2022 EnvEcon Challenge and Compliance Report

Air and Climate - Ireland

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EnvEcon
Decision Support

Table of Contents

Disclaimer

Reference

EnvEcon (2022), 2022 EnvEcon Challenge and Compliance Report, Dublin: EnvEcon

Acknowledgements

This work draws upon the work of the Environmental Protection Agency's inventory and forecasting units who generate the official national data on emissions and manage a variety of official national reporting obligations. They offer excellent support with regard to collating and interpreting many of the various strands of data that are encapsulated within this single report. The EnvEcon CC report also increasingly draws upon the growing body of policy work and research across various national research institutes and Government Departments. The work of all associated agencies, researchers and Departments are vital and hereby acknowledged.

Glossary of Terms

AEA– Annual Emission Allowance

BOS – Biofuels Obligation Scheme

CAP – Climate Action Plan (e.g. CAP 2021)

CDM - Clean Development Mechanism

CER - Certified Emission Reduction

CH_4 – Methane

CO_2 – Carbon Dioxide

CO_{2eq} – Carbon Dioxide Equivalent

DECC – Department of Environment, Climate and Communications

EPA – Environmental Protection Agency

ERU – Emission Reduction Unit

ESD – Effort Sharing Decision (to 2020)

ESR - Effort Sharing Regulation (to 2030)

ETS – (European) Emissions Trading System

EVs – Electric Vehicles

GHGs – Greenhouse Gases

IIR – Informative Inventory Report

JI – Joint Implementation

Kt – Kilo Tonnes

LULUCF – Land use, Land use Change and Forestry

MMR – Monitoring Mechanism Regulation

Mt – Mega Tonnes (1 Mt = 1,000 kt)

N_2O – Nitrous Oxide

NAPCP – National Air Pollution Control Plan

NDP – 2018 National Development Plan

NECD – National Emission Ceiling Directive

NECP – National Energy and Climate Plan

NEEAP – National Energy Efficiency Action Plan

NETS – Non-Emissions Trading System

NH_3 – Ammonia

NIR – National Inventory Report

NMVOC – Non-Methane Volatile Organic Compounds

NO_x – Nitrogen Oxides

NREAP – National Renewable Energy Action Plan

PHEVs – Plug-in Hybrid Vehicles

$PM_{2.5}$ – Fine Particulate Matter

SEAI – Sustainable Energy Authority of Ireland

SO_x – Sulphur Oxides

WAM – With Additional Measures Scenario

WEM or WM – With Existing Measures Scenario

List of Tables and Figures

In order of placement

Executive Summary

Presented in this report are the latest official national data on air and climate emissions inventory and forecast emissions across all primary sectors and activities for Ireland. The 2022 EnvEcon Challenge and Compliance (CC) Report endeavours to present these data with analysis in a harmonised structure, highlighting the big picture in terms of emissions targets and reductions, as well as noting specific strategic ambitions outlined within national and international environmental policies. One of the main objectives of this report is then to allow those who may not be familiar with all sectors or thematic areas to recognise important interactions, overlap, opportunities and risk in relation to emissions and emissions mitigation policy. The EnvEcon CC report for 2022 also endeavours to deliver some insight on relevant technical developments as they relate to the nuances of emissions reporting and compliance in an Irish and European context. The ambition in these cases is to provide an accessible overview, as many of these reporting aspects are rarely intuitive but can be very important in regard to determining default or compliance.

This EnvEcon CC Report 2022 also continues to build from the previous iteration in its departure from strictly emissions reporting and analysis towards an enhanced focus on highlighting and recognising the performance of policy in Ireland in the context of established national targets that have been articulated in the CAP21 and the forthcoming CAP23. Additionally, it includes a spotlight on some relevant EnvEcon research across key sectors that has been designed to assist in better informing the associated policy direction and actions to 2030 and beyond.

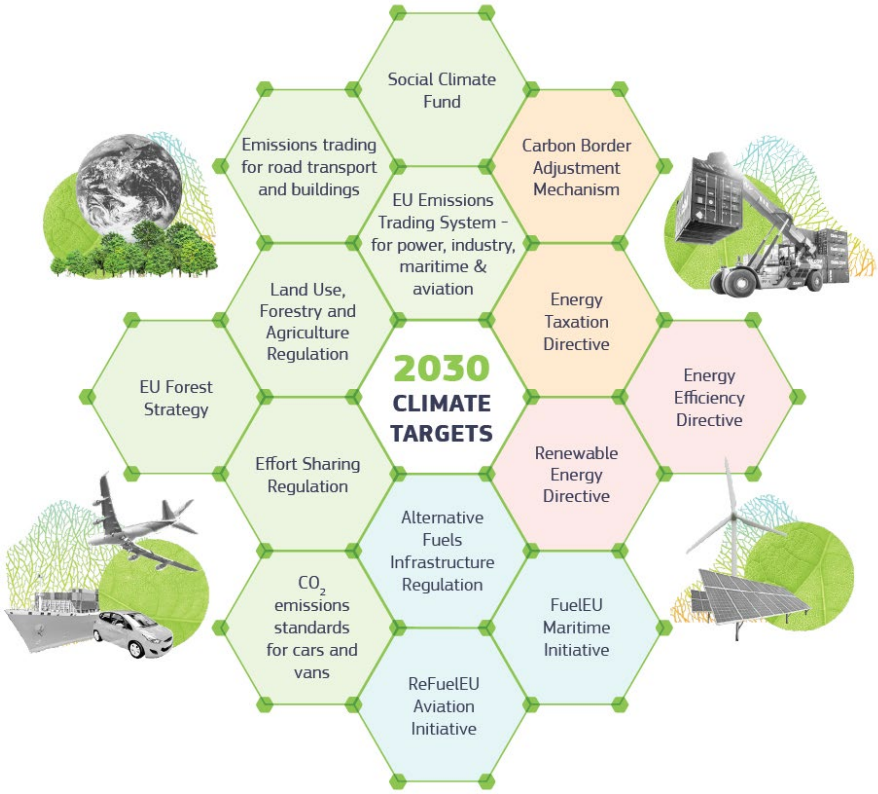
In terms of the international context for this 2022 EnvEcon CC report, the EU has now moved to increase climate action ambition by committing to a 55% reduction in Greenhouse Gas (GHG) emissions by 2030 relative to 1990 levels, as compared to the previous agreement for a 40% reduction as part of the European Green Deal[1]. As of late 2022 there remain ongoing negotiations in relation to the 'Fit for 55' package of legislative proposals which cover a very wide range of policy areas that are aimed at delivering on the updated emission reduction targets and managing a just transition. The scope of the Fit for 55 package is as indicated in the infographic that follows below in this executive summary. More details on specific elements are captured within the policy context section of this report.

Ireland's national policy commitments now mirror the increased ambition of the EU, in order to deliver the requisite abatement in the 2021-2030 period. Negotiations are ongoing on the Fit for 55 proposal[2] as it relates to Ireland, but the current proposed ESR amendments would commit Ireland to a 42% reduction by 2030. Aligned with the proposed increase in European climate ambition, the Programme for Government 2020 outlined a target for Ireland of achieving a 51% reduction in overall GHG emissions compared with 2018 by 2030, an average of a 7% reduction per annum from 2021-2030, as well as a longer-term goal of achieving net zero emissions by 2050, mirroring the

[1] Note that the new 55% target is a 'net' figure which includes emissions and removals, whereas the previous target of 40% was a 'gross' figure that mainly concerned emissions only. Details on the Fit for 55 package and revisions are available online at Delivering the European Green Deal (europa.eu) and also at Fit for 55 - The EU's plan for a green transition - Consilium (europa.eu)

[2] Timeline - European Green Deal and Fit for 55 - Consilium (europa.eu)

European Green Deal. The 2050 net zero target has been committed into law by the Climate Action and Low Carbon Development (Amendment) Bill in 2021. The 2021 (Amendment) Bill includes amendments to increase the climate ambition to be a climate neutral economy by the end of the year 2050. Additionally, there are certain amendments in relation to the Climate Change Advisory Council, the provision of carbon budgets, and sector specific decarbonization targets. Carbon Budgets represent the total amount of emissions calculated on an economy-wide basis, that may be emitted over a 5-year period. The first two carbon budget periods have been used to inform the setting of sectoral targets and emission ceilings in the forthcoming CAP 23. CAP 23 builds from the prior CAPs.



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In terms of Ireland's climate performance, the official inventory shows that in the year 2020 Ireland exceeded its annual emissions limit by 6.76 Mt CO_{2eq}. This leaves Ireland falling short of the overall target of a 20% reduction from 2005 levels by 2020 by only achieving 7%. Under the most recent WEM outlook, without the application of flexibilities, Ireland will also exceed its annual limits in each year of the ESR period 2021-2030, culminating in a substantial cumulative deficit by 2030 of approximately 58.7 Mt CO_{2eq}. However, this is the WEM outlook and there are specific flexibilities that are available to Ireland. One of these is the one-off Emission Trading Sector (ETS)

credit which is a maximum of 4% of 2005 emissions per year, and another is the Land Use, Land Use-Change and Forestry (LULUCF) transfer credit of up to 26.8 Mt over the ten-year period. Under the WEM scenario, with the full use of these flexibilities up to their annual limits, Ireland could realise cumulative surpluses out to 2026 before falling out of compliance in 2027, and each year thereafter, with a cumulative gap to target in 2030 of approximately -12.8 Mt CO_{2eq}. The WAM scenario shows that with the application of any year to year surplus and LULUCF credits only, Ireland can achieve compliance for all years from 2021-2030, under the existing level of ESR ambition, and even have a cumulative surplus in 2030 of 10.6 Mt CO_{2eq}. However, flexibilities carry a cost and present a challenge to realise in the case of forestry, and furthermore, policies and measures will need intensive support now to 2030.

The key challenges and pressure points in climate mitigation identified in this report finds that the historically top 5 contributing activities still consistently make up approximately 80% of total Non-ETS (NETS) emissions each year. These include the residential sector, road transport and agriculture (enteric fermentation, agricultural soils, and manure management). There are actions to reduce emissions in these sectors available. For the residential sector, the 2021 CAP maintains the target for residential retrofits of 500,000 homes to a B2 BER standard or better by 2030, or 62,500 homes per year now. However, in 2020, 18,400 homes were retrofitted and only 4,000 were to a B2 standard[3], indicating that progress is slow. As of yet the scale of retrofitting and heating technology change has not approached the levels necessary to deliver on the abatement potential in that sector. Similarly, in the road transport sector, policy has rightly prioritised increased active travel and mass transport, however decarbonising the fleet is also needed through higher shares of EV deployment. As of 2021, there were 135,339 EV's on the road in Ireland, relative to a 2030 target of 945,000. However, there is clear and faster progress now on EVs. It is also expected that the new transport pathfinder projects as well as major planned transport initiatives (e.g., BusConnects) will deliver a growing contribution to active and mass transit travel in the years ahead. For the agriculture sector, the cumulative total projected GHG emissions over the 2021-2030 period is 209 Mt, which would represent 54% of the total cumulative carbon budget of 384 Mt over the 2021-2030 period. In the current form of national and international emissions accounting (e.g., treatment of methane emissions), agriculture is, on these numbers, the single most important sector in the context of Ireland delivering national NETS compliance in the 2021-2030 ESR phase. Valuable work by the Food Vision Dairy Group for example in 2022 restates the measures to mitigate emissions from key activities such as dairy, however, the uptake rates and management of incentives clearly need further work.

The scale of the climate mitigation challenge remains substantial, and although the CAP21 includes a step-up in ambition across all key sectors, these plans must now be matched with implementation and the necessary incentives that can create the changes in behaviours, practices, and technologies that progress will require. The capstone measures in the key sectors are well known (e.g. energy efficiency in the built environment, avoid shift improve measures in transport) and will require action oriented, project-based initiatives, such as the Signpost programme in the agriculture sector and the Pathfinder projects in Transport to continue to shape and encourage direct

[3] COVID-19 was suggested as having impacted the level of activity due to related restrictions.

intervention in important areas. A programme like these in the built environment sector would likely have similarly positive implications, particularly one that targets and ringfences retrofit projects at scale. Outside of policy innovation, bioenergy solutions, CCS and hydrogen fuel will be considered, however on the time horizon to 2030, the scope for credible and proven actions that can deliver is more limited than those which may deliver impact on the longer pathway to net zero in 2050. Whilst international evidence suggests that green hydrogen offers long-term potential that will attract substantial investment over the coming years, the risk of stranded assets or short-lived pathways in other areas, that require heavy investment or sustained subsidy, should be carefully considered before any commitment. Decarbonisation of the power sector, improved energy efficiency, and mass electrification of transport[4] and buildings remain the core pillar strategies to advance to 2030. Coupled with this technology driven decarbonisation, it is also imperative that policy and research consider non-technical initiatives and incentives that can alter mindsets and behaviours so as to curtail or reverse activity growth in key GHG emission source sectors.

In terms of the air mitigation challenge, the National Emissions Ceiling Directive (NECD) designates emission ceilings in relation to key air pollutants from 2010-2019, 2020-2029, and 2030-2039. The five primary air pollutants are NO_x, SO_x, NMVOC, NH_3, and $PM_{2.5}$, and the overall outlook as of the current year shows that without the use of any flexibilities or adjustments, Ireland has exceeded the emission ceilings for NO_x, NMVOC, and NH_3 in 2019. However, with the full application of adjustments outlined in Directive 2016/2284, both NO_x and NMVOC emissions can comply in 2019, the final year of the first emissions ceiling period. For the period beyond 2030, where even stricter emission ceilings will be applied, NH_3, $PM_{2.5}$, and NMVOC are all of particular concern for compliance, with their respective gap to ceilings becoming increasingly narrow. The measures included in the CAP do improve upon the current WEM outlook for many air pollutants, particularly for NH_3, but we fully expect that action beyond those measures will be required to maintain compliance across all air pollutants in the NECD, and to address ambient air quality goals. The key pressure points for air are the residential, transport, and agricultural sectors.

Broadly, some of the core mitigation policies from the CAP21 that are expected to have a substantial impact on sectoral mitigation efforts for air pollution are, a focus on renewable electricity generation, the phasing out of peat and coal, residential retrofit programmes, solid fuel regulation, encouraging modal shift for road transport, EV uptake, and innovation and technology in farming practices. Many of the measures highlighted as part of addressing the air mitigation challenge are also highlighted in addressing the climate mitigation challenge. This is because many key measures offer co-benefits for both climate and air (e.g. electrification of transport, energy efficiency). Consideration of these interdependencies between climate and air policy should continue to play an important role in the development of comprehensive policy design and stronger communications. Furthermore, caution is always required to ensure that climate actions present synergies and not trade-offs for air policy compliance in Ireland. Policy actions should always be assessed broadly, and communicated across their full range of potential benefits.

[4] Notwithstanding that active travel and mass transit travel are crucial to sustainable transport, electrification of the emitting source in the sector via electrification is essential for future compliance with targets.

1. Report Overview

This report offers a concise and integrated overview of national emission trends and outlooks for both climate and air emissions in Ireland. Each year we independently review official data and reports on progress and changes from the prior year. As part of this process, we detail the officially projected national outlook from the with existing measures (WEM) scenario; anticipate shortfalls in emission reduction progress relative to targets; and highlight new developments in policy and their potential impacts. This is done to support the prioritisation of new or enhanced measures, strategies and research. Furthermore, we consider the possible use of flexibilities, and explain any particularly relevant developments or changes in terms of European Directives, data reporting and management.

The EnvEcon Challenge and Compliance (CC) Report can offer support for the compilation of progress reports required under the National Emission Ceiling Directive (NECD), the Effort Sharing Regulation (ESR) to 2030, and reviews of progress for national Climate Action Plans (CAPs). It does so by indicating progress towards compliance on both air and climate goals simultaneously, whilst also informing alternative or modified actions that may support compliance, as well as showcasing emerging research and evidence that are relevant to policy design and delivery.

All emissions data is sourced from official national inventory and projections provided by the EPA. Their support and that of the Department of Environment, Climate and Communication (DECC) are, as always, acknowledged and appreciated. Further context and analysis are derived from various key Government publications including CAP 19, CAP 21, 2021 National Development Plan (NDP), 2020 Programme for Government, 2020 Ag-Climatise, and the 2021 National Air Pollution Control Plan (NAPCP). Links to specific reports are provided in the annex.

The first part of this report deals with the climate challenge and offers an overview of current greenhouse gas emissions, sectoral performance, and the national climate policy strategy. The subsequent section is focused on the air emissions challenge, with a similar structure of overview, sectoral performance, and mitigation policy strategy.

Prior versions of this report were accompanied by an extended annex which provided additional context as well as non-technical overviews of national and international policy frameworks, reporting requirements and available flexibilities. Excerpts of the specific language from EU Directives and Regulations that pertain to particular aspects of compiling and reporting emissions data were also included within that early annex for ease of reference. However, this original extended annex will not be repeated now within this 2022 or subsequent EnvEcon CC reports.

Note on With Existing Measure Outlook and Official Data

To ensure clarity on the underlying data, we confirm that the current With Existing Measures (WEM) emission scenario in this report uses the baseline energy projections from SEAI, including all policies and measures already in place and actions committed to by government policy before the end of 2020. Their projected impact on emission reductions is in-line with resources and legislation. The With Additional Measures (WAM) scenario uses the advanced energy projections from SEAI which incorporate the full WEM scenario plus all measures outlined in latest government plans but not yet implemented at the time of forecast publication, for example, those planned for in the CAP21. In simple terms, the WAM is a more ambitious scenarios that assumes defined ambitions are realised.

At the outset we also remind readers again that whilst we make references to the WAM scenario, this EnvEcon CC report is focused on the current inventory up to 2020 and the WEM forecast scenario as released in 2022 for all years from 2021 onwards. The reason for this is not to disregard the policy outlook designed to deliver compliance (the WAM) but rather to centre attention on where the **current** policies and measures are expected to leave Ireland in regard to air and climate emission targets. This is to afford clarity for the scale of the **additional action** yet required in Ireland, and to highlight the **sectoral and sub-sectoral focus** for those measures that must yet be taken.

We rely on the official EPA data shared with us directly and reported for 2022. The EPA Greenhouse Gas Emissions Projections 2020-2040 report uses Global Warming Potentials (GWPs) laid out in the IPCC's fifth assessment report (AR5) for the calculation of projected emissions and annual emission allocations (AEAs) for all years from 2021-2030. Whereas the official projections data that is compiled and submitted in accordance with Implementing Decision (EU) 2020/2126, and that we use for all figures and data in this report, uses the GWPs from IPCC's fourth assessment report (AR4) and will continue to do so until 2023. Therefore, there is some variance in the reporting of figures, particularly in relation to cumulative emissions for 2021-2030 and annual gaps to target in 2030, from what is presented in the most recent EPA reports. These data sets are always evolving and recent years have seen changes in the broader framework that should be more settled by 2024.

The next EnvEcon CC report will be updated with the latest official data when released around April 2023.

2. Context

This section is intended to outline some of the important policy developments and background context shaping and influencing policy decisions on a national and international level. There are significant changes in climate ambition for the period to 2030 and beyond, and global pressure to address environmental issues is increasing.

EU Green Deal

The new European Green Deal sets out the ambition and pathway towards climate neutrality by 2050 as well as reductions in net GHGs of 55% by 2030 compared to 1990 levels. These targets are now legally binding and set by the European Climate Law. Included in the deal are additional considerations for the governance process for Member States as well as revisions to existing EU legislation regarding the EU Emissions Trading Scheme (ETS), Effort Sharing Decision (ESD), transport sector and Land Use, Land-Use Change and Forestry (LULUCF). The Fit for 55 package sets the EU plan for a green transition under the European Green Deal. The package sets out interconnected policy proposals that include revisions of climate, energy, and transport legislation.

Furthermore, to achieve the climate objectives in a manner that is fair and socially just, as well as supporting innovation and competition, the Fit for 55 package also outlines several budgetary supports from the EU. These funding streams will be important for Ireland and present opportunities to match ambitions with resources. Money will be allocated to Ireland from various sources, including the new Social Climate fund, the Just Transition fund, the Cohesion fund and the Next Generation EU programme. The package can *inter alia* support major key investment actions, including the renewable energy transition and developing Ireland's offshore wind potential.

Climate Action and Low Carbon Development (Amendment) Bill 2021

The 2021 (Amendment) Bill is an act to amend the Climate Action and Low Carbon Development Act of 2015. Specifically, the amendments are to increase the climate ambition to realising a climate neutral economy by the end of the year 2050. Additionally, there are amendments in relation to the Climate Change Advisory Council, the provision of carbon budgets and sector specific decarbonization targets. A Carbon Budget Technical Report has also been prepared and released at the end of 2021.

Climate Action Plan (CAP21 and CAP23)

The 2021 Climate Action Plan (CAP) builds from the CAP 2019 with a step up in climate ambition that matches and reinforces the commitments of the 2020 Program for Government with targets for reducing total GHG emissions by 51% compared to 2018 by 2030 and reaching net zero emissions by 2050 as outlined in the Climate Action and Low Carbon Development (Amendment) Act 2021. The CAP 19 set out the policies and measures that Ireland must take in order to meet the existing -30% target by 2030 and thereby avoid costs arising from non-compliance. The CAP 21 sets out measures to meet a higher level of domestic ambition in the same manner.

In broad terms, the CAP 21 renews the commitment to core measures that were included in the CAP 19 and works to build and extend on those actions, such as growing the renewable electricity system, delivering electrification of transport and the built environment, and improving farm efficiency and land management. There are also further measures and initiatives aimed at bringing Ireland closer to the more challenging targets set for 2050, including accelerated sustainable transformations in agriculture, exploring long-term zero emission gas options (i.e., green hydrogen), and encouraging fundamental demand shifts across all sectors. The CAP 21 considers all sectors of the economy as well as other thematic areas that are deemed critical for the smooth transition and implementation of climate policies. These latter aspects include citizen engagement, just transition, investment strategy, enterprise support, circular economy, governance, and adaptation. The CAP 21 thus sets out a roadmap across all sectors (e.g., electricity, transport, built environment, and agriculture) that is designed to deliver emission reductions that are roughly double the abatement ambition of the CAP 19[5].

As of November 2022, the discussions to inform CAP 23 are largely complete, and this new CAP is scheduled for release shortly. The CAP 23 focuses on policies with a short-term impact, accounts for the newly introduced sectoral ceilings, and recognises the 1st carbon budget period to 2025 as the immediate challenge to be addressed. Success for CAP 23 will largely be determined by the capacity of key actors to deliver on proven and established abatement options from the existing policy menu. In particular measures promoting efficiency and behaviours change, measures on feed and fertiliser use in agriculture, clustered and scaled initiatives focusing on built environment retrofits, fast tracked renewables projects, and the continued support for faster electrification of heat and transport.

Budget 2023

The Government faces a challenge with the current interconnected backdrop of high inflation, an increasing cost of living, the energy crisis and conflict in Ukraine. Price sensitivity will be heightened, and resources for initiatives will face broader competition in this context. Budget 2023 presented some notable decisions in relation to energy, farming and the carbon tax. In relation to energy, Budget 2023 has included that excise reduction on petrol and diesel will continue until the new year, extended until February 2023. This is intended to help cut rising fuel costs in the short-term. On the farming side, a new beef scheme to replace the BEEP-S scheme and to run alongside the suckler carbon efficiency scheme has been introduced, as well as energy supports and funding of €8 million in grant aid available for liming of soils. There is also capital funding to support the development of anaerobic digestion in 2023 and a new €10 million tillage incentive scheme.

As per the Programme for Government, the carbon tax will still increase by the same amount every year until 2029. Therefore, the carbon tax will increase by €7.50 a tonne bringing the rate up to €48.50 per tonne. This will take

[5] The CAP21 is designed to deliver a 51% reduction in emissions by 2030 compared to 2018 levels. Latest WAM projections, which includes all measures planned for in the CAP19, currently forecast a total reduction of 58.4 Mt over the 2021-2030 period or 1.8% per annum compared to the WEM scenario over the same period. The CAP21 indicates that the new reduction target is more double the ambition of the CAP19.

effect on transport fuels from October 12th, 2022 and for home heating fuels from May 1st, 2023. It will, however, be offset by a cut in the National Oil Reserves Agency (NORA) levy to counter price increases. The estimated €9.5 billion in revenue earned over the 2021-2030 period is ringfenced as follows; €3 billion for just transition, €5 billion for national retrofitting program, and €1.5billion for green and sustainable farming initiatives.

Note on COVID-19 Impacts and 2020 Emissions

As a result of strict lockdown measures there has been a reduction in economic activity and travel throughout 2020 and into 2021. An SEAI report released earlier in 2021 projected a short-term reduction in total GHG emissions of 5.9% in 2020 from 2019 levels[6]. However, inventory released in 2022 shows that overall GHG emissions decreased by 3.6% in 2020 from 2019, which is actually on par with the reductions observed in 2019 of 4% from 2018. This would indicate that even such an extreme version of economic shutdown has not in itself delivered the extent of emission reductions that will be required for the next period across 2021-2030. Closer assessment reveals that the pandemic did not affect all sectors equally and while greater reductions were seen in areas like transport, emissions from the residential sector rose. The dampening effect of COVID-19 on 2020 emissions are relevant, but ultimately policy and technology driven abatement progress has not been as rapid as desired or required in the period to 2020. Beyond the impact on emissions, notable ambient air quality improvements have also been observed in urban areas and cities during lockdown periods. These are associated primarily with reduced road transport activity. It will be important to manage, in so far as possible, any post-COVID rebound in emissions, and to utilise the pandemic to refocus on a green transition in so far as possible by holding onto the positive trends e.g., active travel. The next iteration of the EnvEcon CC report for 2023 will contain the first official post-COVID inventory for the year 2021, which will highlight more definitively the early impacts of our pandemic recovery and post-pandemic behaviour.

Note on BREXIT and the Irish Economy

The EU-UK Trade and Cooperation Agreement came into force on May 1st, 2021. This was the last official step in formalising the new relationship between the EU and the UK and consists of a Free Trade Agreement, with ambitious cooperation on economic, social, environmental and fisheries issues, a close partnership on citizens' security and, an overarching governance framework. Additionally, the Protocol on Ireland/Northern Ireland which came into force on January 1st, 2021, should[7] prevent a hard border on the island, protecting the all-island economy and the Good Friday Agreement. It allows for North-South cooperation in areas such as agriculture, transport, education, tourism and the continuation of the Single Electricity Market and the Common Travel Area. Related to this, the Brexit Adjustment Reserve is a fund of €5.37 billion which will provide support to Member States, regions and sectors worst affected by Brexit. It has been proposed that €4.24 billion of the funding be allocated from 2021,

[6] The impact on 2020 greenhouse gas emissions of COVID-19 restrictions, *SEAI*, January 2021.

[7] Noting the concerns regarding Article 16 as of November and December 2021.

with the remainder distributed in 2024 after the full impact of Brexit has been assessed. As the Member State most impacted by BREXIT Ireland is expected to receive a relatively larger portion of this support.

However, there are significant consequences expected from BREXIT over time for Irish businesses and citizens. According to a recent report from the CSO, BREXIT has resulted in a major decline in food trade between Ireland and the UK as exports of food and drink products to Britain fell by 35% from €641 million to €418 million in the first two months of 2021 compared with the same period in 2018[8]. Sales to seven of Ireland's ten largest food and drink markets went up during the period, however, the decline in exports to Britain still led to a decline in total food and drink exports. A fuller picture of the impact of BREXIT on the Irish agri-food industry will emerge over time.

Similarly, the impact of BREXIT on 2nd hand vehicle imports and vehicle trade – as the sole right hand drive vehicle trading partner in Europe - will have implications for the Irish fleet transition and cost. Access to a larger market of second-hand hybrid and electric vehicles would have been valuable as Ireland seeks to accelerate EV uptake rates. In the absence of a readily accessible large trading pool of such second-hand EV cars many consumers will need to consider not only an EV, but a new EV, which will set the investment cost bar in a considerably higher bracket.

Note on Impacts of Conflict in Ukraine

The recent and ongoing conflict in Ukraine has sent shockwaves throughout the world, including in the context of energy and commodity markets. Russia had previously provided up to 40% of EU natural gas and Ukraine, referred to as the 'bread basket' of Europe, accounted for more than a quarter of global wheat and nearly a fifth of global corn production. Ireland's direct trade links with Russia are limited, however, disruptions to trade and prices on a regional and global scale can still impact Ireland. The key concerns are energy markets and supply chain disruptions.

In 2020, the EU generated more electricity from renewables than fossil fuels for the first time. Coal generation has fallen by a third in the last five years, mostly replaced by wind and solar, but the ongoing gas crisis has interrupted the rapid coal exit. Following Russia's invasion of Ukraine, the EU Commission and national governments are developing plans to rapidly reduce the EU's reliance on gas imports by accelerating deployment of clean electricity[9]. There are certainly challenges ahead particularly for winter energy and heating in future years. However, it is also possible that greater progress can, and must, be made in the wake of these challenges. Today's energy crisis could potentially drive great positive changes in terms of energy efficiency, innovation and transition for Europe and thus interrupt and arrest the dependency on gas and oil from the broader international market over the longer term.

[8] https://www.cso.ie/en/releasesandpublications/fp/p-favca/foodandagricultureavaluechainanalysis/effectofbrexitontrade/

[9] European Union | Electricity Transition | Ember (ember-climate.org)

3. Climate Mitigation Challenge

The 2013-2020 climate challenge period has been defined by the European Effort Sharing Decision (ESD). The current period from 2021-2030 is now covered by the Effort Sharing Regulation (ESR). Under this agreement Ireland is committed to substantially reducing national emissions from the Non-Emission Trading Sector (NETS). The NETS sectors include transport, agriculture, the built environment, waste and non-energy intensive industry. Figure 1 presents the split of Emission Trading Sector (ETS) and NETS emissions in Ireland, as well as a further sectoral breakdown of NETS emissions as a percentage of the national total NETS excluding LULUCF.

Compliance in the context of the ESD and ESR is determined in reference to an amount of annual emission allocations (AEAs) that are calculated based on a linear trajectory from the start point of the defined period to the final emissions target at the end of the period. For the ESD period, 2013-2020, the AEA starting point in the year 2013 is calculated from an average of 2008-2010 emissions and a linear AEA trajectory then follows through to achieve the 20% reduction target by 2020. For the ESR period, 2021-2030, the AEA trajectory is calculated from a May 2019 start point with a pathway to **achieving the existing 30% reduction by 2030**. In December 2020, a Commission Implementing Decision (EU) 2020/2126 was adopted that sets out the AEAs for every member state. Tables 3a and 3b list all these official AEAs for both ESD and ESR periods, they are also shown in Figure 2. Compliance with AEAs is still to be settled annually based on the official emissions inventory. An adjusted inventory cannot be considered retrospectively for compliance and cannot change deficit or surplus. Thus, the surplus and deficit for all years from 2013-2019 have now been locked in. There is also a standard two-year lag in the accounting of official inventory, and so we rely on official projections data and forecast emissions for each year after 2020 including for the entirety of the ESR period 2021-2030. We note that the updated Fit for 55 ambitions will see a revision of the AEAs to allow for the new abatement goal.

The compliance pathway with AEA's, inventory, projections and cumulative estimates for each reporting period are summarised in Tables 3a and 3b. Figures 2 and 3a illustrate the current WEM GHG outlook and indicate the impact of flexibilities under the WEM scenario. Figure 3b shows the WAM outlook with the same flexibility options.

Effort Sharing Decision 2013-2020

The latest official inventory released in 2022 shows total national emissions, excluding LULUCF, in Ireland in 2020 to be 57.7 Mt CO_{2eq}. This represents a reduction of 3.6% from 2019 total national emission levels. Total NETS emissions for the year 2020 are 44.4 Mt CO_{2eq}, representing a 2.6% decrease from 2019 levels. In terms of the ESD, and compared to the 2005 emissions level of 47.69 Mt, Ireland has reduced NETS emissions by approximately 7% in 2020 compared to 2005, which is significantly short of the 20% reduction target[10]. The challenges presented in

[10] Since 2005, emission in the ETS have decreased 40.8% whereas emissions under NETS have only decreased by 7% (Ireland's Provisional Greenhouse Gas Emissions 1990-2020).

meeting the 2020 target for Ireland can be at least partially attributed to the reduced investment capacity over the years of the economic downturn from 2008, and the challenge posed by the NETS target in a country where such a substantial share of emissions are associated with biogenic methane and agriculture. However, Ireland has options to close this gap to compliance:

1. As a given, Ireland has banked all AEA surpluses expected in the current period to support compliance with 2020 targets. Surplus AEAs were not enough to afford Ireland full compliance in 2019 and there are no further banked surpluses to be applied for 2020. Therefore, a combination of the following 2 options are required for compliance in 2019 and 2020.

2. Ireland had the option to purchase and stockpile the 4% annual limit for Clean Development Mechanism and Joint Implementation (CDM/JI) credits. This amounts to circa 1.9 million tonnes of CO_{2eq} annually. There are three ways to acquire CDM/JI credits; undertake CDM/JI projects, purchase ERUs/CERs from member states that directly undertake CDM/JI projects or invest in a fund that finances CDM/JI projects and acquires credits.

3. International AEA's from other member states may also be purchased and should also become available at competitive prices for the period to 2020. It is likely that most countries are going to have a considerable surplus of credits in the final reckoning for 2020. Based on in-house EnvEcon research, using inventories released in 2018, only Germany, Malta, Poland and Ireland are expected to have an AEA deficit in 2020. As surplus credits held by all other member states are not eligible for carry over into the ESR period from 2021 to 2030, countries may either sell their surplus credits or retire them. Several countries (Sweden, France and the UK) had already retired surplus AEAs from 2013 to 2017 amounting to 244 Mt[11]. However, there are expected to be purchase options available. EnvEcon produced a report in 2019 for DECC in relation to overall EU AEA positions to offer more detailed context on this specific topic. It is noted that Ireland has used similar style flexibilities in the context of renewable electricity targets.[12]

To date then Ireland has complied with its obligation under the ESD through direct emission reduction over the years 2013-2015 and through availing of flexibilities and options to bank allowances and to purchase additional credits for the remaining years from 2016-2019. After using additional purchases to meet compliance in 2019, the balance of credits Ireland currently holds is 2.92 million. The estimated shortfall in 2020 is 6.76 Mt CO_{2eq} meaning that an additional 3.83 million credits will need to be purchased from the international market or from other Member

[11] See EU Climate Action Progress Report 2020 for more information:
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=COM:2020:777:FIN

[12] In a statement made in the Dáil December 2020, the government has agreed to pay €50 million in statistical transfers to Denmark and Estonia to cover the shortfall in renewable energy targets. Estonia will receive €37.5million and €12.5million will go to Denmark for a total of 3,500 Gigawatt hours of renewable electricity. The Funds will be used to accelerate the deployment of renewable electricity in their jurisdictions in line with their respective National Energy and Climate Plans.

States to comply with the ESD target for 2020. However, the Department of Public Expenditure and Reform have estimated that after the application of the unused credits, the cost of purchasing the additional credits required could range from €2 - €14 million depending on the final quantity needed and the prevailing market price[13]. The deadline for demonstrating compliance for 2020 will likely be the end of 2022 or early 2023 and the additional credits will need to be purchased by the State by then. Text Box 1 below details the purchases of credit over the ESD period.

Text Box 1. GHG related financial transactions[14]

A government decision in March 2006 approved the establishment of a carbon purchasing programme, whereby the State could purchase up to 18 million carbon credits over the 2008-2012 period (the first Kyoto Protocol commitment period). This was in response to the initially projected exceedance of national limits set for the period.

By the end of 2012, the State had spent €89.5 million on purchasing 5.255million carbon credits (1 carbon credit = 1 metric tonne of carbon dioxide) and invested €31.8 million in 3.442 million carbon fund units attached to managed environmental funds, for a total investment of €121 million.

Ireland was able to carry forward 5.27milllion unused carbon credits from this period that can be used for compliance with its obligations for the 2013-2020 period. By the end of 2018 this balance had increased to 5.51 million credits. In December 2019 the National Treasury Management Agency (NTMA) reactivated the carbon credit purchasing programme to purchase 400,576 units at 25 cents per unit. This was the first transaction in the fund since 2009 and the justification was to recommence purchasing of carbon units to address ESD shortfall and the gap to compliance in 2020. The balance held in the fund at the end of 2019 was 6.05 million. During 2020 the NTMA bought 1,117,466 CERs. Additionally, the fund received units from Ireland's multilateral investment funds for a total number of carbon credits held in the fund at the end of 2020 at 7.485 million. Approximately 5 million of those credits were used for 2019 compliance leaving the remaining balance to go towards 2020 compliance.

EnvEcon
Decision Support

Effort Sharing Regulation 2021-2030

For the period 2021-2030 the EU had previously set itself a reduction target of 40% from 2005 emission levels for the ETS and a 30% reduction from 2005 levels from the NETS. Under this agreement, Ireland had committed to reduce NETS emissions by 30% from 2005 emission levels by 2030. However, under the European Green Deal and as part of the 'Fit for 55' package, the ambition has been increased and is now set for at least 55% net GHG emissions reductions compared to 1990 by 2030. Negotiations are ongoing on the Fit for 55 proposal as it relates

[13] March 2020 Briefing Note: Compliance cost associated with 2020 & 2030 Climate & energy targets.

[14] Taken from the Report on the Accounts of the Public Service 2018, published in September 2019 on behalf of the Comptroller and Auditor General, as well as the NTMA Annual Report 2019 and the NTMA Annual Report 2020.

to Ireland, but the current proposed ESR amendments would commit Ireland to a 42% reduction by 2030. Legislative proposals for implementing the new EU 2030 target, including revising member States' AEAs from 2021-2030 were presented by the European Commission in July 2021 and are progressing as of November 2022[15].

Aligned with the proposed increase in European climate ambition, the Programme for Government outlined a similar target for Ireland of a 51% reduction in overall GHG emissions compared with 2018 by 2030, an average of a 7% reduction per annum from 2021-2030, as well as a longer-term goal of achieving net zero emissions by 2050, mirroring the European Green Deal. The 2050 net zero target has been committed into law by the Climate Action and Low Carbon Development (Amendment) Bill in 2021. The actions and targets required to achieve the agreed step up in ambition to 2030 have also been outlined in the CAP21. These include increased penetration of technologies and measures across all sectors from power, transport, built environment and agriculture.

The proposed 'Fit for 55' amendments for the ESR period 2021-2030 will require that AEAs progressively lead to the legally binding 2030 target (proposed -42%) and are established for the years 2023-2030. AEAs for 2023, 2024, and 2025 will be calculated on the basis of GHGs from 2005 and an average of emissions from 2016-2018 as reviewed by the Commission. AEAs from 2026-2030 will be calculated based on average GHGs from 2021-2023 following a full review of national inventory data to be carried out by the Commission in 2025. The AEA start point will remain May 2019 and an average of 2016-2018 emissions on a linear pathway to the amended 2030 target.

For the purpose of compliance, the ESR includes two main flexibilities over the 2021-2030 period. Ireland may consider the use of one or both of these flexibilities. The first flexibility is the one-off ETS allowance available to countries listed in Annex II of Regulation (EU) 2018/842. Under the one-off ETS allowance, Ireland may avail of a maximum purchase allowance of 4% of 2005 emissions per year. The Implementing Decision 2020/2126 has determined that based on the accepted 2005 emission level listed in Annex I[16] that Ireland has a total of 19.1 Mt CO_{2eq} to purchase and use over the 2021-2030 period or a maximum of 1.91 Mt per year. Eligible Member States needed to notify the Commission by 31 December 2019 how much of the maximum amount of this flexibility they intend to use during the compliance period 2021 to 2030. Ireland has notified the Commission that they intend to use their full amount of 19.1 million tonnes. A member state may decide to revise and lower their notified percentage twice during the ESR period in 2024 and 2027.

The second flexibility that is available under the Regulation relates to a recognition of the lower mitigation potential of the agriculture and land use sectors, and provides a land use, land use change, and forestry (LULUCF) credit. A LULUCF credit can offset emissions under the ESR if Ireland's emissions are over the AEA in a given year and the total accounted for LULUCF emissions are less than zero. In this case that net credit can be applied for Ireland's compliance assessment in that year. However, the cumulative quantity of LULUCF credits for the full period 2021-

[15] EU reaches agreement on national emission reductions (europa.eu)

[16] The 2005 emission value for 2005 listed for Ireland in Annex I of Implementing Decision 2020/2126 is 47,687.589 CO_{2eq}.

2030 (assessed over two periods 2021-2025 and 2026-2030) cannot exceed the maximum flexibility allocated to Ireland of 26.8 Mt CO_{2eq}. The LULUCF credit limit for the whole of the EU is an absolute figure of 280 Mt of CO_{2eq} over the 10 years from 2021-2030. Whilst the LULUCF credit is a valuable flexibility option, the challenge in realising LULUCF potential in Ireland to capitalise on the credit option for use in this process will be substantial based on current forestry analysis for Ireland. Detail on the LULUCF sector is provided later in this report.

Furthermore, for the 2021-2030 period the option to purchase international credits from other member states will remain. However, this option is expected to become increasingly limited as all countries will be under more pressure with their own revised targets and may not have surplus credits to put on the market. This should also drive prices up where the market becomes more competitive, and more countries are competing for fewer surplus AEA's. Another flexibility option is that for the period from 2021-2025 member states can borrow up to 10% of their AEA's from the following year. From 2026-2029 this amount is limited to 5% of the following years' allocation. Member states may also transfer up to 5% of their AEAs each year to another member state for the years 2021-2025, and from 2026-2030 this is increased to 10%. These mechanisms again offer value where abatement policies and initiatives need additional time. However, whilst it is important to recognise these options and their associated costs, Ireland should at this point focus its effort on delivering all the measures and actions set forth in the CAP.

Outlook Summary with Flexibilities

The current WEM outlook as of 2022 indicates that with the full use of both LULUCF, ETS credits and surplus carry over, compliance will be achieved from 2021-2026. However, even with the full use of flexibilities, Ireland is thereafter projected to exceed the AEA in each subsequent year and to fall out of compliance from 2027-2030 with a final gap to compliance of -12.8 Mt CO_{2eq} estimated. With only the use of only the LULUCF flexibility and surplus carry over, under the WEM projections, Ireland will achieve compliance in 2021 and 2022 before exceeding annual limits for the remainder of the period with a final gap to target in 2030 estimated at -31.9 Mt CO_{2eq}.

The WAM outlook delivers a more encouraging outcome, as would be expected. The WAM scenario with LULUCF and surplus carry over only is projected to be compliant throughout the period 2021-2030 period, resulting in a cumulative surplus in 2030 of 10.6 Mt CO_{2eq}. Where all flexibilities are fully applied that surplus rises to 29.69 Mt CO_{2eq} for the 2021-2030 period. In all cases the challenge of realising the LULUCF credit should be recognised.

The Gap between WEM and WAM shows that current levels of implementation rates will not achieve the target for 2030, faster implementation is required. Both WEM and WAM scenarios with the application of various flexibilities are illustrated below in Figures 3a and 3b. It must be remembered that the ambition and abatement level for 2030 will be revised shortly for Ireland with a direct impact on the compliance trajectories.

It should be remembered that the use of flexibilities clearly has associated costs and in the case of the one-off ETS will provide few local co-benefits. The use of flexibilities principally buys time for more cost-effective actions to be developed. However, a failure to invest appropriately may impact on national capacity to meet the more strenuous

reduction targets in subsequent phases. It is clear from current figures that measures and actions to reduce national emission levels are urgently required to shift the emissions trajectory toward compliance with the ambitious goals now being set for 2030 and 2050. Flexibilities can assist in meeting obligations, but are not a long-term strategy.

Proposal for Amending the ETS and ESR

A proposal for amending the EU ETS is currently undergoing EU Parliamentary legislative procedure. Currently, the EU ETS is operating in its 4th phase for the 2021-2030 period, and has set a reduction target of -43% compared to 2005 by 2030. However, the EU is on track to deliver -51% compared to 2005 by 2030, therefore outperforming the current ETS target but still delivering an insufficient contribution in order to meet the -55% net overall EU ambition by 2030. Therefore, the main proposal for revising the current EU ETS is to increase its ambition in a manner commensurate with achieving the 2030 EU climate ambition of reaching at least 55% net GHG reductions, specifically, the Commission are proposing to reduce EU ETS emissions by 61% by 2030.

In so far as Ireland is concerned, in 2005 ETS sectors contributed a 31.9% share of National total emission for that year. In 2020 that share had decreased to 23.1%. Total ETS emissions in Ireland have decreased by 40.6% in the year 2020 compared to 2005 level emissions. Specifically, ETS energy sector emissions decreased by 49.4% in the year 2020 compared to 2005, ETS manufacturing combustion emissions decreased by 16.4% in the year 2020 compared to 2005, and ETS industrial processes emissions decreased by 25.4% in the year 2020 compared to 2005.

The Table below summarises the existing and proposed EU and National ETS and NETS targets for 2030.

Table 1. Current and Proposed 2030 Targets

	EU		**Ireland**
Current 2030 Targets	-40% Total GHGs from 1990 (Equivalent to -37% from 2005)	-43% ETS from 2005	
		-30% NETS from 2005	-30% NETS from 2005
Proposed 2030 Targets	-55% Total GHGs from 1990 (Equivalent to -52% from 2005)	-61% ETS from 2005	-51% Total GHGs from 2018
		-40% NETS from 2005	-42% NETS from 2005

There is a broad suite of specific elements in the EU ETS that would be amended through the proposal, of particular interest is the concept for a separate emission trading system for buildings and road transport. This matter has not yet been finalised and is still under consideration. The broad argument for including emissions from buildings and road transport into an ETS structure is that it might provide for increased and more harmonised economic incentives to reduce emissions across these sectors in the EU and thereby assist the delivery of emission reductions from those sectors. From an Irish perspective it is important to note that while the transport and built environment sectors still require further action to bring them in line with climate policy targets, the levers and policies to deliver change (e.g., carbon tax, transport taxation policy) already exist within the state as established mechanisms and as such there is little to be gained by including these sectors in an ETS structure that will diminish net revenue and add administrative burden. An ETS would only offer another mechanism to encourage action. Ultimately the existing policy levers can stimulate greater direct action nationally as outlined in a prior memo by EnvEcon on this topic[17].

The proposed changes to the EU ETS will have to be reflected through amendments in the ESR and the proposal for those revisions are also undergoing Parliamentary decision-making processes. Following public consultation of the proposal for amending the ESR, the majority of respondents were in favour of extending the ETS to include buildings and road transport, however the matter will have to be decided upon by each individual Member State whether or not the system will work best nationally. There are three policy options being discussed[18]:

1. Extend the ETS to key sectors currently covered by the ESR (i.e. buildings and road transport), while keeping such sectors also under the ESR.
2. Transfer certain sectors to the ETS (i.e. buildings and road transport) and reduce the scope of the ESR.
3. Transfer certain sectors to the ETS (all fossil fuel combustion) and phase out the ESR by merging non-energy related ESR emissions from agriculture with the sectors covered by the LULUCF regulation and specific new regulations to cover all non-ETS sectors.

Carbon Tax and Resources for Action

The cost of implementing actions required for an economy-wide, all of society transition to a greener more sustainable future, as well as, meeting our commitments and targets for 2030 and 2050 will be substantial. It will continue to be important to identify the estimated costs, sources of finance and, where possible to ensure the ring-fencing of additional revenues for measures that can support the achievement of our climate action objectives.

In relation to carbon tax in Ireland, the Finance Act 2020, allows for annual increases of €7.50 per tonne until a rate of €100 per tonne is reached in 2030. There has been an increase in the carbon tax of €7.50 from €33.50 in 2021 to €41 per tonne in 2022 and the next increase is to €48.50 for 2023. The increases are effective on transport fuels

[17] For more perspective on the expansion of the EU ETS to non-ETS sector see the EnvEcon ETS Plus Memo, April 2021.

[18] COM(2021) 551 final.

from October and home heating fuels from May after the winter heating season each year. These phased increases are expected to raise an additional €9.5bn in revenue over the 2021-2030 period and will be allocated to the following programmes; energy efficiency and socially progressive national retrofitting programme (€5bn), targeted social welfare and other initiatives to addressing fuel poverty and supporting a just transition (€3bn), and the promotion of sustainable agriculture practices to encourage and incentivise farmers to farm in a greener and more sustainable way (€1.5bn)[19]. For the year 2022, carbon tax revenues of €412m has been allocated to the following programs - €174m on targeted social welfare and other initiatives to prevent fuel poverty and support a just transition, €202m for residential and community energy efficiency with a special focus on households in or at risk of energy poverty, €36m to other support programmes such as peatlands rehabilitation and the Midlands Just Transition Fund. Additional funding for just transition includes €84.5million for the period 2021-2027 that Ireland has secured from the EU as part of a broader EU-wide just transition fund under the EU green deal. This fund will assist local communities and businesses to adjust to the low carbon transition.

Other major sources of revenue have also been earmarked. These include €165bn in public investment over the period 2021-2030 outlined in the NDP 2021. Project Ireland 2040 funds have a collective budget of €4bn out to 2027 to be dispersed between the Climate Action Fund, Disruptive Technologies Innovation Fund, Urban Regeneration and Development Fund, and the Rural Regeneration and Development Fund. Finally, the National Resilience and Recovery Plan commits €518million to prioritizing and advancing the green transition to significantly reform and direct relevant funding towards decarbonizing projects such as retrofitting, ecosystem resilience and regeneration, climate mitigation and adaptation, and green data systems.

Carbon Budget Periods and Sectoral Ceilings Summary

Carbon budget periods represent the total amount of emissions, calculated on an economy-wide basis, that may be emitted over a 5 year period. Thus far two carbon budget periods with respective carbon budgets have been approved for Ireland, and a third provisional period and budget has been announced. They are as follows:

1) 2021-2025: 295 Mt ~ 4.8% reductions per annum
2) 2026-2030: 200 Mt ~ 8.3% reductions per annum
3) 2031-2035: 151 Mt ~ 3.5% reductions per annum (*Provisional)

All carbon budgets are in total GHGs, and include all sectors of the economy ETS and NETS. As a point of comparison, the current ESR (NETS only) emissions budget for the 2021-2030 period is 384 Mt. This ESR emissions budget will almost certainly be revised with subsequent adjustments to the AEAs, and the step-up in ambition. However it is worth noting that as it stands the ESR emissions budget alone would account for approximately 78% of the total 2021-2030 budget that is currently approved for Ireland.

[19] Budget 2022 – The Use of Carbon Tax Funds 2022

Publication of the SEAI Energy Balance for 2021 show that energy related emissions were up 5.4% in 2021, energy demand for transport increased by 8.3% from 2020 and Ireland's share of renewable energy remained unchanged from 2020 to 2021 at just 13.6%. These early data would thus suggest that in the first year of these legally binding carbon budgets, emissions in Ireland are actually trending in the opposite direction. It also means that there will be a disproportionate amount of the carbon budget used in 2021 rendering the subsequent years of the 2021-2025 period even more challenging. Further analysis on 2021 performance will be included in the next iteration of the EnvEcon CC report for 2023 as updated inventory and emissions data becomes available.

The carbon budgets and periods will be used to inform sectoral targets and emission ceilings. The CAP 21 had set sectoral ranges before the ceilings had been finalized at the end of July 2022. The ceilings now set maximum limits on GHG emissions for each sector of the Irish economy – electricity, buildings, transport, industry and agriculture. Achieving the overall target of 51% reduction by 2030 will thus require cooperation and commitment from all sectors. Table 2 outlines the current sectoral emissions ceilings. The next Climate Action Plan (CAP 23) will reflect the carbon budgets and sectoral emissions ceilings as well as providing a roadmap of actions for compliance.

Table 2. Sectoral Emission Ceilings and Targets[20]

Sector	2018 Emissions (Mt CO_{2eq})	*CAP21 Range* (2030 Target Mt CO_{2eq})	*CAP21 Range* (% Reduction from 2018)	2030 Ceiling (Mt CO_{2eq})	2030 Ceiling (% Reduction from 2018)
Electricity	10.5	2-4	62-81%	3	75%
Transport	12	6-7	42-50%	6	50%
Built Environment – Commercial/Public	2	4-5[21]	44-56%	1	45%
Built Environment - Residential	7			4	40%
Industry	7	5-6	23-37%	4	35%
Agriculture	23	16-18	22-30%	17.25	25%
LULUCF	4.8	2-3	37-58%	*Finalising LULUCF ceilings has been deferred until the completion of the Land-Use Strategy.*	
Other (F-gases, Waste and Petroleum refining)	2	1	50%	1	50%

[20] gov.ie - Government announces sectoral emissions ceilings, setting Ireland on a pathway to turn the tide on climate change (www.gov.ie)

[21] CAP21 did not split out residential and commercial buildings.

Figure 1. Sectoral Share of National Total Emissions and EU ETS/NETS Split from Latest Official Climate GHG Inventory

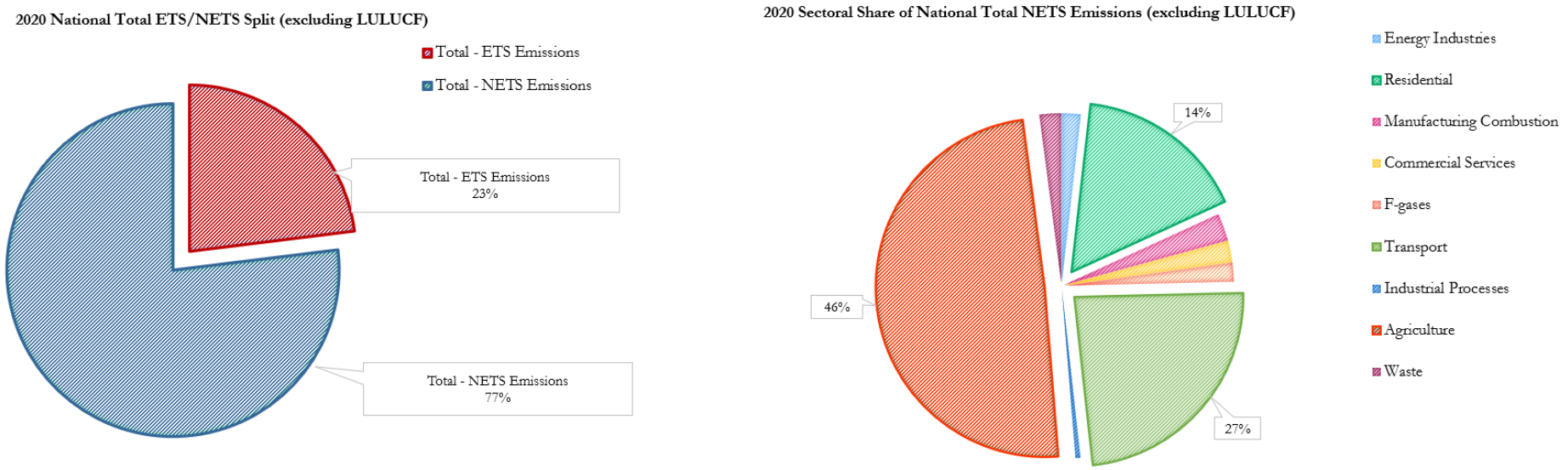


Table 3a. ESD/ESR Challenge to 2020 (kt CO_{2eq})

	2013	2014	2015	2016	2017	2018	2019	2020	Cumulative Total 2013-2020
Total Annual NETS Emissions WEM (Excl. LULUCF)[22]	42,207*	41,663*	43,037*	43,798*	43,829*	45,379*	45,580*	44,412	349,905
2020 ESD Target w./ Amended AEA's	46,892	45,761	44,630	43,499	40,885	39,807	38,729	37,651	337,854
Projected Annual Gap to Target	4,685	4,098	1,593	-299	-2,944	-5,572	-6,851	-6,761	**-12,051**

Table 3b. ESD/ESR Challenge 2021-2030 with WEM Projections and AEA Amendments (kt CO_{2eq})

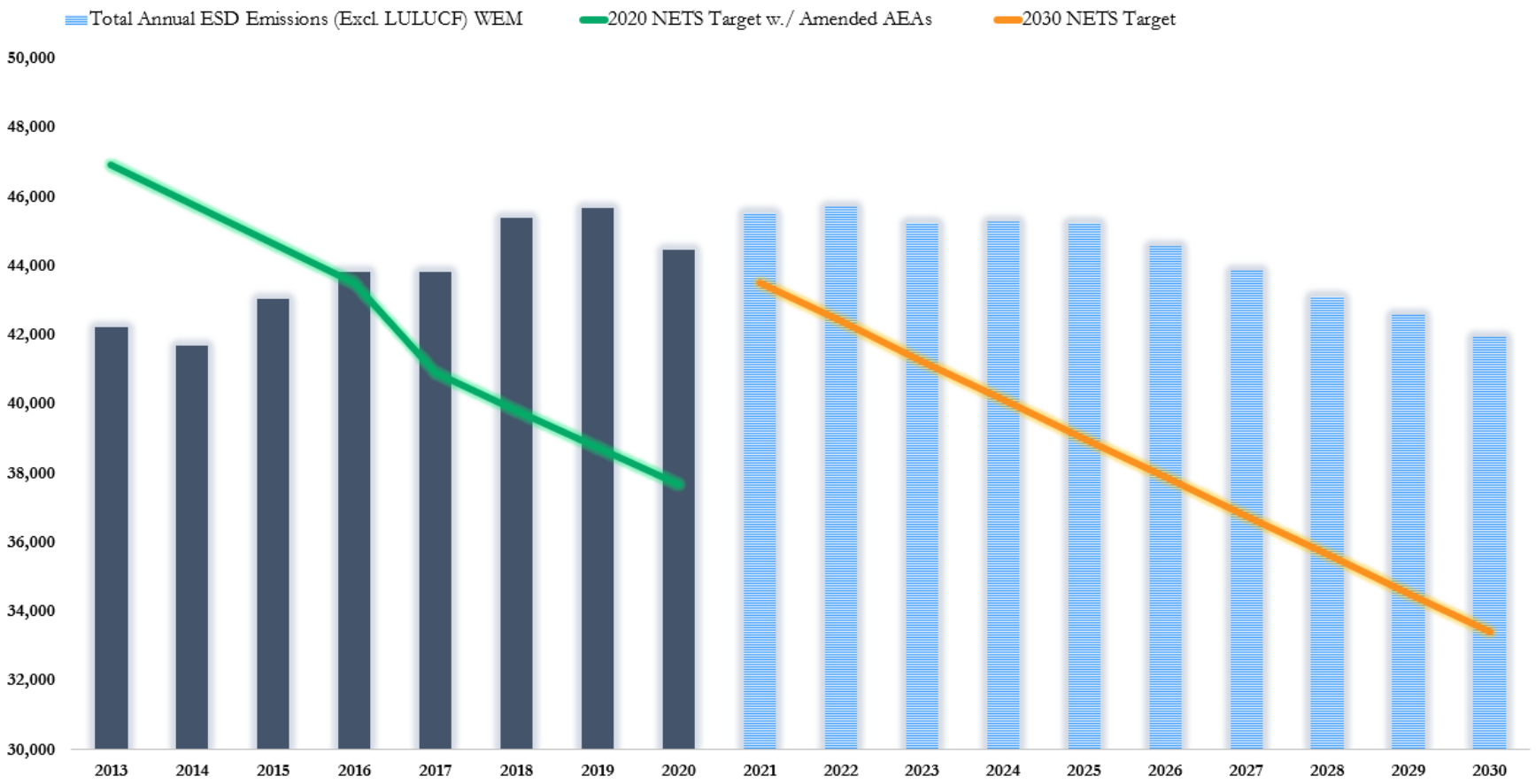
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Cumulative Total 2021-2030
[23]Total Annual NETS Emissions WEM (Excl. LULUCF)	45,533	45,698	45,244	45,263	45,235	44,554	43,851	43,116	42,586	41,937	443,016
2030 ESR Target AEA's[24] (2020+5months Start Point)	43,479	42,375	41,235	40,113	38,991	37,869	36,747	35,625	34,503	33,381	384,322
Projected Annual Gap to Target	-2,054	-3,323	-4,008	-5,150	-6,243	-6,684	-7,103	-7,491	-8,083	-8,555	**-58,695**

[22] * Any adjustments or recalculation to inventory will not impact compliance once it has been agreed by the EU Commission. Compliance totals for 2013-2020 have been agreed and surplus/deficit has been settled. Any further surplus or deficit for years 2021-2030 will be settled annually with the national total at the time of inventory publication.

[23] EPA projections reporting uses GWPs laid out in the IPCC's AR5 for the calculation of projected emissions and AEAs for all year 2021-2030. All figures and data in this report use the GWPs from IPCC's AR4 and will continue to do so until 2023.

[24] AEAs are taken directly from Implementing Decision EU 2020/2126 Annex II of 16 December 2020. The WEM emissions data is taken from the 2022 inventory for data up to the year 2020 and forecast data for all years from 2021-2030 are from the official projections data released in 2022.

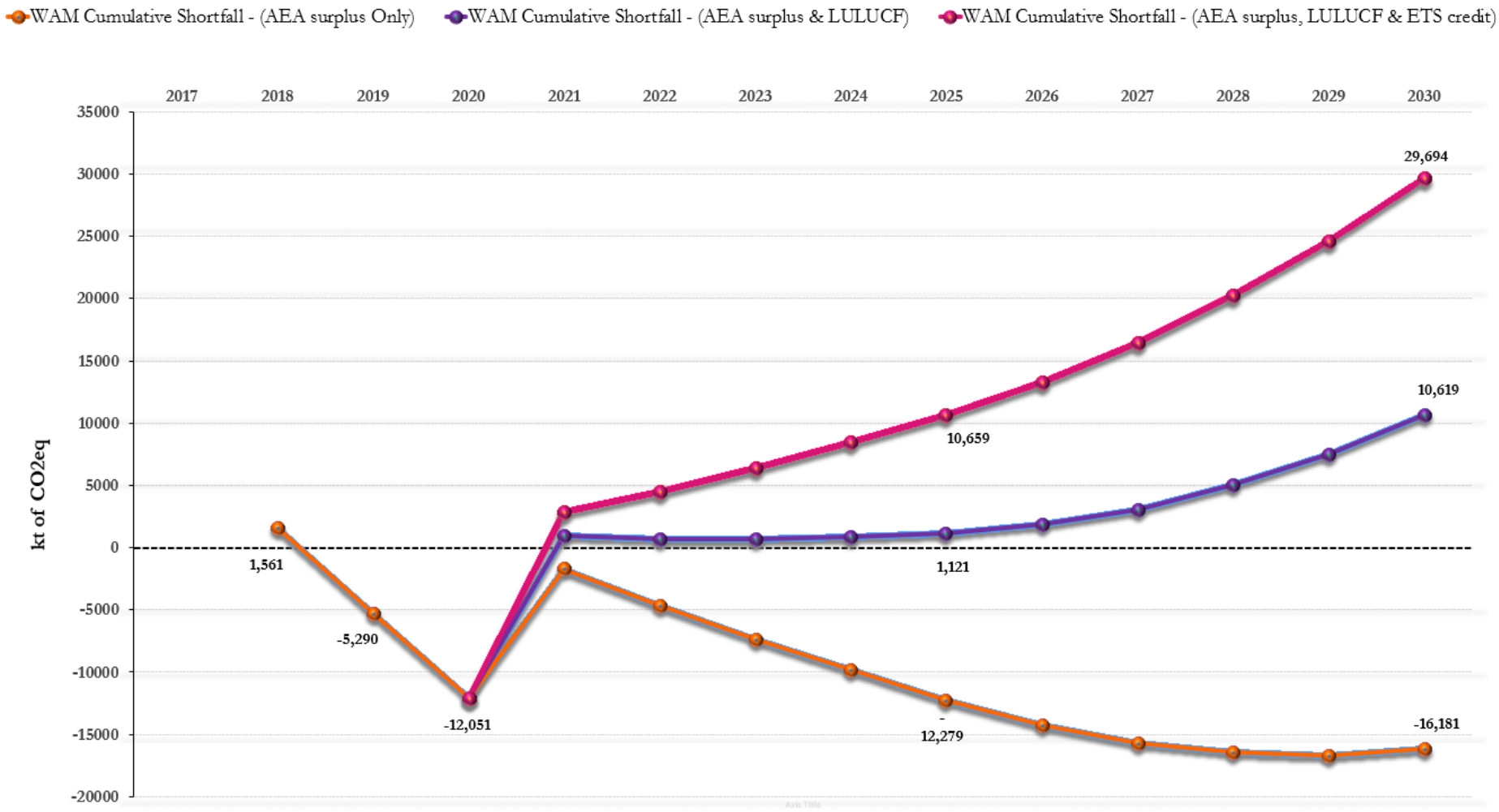
Figure 2. ESD/ESR Challenge to 2020 and 2030 with Inventory, WEM Projections and AEA Amendments (kt CO_{2eq})[25]



[25] Note that the vertical axis begins at 30,000 Kt CO_{2eq}. This is done to offer greater clarity on the modest changes in emissions outlook relative to the sharp decline in AEAs.

Figure 3a. Cumulative AEA Shortfall WEM, 2018 to 2030 with Varied Flexibilities Applied (kt CO_{2eq})

Figure 3b. Cumulative AEA Shortfall WAM, 2018 to 2030 with Varied Flexibilities Applied (kt CO_{2eq})



3.1 Climate – NETS Sectoral Highlights and Trends

The sectoral highlights focus on activity and emission trends within key sectors across two periods. Firstly, the historical trend from 1990 to 2020, and then the forecast WEM and WAM emission outlooks for the period from 2021-2030. This section considers only NETS emissions; therefore it is noteworthy to mention that much of the 'heavy industry' emissions saw a significant drop-off where those emissions were first allocated to the ETS in 2005. These change points are noted clearly within the text describing the trends. As a broader general point, we acknowledge that whilst a sector may diminish in importance in the NETS context, national emissions are relevant.

Fuel Combustion

Fuel combustion as a whole has contributed nearly 57.4% of national net total emissions in 2020. The fuel combustion sector is a large composite sector that is made up of several major sub-sectors in their own right. These include energy industries, manufacturing and construction, transport, commercial/institutional, and residential fuel combustion.

1. **Energy Industries**

The energy industries sector includes electricity generation, waste to energy incineration, oil refining, briquette manufacturing and fugitive emissions. NETS emissions from energy industries were responsible for 1.8% of total NETS emissions in 2020. In 1990 emissions from this sector contributed approximately 20% of the national total in that year. The majority of energy industry emissions shifted to the ETS between 2004 and 2005 in the official inventory. This diminishes their relevance in the context of the ESR and NETS emissions, but of course power and heavy industry emissions remain highly relevant in the context of total GHGs. The outlook under WEM shows that NETS emissions from the sector are expected to remain steady. Cumulatively, this sector is projected to emit circa 7.7 Mt CO_{2eq} over the 2021-2030 period, approximately 2% of the current total NETS emissions budget for the 2021-2030 ESR period. The WAM scenario projects a similar outlook with lower annual emissions than the WEM scenario from 2026 but still with similar cumulative emissions of approximately 7.6 Mt CO_{2eq} over the 2021-2030 period.

2. **Manufacturing Industries and Construction**

Manufacturing combustion sectors include combustion of fuels for heating, steam generation and powering machinery. Manufacturing industries and construction contributed 2.6% of total NETS emissions in 2020. In 1990 emissions from this sector contributed 7% share of total national GHG emissions. However, as with major energy industries, large heavy industry sources shifted to the ETS between 2004 and 2005 in the official inventory. Cumulatively, NETS manufacturing and construction emissions are expected to produce approximately 10.6 Mt CO_{2eq} over the 2021-2030 period, 2.8% of the total ESR emissions budget. The WAM scenario reduces the cumulative sum to 10.7 Mt, still 2.8% of the total emissions budget for 2021-2030. It is worth noting that parallel public policy priorities

exist in regard to construction and development in Ireland. These ambitions may therefore limit the opportunities to aggressively cut emissions from the construction sector element of this source category in the time horizon to 2030.

3. Transport

Transport sector emissions primarily include combustion of fuel used in road, rail, navigation, and domestic aviation. Absolute emissions from the transport sector in 2020 are more than double what they were in the year 1990. In 1990, emissions from transport contributed a 9% share of total emissions. Emissions from this sector have increased annually since 1990 with the exception of the economic recession post-2008 where transport emissions declined slightly before resuming a modest growth trajectory in 2013. In 2020, transport emissions declined from 2019 and that trend has largely been attributed to the impact of the COVID-19 pandemic travel restrictions. The transport share of NETS emissions in 2020 was approximately 23%.

Transport emissions are expected to return to 2018/19 levels from 2022 onwards, followed by a WEM outlook that is presents a steady plateau trajectory with only minor reductions out to 2030. Cumulatively, transport emissions are expected to produce 115.6 Mt over the 2021-2030 period, which would be approximately 30% of the total ESR emissions budget of 384 Mt CO_{2eq}. The WAM scenario outlook improves on this, projecting a cumulative emissions total of 102.1 Mt over the 2021-2030 period. This represents a substantial potential emissions savings of 13.5 Mt CO_{2eq} over the ESR period. Transport, in particular road transport, is clearly a key sector in national climate policy.

4. Commercial/Institutional

The commercial services sector emissions include combustion for commercial space and water heating. Emissions from the commercial/institutional sector contributed 4% of the 2020 NETS total. In 1990 this sector also contributed approximately 4% of the national total. Absolute emissions from commercial/institutional combustion have been relatively consistent from 1990-2020 with only moderate fluctuations. The projected WEM scenario exhibits a similar trend. The cumulative emissions projected under the WEM scenario for the 2021-2030 period are 15.4 Mt, 4% of the total cumulative budget for the ESR period. The WAM scenario estimated a cumulative emissions total of 14.6 Mt over the 2021-2030 period or 3.8% of the total ESR budget.

5. Residential

Residential emissions include combustion for domestic space and water heating. The residential sector contributed 16% of the 2020 NETS total. Residential emission in 2020 are approximately 9% higher than 2019 due to the impacts of COVID-19 restrictions. However, from 1990-2010 emissions from this sector were fairly level with modest fluctuations. From 2010 onwards the trajectory has been mostly downward. Sudden fluctuations in emissions, particularly when attributed to factors such as warmer or colder winters, highlight the variability of the Irish housing stock emissions, which also flags considerations regarding heating system efficiencies and technologies across the housing stock. Measures that encourage residential retrofitting and energy efficient heating systems are critical to

improving this and reducing both emissions, and emissions volatility. This sector represents an important focus point for climate action policy in Ireland, given that the technologies, investments and policy requirements are well established. Furthermore, this is an area where parallel concerns and challenges e.g., energy poverty risk, just transition, ambient air quality, and citizen health can all be addressed with targeted policies.

WEM projections for the 2021-2030 period show expected annual reductions and emissions in the year 2030 to be 24% lower than the 2018 level of 6.8 Mt. The WEM outlook estimates cumulative emissions of nearly 59.1 Mt over the 2021-2030 period, representing 15.4% of the total 384 Mt carbon budget for the ESR period. Under the WAM scenario the cumulative emissions are estimated to be 54.2 Mt, or 14.1% of the total ESR budget. The sector offers clear opportunity for climate action, but as of yet the scale of retrofitting and heating technology change has not approached the levels necessary to deliver on the abatement potential across the multiple linked thematic areas.

Agriculture

The agriculture sector includes emissions from fertiliser application, ruminant digestion, manure management, agricultural soils and fuel used in agriculture, forestry and fishing. Agricultural activity contributed a total of 48% to total NETS emissions in 2020, and 37% of total national GHG emissions, highlighting the particular importance of the sector to national climate policy in Ireland. The trajectory of agriculture emissions has generally been one of only moderate change, the total share of agriculture in 1990 was 36% of NETS total emissions. Emissions increased from 1990-1999, decreased from 2000-2011, and have been increasing again now since 2012.

The WEM outlook for agriculture emissions from 2021-2030 shows a very modest reduction over the period with a projected emission total in the year 2030 only 175 kt less that the projected annual total in 2021. The cumulative emission total projected over the 2021-2030 period is 209 Mt, which would represent 54% of the total carbon budget of 384 Mt over the 2021-2030 period. Under the WAM scenario a projected cumulative total of approximately 186 Mt, equates to emission savings of 23 Mt compared to the WEM scenario. In the current form of national and international emissions accounting (e.g. treatment of methane emissions), agriculture is quite simply the single most important sector in the context of Ireland delivering national NETS compliance out to 2030 ESR.

Industrial Processes

Industrial process emissions include process emissions from mineral, chemical and metal industries, non-energy products and solvents. GHG emissions from the industrial processes sector accounted for 2.2% of the overall NETS emissions total in 2020. Industrial processes accounted for approximately 6% of the national total in 1990, but a share of emissions from this source was transferred to the ETS from 2005, thereby diminishing its relevance in the NETS/ESR context. Fluorinated gases (F-gases) have been a problematic growth area from this sector, largely driven by HFCs and PFCs used as ODS substitutes in sterilization equipment and as solvents in the manufacturing of adhesives, coating and inks. F-gases are used in refrigeration, air conditioning and semiconductor manufacturing. An

F-gas Regulation was published in 2014 which introduced a phase down schedule for HFCs as well as additional product bans in an effort to move towards climate friendly alternatives. 2020 was the 4th consecutive year of decreased annual emissions from F-gases, a sign perhaps that the regulation is having a positive impact.

Cumulatively, this sector is projected to produce 9.5 Mt CO_{2eq} over the 2021-2030 ESR period, representing approximately 2.1% of the currently estimated cumulative emissions budget of 384 Mt CO_{2eq}. There is only one scenario, the WEM scenario, for industrial processes based on available data.

Waste

Waste sector emissions include emissions from solid waste disposal on land, solid waste treatment (e.g. mechanical biological treatment of waste, composting), wastewater treatment, waste incineration and open burning of waste. Waste emissions contributed 2% of the total NETS emissions in 2020. Emissions in the year 2020 are 647 kt lower than in 1990, and this represents nearly a 43% reduction. Over the 1990-2020 timeframe emissions from the waste sector have gone up and down with a significant drop across the period from 2007-2014. The WEM outlook for the waste sector shows a steady downward trajectory and estimates total emissions in the year 2030 of 769 kt – approximately 136 kt CO_{2eq} less than the 905 kt recorded in the year 2020. The cumulative emissions estimate over the 2021-2030 period are 8.1 Mt. There is only one scenario, the WEM scenario, for waste based on available data.

3.2 Climate Key Pressure Points by Activity

This section focuses on reporting the key pressure points by disaggregated sub-sectoral activities that contribute the most to national climate emissions. The objective of highlighting these pressure points is to enable research and policy action to be prioritised more effectively towards those specific activities of most relevance to emissions abatement.

The data presented in Figure 4 illustrates the top ten GHG contributing activities at a sub-sectoral level based on the most recent inventory data for 2020. Table 4 elaborates on this, including projections for 2025, 2030, 2035 and 2040. The table uses only NETS emissions in kt CO_{2eq} under the WEM scenario. It includes the top ten contributing activities at a sub-sectoral level and the percentage of total NETS emissions from the top five.

Examining the climate pressure points in Table 4, we note that **across the time series the top 5 contributing activities consistently make up in the region of 80% of total NETS emissions each year**, with agriculture (enteric fermentation and soils), road transport and the residential sector making the largest contributions. Reductions in emissions from these core activities must therefore remain the priority for policy and research. Further work on policy revisions, new strategies and novel mitigation measures focused on these priority areas is reiterated. It is also imperative that policy and research consider not only technological adoption as abatement measures, but also initiatives and incentives to curtail or reverse trends in activity growth in key source sectors to 2030.

Figure 4. Top 10 Climate Pressure Points Sectoral Share of National Total Emissions (2020)

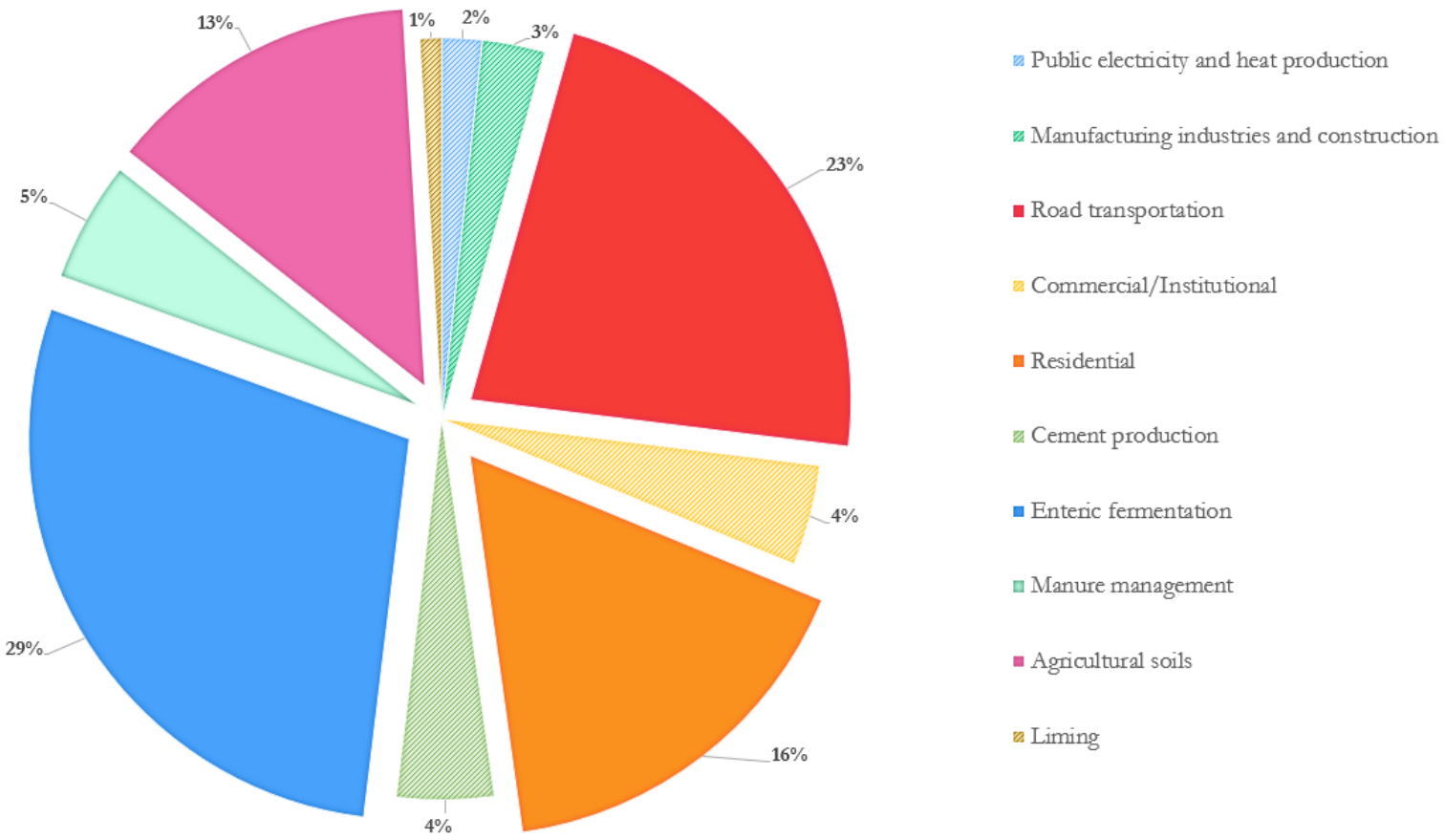


Table 4. Top 10 Climate Pressure Points (highest emitting sub-sector activities) using only 2022 WEM projections (kt CO_{2eq})

Sector	Sub-Sector	2025	% of National Total	2030	% of National Total	2035	% of National Total	2040	% of National Total
Fuel Combustion	Public electricity and heat production	804	1.78%	647	1.54%	464	1.17%	468	1.19%
	Manufacturing and construction	1,086	2.40%	932	2.22%	897	2.25%	874	2.23%
	Road transport	11,715	25.90%	9,731	23.20%	8,556	21.49%	7,869	20.07%
	Commercial/institutional	1,561	3.45%	1,276	3.04%	1,006	2.53%	934	2.38%
	Residential	5,988	13.24%	5,178	12.35%	4,487	11.27%	4,277	10.91%
Industrial Processes	Cement production	1,897	4.19%	2,034	4.85%	2,180	5.48%	2,337	5.96%
Agriculture	Enteric fermentation	12,248	27.08%	12,417	29.61%	12,581	31.61%	12,766	32.56%
	Manure management	2,190	4.84%	2,197	5.24%	2,198	5.52%	2,201	5.61%
	Agriculture soils	5,632	12.45%	5,574	13.29%	5,533	13.90%	5,516	14.07%
	Liming	715	1.58%	841	2.00%	841	2.11%	841	2.14%
% Total NETS Emissions from Top 5 Activities			**82.11%**		**81.49%**		**79.44%**		**83.21%**

3.3 Policy Response – ESR Compliance and Mitigation in Key Sectors

Selected actions are presented below from the CAP that are expected to have an impact on sectoral mitigation efforts into the future. Progress is visually represented in figures 5-9. In this section we examine these headline elements of climate action as articulated within the CAP and consider the progress made and opportunities to drive further change. This includes highlighting research or research plans as well as recommending policy revisions. Targets are considered under the separate headings of Energy, Built Environment, Road Transport, Agriculture and LULUCF. This is not an exhaustive list of all actions, but rather a selection of relevant aspects under each of the headings.

Energy

1. Increasing the share of Renewable Energy in Electricity Generation

As illustrated in Figure 5 (a), Ireland had an ambitious renewable electricity generation target of 40% by 2020. This renewable electricity target formed the backbone of the overall renewable energy target for Ireland of 16% by 2020. Data for 2020 shows that Ireland achieved a 39.1% renewable share of electricity, up 2.6 percentage points from 2019[26]. Ireland did not therefore reach the 2020 target of 40%, missing out marginally by 0.9 of a percentage point. By 2030 the contribution of renewable energy is expected to increase to 55% of electricity consumption. This share will be dominated by wind energy. As of January 2021, two peat stations[27] have closed, with the third remaining plant currently continuing with a biomass and peat blend to 2023. The Moneypoint coal fired power station is set to close by 2025. The current energy crisis may influence plans. These developments, in parallel with the ongoing growth in renewable generation, will have a strong direct impact on the emissions profile of the power sector in Ireland.

2. Electricity Interconnection

The measures included in the CAP 19 ramp up the ambition to achieve 70% renewable energy in electricity consumption by 2030, with the CAP 21 raising the bar again to a target of 80% by 2030. This greater renewable electricity consumption is to be driven primarily by further wind expansion on the grid. The CAP 21 strategy also emphasises electricity inter-connection through the development of the Greenlink 500MW interconnector to the UK (2025) and the Celtic 700MW interconnector to France (2026). These will be key infrastructural developments.

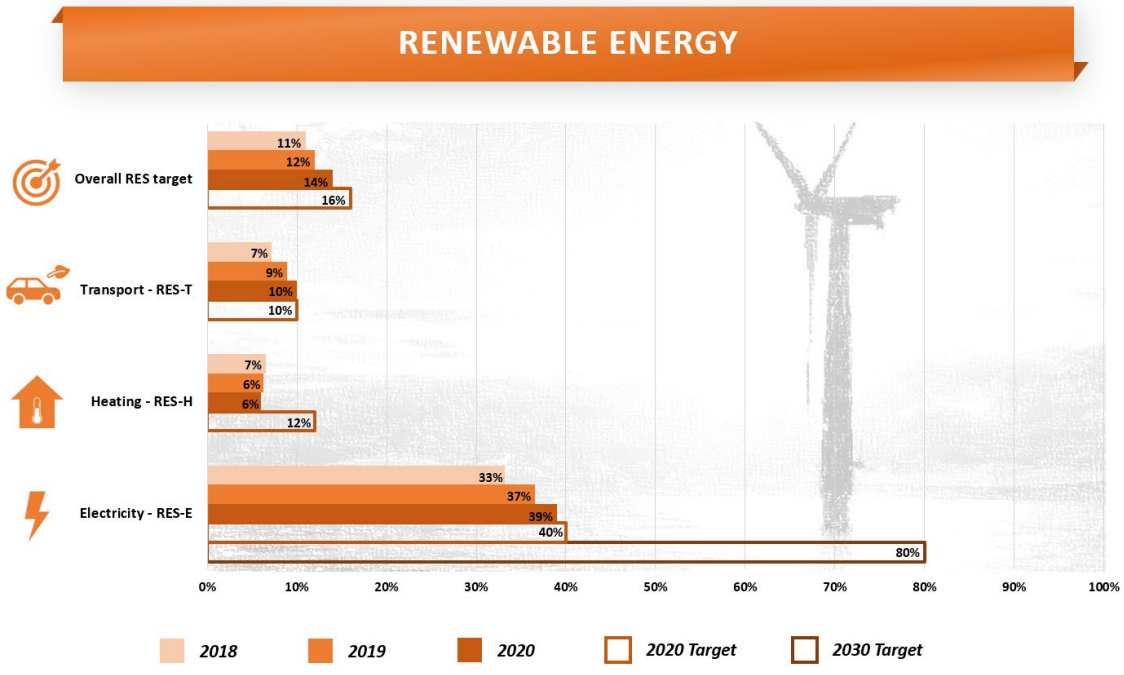
[26] https://www.seai.ie/publications/Energy-in-Ireland-2020.pdf

[27] ESB's stations in Shannonbridge in West Offaly and Lanesboro on Lough Ree. BNM's Edenderry power station will operate with a mix of peat and sustainable biomass until 2023, with an application in prospect to extend its operation using 100% biomass from 2024 to 2030.

3. Smart Meter Installation

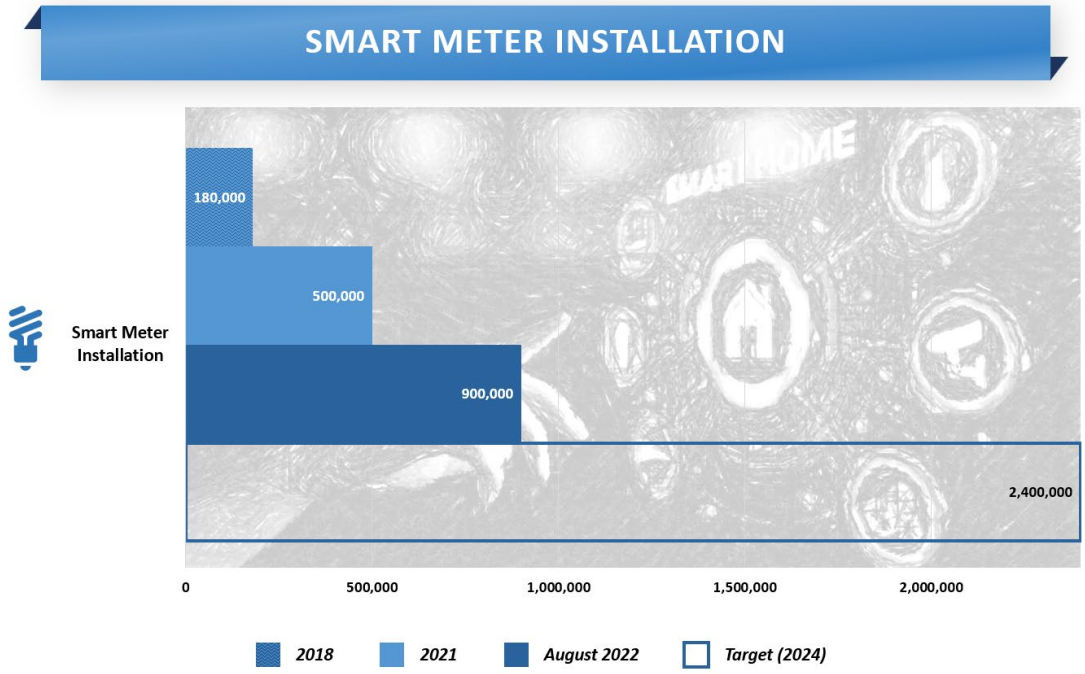
The CAP21 strategy outlines the roll-out of 2.25 million smart meters by 2024 to support better management of energy demand across the grid. As shown in Figure 5(b), Ireland was to have 250,000 meters installed by the end of 2020 with an additional 500,000 meters installed in each of the four years thereafter. However, COVID-19 restrictions have had an impact on the installation progress with an estimated total of 900,000 meters installed as of August 2022[28]. In time, the presence of smart meters, smart appliances and a smarter grid should enable artificial intelligence innovations to deliver further operational efficiency savings across many energy-consuming sectors. This latter development will represent an important factor in unlocking further energy efficiency improvements into the future without necessarily requiring an involved behavioural engagement of residential consumers and other energy users in terms of energy use decisions. However, if behaviour change and residential energy efficiency improvements based on consumer choices is a goal, then it could be beneficial to improve "real-time" options that allow more consumers to see the effect of their usage patterns. Consumers would be more likely to adjust their usage in an efficient way if tariffs were easier to calculate and for consumers to comprehend and calculate their net savings or potential savings.

Figure 5a. Targets and Progress against key measures in the Energy Sector



[28] https://www.esbnetworks.ie/existing-connections/meters-and-readings/smart-meter-upgrade/background

Figure 5b. Targets and Progress against key measures in the Energy Sector



Built Environment

1. National Retrofit Strategy

The 2021 CAP maintains the target for residential retrofits of 500,000 homes to a B2 BER standard or better by 2030, or what is now approximately 62,500 homes per year. However, the National Retrofit Plan indicates that between 2019 and 2025 120,000 B2 equivalent retrofits will be achieved which means that on average 75,000 B2 equivalent retrofits will be required per annum from 2026-2030. Achieving these targets will be supported by €8 billion in funding activated through the NDP 2021-2030 and delivered through expanded and enhanced SEAI retrofit schemes. All of this will operate in conjunction with a new nationally scaled systematic approach aimed at increasing the numbers of residential retrofits, mobilising scalable capacity development in terms of labour, supply chain integration and new approaches for aggregating and providing access for work to be done. The jump in retrofit numbers ambition to 75,000 in the second period will require the presence of multiple major retrofit operators of scale that do not exist at present within the Irish market.

The Housing for All Q2 2022 Progress Report (Government of Ireland, 2022)[29] indicates that progress on achieving the CAP target of 500,000 homes to B2 or better, has been slow. In 2020, 18,400 homes were retrofitted but only 4,000 were to a B2 standard[30]. This highlights the need to greatly increase the depth and volume of retrofits in Ireland.

[29] Gov. of Ireland - Housing for All Q2 2022 Update

[30] COVID-19 impacted the level of activity due to related restrictions.

For 2022, a total of €267 million was allocated for SEAI residential and community schemes. From this investment over 8,600 homes are targeted for upgrades to a BER of B2 (nearly doubling the output from 2021), free energy upgrades to 4,800 homes at risk of energy poverty, as well as an additional €85 million to go towards local authority upgrades of 2,400 to B2 or equivalent[31].

Progress on this front will be supported by some key cornerstones of the National Home Energy Upgrade Scheme[32]. Investment in the Better Energy Warmer Homes Scheme, commits to protecting those most at risk of poverty by more than doubling the number of free energy upgrades carried out, specifically targeting those homes with the worst energy performance. Another relevant aspect of the Upgrade Scheme is the extension of grants for attic and cavity wall insulation equivalent to 80% of the costs. This is part of the government's response to the high energy prices which have characterised the 2021 heating season and which are expected to reach record levels for winter 2022. The scheme also aims to provide increased fixed grants through the 'One-Stop-Shop' stream. Going forward support of a typical deep retrofit will increase from roughly 30% to 50%. In conjunction with the improved grants scheme, the Energy Efficiency Obligation Scheme[33] has been upgraded to focus on more extensive upgrades as well as energy poor homes. Obligated parties under the EEOS are required to provide a minimum energy uplift and to set homes on to a B2 pathway in order to be in receipt of credits. Further to this, 33% of all residential credits must come from energy poor homes.

Persisting with existing strategies will deliver some progress on retrofit, but achieving an annual rate of B2 retrofits more than 5 times greater than the rate in 2021 will require approaches that go beyond the existing elective grant supported methods and the small scale one-stop shop model that is currently being offered. A retrofit industry must be developed with projects that offer scale, cost-efficiency and increasing speeds and performance for delivery. This is necessary to ensure that the numbers of retrofits can be credibly delivered and that there is adequate incentive for supply side innovation that will drive down the overall costs of this substantial initiative. In the absence of such changes, it is difficult to envisage the pathway to be retrofitting in the region of 75,000 homes per year from 2026.

2. Air Source Heat Pump Installation

Figure 6 illustrates the target for heat pump installations as 600,000 by 2030, including 200,000 in new builds and 400,000 in existing homes, focusing on oil and solid fuel heated homes that represent roughly 50% of the housing stock. The NDP target for 2030 was 170,000 heat pump installations. The CAP 21 holds the retrofit target for air source heat pumps (ASHP) and increases the target for zero emission new dwellings to between 250,000-280,000 homes with a ramp up also of the target for zero emission heat in commercial buildings from 25,000 to between 50,000-55,000 buildings. To the end of 2020, 55,780 air source heat pumps have been installed in homes across Ireland.

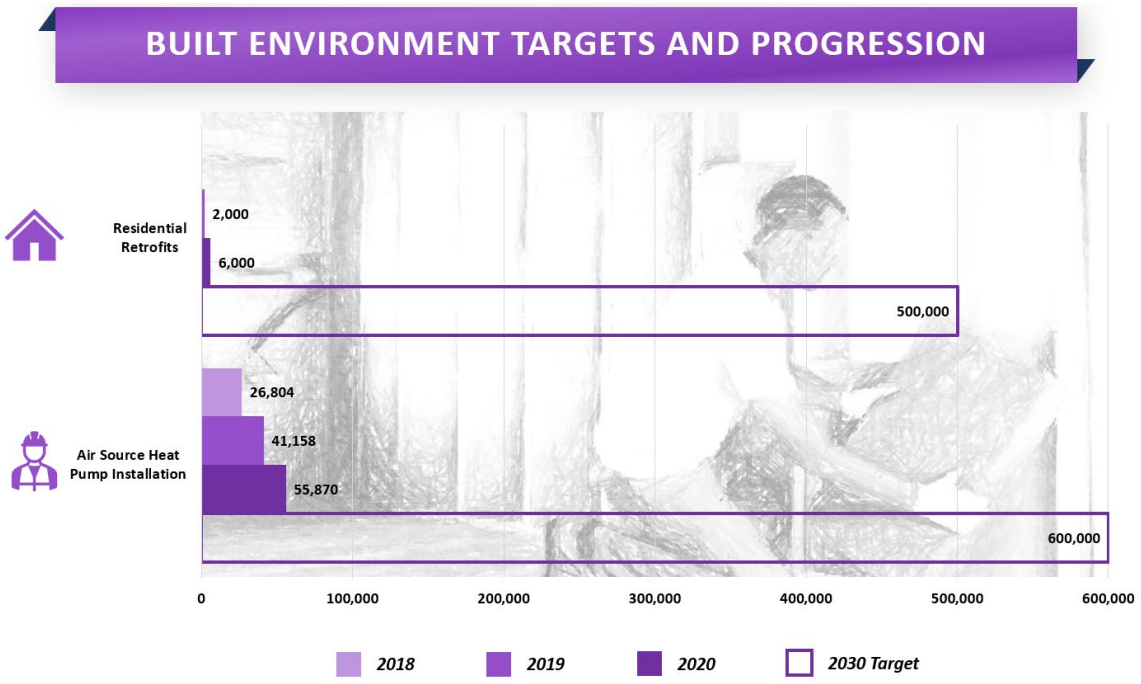
[31] gov.ie - Government launches the National Retrofitting Scheme (www.gov.ie)
[32] National Retrofit Scheme: Press Release (2022)
[33] Ireland's EOSS

The CAP 21 target will require that a new approach is developed in order to achieve the sharp increase in retrofit ASHP installation numbers. This target should certainly link with the retrofit initiative, though this should not preclude other homes from adopting an ASHP (i.e., where the heat loss performance is already adequate for an ASHP), nor indeed should it be a requisite condition such that fabric retrofits must also always choose to install an ASHP. Other approaches should also be considered to identify target markets in Ireland. Additional research by EnvEcon has been released at the end of 2022 which investigates how a targeted approach to a portion of the ASHP installation goals could positively impact on ambient air pollution and emissions of national air pollutants by addressing the substantial relative significance of residential home heating on poor ambient air quality in certain air pollution hotspots nationally. This synergistic action would also mitigate national emission totals of key air pollutants such as $PM_{2.5}$.

3. Further implementation of Energy Efficiency programmes

There are a range of residential and commercial energy efficiency schemes currently highlighted in the NDP that will further support progress in the built environment sector. These actions, including those that highlight public sector leadership, will also be important drivers of energy efficiency in the broader built environment context. Again, the CAP 21 has stepped up the targets in these areas by increasing the roll-out of district heating from 0.12 TWh to up to 2.7 TWh and increasing targets for public sector buildings from emission abatement of 30% to now 50% by 2030.

Figure 6. Targets and Progress against key measures in the Built Environment Sector[34]



[34] Retrofit figures from National retrofit Plan, heat pump figures include both retrofit and new build installations.

Road Transport

1. Active Travel and Sustainable Mobility

Active travel refers to purposeful journeys taken through means of an individual's own energy. For example, walking or cycling as part of a commute to work, school or shops. Sustainable mobility provides alternatives to private vehicle trips. This emphasises the importance of public transport infrastructure and services across the country. Both active travel and sustainable mobility are included in the CAP 21 with a target of 125,000 additional public transport and active travel journeys by 2025 and 500,000 additional public transport and active travel journeys per day by 2030. These measures will be supported by demand management measures such as reallocating road space from the private car to prioritise walking, cycling and public transport enhancing permeability for active travel, delivering safer walking and cycling routes to encourage greater uptake of active travel, and more.

The Pathfinder Programme[35] of projects 2022-2025 under the National Sustainable Mobility Policy establishes a baseline for action and implementation of related measures in real time and at a local level. These projects will, it is hoped, become the examples and case studies from which further implementation will be based across Ireland. There are 35 Pathfinder projects for 2022 across Ireland involving cycle networks, public transport and active travel.

2. Electric Vehicle (EV) Deployment

According to the MACC analysis undertaken for the CAP 21, nearly 1 million EVs will need to be on the road, in place of petrol or diesel cars, in 2030 to deliver the desired levels of emissions reductions from the anticipated fleet in the road transport sector. This figure is a substantial step-up from the target set in the NDP of just under 500,000. Included in the 1 million vehicles are passenger EVs and plug-in hybrid electric vehicles (PHEVs), as well as electric delivery vans, trucks and buses. Figure 7 illustrates Ireland's fleet electrification targets to date. As of 2021, there were 135,339 EV's on the road in Ireland, relative to a 2030 target of 945,000. Electrification of road transport was noted as being amongst the most cost-effective of measures according to the MACC developed in support of the CAP 19 and this emphasis on transport is maintained in the CAP 21. However, the emission abatement contribution from the transition will be affected by the rate of change and timing (early or late uptake), the type of vehicles and type of vehicle users that ultimately adopt them. See recent research from Guo, Kelly, and Clinch (2021) on EV uptake rates and emission impacts at https://doi.org/10.1016/j.trip.2021.100478.

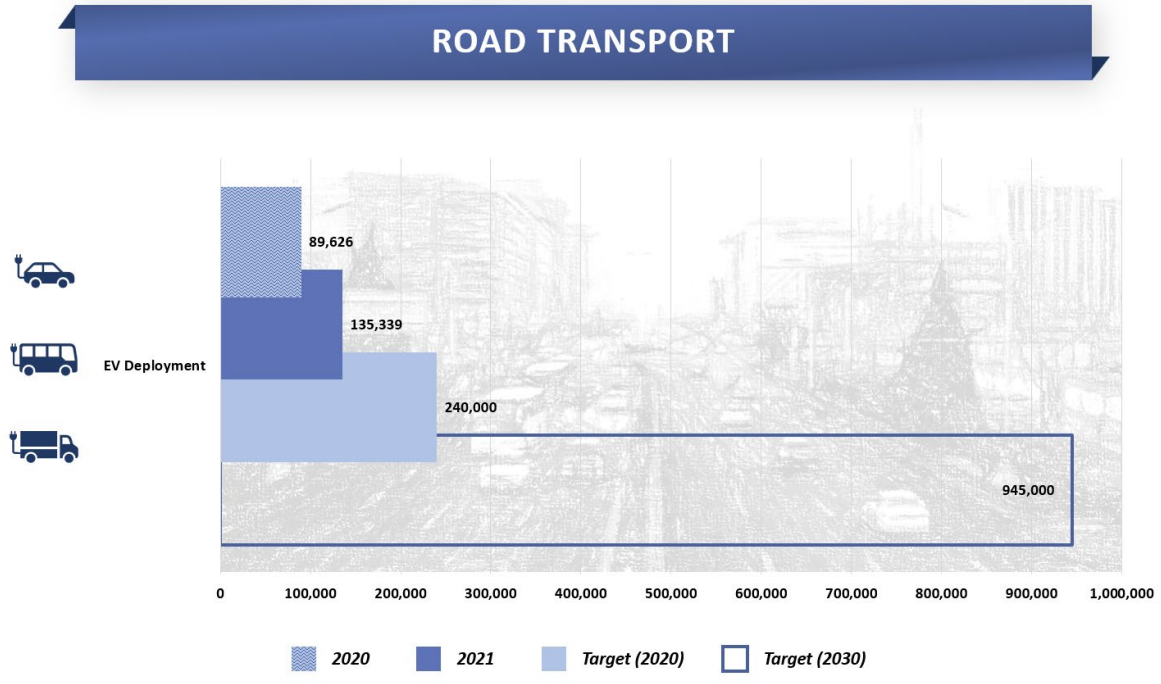
Outcomes in this sector will be sensitive to the evolution of market offerings, the natural turnover in the existing fleet, public perceptions of cost, reliability and infrastructure, the types and use profiles of vehicles displaced and so on. Thus, these all remain priority areas for research and policy design. The commercial delivery van/truck aspect is another area that warrants particular focus in the short-term given the scale of that sub sector as an emissions source.

[35] gov.ie - Pathfinder Programme (www.gov.ie)

Analysis by EnvEcon suggests that the electrification target for the commercial vehicle segment is close to equal in importance for decarbonisation of the road transport sector as the transition for the passenger car category to 2030.

Whilst challenging, the anticipated broadening of electrified vehicles available on the market is expected to offer a major boost to EV ambitions. New mainstream EVs are coming onto the market already, but expectations based on manufacturer development plans suggest 2023 onwards will see a much-enhanced selection of vehicles. There may however be supply chain challenges that prove an additional challenge in achieving the rates of sales required. In this regard, the second-hand market will be important to EV penetration in Ireland. The larger UK second-hand market will be particularly important for Ireland in accessing a larger pool of 2nd hand EVs. Whilst BREXIT presents a new complication in this regard, efforts to support access to this much larger right hand drive market could be particularly important in driving EV adoption rates in Ireland and shifting market perceptions. Importantly, contemporary detailed Total Cost of Ownership work by EnvEcon in this area highlights that for the most popular vehicle segments EVs are already more favourable even on a shorter 4 year ownership period than their petrol or diesel equivalents https://doi.org/10.1016/j.commtr.2022.100071.

Figure 7. Targets and Progress against key measures in the Transport Sector



3. Increasing the Biofuels Obligation Scheme

The biofuels obligation scheme increased to 11% in 2019 and to 12% in 2020. It will be increased to 22% by 2030. This measure can deliver a steady and reliable impact on emissions but will also ultimately be affected by fleet evolution

trends. The planned shift towards EVs will increasingly diminish the relevance of the biofuel obligation scheme, although it will remain relevant for a number of years to come as a transition measure.

While biofuels are an important aspect of national and EU policy in the context of GHG reduction targets, biofuels typically require croplands which can subsequently lead to indirect land-use changes and may cause releases of CO_2 if land with a high carbon stock is involved. The EU RED II directive, a recast of the Renewable Energy Directive, has set targets for advanced biofuels, which are liquid fuels generally derived from non-food-based feedstocks, as a share of total consumption of energy in transport sector to be at least 0.2% in 2022, at least 1% in 2025 and at least 3.5% in 2030. Simultaneously, the directive has put in place a cap of 7% on first generation biofuels, which are fuels made from food crops grown on arable land, in the transport sector by 2020. Additionally, RED II defines a series of sustainability criteria and GHG emissions criteria that bioliquids used in transport must comply with. It will be important to understand and consider what needs to be done in order to comply with the new directive sustainability requirements, how it will add to costs and potentially constrain supply.

Agriculture

1. Ag-Climatise Roadmap 2020

The Ag-Climatise Roadmap 2020 sets out a national climate plan to transition the agriculture and land use sector to achieve climate neutrality by 2050. Notably, the plan also sets out a pathway to meeting air pollution goals – particularly with regard to ammonia emissions. The report outlines a target of reducing agricultural emissions by 2030 and this ambition is underpinned by a number of key actions. The major actions are familiar, crossing themes of both climate and air, and include enhancing soil fertility, promoting the use of protected nitrogen products, developing enhanced dairy and beef breeding programs, and establishing a charter on crude protein content in animal feed.

Figure 8 shows agricultural emissions of 20.76 Mt of CO_{2eq} recorded in 2020, an increase of 0.28 from the 2019 figure of 20.48 Mt of CO_{2eq}. Action will be necessary to progress towards the CAP 21 target of 16-18 Mt of CO_2eq.

2. Improving Farm Efficiency

There are several measures and actions that are worth considering at the farm level. Specific actions include changes in fertiliser types, genomics and targeted agriculture modernisation schemes (TAMS II). Many of these measures will rely on strong knowledge transfer mechanisms to support uptake and monitor change. The Department of Agriculture has established the Agriculture Greenhouse Gas Research Initiative for Ireland (AGRI-I) which is a collaborative framework designed to build scientific expertise, measurement protocols and to address specific research issues[36].

[36] For more information Home - Agricultural Greenhouse (agri-i.ie)

This will include a focus on including mitigation strategies into the national inventory. The MACC analysis included in the CAP suggests that establishing a single point of contact or advisory board for farmers would increase the uptake of efficiency measures. Driving higher uptake rates of these measures will be a prerequisite for sectoral success. Reviewing the incentives and commitments for action will also be key in this context.

3. Herd Emissions and Feed

Reducing herd population would reduce overall methane emissions. During COP 26 negotiations, Ireland signed the Global Methane Pledge to reduce global output of methane emissions by 30% by 2030, relative to 2020 levels. However, government ministers have noted that this will be achieved through a 50% cut in non-agricultural methane, with a modest 10% reduction in agricultural methane emissions by 2030. It is probable that even this target will not be realised without additional efforts, as figure 8 (b) illustrates. Notably the recent Food Vision Dairy Group Report of 2022 highlighted, without recommendation, the abatement potential of a voluntary exit or reduction scheme in the dairy sector. It noted a voluntary exit/reduction scheme, could reduce 0.45 Mt CO_{2eq} per 100,000 dairy cows reduced.

The impact of herd number scenarios over the long-term was also a focus of the Teagasc report *Future Scenarios for Irish Agriculture: Implications for Greenhouse Gases and NH_3 Emissions* published in June 2018, which presented a series of scenarios modelled form the FAPRI-Ireland Model. The baseline scenario (S1) and five other scenarios (S2-S6) each considered uncertainties regarding future levels of agriculture activity, namely the reduction of herd numbers in relation to both dairy and suckler cows. The scenarios covered the period from 2018-2030 and clearly illustrated the strong relevance of herd size to overall agricultural emissions.

There are also new and advanced feed additives emerging in the market that suggest impressive methane reduction potentials. Whilst these have not been focused on predominantly grass-fed herds, there is development work on once daily feed additives, that could provide an operationally viable option for grass fed dairy herds in Ireland. See work at DSM on their Bovaer® product[37] and Blue Ocean Barns on their Brominata™ product[38] as examples.

4. CAP Strategic Plan 2023-2027: Development for Pillar I & II

The new Common Agriculture Policy (CAP) Strategic Plan 2023-2027 will soon be finalised. The draft CAP 2023-2027 requires that 25% of Pillar I payments (€297 million annually) be ringfenced for an 'Eco scheme' and it provides about the same level of funding, in the co-funded Agri-Environment climate measure (AECM) in Pillar II, which will replace GLAS (opt in). The draft CAP 2023-2027 also includes changes envisaged in Pillar II. This plan is all about how the financial flows from the CAP will be spent over the 5-year 2023 to 2027 period. It will come in two tranches

[37] Bovaer® (dsm.com)

[38] Blueoceanbarns.com

– Pillar I will be fully funded by the EU, and Pillar II (Regional Development) which is co-funded (43%) by the Irish Exchequer. Elements of the pillars are outlined below.

Pillar I

Ireland's response to the EU decision to ring fence 25% of direct payments (Pillar I) for eco schemes, is to propose five schemes of which farmers will have to implement two of these in order to receive the payment. These are:

a) Non-productive areas and landscape features; increased proportion of land devoted to non-productive areas and features above baseline required under GAEC i.e. 4%.

b) Extensive livestock production; specified maximum overall stocking rate for the calendar year.

c) Limiting chemical nitrogen input; specified chemical nitrogen usage limit for the calendar year.

d) Planting of native trees; planting a minimum number of native trees per eligible hectare.

e) GPS controlled fertiliser spreader to apply to chemical fertilisers; application of chemical fertiliser with a GPS controlled fertiliser spreader.

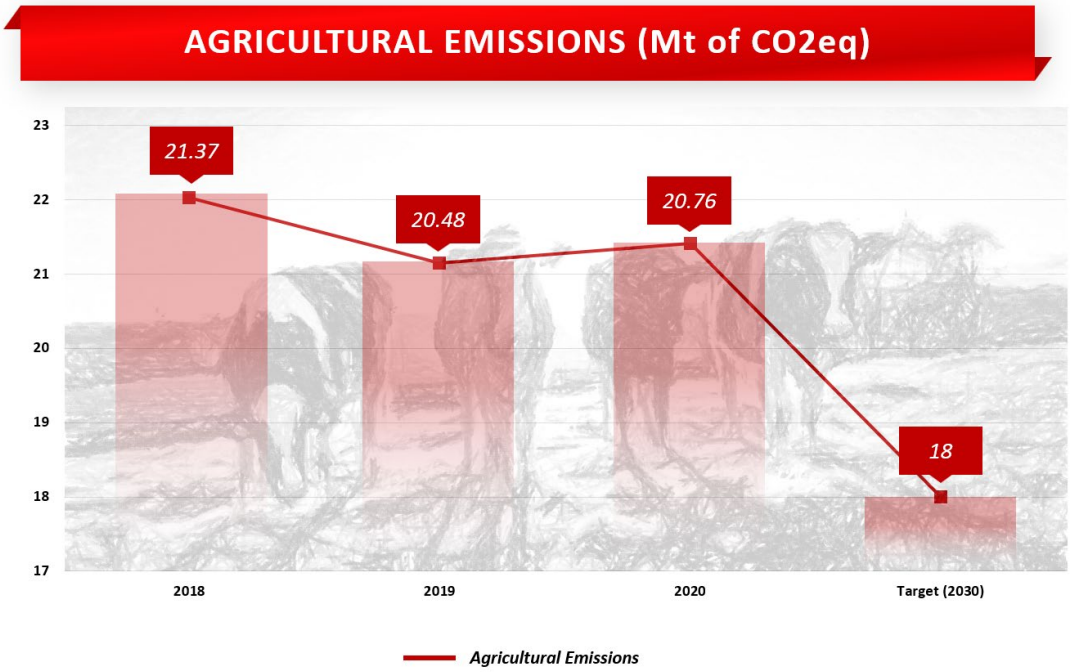
Pillar II

Under this heading, the main programme to fund climate and environmental action by farmers and foresters over the 2023-2027 period will be the Agri-environment climate measure (AECM) with an annual budget of €300 million. However Organic Farming (€51 million) and the Suckler Carbon Efficiency Programme (€52 million) will also contribute. The AECM aims to contribute significantly to achieving improved biodiversity, climate, air and water quality outcomes. These will be achieved through two options under the scheme:

1. **AECM General** option offering a range of measures for individual farmers (both targeted and general); and

2. **AECM Co-operation Project** option, available to farmers in *defined high priority geographical areas*, who opt to undertake standard measures, as well as bespoke farm, landscape and river catchment measures. Farmers participating in this option will have the assistance of a Local Cooperation Project (CP) Team, who will assist with implementation of the scheme at local level.

Figure 8. Trend and Target for Agriculture Emissions



Land-use, Land-use Change, and Forestry (LULUCF)

1. Improved Land Management Practices for Increased Carbon Sequestration

Measures targeted at generating LULUCF credits if Ireland intends to maximise use of the available flexibility for the purposes of achieving compliance are crucial. Additional measures to change and improve land management practices will also play a vital role. The CAP 21 has created targets in several areas of land management that will make improvements, these include limiting deforestation by 900ha/year, increasing the areas of rewetted peatlands, wetlands, and grassland soils, and increasing the area of cover crops planted. However, further initiatives will likely be required in the following specific areas;

a) Afforestation

As of 2017, Ireland's national forest estate had reached approximately 11% of the total land area, and the total forest area had increased from 697,842 ha in 2006 to 770,020 ha in 2017[39]. Long-term planning is critical for the forestry sector. 2022 data from the CSO suggest that the rate of tree planting has however dropped now from 6,947 ha in 2007 to just 2,016 ha in 2021. This represents a major challenge. An increase in afforestation rates will come at a cost, with more than €100million already invested in 2018 alone. The CAP 21 affirms the target of 8,000 hectares per annum target for afforestation as well as highlighting other key measures such as sustainable management of existing

[39] Figure taken from the National Forestry Inventory (2017). This inventory was updated in 2006, 2012 and 2017 and will be updated in 2023.

forests, 40,000 hectares per annum of rewetting organic soils, 450,000 hectares of improved grassland management, better management of grasslands, tillage land and non-agricultural wetlands.

Project Woodland is an interesting new forest strategy being prepared to help recognise the multiple benefits of forests in Ireland. This project proposes to deliver increased afforestation to 8,000 ha per year through the facilitation of a new forestry programme 2023 which focusses on climate smart forestry as well as continued support for sustainable forest management intervention like woodland improvement schemes, forest road schemes, forest management plans, native woodland conservation and forest knowledge transfer group.

b) Grassland management

Reducing the management intensity of grassland on drained organic soils will provide substantial potential for reducing CO_2 emissions from Ireland's land-use sector. There are many potential co-benefits from reducing grassland management on drained organic soils, such as enhanced resilience to changing weather patterns, improved water quality as well as increased biodiversity. It is worth noting that currently grassland under the LULUCF category is a net emitter, with emissions of approximately 7.6 Mt CO_{2eq} in 2020. Proposed actions for this sector include reduced management intensity of at least 80,000 ha of drained, agricultural carbon rich soils by 2030 and leveraging opportunities from the EU Just Transition Fund to support research, knowledge transfer and monitoring activities of farmed peat soils.

There are also areas which require improved grassland management approaches. Enhanced grassland management activities and practices include increased time for reseeding, expanding legumes in pasture sward embracing clover and multi-species swards, avoiding compaction, and long-term pasture management plans. Specific actions to improve sequestration on mineral grasslands, such as imposing minimum requirements under the Nitrates Regulations, will improve the management of grasslands on mineral soils.

c) Increase area of planted cover crop

Keeping up a green cover over the winter period has several environmental, agronomic, and economic benefits including taking up any remaining nutrients after harvest particularly nitrogen and reducing potential nitrate leaching over the winter period, improving soil structure and soil drainage, protecting soils from winter rainfall, and adding valuable soil organic matter over time. Actions and measures will be required to deliver an increase of cover crops in tillage and it is expected that the new Common Agriculture Policy Strategy Plan (CSP) will include a cover crop measure and a capital support measure for investment in the tillage sector to achieve to at least 50,000 ha by 2030.

d) Peatland rehabilitation

Peatlands cover approximately 21% of Ireland's land area, and make up 64% of the total organic soil carbon sink. They are the largest store of carbon in the Irish landscape. Nevertheless, this carbon store is susceptible to weather

conditions and extreme weather events. The Irish Government is committed to the rehabilitation of degraded peatlands to deliver the potential ecosystem services which offer capacity for mitigation and future carbon sequestration. There are also positive socio-economic outcomes for the Irish Midlands communities such as increased natural capital, enriched biodiversity, improved water quality, and flood attenuation. Proposed actions to deliver results in this area include restoring and rewetting raised bog Special Areas of Conservation and Natural Heritage Areas (restoration measures, hydrological management to reside peat oxidation), improve peatland mapping by continuing to fund the RePEAT Project, investing in further research to assess the potential for carbon sequestration, improved management of degraded sites and further measures to assist rehabilitated, exploited and degraded peatlands.

Figure 9a. Targets and Progress against key measures in the LULUCF Sector

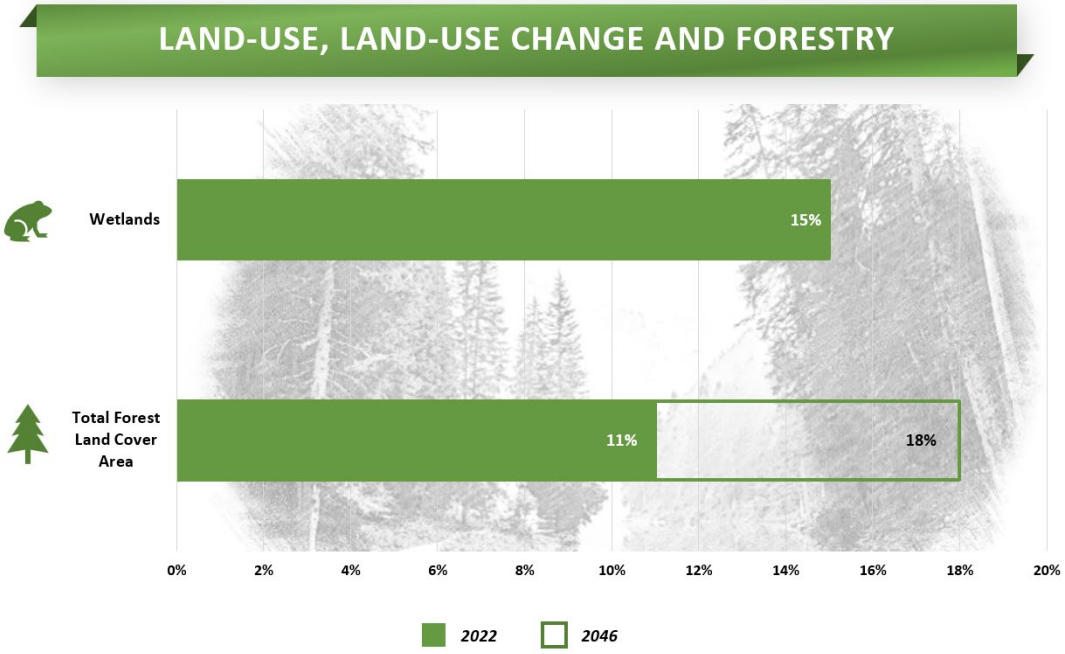
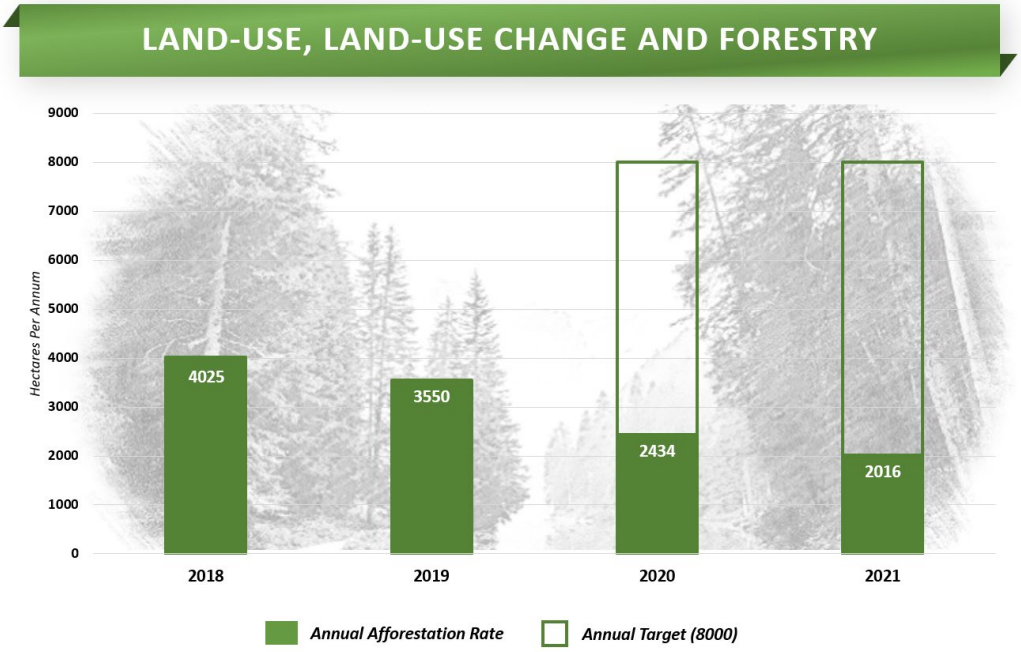


Figure 9b. Trend and Target for Afforestation[40]



Member State Climate Action Plans: How does Ireland compare?

An internal EnvEcon review of EU Climate Policies & Measures to 2030, which examined eight countries - France, Germany, Ireland, Netherlands, Latvia, Poland, Spain, and Sweden, has found that member state pathways to their respective 2030 emission reduction targets can differ considerably across sectors[41]. We note these policy documents can relate to different stages of ambitions, and it is expected that all will be enhanced in the future as part of the change in the broader EU level climate ambitions. This section offers a brief review of this prior work for Ireland.

In the built environment sector, Ireland's targets were the most ambitious of the examined countries with a target of 500,000 residential retrofits, representing the highest per capita rate of ambition. However, in this case it is important to note that this may be influenced by the house to apartment ratios of each country. In the same context, Ireland's de facto ban on the installation of fossil fuel boilers by 2023 is the earliest deadline for a measure of this kind. The Netherlands target for 75% of new homes to be built natural gas free by the end of 2021 was deemed the next most progressive target. Arguably the most ambitious long-term target was set by Spain where they are aiming for 'zero or low-emission sources' in all households by 2040. Denmark and Poland meanwhile outlined a potential model for addressing both household emissions and energy poverty simultaneously by concentrating energy efficiency upgrades

[40] Figures from CSO and Forest Statistics Ireland (2021).
[41] EnvEcon Internal Research. Gallagher, Kelly and Clinch (2021). Review of EU Climate Policies & Measures to 2030.

on low-income/social housing. Moreover, Germany's proposal for an emissions trading scheme for the transport and heat sectors aligns with the proposed EU-wide scheme, based on the recent EU 'Fit for 55' package.

In the transport sector, Ireland's targets were the most ambitious of the examined countries, having the highest EV deployment target for 2030 on a per capita basis despite having the second lowest number of passenger cars per 1000 persons. Further to this, Ireland, Denmark and the Netherlands have all committed to ending the sale of new fossil fuel cars in 2030, exceeding the EU 'Fit for 55' proposal of 2035. Moreover, Ireland's goal to stop issuing NCT certificates for all fossil fuel cars from 2045 is the only de facto target for a full phase out of fossil fuel cars. Regarding EV incentive measures, the multi-pronged approach of the Netherlands excels. The use of purchase subsides, an exemption from private motor tax for zero-emissions vehicles till 2025, and the creation of low-emission zones in large cities and towns have all contributed to the Netherlands experiencing high uptake rates in recent years, with a 14.9% share of new cars being electric in 2019. A similar solution in Ireland could help to meet targets to 2030. In terms of investment priorities, many countries have also focused on public transport, active mobility, and EV measures. Although the most significant investment for Denmark has been a new mileage-based toll system for trucks.

In the agricultural sector, Ireland's emission reduction pathway is similar to the other countries examined. Additional measures from other countries include the use of stricter requirements for manure management, targeted financial supports, and the promotion of organic farming for farms with low stocking rates. In the LULUCF sector, Ireland has an annual forestry planting target of 8,000 ha/annum, while targets relating to increased harvesting in France are the only other measures related to sustainable forestry in the examined country reports. Germany and France's land take targets are notable, with respective targets pf a maximum 30 ha/day target for 2030 and 'net zero land take' by 2050. Netherlands was the only country aiming to utilise Carbon Capture Storage (CCS) up to 2030, with an emission reduction contribution limit for CCS of 50% of all industrial emission reductions.

4. Air Mitigation Challenge

The National Emissions Ceilings Directive (NECD) 2016/2284/EU sets out the emission ceilings for each primary air pollutant from 2010-2019, from 2020-2029, and from 2030 onward where further and more ambitious ceilings will come into force. The five primary air pollutants are NO_x, SO_x, NMVOC, NH_3, and $PM_{2.5}$. The NECD also works to harmonise the reporting obligation of the Convention on Long-range Transboundary Air Pollution that requires annual submissions of an Informative Inventory Report (IIR). The EPA produces the IIR and the data and analysis shown in this EnvEcon CC report 2022 are drawn primarily from across the inventory and forecast data as reported.

Table 5 below details the emission ceilings for each air pollutant and the compliance gap for 2019 (the final year of the 1st ceiling), a compliance gap in 2020 (start of the 2nd ceiling), projected compliance gap in 2022 (current year), and projected compliance gaps in 2030 (start of 3rd ceiling) and 2035. With the exception of the 2010 ceilings, which were set as absolute values, the 2020 and 2030 ceilings are set as relative proportions of 2005 baseline emissions e.g., an X% reduction on the 2005 level of emissions for a given pollutant.

Text Box 2. Note on adjustments and emission accounting flexibilities

In exceptional circumstances the emissions inventory may be adjusted based on two criteria; the addition of new sources that were not included in inventory pre-2001, or changes in methodology based on best science, improved emission factors, or the occurrence of extraordinary weather events. This process is detailed in the Directive EU 2016/2284 under Article 4(3) and Article 5(1).

For calculating the compliance totals of NO_x and NMVOC specifically, emissions from (3b) Manure management and (3d) Agriculture soils have been adjusted as these are accepted to be new sources not included in inventory prior to 2001. Additionally, there are several sub-sectors that have been subjected to improve emission factors in relation to NOx and have therefore been approved by the EC for adjustment for all years from 2017-2021. In relation to NMVOC, there have been improved methodologies and new data made available for the Food and Beverage industry that have also allowed for EC approved adjustment for all years from 2017-2021. However, due to significant growth in this sector there is some concern over the adjustment approval going forward beyond 2021. There is more detail technical detail on adjustments included in Chapter 9 of the IIR 2022.

Importantly for the purposes of this report, there are challenges with applying compliance adjustments from inventory to projection data, and thus there is an added level of uncertainty with these projections. Adjustment are a compliance flexibility mechanism only used retrospectively once non-compliance has been made certain. For the purposes of this report and the outlook presented, particularly in the case of NMVOC, the full application of all relevant adjustments into the future have been assumed and applied. As well as, adjusted ceilings for 2020 and 2030 through a revised 2005 base year. Table 5 and Figure 12 below apply this outlook with the assumed application of all adjustments into the future and adjusted ceilings.

There are some adjustment processes of particular relevance to compliance for air pollutants. These are detailed in Text Box 2. For the purposes of this EnvEcon CC Report 2022, the same adjustments and full flexibilities used in the recalculation of inventory emissions for the purposes of compliance are also applied for NO_x and NMVOC forecast emissions, even though approved adjustments beyond the year 2021 are not yet agreed by the European Commission. EPA reporting considers the outlook for NMVOC with only the removal of particular agriculture categories as listed in Article 4(3) of Directive 2016/2284. However, this report and the outlook provided in Table 5 and Figure 12 focus on the NMVOC outlook with the full use of projected flexibilities which would include removal of food and beverage categories from NMVOC emissions now and into the future.

The overall outlook as of the current year shows that without the use of any flexibilities or adjustments, Ireland exceeded the emission ceilings for NO_x, NMVOC, and NH_3 in 2019. However, with the full application of adjustments outlined in Directive 2016/2284, both NO_x and NMVOC emissions comply in 2019, the final year of the first emissions ceiling.

In relation to NMVOC, with the application of adjustments both the WEM and WAM scenarios project that Ireland can achieve compliance for the 2020 period but the challenge for the 2030 period becomes greater. The WEM scenario shows emissions of NMVOC going above the emissions ceiling from 2037 onwards, whereas, under the WAM scenario, emissions of NMVOC remain below the ceiling out to 2040 and beyond. Clearly, measures beyond those included in the CAP 19 will be required in order to reduce emissions and deliver compliance beyond 2030.

Under the WEM scenario, although non-compliant in 2020, NH_3 emissions fall below the ceiling in 2022 and remain below the 2030 ceiling until 2040. However, the gap to ceiling is very narrow and the margin for error or deviation from the forecast is limited. Therefore, it is clear that the full implementation of CAP 19 measures are necessary as well as the additional impacts of measures and actions outlined in strategic national plans such as the updated CAPs, the NAPCP and Ag-Climatise. The pressure for action on NH_3 is a further driver for change in agriculture.

National totals for emissions under the NECD are based on values which record the amount of fuel sold across the country, and not the amount of fuel necessarily used in the country. The disparity between net fuel prices in Northern Ireland and the Republic of Ireland creates the possible incentive for "fuel tourism". This is where vehicles purchase fuel in one country for use in another. Inventories based on fuel used and fuel sold are provided for all pollutants, however, in recognition of the potential and scale of fuel tourism, Ireland can report emissions on the basis of a fuel used estimate. This EnvEcon CC report relies on the fuel used totals.

Figures 10-14 below present the most recent inventory (released in 2022 with emissions data up to and including the year 2020) projections and ceilings for each of the primary air pollutants. These figures all illustrate the WEM scenario which is the baseline scenario. The potential impacts of the WAM scenarios are discussed in the text under the sectoral highlights for each of the individual air pollutant sections. The WEM and WAM scenarios are shaped by both energy projections and agriculture projections. SEAI compile two energy projection scenarios underpinned by key

assumptions like GDP, GNP, housing stock, population, fuel price and carbon price. According to the IIR, the baseline WEM assumptions specifically include continued economic growth at a consistent rate, a €20 per tonne carbon tax that does not increase further, and a low fuel price. The WAM scenario gradually increases the carbon tax to €80 per tonne by 2030 and uses energy projections that account for the additional policies and measures that are outlined in the CAP19. Elements of these will be updated in the next round of official projections such as carbon tax trajectory to €100 by 2030 as per CAP 21.

Table 5. NECD Challenge from 2010-2019, 2020-2029, and 2030-2039, with Inventory data for 2019 and 2020 and WEM Forecast data from 2021 onwards (Green – Compliant / Red – Exceedance)

	NOx	SOx	NMVOC	NH_3	PM2.5
2005 Emissions Base Year (kt)	134.7	72.8	69.0	119.7	18.1
2010-2019 Emission Ceiling (kt)	**65.0**	**42.0**	**55.0**	**116.0**	**N/A**
2019 Compliance Assessment Total (kt)	54.5	10.9	48.5	125.4	11.8
2019 Gap to Compliance (kt)	10.5	31.1	6.5	-9.4	N/A
2020 Gothenburg Target (% reduction from 2005)	0.5	0.7	0.3	0.0	0.2
2020-2029 Emission Ceiling (kt)	**68.7**	**25.5**	**50.6**	**118.5**	**14.9**
2020 NECD Comliance Total (kt)	59.3	10.7	46.2	123.4	12.1
2020 Gap to Compliance (kt)	9.4	14.7	4.4	-4.9	2.8
2022 WM Compliance Total (kt)	56.9	8.5	45.8	117.5	11.1
2022 Projected Gap to Compliance (kt)	11.8	17.0	4.7	1.1	3.7
2030 Negotiated Compromise (% reduction from 2005)	0.7	0.9	0.3	0.1	0.4
2030-2039 Emission Ceiling (kt)	**41.8**	**10.9**	**45.8**	**113.7**	**10.7**
2030 WM Projected Compliance Total (kt)	32.0	5.3	43.8	112.6	9.5
2030 Projected Gap to Compliance (kt)	9.7	5.6	2.0	1.1	1.2
2035 WM Projected Compliance Total (kt)	30.4	4.2	44.0	113.1	9.9
2035 Projected Gap to Compliance (kt)	11.3	6.7	1.8	0.6	0.8

* This outlook summary uses fully adjusted totals for NO_x and NMVOC – this includes adjusted 2020 and 2030 ceilings (calculated from an adjusted base year for NMVOC), as well as full expected use of adjustments and flexibilities (from agriculture and food & beverage categories) for projections. The assumption is that the expected adjustments will be allowed but this is not guaranteed.

Figure 10. 2022 publication of Inventory, WEM Projections and NECD Ceilings – NO_x in kt (with full projected adjustments)

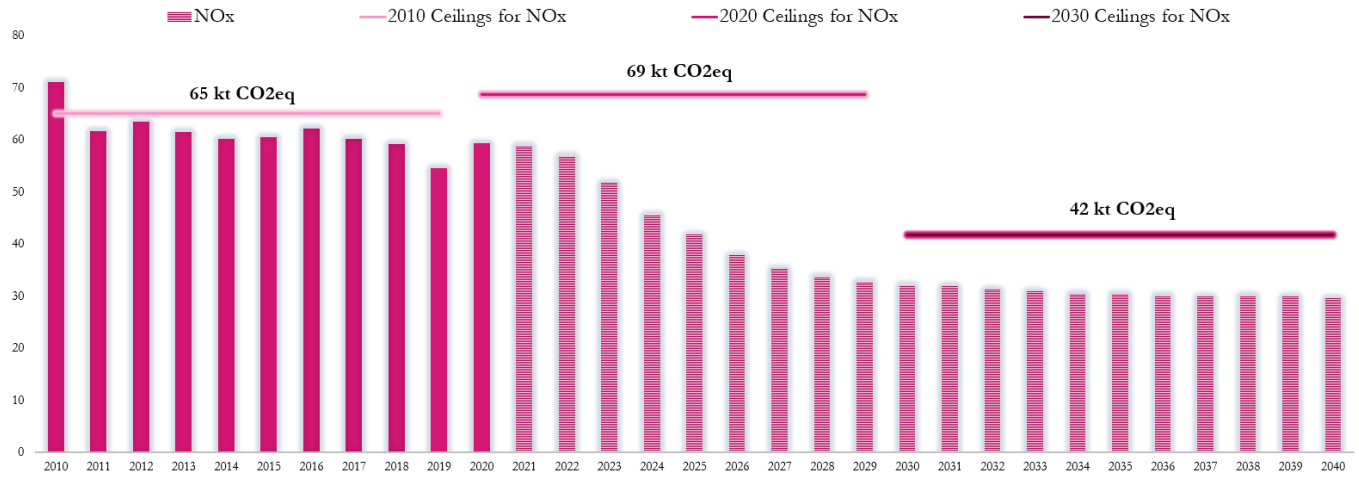


Figure 11. 2022 publication of Inventory, WEM Projections and NECD Ceilings – SO_x in kt

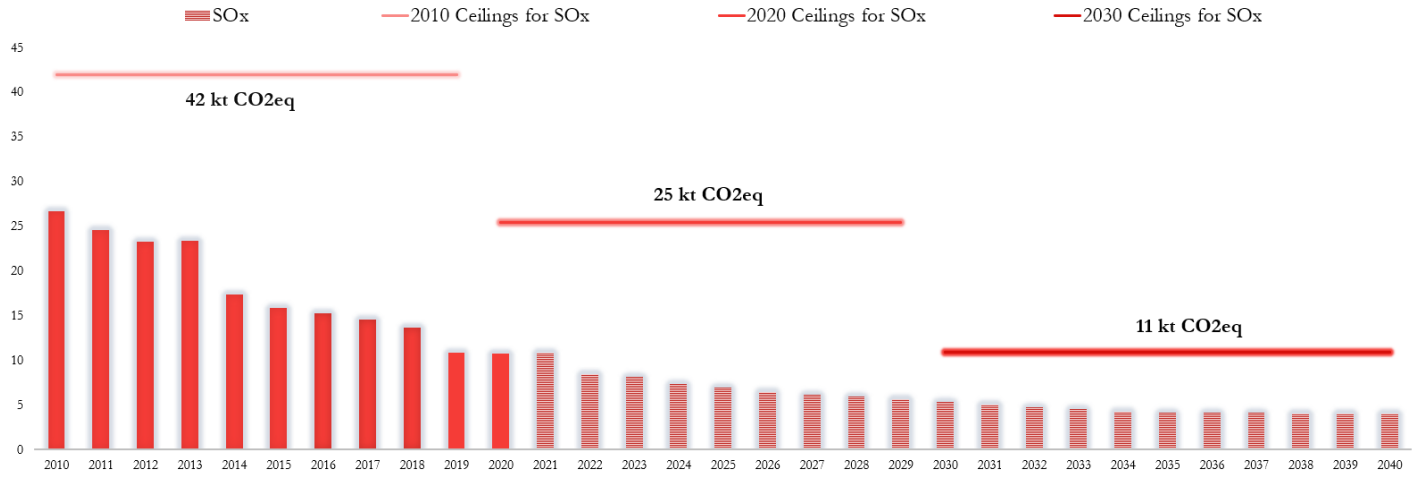
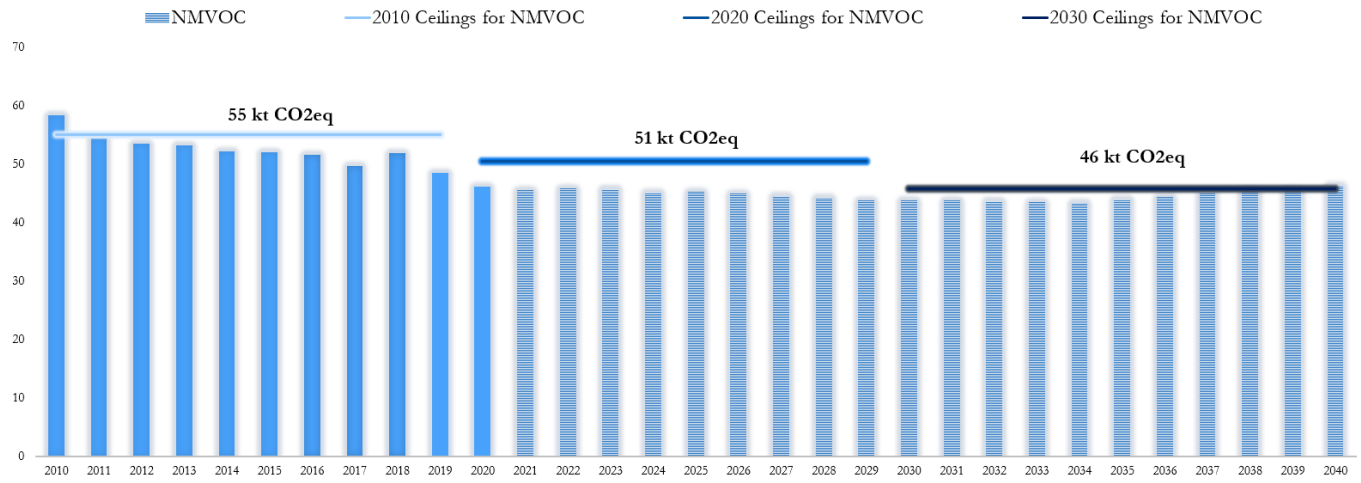


Figure 12. 2022 publication of Inventory, WEM Projections and NECD Ceiling – NMVOC in kt (with full projected adjustments and adjusted 2020 & 2030 ceilings)



*This outlook considers the full use of adjustments from Article 4(3) and Article 5(1) of EU Directive 2016/2284, including categories from the agriculture sector and food & beverage industry. Assuming the full use of these adjustments into the future, the 2020 and 2030 ceilings have also been recalculated based on an adjusted 2005 baseline figure.

Figure 13. 2022 publication of Inventory, WEM Projections and NECD Ceilings – NH_3 in kt

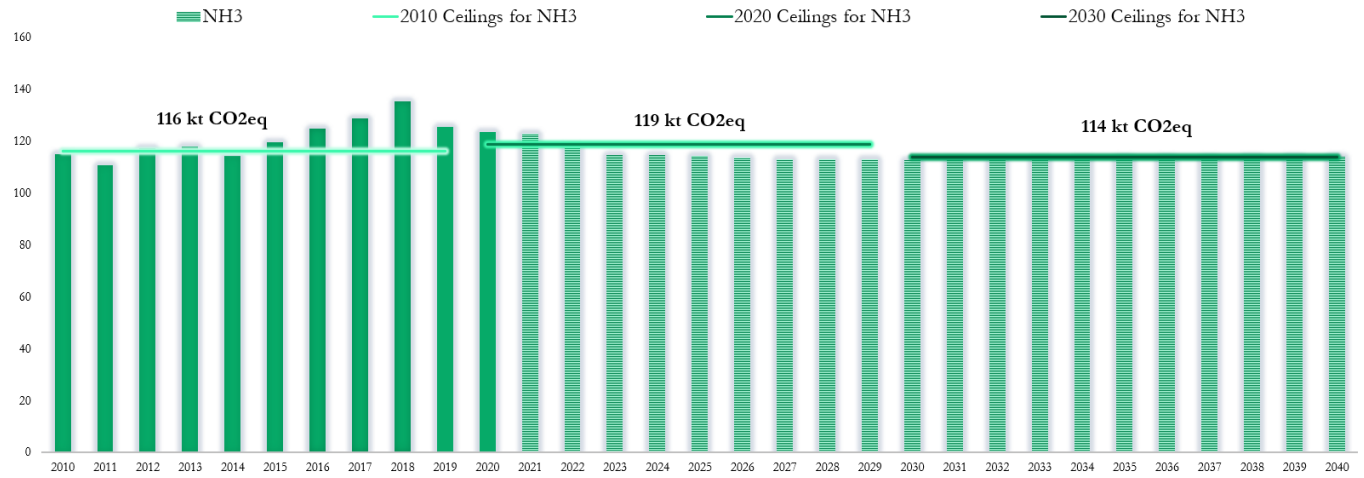
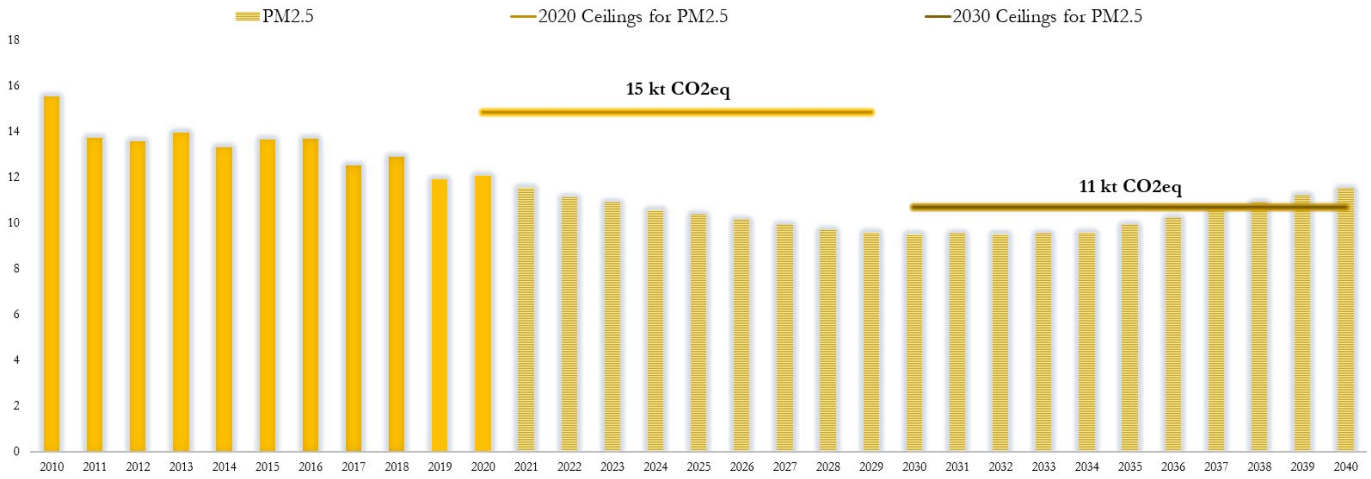


Figure 14. 2022 publication of Inventory, WEM Projections and NECD Ceiling – $PM_{2.5}$ in kt



4.1 Air Pollutants – Key Pressure Points by Air Pollutant and Activity

This section provides a summary analysis of sectoral activity and trends that are discussed in greater detail in the most recent IIR 2022 and also Ireland's Air Pollutant Emissions Report published by the EPA in 2022. For each air pollutant below the outlook under both WEM and WAM scenarios is highlighted, however, Tables 6-10 below show only the WEM forecast emissions.

The objective of analysing the key pressure points is again to identify those activities that are contributing the most to emissions and to thereby help to target research, policy and action towards those activities. To that end, it is also helpful to identify where there are activities contributing high levels of emissions of multiple pollutants and/or emissions across both air and climate. This will allow for the prioritisation of synergistic climate and air policies.

Tables 6-10 highlight the five most significant source categories of emissions for each of the main air pollutants. The categories are labelled according to the IIR to illustrate the forecast trends and changes in emissions activity. The contributions of each source are highlighted as the percentage contribution to annual national emissions for the years 2020, 2025, and 2030. The pressure point tables show total emissions before any adjustments or applied flexibilities. Note that NO_x and NMVOC emissions from agriculture should be disregarded for the purposes of compliance with ceilings, as well as a proportion of NMVOC emissions from the food and beverage industry and solvent use. However, emissions from these categories are still relevant to overall total emissions and are therefore included in the pressure points tables and analysis.

NO_x

Emissions of NO_x in the year 2020 are nearly 47% lower than they were in the year 1990. Over the current period from 2021-2029, emissions are projected to steadily decline and remain below the emission ceiling after the application of adjustments.

- Road transport is the principal source of NO_x emissions in Ireland, with the combined road transport sector contributing nearly 28% of 2020 NO_x emissions.
- Manufacturing industries and construction have had a growing share of total annual NO_x emissions since 1990 when it contributed just over 5% to the national total. This is mainly due to increased cement production. This sector contributed a total of 8.4% of the 2020 national total NO_x emissions.
- Emissions from plant production and agriculture soils accounted for nearly 36% share of total NOx emissions in 2020. This is an increase of 6.4% share since 1990. Specific sources of NO_x within this category are associated with inorganic fertilizer application and urine and dung deposited by grazing animals. These sources and the associated emissions are omitted from the compliance assessment of NOx due to the flexibilities under Article 4(3) of Directive 2016/2284.

Table 6. Top 5 Air Pressure Points – NO_x (kt)

Sub-Sector Longname	2020 (kt)	% of Total	2025 (kt)	% of Total	2030 (kt)	% of Total
Passenger cars	10.0	10.6%	4.3	5.7%	1.3	2.0%
Heavy duty vehicles	7.9	8.4%	2.1	2.7%	1.0	1.5%
Off-road transport	8.5	9.1%	9.5	12.6%	9.7	14.8%
Other sectors (Commercial, institutional, residential, agriculture and fishing stationary and mobile combustion)	12.1	12.9%	10.3	13.7%	8.8	13.5%
Plant production and agricultural soils	33.4	35.7%	32.8	43.4%	32.7	49.8%
% of Total Emissions from Top 5 Activities		76.7%		85.6%		90.4%

SO_x

Emissions of SO_x in the year 2020 are 94.2% lower than they were in the year 1990. Steady declines in the use of coal, peat and oil in the commercial and residential, public electricity and heating sectors, as well as sulphur controls have been largely responsible for the significant reductions of SO_x since 1990. Both WEM and WAM scenarios project compliance with the SO_x ceiling for the remainder of the current period as well as the 2020 and 2030 ceilings. Continued efforts to increase the use of renewable energy sources for electricity generation and reduced fossil fuels for combustion in residential, commercial, and industrial sectors should secure the current trend of declining SO_x emissions in Ireland.

- The Commercial/institutional and residential sector accounted for more than 66% of total emissions of SO_x in Ireland in 2020. In 1990 the share of national total emissions from this sector was at 83%. This remains the dominant sector for SO_x emissions in Ireland into the future.
- Energy Industries, which accounts for emission from public electricity and heat production, contributed approximately 20% to 2020 total SO_x emissions. Absolute emissions in this sectoral category have decreased by more than 98% between 1990 and 2020.
- Combustion sources from manufacturing industries and construction make up the third largest source of total SO_x emissions with just over 11% in 2020.
- In 1990, emissions from coal combustions accounted for more than 51% of SO_x emissions and fuel oil accounted for over 30% of SO_x. In 2020, coal combustion accounted for nearly 40% of SO_x and fuel oil accounted for nearly 14%.
-

Table 7. Top 5 Air Pressure Points – SO_x (kt)

Sub-Sector Longname	2020 (kt)	% of Total	2025 (kt)	% of Total	2030 (kt)	% of Total
Energy industries (Combustion in power plants & Energy Production)	2.18	0.20	0.31	0.05	0.16	0.03
Manufacturing Industries and Construction (Combustion in industry including Mobile)	1.21	0.11	1.14	0.17	0.97	0.18
Passenger cars	0.02	0.00	0.02	0.00	0.02	0.00
Off-road transport	0.16	0.01	0.22	0.03	0.24	0.04
Other sectors (Commercial, institutional, residential, agriculture and fishing stationary and mobile combustion)	7.15	0.67	5.20	0.75	3.91	0.74
% of Total Emissions from Top 5 Activities		99.8%		99.7%		99.6%

NMVOC

Emissions of NMVOC in the year 2020 are more than 26% lower than they were in the year 1990. Emissions of NMVOC are largely derived from agricultural activities, however, the flexibilities and adjustments included under Article 4(3) of EU Directive 2016/2284 allow for emissions from manure management and inorganic N-fertilizers to be removed from totals for the purposes of compliance. Emissions from the food and beverage industry, another large source of NMVOC emissions, can also be adjusted for the purpose of compliance under Article 5(1) of EU Directive 2016/2284, but only retrospectively should annual totals prove to be non-compliant. For both the WEM and WAM scenarios, with only the agriculture categories omitted in accordance with Article 4(3), it is projected that NMVOC emissions will be above the 2020 and 2030 ceilings. Assuming a full application of adjustments included in Article 5(1), both WEM and WAM scenarios project that Ireland can remain below the 2020-2029 ceiling. Under both WEM and WAM outlooks, emissions of NMVOC begin to rise from approximately 2035 making the gap to ceiling very narrow and indeed exceeding the 2030 ceiling in the final year of the 2030-2039 period under the WEM outlook.

- Combined agricultural categories accounted for 41% of national total NMVOC emissions in 2020 - dairy cattle and non-dairy cattle alone account for over 30% of the national total NMVOC emissions in 2020. This shows an increase combined agriculture emissions of 12% from 41kt in 1990 to 46kt in 2020.
- Solvent and other product use contributed over 16% to total NMVOC in 2020.
- Industrial processes, including the food and beverage industry, contributed nearly 24% to total NMVOC in 2020.
- Combustion sources from residential and commercial/institutional sectors contributed 9.7% to total NMVOC emissions in 2020.

Table 8. Top 5 Air Pressure Points – NMVOC (kt)

Sub-Sector Longname	2020 (kt)	% of Total	2025 (kt)	% of Total	2030 (kt)	% of Total
Other sectors (Commercial, institutional, residential, agriculture and fishing stationary and mobile combustion)	10.9	9.7%	8.0	7.2%	6.4	5.8%
Industrial Processes	26.7	23.7%	27.8	25.0%	28.9	26.2%
Solvent and other product use	18.2	16.2%	18.9	17.0%	19.7	17.9%
Cattle Dairy	11.3	10.0%	11.8	10.6%	12.4	11.2%
Cattle Non-Dairy	23.5	20.8%	21.5	19.3%	20.1	18.2%
% of Total Emissions from Top 5 Activities		80.4%		79.1%		79.4%

NH_3

National total emissions of NH_3 have increased by 12.4% in 2020 compared to 1990 levels, emissions from the agriculture sector accounted for 99.4% of total ammonia emissions in 2020. The main sources of NH_3 emissions are combined livestock production, primarily the cattle herd. The second most significant source is agricultural soils. Ireland has exceeded emissions of NH_3 for all years from 2016-2020. The current outlook for both WEM and WAM scenarios shows emissions of NH_3 exceeding the 2020 ceiling in 2020 and 2021 before falling below the ceiling from 2022 onwards. Compliance is maintained for each year from 2022 to 2029 and continues under the 2030 ceiling for all years from 2030-2039.

- Combined activities within livestock production and manure management accounted for nearly 48% of total NH_3 emissions in 2020. Within this sector it is dairy cattle and non-dairy cattle that account for the majority share, contributing a combined total of 40.5% of the total NH_3 emissions.
- Plant production and agricultural soils includes a number of categories and activities such as animal manure applied to soils, sewage and sludge applied to soils, inorganic N-fertilisers, and urine and dung deposited by grazing animals. These combined categories account for over 50% of total NH_3 emissions in 2020.

Table 9. Top 5 Air Pressure Points – NH_3 (kt)

Sub-Sector Longname	2020 (kt)	% of Total	2025 (kt)	% of Total	2030 (kt)	% of Total
Cattle Dairy	15.1	12.2%	16.2	14.2%	17.5	15.5%
Cattle Non-Dairy	34.7	28.1%	32.7	28.6%	30.8	27.4%
Swine	4.9	4.0%	5.0	4.4%	5.2	4.6%
Poultry	3.4	2.8%	3.8	3.3%	4.1	3.7%
Plant production and agricultural soils	62.7	50.8%	53.6	47.0%	52.0	46.1%
% of Total Emissions from Top 5 Activities		97.8%		97.6%		97.4%

$PM_{2.5}$

Emissions of $PM_{2.5}$ in the year 2020 are nearly 58% lower than they were in the year 1990. Emissions from residential, commercial/institutional sectors account for the majority of $PM_{2.5}$ emissions in Ireland, there has been a significant reduction in emissions from these sectors due to reduced coal and peat combustion. The WEM scenario for $PM_{2.5}$ shows compliance for the remainder of the current period out to 2029. However, under the lower 2030 ceiling emissions of $PM_{2.5}$ are shown to exceed the 2030 ceiling in the years 2038 and 2039. The WAM scenario shows compliance throughout the 2030-2039 period however with an increasingly narrow gap. It is also stressed that from a human health policy perspective there are no presumed 'safe' levels of particulate emissions.

- Emissions from combined residential and commercial/institutional sectors contributed over 59% of total $PM_{2.5}$ emissions in 2020. Emissions of $PM_{2.5}$ from these sectors are 66% lower in the year 2020 than 1990 levels.
- Combined transport categories contributed just over 10% of total $PM_{2.5}$ emissions in 2020. Transport emissions of $PM_{2.5}$ have been on a steady downward trajectory due largely to improvements in vehicle technology and advancements in the age and structure of the national vehicle fleet.
- Emissions from manufacturing industries and construction contributed over 11% to total $PM_{2.5}$ emissions in 2020, a 12% reduction in emissions of $PM_{2.5}$ from this sector since 1990. This downward trajectory has continued since 2005 due to technological advancements.

Table 10. Top 5 Air Pressure Points – PM2.5 (kt)

Sub-Sector Longname	2020 (kt)	% of Total	2025 (kt)	% of Total	2030 (kt)	% of Total
Manufacturing Industries and Construction (Combustion in industry including Mobile)	1.4	11.6%	1.7	16.0%	1.8	18.4%
Automobile tyre and brake wear	0.5	4.1%	0.6	5.9%	0.5	5.3%
Other sectors (Commercial, institutional, residential, agriculture and fishing stationary and mobile combustion)	7.2	59.9%	5.4	52.3%	4.7	49.4%
Industrial Processes	0.4	3.3%	0.5	4.3%	0.5	5.1%
Cattle Non-Dairy	0.3	2.7%	0.3	2.8%	0.3	2.9%
% of Total Emissions from Top 5 Activities		80.0%		81.6%		81.0%

4.2 Policy Response: NECD Compliance and Mitigation in Key Sectors

Improving air quality has important implications for our natural environment and human health. The five main regulated air pollutants, NO_x, SO_x, NMVOC, NH_3 and $PM_{2.5}$, are associated with dangerous and harmful effects including acidification of soils and surface water, as well as having a range of negative impacts on human health.

Broadly, some of the key cross-cutting policy drivers that have the largest positive impact on emission trends across air pollutants include fuel switching away from coal and peat to cleaner fuel sources in the residential sector, higher penetration of renewables in electricity generation and shifts away from coal and peat fired power. In terms of the transport sector, in spite of a growing national vehicle fleet, particularly for passenger vehicles, changes in the age structure of the fleet and improved Euro standard penetration have made a strong positive impact, notwithstanding the challenges posed by the prior dieselisation trend in the fleet. Based on the pressure point analysis in the previous section, the compliance and mitigation strategy for air pollutants should continue to focus on the transport, agriculture and residential sectors. Thankfully, many of the measures that are highlighted here as part of addressing the air mitigation challenge are also highlighted in addressing the climate mitigation challenge. This is because many key measures offer direct co-benefits for both climate and air (e.g. electrification of transport, energy efficiency). Consideration of the interdependencies between climate and air policy should therefore continue to play an important role in the development of comprehensive air and climate policy design and effective implementation. It also affords the opportunity to communicate broader wins for society to encourage further change.

There are several policy priorities and actions highlighted in the CAP 19, and reinforced in the CAP 21, that will help to set Ireland onto a pathway for compliance for 2030 and indeed 2050. These measures include approximately 1 million EVs on the road by the end of 2030; a total of 600,000 heat pump installations across both new (200,000) and existing houses (400,000) by 2030; and 500,000 residential retrofits to a B2 building energy rating (BER) standard by 2030. Below is a list of some of the current core mitigation policies in line with the CAP 21 that are expected to have a substantial impact on sectoral mitigation efforts for air pollution into the future.

Energy

1. **Focus on Renewable Electricity Generation**

Electricity generation has been an important source of NO_x and SO_x in Ireland. Longer term changes in the power sector and increased levels of renewable energy for power generation in Ireland have been highly relevant to further reductions of these key air pollutants. 2020 was an important year in terms of determining whether or not Ireland would meet the EU renewable energy targets. Despite the most significant annual reduction in total energy use since the height of the economic recession in 2009, down almost 9% in 2020 due to COVID-19 pandemic, Ireland missed the renewable energy target. The overall share of renewable energy was 13.5%, falling short of the 16% 2020 target.

The share of renewable electricity was 39.1%, just shy of the 40% 2020 target, the renewable transport target of 10% was met, however just half, 6.3%, of the renewable heating and cooling 12% target was achieved.

WEM projections show renewable energy contributing 55% of electricity consumption by 2030. This is expected to be dominated by wind energy. The more ambitious WAM target set out in the CAP 19 aims for this to increase to 70% renewable energy in electricity generation by 2030, again driven primarily by further wind expansion. The CAP 21 goes even further and increases this target to 80%. These changes, in particular the displacement of other more polluting activities in an air pollution context, are expected to deliver strong sectoral abatement progress for the future.

2. Phasing out Peat and Coal

Two of the Irish peat stations[42] have closed as of December 31st, 2020, with the third remaining plant currently continuing with a 30% biomass and peat blend out to 2023. Removing peat from the power generation sector will have a direct and substantial impact on air pollutant emissions from this sector. Similarly, the planned closure of Moneypoint, Ireland's only coal fired power station, by the end of 2025 will remove another relevant and substantial source from the national air pollutant inventory.

Built Environment

1. Energy Efficiency Retrofit Programmes

There are various support schemes from the SEAI that focus on improving energy efficiency and electrification through retrofitting including the development of 'One-Stop-Shop' mode for residential and commercial energy efficiency upgrades. The scale of action to date has been modest – in terms of deeper retrofits – however the goal of retrofitting, and in particular targeted retrofitting of those at risk of energy poverty, and those who use higher emitting fuels to heat their homes, remains a necessary goal for addressing emissions from this sector. Greater effort on targeted actions of scale to address residential and commercial energy efficiency are required. EnvEcon has a variety of work in the context of retrofit and heat pump targeting – see 2022 paper https://doi.org/10.1016/j.aeaoa.2022.100155

2. District Heating

District heating is an efficient approach to heating, employed in many northern European countries whereby large heating networks are used to fuel entire districts. The fundamental idea is that these larger systems are more efficient and can capture fuel or heat that would otherwise be wasted to provide heat for end users[43]. Johansen and Warner

[42] ESB's stations in Shannonbridge in West Offaly and Lanesboro on Lough Ree. BNM's Edenderry power station will operate with a mix of peat and sustainable biomass until 2023, with an application in prospect to extend its operation using 100% biomass from 2024 to 2030.

[43] Regulation and Planning of District Heat in Denmark

(2022)[44] detail the Danish District Heating system in which the majority of generation comes from Combined Heat and Power (CHP) generation however district Heating can rely on large fossil fuel boilers as well as renewable heat sources. The present focus in the Danish context is on further decarbonisation of the system[45], with heat pumps seen as a way of replacing thermal generation and the potential to add additional CHP and waste heat from industry recognised. District Heat is most effective in areas where the building density (and thus heating density) is relatively high as this allows for installation of more heating capacity and reduces the cost of pipe infrastructure and heat loss.

Deployment and effective roll-out of district heating systems and the establishment of a suitable district heating regulatory framework are identified by CAP 21 as necessary contributions to achieving sectoral targets. The District Heating Steering Group is due to report to Government by the end of 2022 and will advise on how targets may be met. CAP 21 sets out a core measure to increase targets for roll-out of district heating up to 2.7 TWh of district heat supplied by 2030. At present there are two district heating projects in development which aim to supply low- and zero-carbon heat to homes, businesses and public buildings. These include: the Tallaght District Heating Scheme through which waste heat from an Amazon Data Centre will provide heat to local buildings[46] ; and the Dublin District Heating System[47] in which the Waste to Energy facility in Dublin's inner-city will be harnessed to provide heat locally.

3. Solid Fuel Regulation

From September 2020, all towns in Ireland with populations over 10,000 people are covered by the Low Smoke Zone (LSZ) regulation. This regulation places a ban on the burning of smoky coal and other prohibited fuels, including the marketing, sales and distribution. EnvEcon have previously provided detailed research to DECC in relation to the potential options for smoky coal regulation and low smoke zones. Whilst low smoke fuel is not emission free, this measure can deliver a positive interim effect and potentially trigger a broader shift away from solid fuel combustion.

In 2021 a suite of new nationwide solid fuel regulations were formally proposed to address the impacts associated with residential air pollutant emissions. These came into effect as of October 31st 2022. To provide a policy impact assessment, EnvEcon developed a methodology to estimate the associated emissions, health, and environmental impacts of the proposed changes included in the new regulations subject to specific defined assumptions. A time-series analysis was presented across the years 2023, 2024 and 2025 to capture the impacts of the transitions. This method characterises the outcomes of the proposed regulations principally in the form of fuel switches and changes in the associated emission factors of specific fuels. These actions are a good step in the right direction for air pollutant abatement and air quality, however further efforts to address solid fuel combustion in the sector will be required.

[44] Something is Sustainable in the state of Denmark (2022)

[45] Foresight Denmark

[46] Codema: Tallaght District Heating

[47] Dublin District Heating System

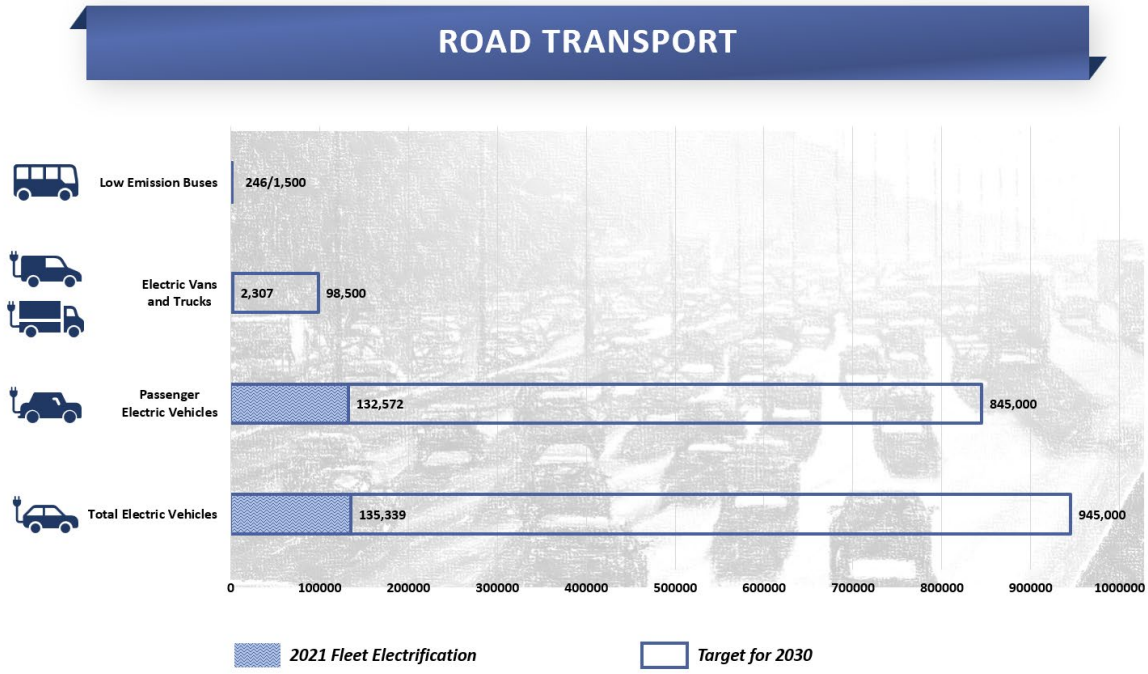
Road Transport

1. Encouraging Modal Shift

Modal shift is challenging, but there is evidence of progress. The Canal Cordon Report 2019[48] recorded an overall mode share for sustainable transport modes – walking, cycling and public transport was 72%, the highest level recorded since 2006. There has been a trend of increased mode share for sustainable transport modes since 2010. Nonetheless, further growth in walking and cycling is necessary nationwide and this should be facilitated by the ongoing walking and cycling infrastructure investments.

Initiatives taken by the government, such as the Pathfinder Programme[49] of projects 2022-2025 under the National Sustainable Mobility Policy, is an essential step in establishing a baseline strategy of good specific initiatives in the transport sector. The Pathfinder projects will set a precedent for actionable measures that can be implemented at a local level. So far these include 35 projects across Ireland involving cycle networks, public transport and active travel.

Figure 15. Targets and Progress of EV Deployment by Vehicle Type[50]



[48] Canal Cordon Report 2019 - National Transport

[49] gov.ie - Pathfinder Programme (www.gov.ie)

[50] Fleet figures sourced from vehicle license data and registration data from the Department of Transport.

2. Electric Vehicle (EV) Grants and Tax Scheme

As of 2021, there were 135,339 EV's on the road in Ireland, relative to a 2030 target of 945,000. Illustrated in Figure 15 are the number of electric vehicles in 2021 according to vehicle type. Of the total fleet in 2021 4.68% of vehicles were electric with 1.6% of buses electric, 0.49% of vans and trucks electric and 5.63% of passenger vehicles electric.

Text Box 3. EnvEcon Transport Fleet Modelling Assumptions and Outcomes from 2021

In house transport fleet modelling has shown that air pollutant emission reductions can be delivered by achieving a target for EV deployment. However, electrification goals and their impact on emission outcomes are highly sensitive to the total number of EVs, the speed and timing of EV uptake in the market, the technology and use characteristics of the vehicles displaced or replaced by policy and the degree to which policy targets the categories of passenger cars, trucks and vans as part of the overall strategy.

The potential impact of EV penetration on key air pollutants has been modelled under three distinct scenarios:

1) The NDP 500,000 passenger EVs by 2030 (moderate ramp-up)
2) 1million EVs by 2030 (moderate ramp-up)
3) The CAP19 840,000 passenger EVs, 95,000 e-vans, and 1,200 e-buses by 2030 (early ramp-up)

The outcomes are as follows:

NOx	**NMVOC**
Scenario 1 - a cumulative reduction by 2030 of 1.42 kt	Scenario 1 - a cumulative reduction by 2030 of 1.19 kt
Scenario 2 - a cumulative reduction by 2030 of 3.53 kt	Scenario 2 - a cumulative reduction by 2030 of 2.39 kt
Scenario 3 - a cumulative reduction by 2030 of 13.62 kt	Scenario 3 - a cumulative reduction by 2030 of 4.66 kt
PM10	**SO2**
Scenario 1 - a cumulative reduction by 2030 of 0.29 kt	Scenario 1 - a cumulative reduction by 2030 of 0.03 kt
Scenario 2 - a cumulative reduction by 2030 of 0.61 kt	Scenario 2 - a cumulative reduction by 2030 of 0.07 kt
Scenario 3 - a cumulative reduction by 2030 of 1.39 kt	Scenario 3 - a cumulative reduction by 2030 of 0.18 kt

Text Box 3 contains detailed information based on in house fleet analysis research conducted by EnvEcon. The research paper is available at https://doi.org/10.1016/j.trip.2021.100478. This research uses measures and targets from the CAP 19 to demonstrate the potential impact of various scenarios on emissions of air pollutants. However, a further challenge in the context of EVs is the overall growth in the transport fleet. Where the EVs are being added to a growing fleet, the absolute emissions will face upward pressure. Therefore, whilst EV policy is key, controlling or incentivising a moderation of the vehicle fleet growth is also important to investigate for future policy. From the air pollution perspective however, the increased Euro standards do have a strong impact on curtailing air pollution emissions from the sector into the future.

Agriculture

The main measures for control and abatement of ammonia emissions in the agriculture sector are well established. Teagasc have provided contemporary analysis of options in this context that are clearly set out in the 2020 Ammonia Marginal Abatement Cost Curve report - NH3-Ammonia-MACC.pdf (teagasc.ie). The main measures related to low emissions slurry spreading for the bovine herd and protected urea. A challenge over the years in this regard has been delivering uptake rates and incentives to act for the key measures. This remains the challenge.

5. EnvEcon Research Spotlight

This section is intended to highlight specific, relevant research by the EnvEcon team. All of our research topics in this context are focused on providing support to inform effective policy adjustment and deployment in Ireland. Beyond this highlighted list of research, EnvEcon is also continuing to work on a research portfolio that focuses on policy design, policy tailoring and the targeting of dynamic policy interventions. In sectors including transport, agriculture, forestry and the built environment, our analyses will support the drive for higher uptake and impact rates.

Transport - Total Cost of Vehicle Ownership (TCO)

This research offered a dynamic and spatial analysis for road transport TCOs in Ireland. The work entails detailed analysis of the total cost of vehicle ownership in Ireland. The presented methodology calculates and contrasts the total cost of ownership across a range of cars and driving profiles, in the current Irish policy framework of taxes, grants and fuel prices. The actionable objective of this research is to ensure routinely updated communication of total cost of ownership metrics to the market to ensure there is clarity on the relative performance of EVs and ICEs for defined driving profiles over short time horizons. Results showed that EV options in the most popular Irish car segments

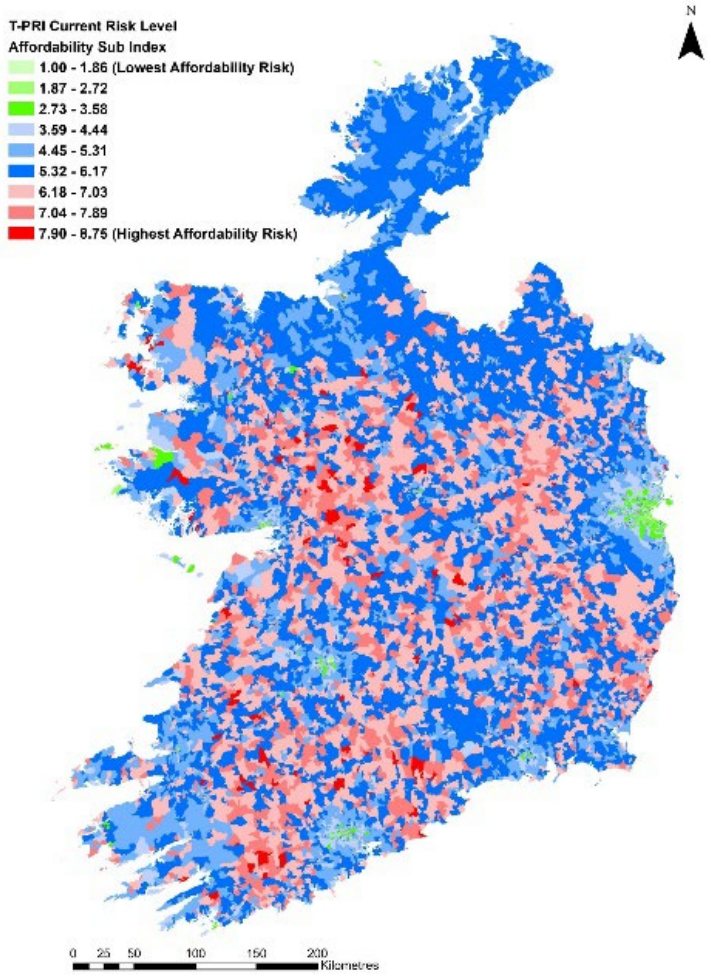
already have existing battery EV options with a TCO averaging respectively 26% and 42% less than their equivalent petrol and diesel ICEV options over a 4-year ownership term when the current grant is included. The paper is available at https://doi.org/10.1016/j.commtr.2022.100071

Figure 16. Components of the Total Cost of Ownership (TCO)

Transport – Transport Poverty Risk Index

This working paper finalised in late 2022, focuses upon private road transport travel and adopts the concept of Transport Poverty Risk (TPR) as a catch-all for the impacts that may result from changes in transport costs, access to transport services, and related transport policy interventions and investments. The motivation for understanding TPR at a fine spatial scale, and objectively analysing how TPR is influenced by potential policy changes, is to offer policy makers valuable decision support for prioritising investments, targeting supports, monitoring relative progress and ultimately supporting policy design that can mitigate emissions whilst also managing TPR as part of a just transition. Taking Ireland as a case study country, a granular spatial index of TPR (TPRI), based on three core pillars of transport affordability, mobility, and accessibility, is constructed. Three illustrative scenarios, all relevant to Irish climate action, are assessed and presented to showcase the TPRI capacity. The results highlight clear disparities in transport poverty risk across Ireland, but similarly they show that high and low risk are not uniquely attributable to either urban or rural areas. This is important as local authorities should be supported in targeting and prioritising their actions over time, as well as monitoring how developments in areas such as fuel prices (e.g. current volatility) and policy (e.g. public transport investments) may impact specific areas in terms of TPR. The map in Figure 17 is at the national scale which masks the finer detail available at the small area resolution which includes spatial clusters of ~<100 homes.

Figure 17. Spatial Distributions of TPR Affordability Sub-Index

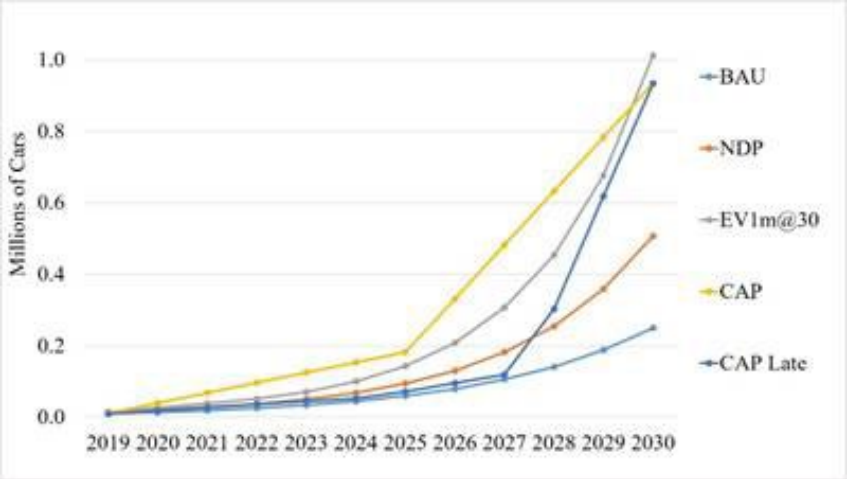


Transport - Road Transport Electrification Timing

Targets for electrification of the road-transport sector are often set as the number of electric vehicles to be operating within the fleet by a certain date. Although there is recognition that timeframes for these transitions matter, research often focuses on these total numbers and upstream power considerations. This can cause uncertainty for policymakers regarding the impact of an aggressive, or deferred, incentive strategy to drive EV uptake rates at a given point in time. This methodology explores road transport electrification scenarios with a particular emphasis on the timing of uptake rates, the focus on passenger or goods vehicles, and the outcomes for air and climate policy. This work can be particularly useful and relevant in the case of understanding the evolution and ambitions of EV uptake rates within commercial and fleet vehicles. Specifically, offering detail on the associated cumulative climate and air outcomes, and the thereby highlighting the emissions benefit that would be linked with a more or less aggressive strategy to support

EV adoption in the Irish fleet. Figure 18 defines the different EV uptake rates considered in this work to date. The open source paper is available at https://doi.org/10.1016/j.trip.2021.100478

Figure 18. EV Uptake Pathways of BAU, NDP, and EV 1million at 30, CAP and CAP late scenarios



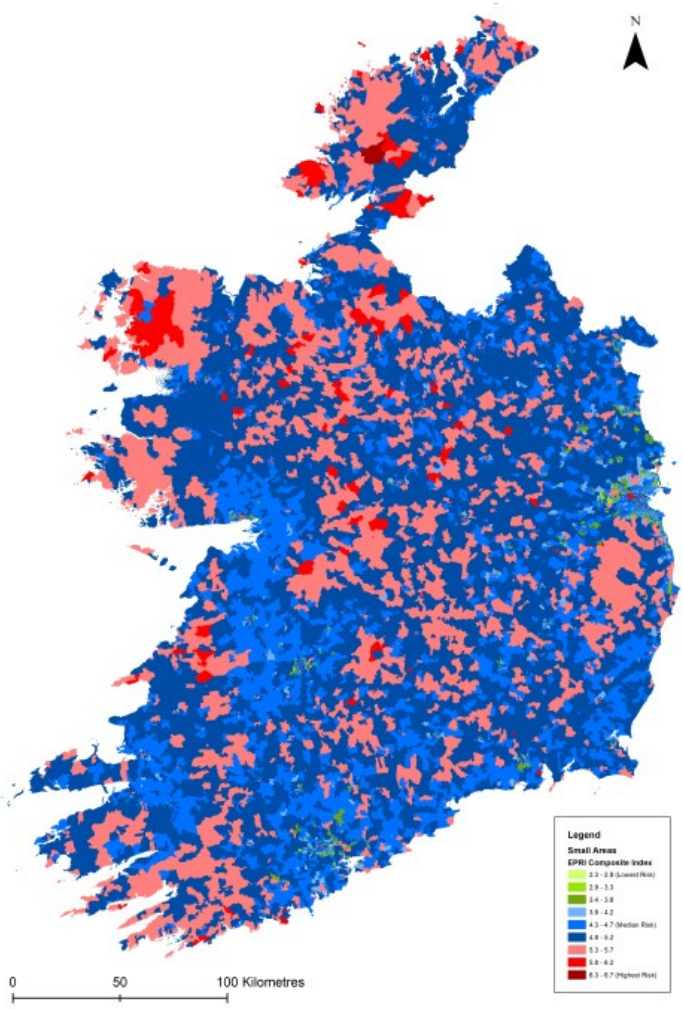
Built Environment - Targeted Deployment of Air Source Heat Pump (ASHP) Technology

As outlined in the Climate Action Plan 2021, the installation of 400,000 heat pumps into existing homes (retrofit rather than new build), by the end of 2030 is a key element of the national strategy to decarbonize heating in the residential sector. The replacement of natural gas, oil, and solid fuel boilers with ASHPs in Ireland will be beneficial to climate objectives. However, the impact on air pollutant outcomes is increased where the ASHP is replacing solid fuel use. Ambient air quality is further improved where concentrated clusters of solid-fuel use are targeted, thereby addressing multiple policy priorities across climate, air, health, and a just transition. An evidence-based targeting methodology, designed by EnvEcon (2022) can be used to support synergistic policy design across climate, air, health and just transition policy goals for the deployment of air source heat pumps (ASHPs) in Ireland. This methodology spatially analyses emissions and air pollutant concentration outcomes for both targeted and non-targeted deployments of heat pumps and shows that a focused deployment of just 3% of the national heat pump target (12,000) on solid-fuel homes could offer similar progress on climate goals but with a substantial impact in terms of reducing air pollution in hot spots by up to a third. Paper available open source at https://doi.org/10.1016/j.aeaoa.2022.100155

Built Environment - Home-Heating Energy Poverty Risk Index

As part of this research a home heating energy poverty risk index has been developed which enables a deeper level of energy poverty analytics and risk assessment. Through this work we can offer home heating energy poverty risk assessments at a fine small area scale nationally in Ireland. The existing means of measuring energy poverty risk as being where a household must spend more than 10% of disposable income on energy costs are aggregate, difficult to measure and lack spatial refinement. The information provided is also limited in terms of effectively guiding decisions on the most appropriate interventions and locations to target in order to mitigate or manage that risk. EnvEcon's Home-Heating Energy Poverty Risk Index (HH-EPRI) can be used to identify energy poverty risk relative to a national or localised scale, and can model the specific spatial impacts of specific interventions (e.g. fuel cost changes, retrofits) on levels of energy poverty risk. This will support both policy design and refinement, as well as the monitoring and reporting of progress on managing energy poverty risk as part of a just transition. This work is available open source at https://doi.org/10.1016/j.enpol.2020.111791

Figure 19. Overall Energy Poverty Risk Index



Built Environment - National Solid Fuel Regulation Analysis

This analysis incorporated EnvEcon's air pollution marginal damage value (MDV) methodology to estimate health and environmental damage associated with the estimated emissions for a base scenario and a series of national solid fuel regulation scenarios to inform the development and adoption of the new national solid fuel regulations. The analytical approach in this case characterised the outcomes of the proposed regulations principally in the form of fuel switches and changes in the associated emission factors of specific fuels. The work informed the development and deployment of the recent National Solid Fuel Regulations in Ireland.

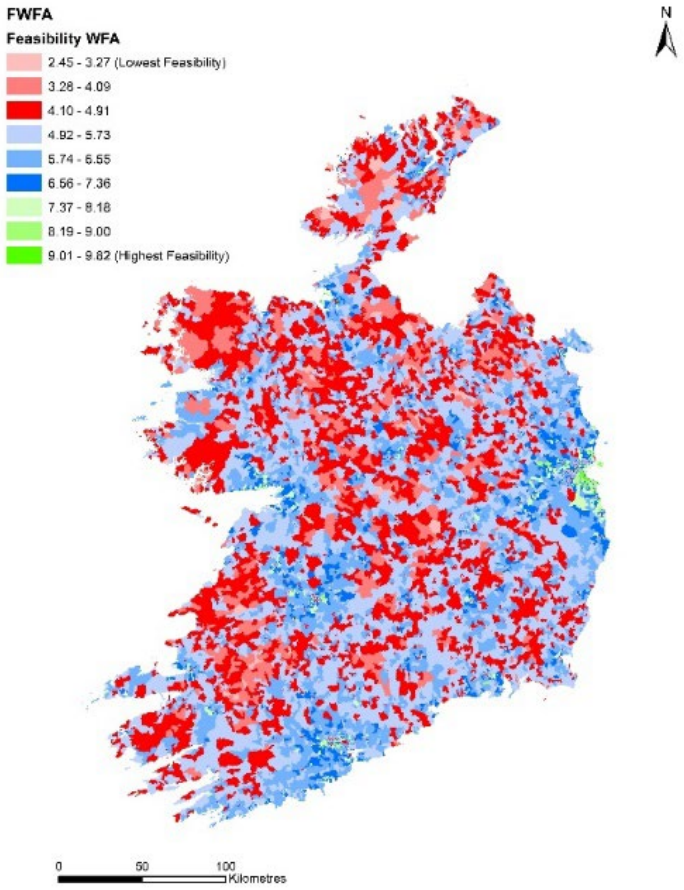
Figure 20. Marginal Damage Value per Tonne of Pollutant (2010 prices per tonne, per annum)

	NOx	NH_3	SO_2	NMVOC	$PM_{2.5}$
	Incl. Secondary PM	Incl. Secondary PM	Incl. Secondary PM	Incl. Secondary PM & O3	Primary PM only
Ireland All	€1,000	€825	€4,825	€875	€7,500
Ireland Rural	€925	€650	€4,825	€850	€6,600
Urban Large (Dublin)	€9,350	€13,175	€10,300	€2,675	€67,650
Urban Medium (Pop > 15,000)	€1,550	€3,300	€4,750	€1,550	€22,825
Urban Small (Pop 10,000-15,000)	€1,375	€1,500	€5,275	€1,350	€14,800
Small Towns (Pop < 10,000)	€1,150	€1,050	€4,725	€1,025	€9,650

Built Environment and Transport - Working from Anywhere

This work assesses the preference and potential of the Irish workforce for working from anywhere. The developed system offers a fine scale spatial Working from Anywhere Index (WFAI) to understand who may wish to work from anywhere, who has the characteristics well suited to working from anywhere, and how different WFA scenarios may impact upon emissions and costs in the state. The system also links with other in-house work to support the identification of ideal locations for remote working hubs across Ireland. The paper is available at https://doi.org/10.1016/j.indic.2022.100190

Figure 21. WFA Feasibility Spatial Distribution



6. Conclusions for 2022

The 2022 EnvEcon CC report presents the latest official national data on air and climate inventory and forecast emissions across all primary sectors and activities for Ireland, offering an overview of emissions targets and reductions, as well as specific strategic objectives outlined within national and international environmental policies. It also provides an enhanced focus on highlighting and recognising the performance of policy in Ireland in the context of those established national targets and the associated policies and measures that have been articulated in the CAP 21 and the forthcoming CAP 23. With respect to both the ESR (climate) and the NECD (air), we have offered a clear integrated perspective on Ireland's current compliance status and outlook for GHG emissions as well as primary air pollutants.

The critical nature of the 2021-2030 decade for limiting dangerous climate change has been highlighted extensively in international and national dialogues. As part of the European Green Deal, the EU has moved to increase the climate action ambition by committing to a 55% reduction in Greenhouse Gas emissions by 2030 relative to 1990 levels, as compared to the previous agreement for a 40% reduction[51]. Aligned with the proposed increase in European climate ambition, Ireland will now work to achieve a 51% reduction in overall GHG emissions compared with 2018 by 2030, an average of a 7% reduction per annum from 2021-2030, as well achieving net zero emissions by 2050.

The current WEM outlook as of 2022 indicates that with the full use of allowed flexibilities under the ESR, Ireland could comply with the emission reductions required in the period 2021-2026, and thereafter would exceed the AEA in each subsequent year and fall out of compliance from 2027-2030 with a final gap to compliance of -12.8 Mt CO_{2eq} estimated. However, the rates of afforestation are currently well below the required levels to allow for the maximum use of that flexibility. Furthermore, the emissions budgets are expected to be reduced for these periods.

The WAM scenario with all flexibility options is projected to be compliant throughout the period 2021-2030 period, resulting in a cumulative surplus in 2030 of just under 30 Mt CO_{2eq}. However, in addition to assuming the availability of the full LULUCF flexibility, this is based on the assumption that the ambitious measures and actions assumed in CAP 21, but yet to be implemented, are realised in full. This simply means that there is an identified path, and again it should be remembered that the level of ambition will substantially diminish any potential WAM surplus next year.

Ultimately, at this juncture, the major headline targets are useful, but iterative progress should be the focus. Implementation rates of existing policies and measures to drive progress is paramount and inadequate. It is for these reasons that this iteration of the EnvEcon CC report has introduced a stronger focus on the key pressure points and the major climate action policies. The focus must shift to policy design, policy deployment and policy redevelopment

[51] Note that the new 55% target is a 'net' figure which includes emissions and removals, whereas the previous target of 40% was a 'gross' figure that mainly concerned emissions only. Details on the Fit for 55 package and revisions are available online at Delivering the European Green Deal (europa.eu)

on an annual basis to drive progress. In particular driving the rate of change for the identified and impactful measures that are available within the short-term in Ireland in the key sectors and activities identified.

The report has highlighted five key pressure points across three sectors – residential, transport and agriculture (enteric fermentation, agricultural soils, and manure management), that make up approximately 80% of total NETS emissions each year. These three sectors are also the key pressure points for the air mitigation challenge, and many key measures offer co-benefits for both climate and air (e.g. electrification of transport, energy efficiency). Ongoing consideration of the interdependencies between climate and air policy is valuable to policy design and effective implementation. Policy revisions, new strategies and novel mitigation measures that focus on the three priority areas are strongly recommended. In the residential sector, progress on achieving the CAP target of 500,000 homes to B2 or better, has been slow. Persisting with existing strategies will deliver some progress but achieving an annual rate of B2 retrofits in 2026 that is 19 times greater than the rate in 2021[52] will require approaches that offer scale, cost-efficiency and increasing speeds and performance for delivery. Clustering of homes, social housing targets and bonuses for higher volumes are all potential measures to incentivise progress. Additionally, the installation of 400,000 heat pumps in existing premises, by the end of 2030 is a key element of the national strategy to decarbonise the residential sector. An evidence-based targeting methodology, designed by EnvEcon (2022) can be used to support synergistic policy design across climate, air, health and just transition policy goals for the deployment of 12,000 of the air source heat pumps (ASHPs) in Ireland. Furthermore, the residential sector is an area where parallel concerns and challenges e.g., energy poverty risk, just transition, ambient air quality, and citizen health can all be addressed with targeted policies. EnvEcon's Home-Heating Energy Poverty Risk Index (HHEPRI), offers an objective and deeper level of spatial analysis to effectively guide policy decisions on the most appropriate interventions to mitigate or manage that risk.

In the transport sector policy focuses on encouraging and facilitating active travel and mass transit travel along with EV deployment. Nearly 1 million EVs are targeted to be on the road in 2030 to deliver the desired levels of emissions reductions from the anticipated fleet in the road transport sector. This figure is a substantial step-up from the target set in the NDP of just under 500,000. However, the emission abatement contribution from the transition will be affected by the rate of change and timing (early or late uptake), the type of vehicles and type of vehicle users that ultimately adopt them. The EnvEcon research on Road Transport Electrification Timing explored road transport electrification scenarios with a particular emphasis on quantifying the emissions impact from the timing of uptake rates, as well as highlighting the particularly strong abatement contribution potential from goods vehicles. This work can be iteratively updated as progress is made, so as to inform the level of associated support and incentives. Additionally, another research piece on the Total Cost of Vehicle Ownership by EnvEcon delivered a dynamic spatial analysis for the road transport fleet in Ireland that quantified the total cost of ownership of electric vehicles relative to petrol and diesel equivalents, with granular assessment of vehicle mileage profiles, varying vehicle segment types and so on. Critically this work highlighted that the two most popular passenger car segments are already far more

[52] 4000 homes in 2021 relative to an ambition for an average of 76,000 homes per annum from 2026.

favourable on a short 4 year total cost of ownership assessment than their petrol or diesel equivalent. Maintaining and communicating this dynamic research as the market and prices evolve will be important in the context of informing consumers at the point of sale, accelerating EV uptake rates, and managing ongoing government supports levels.

The agricultural sector represents the biggest challenge in reducing emissions and driving higher uptake rates of the measures set out in the Ag-Climatise Roadmap 2020 will be important. Subsequent subsectoral reports such as the Food Vision Dairy Group Report in October 2022 outline the familiar key measures and supporting actions that can deliver abatement from the sector. Arguably the key challenge in the sector is not the identification of the measures, but rather an in-depth analysis and management of the economic viability of specific measures, and the potential and merits of intervening to influence that economic viability. Broader access to more detailed grants and payments data, would enable more meaningful work in this context and should be requested in regard to all public funds committed.

LULUCF will also be very important over the coming years. Managed wetlands mainly refer to the rehabilitation and rewetting of degraded peatland in Ireland. This work is one of the initiatives introduced following the peat power plant closures and connects with the Just Transition agenda in Ireland. The addition of managed wetlands could put Ireland on a somewhat stronger footing for meeting the 2030 target and utilising the full LULUCF flexibility over the 2021-2030 period. The management and delivery of an effective LULUCF strategy to 2030 and beyond is critical.

The next iteration of this EnvEcon CC report will focus on policy updates, including the expected additions and updates in CAP 23. CAP23 will reflect the newly introduced carbon budgets and sectoral emissions ceilings with a roadmap to guide compliance. Critically, the new year is also expected to bring the finalisation of ESR AEAs for the remainder of the 2021-2030 period and the impact on gap to target in relation to our new, more ambitious 2030 target. At present we see that our WEM is not enough, our WAM requires substantial acceleration of progress to be realised, and our access to the available flexibilities (specifically LULUCD credits) is set to prove a major challenge.

Furthermore, with consideration of the two-year lag in official data reporting, the official emissions inventory published in 2023 will contain data up to and including 2021, the first 'post-COVID' inventory year. Therefore, it will offer early confirmation of our post-pandemic recovery and possible rebound that will be relevant to the new WEM and WAM outlooks.

Future iterations of the EnvEcon CC report will continue to focus driving progress toward key CAP policy targets, rather than strictly emissions accounting. This means that we will continue to emphasise the importance of targeted policies, delivery of effective actions, relevant research and progress to date.

7. Report Annex

The prior versions of this report included an extended annex that included policy context with regard to relevant International Directives and policy frameworks as well as key national policy responses. There was also a more detailed description of reporting requirements, methodologies and guidelines in relation to compliance, such as specific details on flexibilities and how they apply in an air and climate context. This material is not repeated in this report. However, below is a list of the key source reports and documents that have informed this EnvEcon CC Report 2022:

National Policy Reports:

- Carbon Budget Technical Report, 2021, Climate Change Advisory Council
- Climate Action Plan 2019: To tackle climate breakdown, 2019, DCCAE
- Climate Action Plan 2021: Securing our future, 2021, DECC
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