electrified. In the hard to decarbonise areas such as industrial heat and heavy freight, bioenergy plays an important role in both liquid, gas and solid form with most of Ireland's sustainable indigenous resource required. As the electrification of passenger transport gathers pace post 2030, the role of sustainable biofuel becomes a core pillar in the decarbonising heavy transport and niche areas that are hard or very expensive to electrify. New energy carriers are also needed for these areas and hydrogen is used in heavy freight and other areas. In this analysis, hydrogen also plays an important role as a decarbonised gas and storage vector that is generated using renewable electricity, stored and used as a decarbonised fuel in gas-fired generation in periods of low wind speeds.

On the supply side, over 25 GW of renewable generation meets the new demands for electricity and hydrogen generation. Biomass is used in a bioenergy carbon capture and storage plant to remove 2 million tonnes of CO_2 from the atmosphere allowing a balanced emissions reduction to 2050 and removal of residual emissions from industrial processes such as cement from the system. The land use required for this amount of emissions removal is estimated to be approximately 114 kha which is similar to the level of land used for spring barely in 2016 in Ireland. This land use area however has a wide range of between 45kha and 180kha depending on the land, yield and growing conditions of the energy crop which here is assumed to be miscanthus.

Overall primary energy use on a per capita basis has significantly reduced from 2019, reflecting the important role of energy efficiency across the economy and the more efficient use of electricity in meeting mobility and heating needs on the supply side. Overall import dependence of fuels has reduced to 5% with liquid bioenergy imports and small quantities of oil for transport remaining as imports. The energy system is greater than 100% renewable as the production of energy is higher than overall consumption due to excess generation required for hydrogen and small levels of exports. The losses incurred in the formation of hydrogen reflect an efficiency loss but are accommodated as it ensures that energy-dense fuel can be created without any associated carbon emissions. These options such as conventional power plants with carbon capture, hydrogen as a fuel, and Bio-energy with carbon capture and storage (BECCS), are more expensive than other energy sources but are required to keep the energy system operating in a reliable and robust manner. More cost-effective solutions may emerge in the interim and these options should be kept under review.

IRELAND'S ENERGY SYSTEM 2050

122 TWH PRIMARY ENERGY* | Click here to understand how to read these diagrams



*Solar is less than 5 TWh and this category also includes other renewables as CHP, and ambient heat

TRANSPORT IS FULLY DECARBONISED WITH SUSTAINABLE BIOFUELS, BIOMETHANE, ELECTRIFICATION AND HYDROGEN

Primary Energy*	Energy Emissions	Renewable Energy	Renewable Transport
22 MWh/capita	0 (-2) Mt	100%	approx. 100%

* Excludes International Aviation and Shipping - Note that values don't round out due to rounding assumptions and exchanges with Northern Ireland

CONCLUSIONS | FIVE CORE MEASURES

Sustainable biofuels have played a central role in delivering emissions reduction in Ireland and across Europe because biofuels represent the lowest cost decarbonisation option for transport and can be deployed quickly and sustainably in the existing transport system. **As well as significant EV deployment, enhancements in public transport and modal shift, increasing the use of sustainable liquid biofuels & biomethane is critical to achieving climate ambition in Ireland.** This can be done within the published sustainable resources available in Ireland and in Europe.

Increasing bioenergy introduces risks that need to be managed. To keep it sustainable, it will be essential to maintain carbon cycles, protect biodiversity, and minimise indirect land-use changes. In this regard, **Ireland should play to its strength as a country with an active ecosystem ideal for grass growth and an agricultural industry that has wastes that need processing.** This provides a strong starting platform for an indigenous biomethane industry in Ireland. This would offer benefits for Irish farmers and its production and distribution can help to decarbonise Irish agriculture. It must be acknowledged that the reduction in greenhouse gas emissions from sustainable bioenergy produced on Irish farms is attributed to the end use sector where the fuel is used. This can create a disincentive for the agricultural sector and should be addressed. Unused or underused wastes and residues from farming and grassland can be mobilised to generate additional income for farming families, especially in less advantaged areas. The creation of a market in grass/silage/hay/straw in Ireland would emerge, in the same manner as deployment of large ethanol plants have stabilised the market for maize across Europe, with major benefits to the farming communities there.

In the period to 2030 we have identified **5 core policy actions** that are needed to deliver on the ambition of a 51% reduction in emission in transport

These are:

i) Deliver the Government stated ambition of over 940,000 electric vehicles in 2030

ii) Increase the blend rate of sustainable bioliquids in petrol and diesel (minimum 10% ethanol and 12% biodiesel) as per the Climate Action Plan

iii) Efficiency and behavioural measures that reduce surface transport fuel consumption by 17% by 2030

iv) Target 5 TWh of indigenous biomethane production for use in heavy transport

v) Target 2 TWh of Hydrotreated Vegetable Oils (HVO) following best practice in Swedish Renewable Transport Policy

APPENDIX

BIOENERGY EXPLAINED

BIOENERGY IS THE MAIN SOURCE OF RENEWABLE ENERGY IN THE EU WITH A SHARE OF 60% IN 2018.

ONE THIRD OF RENEWABLE ENERGY IN IRELAND IS BIOENERGY.

EXPLAINER | WHAT IS BIOENERGY

ENERGY THAT WE GROW IS CALLED BIOENERGY

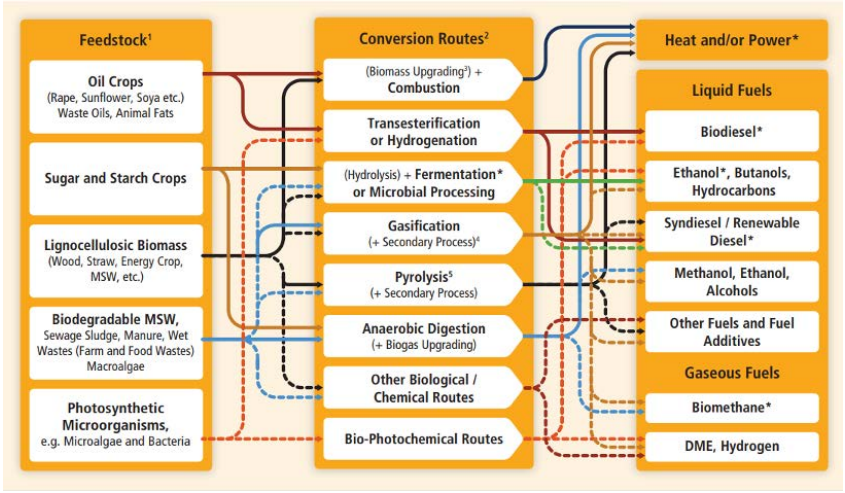
Renewable energy that is generated from organic material or plants is called bioenergy. Other carbon sources such as agricultural and food waste, waste vegetable oils and forest residues can be used as well as resources that can be replenished rapidly such as grass and purpose-grown crops. When bioenergy is combusted, it releases carbon dioxide into the air, and this is offset by new plants that consume that carbon dioxide during growth making it a low carbon renewable resource. This makes it different from fossil fuels which release carbon dioxide into the atmosphere which has been stored for millions of years. Bioenergy technologies are diverse and span a wide range of options and technologies and can be liquid, solid or gas. Biofuels such as bioethanol and biodiesel are substitutes for fossil fuels and when blended with petrol and diesel help dilute the carbon content of emissions from the fuel and lower emissions. Bioenergy can be used in various parts of the energy sector including for electricity, liquid fuel, biogas, and hydrogen production. It is this flexibility that makes bioenergy and bioenergy technologies valuable for the decarbonisation of energy use. Bioenergy is the largest contributor to renewable energy in the EU and to continue playing this essential role, it must be produced and used sustainably and deliver significant reductions in greenhouse gas emissions. It must also avoid negatively affecting land use, food security, water resources, biodiversity and livelihoods.

Bioenergy can play a role in mitigating climate change by replacing fossil fuels, particularly in sectors where electricity produced by renewable sources such as wind and solar is difficult. But at the same time, it must be taken into account that bioenergy is a source of carbon emissions and could cause a number of other environmental and social impacts, such as biodiversity loss if policy is not enforced. Strict regulation is key to mitigating these risks.

BIOENERGY CAN BE A SOLID, A GAS OR A LIQUID AND HAS MULTIPLE USES

Bioenergy fuels have different names depending on their physical nature which can be solid, gaseous or liquid, and their end-use in transport or to produce electricity, heating or cooling.

Biomass | Solid and typically used for heat
Bioliquid | Liquid fuels mainly used in transport
Biogas | A gas mixture of methane and CO_2 and can be used in heat, transport and electricity.

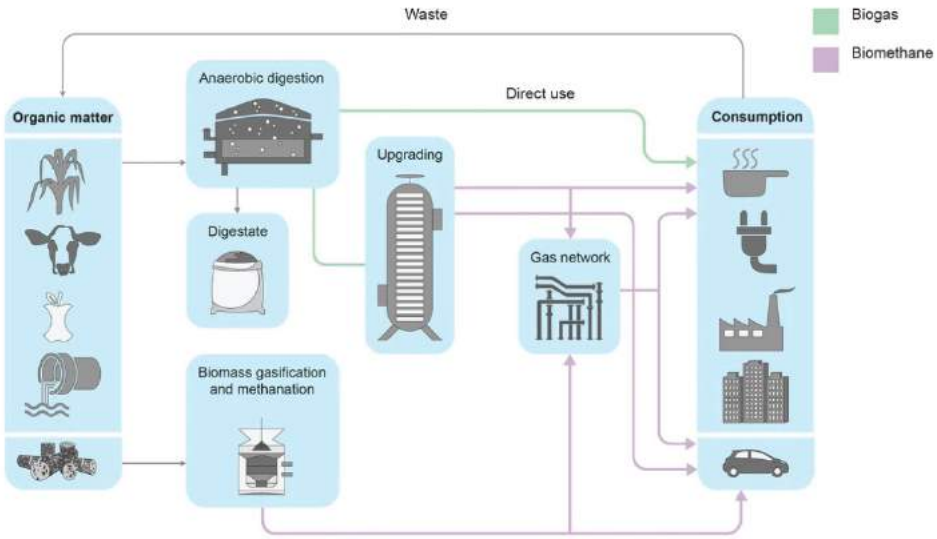


IRELAND | BIOGAS CAN BE USED IN TRANSPORT AND HEAT

BIOGAS CAN PROVIDE SIGNIFICANT EMISSIONS REDUCTION FOR HEAVY TRANSPORT AND CAN ALSO BE USED IN HEAT AND ELECTRICITY

Biogas is a mixture of methane, CO_2 and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment. Sustainably produced biogas and biomethane (purified / upgrade biogas) have the potential to reduce carbon emissions by replacing fossil fuel demand and by increasing the capture of emissions from the management of food and animal wastes. The composition of biogas depends on the type of feedstock and the production pathway. A wide variety of feedstocks can be used to produce biogas including **Crops and residues, Animal manure, Organic fraction of Municipal Solid Wastes and Wastewater sludge.**

The industry in Ireland is less developed compared to other European countries. In 2018, it was estimated that there were 38 anaerobic digestion plants in Ireland, including 8 landfill gas projects and 19 industrial facilities, including those for wastewater sludge treatment. In contrast, there were close to 1,000 AD plants in the United Kingdom by the end of 2016, including 279 plants utilising agricultural feedstocks (IEA, 2018). Gas Networks Ireland, operator of the gas network, have set a target of 11 TWh per annum for biomethane injected into the gas grid by 2030, which corresponds to 20% of current natural gas demand. This is to be derived from grass, animal waste, crop residues and food waste (Gas Networks Ireland, 2019).



Biogas is a flexible fuel that can be produced from a number of feedstocks and methods: source IEA

CERTIFICATION IS KEY TO BEST PRACTICE AND SUSTAINABILITY

Sustainable Biogas can be produced using a mix of different feedstocks, for example, co-digestion of slurry and grass, and by applying best practices on bio-fertiliser application, leakage reduction and grassland management. In Ireland, the role of a Green Gas Certification Scheme has been validated by KPMG to develop a sustainable indigenous biomethane industry in Ireland on a phased basis by 2030, which will stimulate the rural economy and save over 2.6m tonnes of CO_2 emissions per annum.

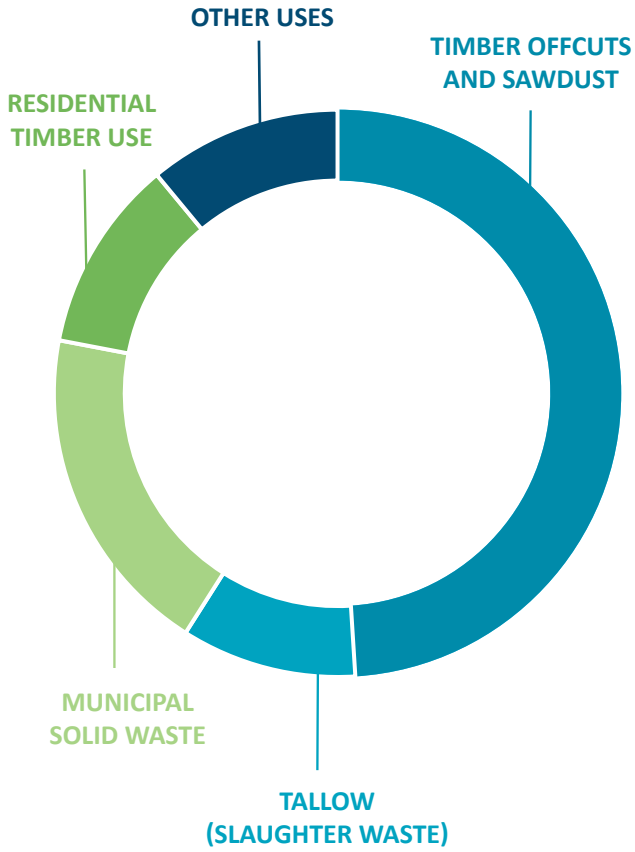
IRELAND | SOLID BIOMASS PLAYS AN IMPORTANT ROLE IN RENEWABLE HEAT

RENEWABLE HEAT IS DOMINATED BY SOLID BIOMASS

Solid biomass is sourced from feedstocks such as forest residues and energy crops. Today in Ireland most of our bioenergy comes from sawdust and off-cuts which are by-products of the forestry industry and play an import role in renewable heat. Energy crops like short-rotation willow have significant potential. But because farming them needs to be a viable prospect they need higher market prices to make financial sense. According to SEAI, Biomass fuels from forest residues and by-products of the wood industry meet EU sustainability criteria. Animal manure creates negative emissions credit under EU rules and performs well against benchmarks. However, certain types of solid biomass such as wood pellets imported from outside Europe and imported wood pellets made from short rotation coppice willow are associated with a high sustainability risk. The current share of biomass resources for energy that is imported is 37% and this is expected to fall to 17% by 2030 (NCEP), with the assumption that domestic forestry, agricultural residues and waste resources are harnessed for growing demands in heat and transport. The Irish Forest estate is forecasted to increase the supply of wood biomass for energy and wood-based panels by 2035, however, if demand exceeds available domestic supply, all imports must meet EU sustainability requirements.

LOOKING TO THE FUTURE OF SOLID BIOMASS AND NEGATIVE EMISSIONS

Negative emissions technologies remove carbon dioxide from the atmosphere. There are uncertainties about the scale of negative emissions that may be possible in the future, and about their impacts and costs. However, 88 of the 90 scenarios in the IPCC SR1.5 report which have at least a 50% chance of staying below 1.5 °C warming in 2100 rely on net negative emissions. Recent research by MaREI has also highlighted the important role of negative emissions technologies deployed in conjunction with high-volume of renewables to achieve, not only emissions reduction but also to contribute to the stable and reliable operation of the European power system. Negative emissions could particularly help offset emissions from hard to-abate sectors, such as aviation or the manufacturing of iron, steel, and cement. However, the future of such technology options is still an open question with significant uncertainty.



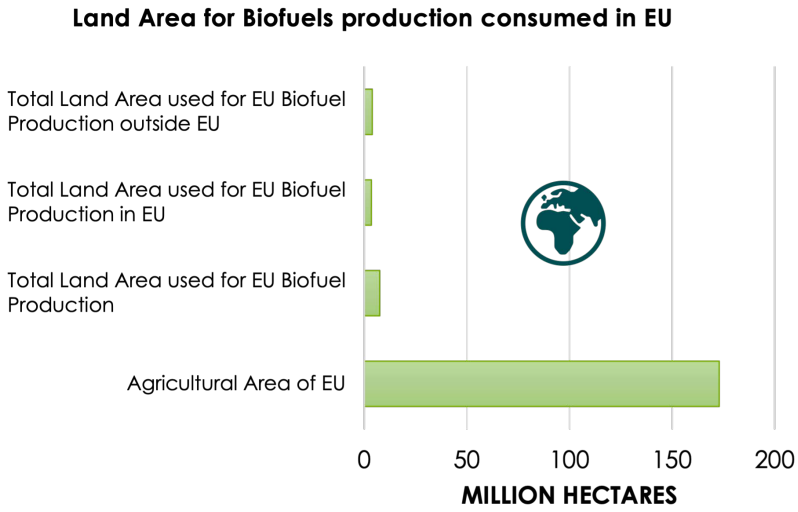
BIOENERGY | FOOD PRODUCTION AND SUSTAINABILITY

BIOENERGY CAN PLAY AN IMPORTANT PART IN A FUTURE ENERGY SYSTEM, BUT IT MUST BE DONE SUSTAINABLY

The production of energy should not impact negatively on biodiversity, food supply and land use. The European Commission monitor and report on the impact of renewable energy on a wide range of criteria such as sustainability and food prices. The latest report finds no observed correlation between food prices and biofuel demand and notes that any impact on food prices is small compared to other dynamics in the global food market. There are contested views as to the historic interactions between the role of biofuels, particularly U.S. maize ethanol and global food prices with little agreement about the precise fraction of the price increases that should be attributed to biofuel demand. The EU's contribution to any historic global cereals prices is small as EU cereals are mostly used for animal feed (nearly two-thirds); one-third is directed to human consumption, while only 3% is used for biofuels.

EXISTING SUSTAINABILITY LEGISLATION MUST BE ENFORCED AND SHOULD PROMOTE TRANSPARENCY

To date, there are Acts, Regulations and Guidelines that directly and indirectly address sustainability for all types of bioenergy including land use and associated agricultural practices. These range from the EU Renewable energy directive to Irelands Green Gas Certification Scheme to Birds and Natural Habitats Regulations 2011. An SEAI report concludes that given the extent of Irish legislation and the monitoring and enforcement systems in place, that Irish forestry and agriculture biomass, once it meets the GHG savings criteria of European legislation, should satisfy the sustainability criteria. The EU's 2021 renewable energy directive requires proof of a significant reduction in greenhouse gas emissions compared with fossil fuels. It also requires proof of suitable land and forest management to reduce the risk of harmful land-use change and carbon debt. However valid concerns have been raised in relation to the role of bioenergy that can pose higher risks, such as wood pellets imported from outside Europe or biogas from grass without co-digestion under current intensive agricultural practices. **Key to addressing these concerns is enforcement of existing legislation and the promotion of transparency and certification, particularly for an indigenous resource which demonstrates low land use impact change.**



HIGH-RISK BIOENERGY FROM OUTSIDE EUROPE SHOULD BE AVOIDED

Biofuels based on palm oil are associated with high environmental risk and it has been shown that enforcing EU sustainability in third party countries to be challenging. The phased elimination of Palm Oil should be brought forward in Ireland, given Ireland has very limited use of biofuels produced from palm oil and the impacts in relation to indirect land-use change.

HOW TO USE THIS ANALYSIS AND FAQS

WHAT ARE THE WEAKNESSES IN THIS ANALYSIS: This report does not provide forecasts or predictions. It provides information to help us make informed decisions about the future based on analysis. The analysis is strong on technology and economic aspects and weak on representing human behaviour.

WHAT ARE THE STRENGTHS OF THIS ANALYSIS: This analysis looks at energy across the full economy and allows us to see interactions across all modes of energy into the future.

WHERE DID THE ASSUMPTIONS COME FROM? Please see the accompanying excel sheet.

WHAT WOULD CHANGE RESULTS MOST: The availability and price of sustainable bioliquids for heavy transport have a significant impact on costs and outcomes beyond the no regret options. Lower access to these liquids raises system costs. The assumption of a 100% non-synchronous electricity system post-2030 is also a significant assumption that would change results if it were not attained.

IS YOUR MODEL AND DATA AVAILABLE TO ME? The TIMES model is large, complex and requires training for competent use. The learning curve is approximately 9-14 months. We are happy to provide the model to people who complete the training.

WHO FUNDED THIS REPORT AND WHY? This report was commissioned by the Irish Bioenergy Association(IrBEA). The development of the report was funded through sponsorship contributions from the Irish Bioenergy Association, Transport Infrastructure Ireland, Ethanol Europe, Green Biofuels Ireland, 3 Counties Energy Agency and Green Generation

WHO CONTRIBUTED TO THIS REPORT? This report was written and coordinated by Paul Deane. Modelling was undertaken by James Glynn, Xiufeng Yue and Paul Deane. This report draws on the research of Shane McDonagh, Vera O'Riordan, Vahid Aryanpur, Tomás Mac Uidhir, Hannah Daly, Fionn Rogan, Laura Mehigan and Niall Hore. Quality Control was undertaken by Brian Ó Gallachóir.

HOW TO READ SANKEY DIAGRAMS

Sankey diagrams show the flow of energy across the economy from primary energy (left-hand side) and Final End Use (right-hand side). Transformation of energy into electricity is shown in the middle. The key to reading and interpreting Sankey Diagrams is remembering that the width is proportional to the quantity represented. Individual fuels such as Oil and Gas are shown by different colours, and this follows the fuel from the primary energy to final consumption.

On the left are the primary energy inputs to the Irish energy system. Primary energy includes the raw fuels that are used for transformation processes such as electricity generation and oil refining.

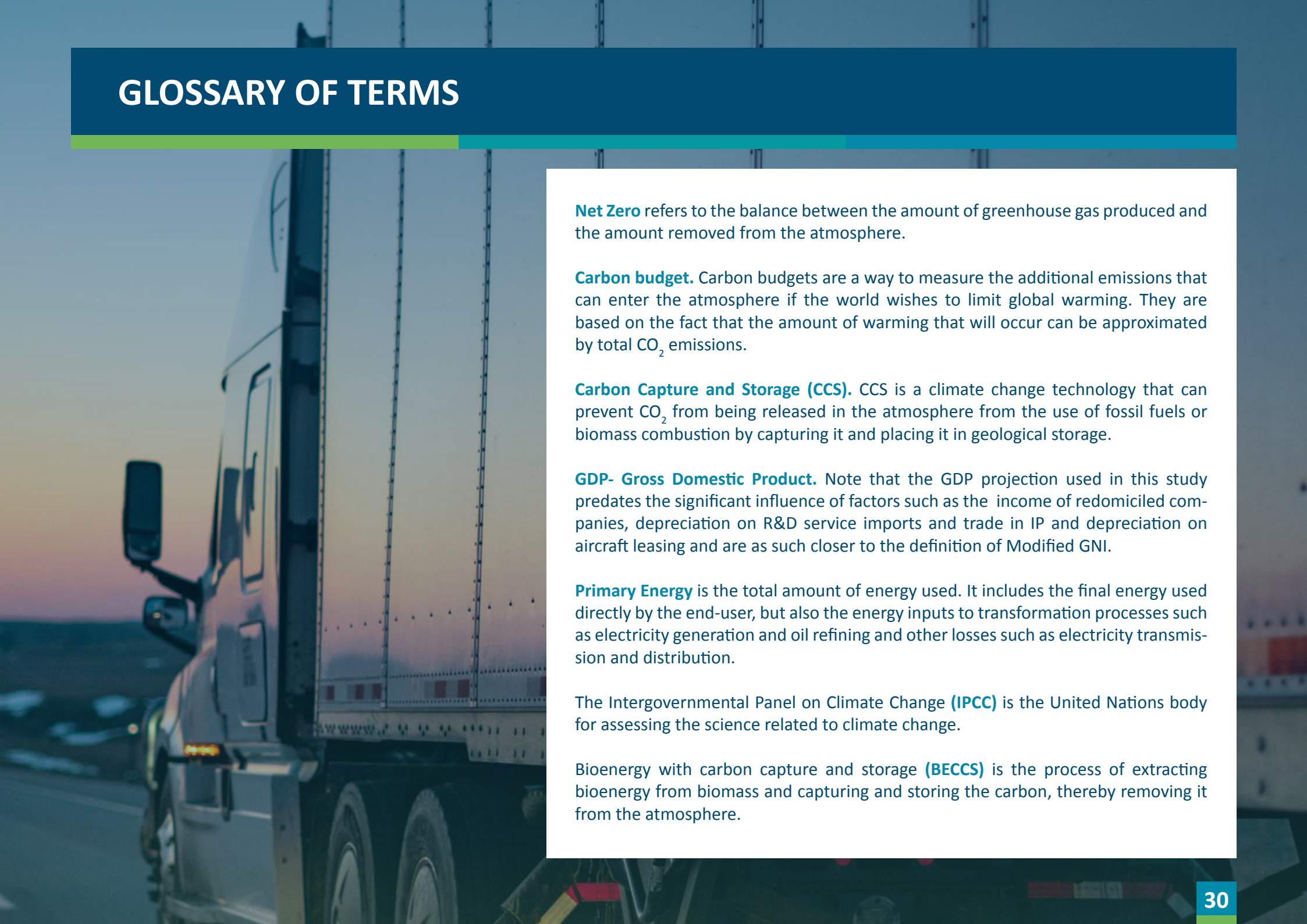
On the right are the sources of demand for final energy. Final energy includes the energy used directly in the different sectors such as transport, residential and industry. Final energy does not include energy lost during transformation processes such as electricity generation. The sum of all final energy used in all sectors is known as Total Final Consumption (TFC).

The sum of all the TWhs on the right-hand side (supply) is equal to the sum of the TWhs on the left-hand side (demand) + System Losses (central). Note that to calculate the full Primary energy you have to add in a small amount for agriculture and fisheries which are noted in the graphs as text but not shown for simplicity.

The numbers on the Sankey Diagrams will not round out to zero, this is because values are rounded to the nearest TWh and in the 2050 Sankey Diagram the flows of electricity from Northern Ireland and Ireland have a small impact on how losses are attributed.

Note that EVs in transport and air source heat pumps for heating are very efficient and require much less energy to meet the same level of energy service demand hence their contribution looks small in comparison to other fuel sources which requires more energy for the same energy service demand.

GLOSSARY OF TERMS



Net Zero refers to the balance between the amount of greenhouse gas produced and the amount removed from the atmosphere.

Carbon budget. Carbon budgets are a way to measure the additional emissions that can enter the atmosphere if the world wishes to limit global warming. They are based on the fact that the amount of warming that will occur can be approximated by total CO_2 emissions.

Carbon Capture and Storage (CCS). CCS is a climate change technology that can prevent CO_2 from being released in the atmosphere from the use of fossil fuels or biomass combustion by capturing it and placing it in geological storage.

GDP- Gross Domestic Product. Note that the GDP projection used in this study predates the significant influence of factors such as the income of redomiciled companies, depreciation on R&D service imports and trade in IP and depreciation on aircraft leasing and are as such closer to the definition of Modified GNI.

Primary Energy is the total amount of energy used. It includes the final energy used directly by the end-user, but also the energy inputs to transformation processes such as electricity generation and oil refining and other losses such as electricity transmission and distribution.

The Intergovernmental Panel on Climate Change **(IPCC)** is the United Nations body for assessing the science related to climate change.

Bioenergy with carbon capture and storage **(BECCS)** is the process of extracting bioenergy from biomass and capturing and storing the carbon, thereby removing it from the atmosphere.

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