Response to Consultation on Carbon Budgets

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1. Introduction.

The Climate Action and Low Carbon Development Amendment Act (2021), among other provisions, mandates the Climate Change Advisory Council to propose carbon budgets for each of the periods 2021-2025; 2026-2030; and for 2031-2035 (provisional), to set Ireland on a pathway consistent with a sustainable economy and society where greenhouse gas emissions are balanced or exceeded by the removal of greenhouse gases by 2050. Under the legislation, the proposed carbon budgets for the periods 2021-2025 and 2026-2030 must provide for a reduction of 51% in the total amount of those greenhouse gas emissions (specified by the regulations) by 2030, relative to 2018.

Total greenhouse gas emissions covered under the carbon budgets were 68.3 Mt CO2eq in 2018, thus the first two carbon budgets must be consistent with emissions of 33.5 Mt CO2eq in 2030:

- 2021-2025: 295 Mt CO2 eq. - an average reduction of 4.8% per annum for the first budget period
- 2026-2030: 200 Mt CO2 eq. - an average reduction of 8.3% per annum for the second budget period.

The provisional carbon budget for 2031-2035 is 151 Mt CO2 eq. - an average reduction of 3.5% per annum for the third budget.

The 51% target applies to greenhouse gas emissions attributable to industrial, agricultural, and energy sectors (Group 1). With regard to land use (Group 2) and forestry (Group 3), because of likely time lag between actions and outcome, the Climate Change Advisory Council has advised that targets for emissions reduction and carbon sequestration should be framed in terms of absolute activity levels, with activity targets set for relevant land areas and soil types on the basis of calculation of the climate mitigation required during each carbon budget period. Methodologies for monitoring implementation and outcomes, and accounting methodologies for carbon emissions reductions and additional carbon removals through sequestration, are detailed for each of the three Groups.

The Minister for the Environment, Climate and Communications, in consultation with other relevant Ministers, will develop a sectoral emissions ceiling for each relevant sector within each 5-year budget, once the overall carbon budget has been adopted. Table 3.1 of the 2021 Climate Action Plan[1] sets out indicative ranges of emissions reductions by 2030 for each sector of the economy as follows:

Group 1 sectors:

- Electricity: 62-81%
- Transport: 42-50%
- Buildings: 44-56%
- Industry/Enterprise: 29-41%
- Agriculture: 22-30% reduction

Group 2 Land Use, Land Use Change, and Group 3 Forestry (LULUCF): 37-58%

[1] https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/

Table 3.1 *Proposed Emissions Reductions by Sector*

Sector[3]	2018 emissions ($MtCO_2eq.$)	2030 target emissions ($MtCO_2eq.$)	% reduction relative to 2018[4]
Electricity	10.5	2-4	62-81%
Transport	12	6-7	42-50%
Buildings	9	4-5	44-56%
Industry	8.5	5-6	29-41%
Agriculture	23[5]	16-18	22-30%
LULUCF	4.8	2-3	37-58%
Unallocated Savings	N/A	4[6]	N/A

Box 1. Proposed Emissions Reduction by Sector – reproduced from Climate Action Plan 2021 Securing Our Future. Government of Ireland. November 2021

The Environmental Protection Agency (EPA) annual greenhouse gas inventory and projection reports, and the Climate Change Advisory Council (CCAC) annual report will inform monitoring of compliance with national and sectoral progress towards each carbon budget and sectoral emissions ceiling. Additional oversight of performance both in implementing Climate Action Plan actions and in adhering to their sector's emissions ceiling under the carbon budget period will be provided by an Oireachtas Committee. The annual revision to the Climate Action Plan acts as a further review mechanism and opportunity to re-adjust or refocus actions to ensure that decarbonisation targets are achieved.

The Climate Change Advisory Council notes that the 51% target represents a significant challenge to all covered sectors. Strong, rapid and sustained reductions in emissions in all covered sectors and all greenhouse gases are required to meet this challenge. The analysis indicates that, while different sectors will transition at different rates, the overall range of pathways to achieving the 51% target is narrow.

This consultation relates to the economy-wide carbon budgets, proposed by the CCAC. The purpose of the consultation is to gather views from the public and interested parties on the economy-wide carbon budgets proposed by the CCAC, to inform the Minister's recommendation to government on final carbon budgets. The consultation documentation invites responses on:

1. How effort is shared to meet the 51% emissions reduction by 2030 across the first two carbon budgets, 2021-2025 & 2026-2030

2. The third carbon budget for 2031-2035 being consistent with the national objective for a climate neutral economy by no later than 2050

3. The CCAC Technical report accompanying the proposed carbon budget programme

4. Any other observations.

The objective of this Response to Consultation on Carbon Budgets by Hydrogen Ireland is to consider the role of Green Hydrogen as a vector in the "least burden and most opportunity pathways to decarbonisation" that can be developed and implemented to assist in the meeting the challenging decarbonisation targets required by Ireland's contribution to climate change mitigation and adaptation within the EU and globally.

2. Rationale for the identification of Green Hydrogen as a decarbonising vector

Hydrogen produced by electrolysis with renewable energy is a zero carbon emission fuel, and is now regarded as a mature technology in the **International Energy Agency (IEA) Global Hydrogen Review 2021** (October 2021[2]). Table 1 gives a comparison of carbon emissions arising from fuel production; these are available for low carbon hydrogen, and for electricity generation in Ireland. Hydrogen and electricity are both zero carbon fuels when in use. Fuel production carbon emissions are not readily available for fossil fuels and peat but are noted as arising; carbon emissions arising from the use of these fuels is listed in Table 1. Data on carbon emissions arising from the production and use of different biofuels are not listed by SEAI currently.

Table 1. Carbon dioxide emission factors for fuels. In the case of hydrogen and electricity, CO_2 emissions arise during the production of the fuel

Fuel Type – EU Taxonomy Low carbon Hydrogen (Source: Hydrogen Council)	**Hydrogen production emissions $kgCO_2eq/kgH_2$**	**Fuel use emissions (gCO_2/kWh) (NCV)**
Hydrogen (electrolysis using hydropower, wind or solar)	< 3	0.0
Hydrogen (electrolysis using hydropower)	0.3 - 0.45	0.0
Hydrogen (electrolysis using wind)	0.5 - 0.70	0.0
Hydrogen (electrolysis using solar)	1.0 – 2.58	0.0
Fossil fuel; solid, liquid, gas (Source: SEAI, accessed 2.02.2022)	**Fuel production emissions**	
Coal	+	340.6
Milled peat	+	420.0
Sod peat	+	374.4
Peat briquettes	+	355.9
Liquid fossil fuel	+	
Gasoline / Petrol	+	251.9
Kerosene	+	257.0
Gasoil / Diesel	+	263.9
Residual Oil / Fuel Oil	+	273.6
LPG	+	229.3
Bottled LPG (Propane or Butane)	+	232.0
Natural Gas	+	204.7
Electricity generation in Ireland (Source: SEAI, accessed 2.02.2022)	**Electricity production emissions (gCO_2/kWh) (NCV)**	
Electricity 2018	375.40	0.0
Electricity 2019	324.50	0.0
Electricity 2020	295.80	0.0

https://hydrogencouncil.com/en/

https://www.seai.ie/data-and-insights/seai-statistics/conversion-factors/

[2] https://www.iea.org/reports/global-hydrogen-review-2021

The carbon intensity of various production routes for hydrogen are shown in Figure 1. Hydrogen produced by electrolysis using hydropower, wind energy and solar energy is all classifiable as low carbon, defined in the current EU taxonomy as <3kgCO_2/kgH_2. Hydrogen produced by electrolysis using hydropower and wind energy is classified as ultra-low carbon <1kgCO_2/kgH_2 (Table 1, Figure 1).

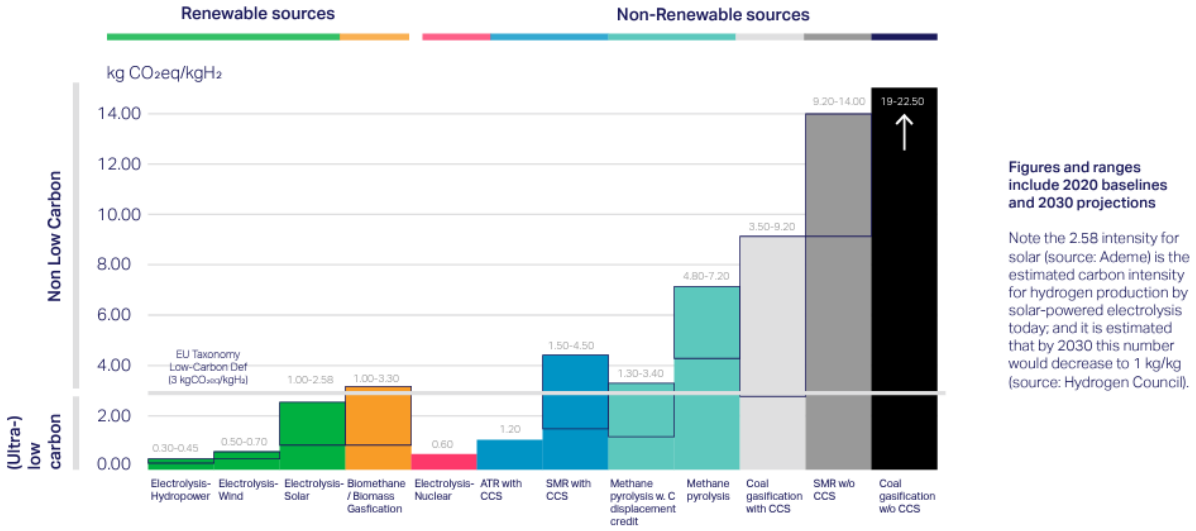

Figure 1. Carbon intensity of various production routes for hydrogen

Source: literature review; Hydrogen Council

The role green hydrogen[3] can play, combined with and supporting other climate actions, in making rapid progress towards decarbonisation and meeting the ambitious targets set out in the **Climate Action and Low Carbon Development (Amendment) Act No. 32 of 2021**, is supported by the **EU Hydrogen Strategy** (July 2021), including the revision of the Renewable Energy Directive currently in progress, promotes the use of renewable hydrogen, and will extend the EU-wide certification system for renewable fuels to include low-carbon hydrogen. The EU Commission will put forward proposals for hydrogen and the decarbonisation of gas markets, to set the regulatory approach for these sectors.

The IEA Global Hydrogen Review 2021 lays out a series of recommendations for near term-action beyond just mobilising investment in research, production and infrastructure. It highlights that governments could stimulate demand and reduce price differences through carbon pricing, mandates, quotas and hydrogen requirements in public procurement.

Among other initiatives, **H2Zero** is a global initiative, presented at COP 26 and also at EUSEW 2021 (EU Energy week), focused on accelerating the use and production of hydrogen with the lowest possible carbon intensity as an essential building block of the future net-zero energy system. H2Zero is a partnership initiative by the **Sustainable Markets Initiative** (SMI) and the **World Business Council for Sustainable Development** (WBCSD). The basis for a functional and significant clean hydrogen economy is the rapid growth of demand and supply, but the system cannot develop without critical enablers. Three categories of pledges can be made under theH2Zero initiative – for demand,

[3] Hydrogen produced by electrolysis with renewable energy is a low to ultra-low carbon emission process and fuel, and is known as green hydrogen, clean hydrogen, and as renewable hydrogen, see Figure 1 and Table 1).

supply and support. A company can decide in how many categories it wants to make a pledge, depending on its activities today and in the future. Pledges are invited for a 2030 horizon, and pledges are aggregated to track the decarbonisation impact against the 2030 potential estimated by the Hydrogen Council in its Hydrogen for Net-Zero report.

3. Response to Consultation Questions on Carbon Budgets

3.1 How effort is shared to meet the 51% emissions reduction by 2030 across the first two carbon budgets, 2021-2025 & 2026-2030

The **Intergovernmental Panel on Climate Change (IPCC, 2021)** notes that because of the complex interactions of the phenomenon of climate change, it is essential to decarbonise quickly, and that emissions reductions over the next ten years (to 2030/31) will be far more impactful than those over the following ten. The proposed first carbon budget for 2021-2025 of 295 Mt CO2 eq. - an average reduction of 4.8% per annum for the first budget period, with an average reduction of 8.3% per annum for the second budget period 2026-2030, is based on a comprehensive review of methodologies for monitoring implementation and outcomes, and of accounting methodologies for carbon emissions reductions and additional carbon removals through sequestration. The proposed budgets are framed in the context that we are now already in 2022, and decarbonisation strategies, regulatory frameworks and supports are still being put in place to meet the proposed budgets, both at EU and at national level. The proposed effort sharing across the first two carbon budgets is probably realistic.

The Environmental Protection Agency (EPA) greenhouse gas inventory and projection reports, and the Climate Change Advisory Council (CCAC) annual reports will inform monitoring of compliance with national and sectoral progress towards each carbon budget and sectoral emissions ceiling. Additional oversight of performance both in implementing Climate Action Plan actions and in adhering to their sector's emissions ceiling under the carbon budget period will be provided by an Oireachtas Committee. The annual revision to the Climate Action Plan acts as a further review mechanism and opportunity to re-adjust or refocus actions to ensure that decarbonisation targets are achieved.

It is noted that decarbonisation should proceed as quickly as possible, and that it may be useful to view the carbon budget as a limit rather than as a target.

3.2 The third carbon budget for 2031-2035 being consistent with the national objective for a climate neutral economy by no later than 2050

The proposed third carbon budget would follow from the successful implementation of all the measures necessary to meet the first and second carbon budget decarbonisation objectives. The annual revision to the Climate Action Plan acts as a further review mechanism and opportunity to re-adjust or refocus actions to ensure that decarbonisation targets are achieved. It is noted again that decarbonisation should proceed as quickly as possible, and that it may be useful to view the carbon budget as a limit rather than as a target.

3.3 The CCAC Technical report accompanying the proposed carbon budget programme

The CCCAC Technical report makes little reference to hydrogen, other than to include it in a list of renewable energies (page 27), and in **Table 7-1 Main Points raised in Sectoral Engagement**

Process (June & July 2021), with reference to electricity – "Storage solutions needed; Hydrogen is the most likely contender"

ESRI Research Bulletin 2021/23 notes that "hydrogen has a potential role to play in decarbonising the economy, particularly in instances where decarbonisation alternatives are challenging. In the example considered in Research Bulletin 21/23, where hydrogen is used for residential heating, carbon emissions from residential heating decline. In contrast to other policies such as home retrofits, there are no costs or hassle imposed on the residential sector thereby circumventing a critical barrier to reducing emissions in the residential sector. However, if hydrogen production is associated with additional carbon emissions, consideration needs to be given to whether decarbonisation in one sector is simply shifting emissions to elsewhere in the economy[4]." With reference to Table 1 and Figure 1, this rationale may be relevant only insofar as insufficient green hydrogen is being produced in Ireland to assist in decarbonising multiple sectors of the economy simultaneously. The main consideration that arises is that green hydrogen is a low to ultra-low carbon fuel to produce, and a zero carbon emission fuel in use, when compared with fossil fuels and with electricity generated in Ireland currently and in the short to medium term.

It is noted that there has been significant very recent investigation of the role green hydrogen can play in making rapid progress towards decarbonisation in Ireland. A number of studies, reports and strategies relating to green hydrogen would not have been completed while the Climate Change Advisory Council was preparing its technical report on Carbon Budgets. These are considered further in Section 3.4 below.

3.4 Any other observations.

Recent studies, reports and strategies relating to green hydrogen that would not have been available or completed while the Climate Change Advisory Council was preparing its technical report on Carbon Budgets are considered further in this section of the Hydrogen Ireland response to Consultation on Carbon Budgets.

3.4.1 Proposed credits for Renewable Fuels of Non-Biological Origin (RFNBOs)

The Department of Transport Renewable Fuels for Transport Policy Statement November 2021 notes that green hydrogen can also be produced through electrolysis which extracts hydrogen from water using renewable electricity. It will be supported through quadruple credits, as set out in Sections 13 and 14 of the Transport Policy Statement.

Section 13 of the Transport Policy Statement: Inclusion of Renewable Fuels of Non-Biological Origin, proposes to extend credits for renewable fuels (previously applied to biofuels), to the new fuel category Renewable Fuels of Non-Biological Origin (RFNBOs), i.e. renewable fuels which are not produced from biomass and are not therefore biofuels. Fuels such as green hydrogen (produced using renewable electricity) and synthetic fuels produced from green hydrogen will be eligible for credits. Subject to enabling legislation, RFNBOs will become eligible for credit under the scheme from 1 January 2023.

Section 14 of the Transport Policy Statement: Treatment of Development Renewable Fuels refers to a category for certain renewable fuels called 'Development Renewable Fuels' will be added to the scheme and multiple credit will be awarded to incentivise their deployment. Subject to enabling

[4] ESRI Bulletin summaries the findings from: Longoria, G., Lynch, M., and Curtis, J. (2021). Green hydrogen for heating and its impact on the power system. *International Journal of Hydrogen Energy*, 46(53):26725–26740. https://doi.org/10.1016/j.ijhydene.2021.05.171

legislation, the highest level of credit proposed among the fuels in question applies to Green Hydrogen, and the credit multiplier to apply from 1 January 2023 is x4.

While the credit level to which the multiplier will apply remains to be determined, this Transport Policy initiative is welcomed by Hydrogen Ireland as indicating an important commitment to facilitating and supporting the production and use of green hydrogen in Ireland. It is noted that the proposed credits would usefully be considered with regard to the production, fuelling infrastructure and end users of green hydrogen, not only in public, commercial, and private transport, but also in other Group 1 sectors of the economy including Electricity, Buildings, Industry/Enterprise, and Agriculture.

https://www.gov.ie/en/policy-information/168c6-renewable-fuels-for-transport-policy-statement/

3.4.2 Actions on green hydrogen listed in the Climate Action Plan Annex, December 2021

Three actions on hydrogen listed in the 2021 Climate Action Plan Annex of December 2021 are reproduced in Appendix 1 of this submission.

Action 169: develop renewable gas in the gas grid

Gas Networks Ireland is currently testing the technical feasibility of safely injecting green hydrogen blends into the gas grid, with reporting of the completed assessment due in Q4 2022. The Department of the Environment, Climate & Communications is scheduled to develop a policy and regulatory roadmap for green hydrogen use in the natural gas grid during Q1 2023.

Action 268: Transition Dublin Metropolitan PSO bus services to low/zero emission bus fleet

The National Transport Authority (NTA) in conjunction with Bus Éireann have been operating three hydrogen fuel cell double deck buses in Dublin since July 2021. The bus model in question – the Wrightbus Streetdeck H2 FCEV – is manufactured by Bamford Bus Company, and assembled at their factory in Galgorm, on the outskirts of Ballymena in Northern Ireland. Hydrogen for the buses is supplied by BOC Gases Ireland, with hydrogen being produced by electrolysis using renewable grid electricity, with refuelling being effected at its Bluebell facility on the Naas Road in Dublin. The NTA is scheduled to complete the pilot of hydrogen fuel cell double deck buses and review performance, and publish a review of pilot findings in Q4 2022.

https://www.nationaltransport.ie/nta-and-bus-eireann-unveil-hydrogen-buses-for-initial-use-on-commuter-route-105/

The current trial of 3 hydrogen fuel cell double deck buses follows a previous trial in 2020, when a Caetano H2.CityGold bus operated on various routes throughout Dublin & Meath. The trial was organised by Hydrogen Mobility Ireland (HMI) and DCU and supported by CIE, Bus Éireann, Dublin Bus, the Department of Transport, and other stakeholders. The hydrogen fuel cell electric bus travelled 3086km on Irish roads during the 8 week trial period. The bus, which can be refuelled in less than 9 minutes and has a range of 400km, received a high level of public passenger satisfaction when surveyed. It was found that the hydrogen bus has suitable design, range, efficiency, refuelling time and comfort for the various circuit and shuttle routes chosen in either urban or suburban and rural settings, in various winter weather conditions on Irish roads. The hydrogen bus performed with an average hydrogen consumption of 5.6kg/100km or 6.7MJ/km with zero tailpipe emissions (zero NOx or CO_2 or CO or CH_4 emissions).

https://hydrogenireland.org/2021/12/13/analysis-of-irelands-first-hydrogen-fuel-cell-bus-trial/

Action 294: Carry out a review of the supply of renewable transport fuels in Ireland, such as biofuels, advanced biofuels, e-fuels, synthetic fuels, biogas, and green hydrogen.

The Department of Transport is scheduled to progress a study reviewing the profile, sustainability, and supply of renewable transport fuels in Ireland, such as biofuels, advanced biofuels, e-fuels, synthetic fuels, biogas, and green hydrogen, and to complete a research report including recommendations for sustainable biofuels policy development, due to be published in Q2 2022.

The relevance of the Department of Transport Renewable Fuels for Transport Policy Statement of November 2021 with regard to green hydrogen is noted in this regard (see Section 3.4.1 of this Response to Consultation on Carbon Budgets), and it is requested that recommendations on the profile, sustainability, and supply of green hydrogen as a renewable ultra-low carbon transport fuel are also brought forward for implementation on 1 January 2023.

With regard to hydrogen refuelling of vehicles, a number of products are available currently and are being installed in a number of EU member states, including NanoSUN's Pioneer Station, a fully mobile, self-contained and automated hydrogen refuelling solution available for sale or for lease, which offers an affordable and rapidly deployable way of delivering hydrogen fuel to the point of use, where it is dispensed directly into hydrogen powered vehicles.

https://hydrogenireland.org/2021/12/13/nanosun-investment/

Against the backdrop of the requirement to meet RED II obligations, the need for hydrogen refuelling infrastructure is bolstered by the European Commission's proposal on a Regulation for Alternative Fuels Infrastructure. Part of the Fit for 55 package, Article 6 contains provisions for Member States to ensure minimum coverage of publicly accessible refuelling points for hydrogen dedicated to heavy and light-duty vehicles on the TEN-T core and comprehensive network. Subject to agreement at EU level, these refuelling points are to be in place by 31 December 2030. Member States will therefore have a mandatory obligation to provide this refuelling infrastructure.

3.4.3 Hydrogen in the Irish Energy Transition: Opportunities and Challenges

The Department of the Environment, Climate, and Communications (DECC) Research & Development (R&D) Programme has commissioned a study entitled Hydrogen in the Irish Energy Transition: Opportunities and Challenges, which is being prepared under International Energy Research Centre's (IERC) Energy Policy Insights for Climate Action (EPICA) Project. The International Energy Research Centre at Tyndall National Institute is Ireland's leading not-for-profit professional energy research centre. Hydrogen Ireland has made a submission to this project in response to a call for evidence.

It is anticipated that the completed paper will provide an important resource for the further development of strategies for the production, storage, distribution, and use of green hydrogen for decarbonisation in Ireland and will assist in meeting the carbon budgets set out by CCAC.

3.4.4 Hydrogen and Wind Energy – The Role of Green Hydrogen in Ireland's Energy Transition

Hydrogen and Wind Energy – The Role of Green Hydrogen in Ireland's Energy Transition was authored by Gavin and Doherty Geosolutions Ltd. (GDG) on behalf of Wind Energy Ireland, with support from Green Tech Skillnet, and published in January 2022. Wind Energy Ireland is calling on the Government to:

- Release a robust hydrogen strategy by the end of Q2 2022, setting out targets across industry, heavy road transport, shipping, aviation and power generation

- Immediately establish a high-level cross-Government Group to develop recommendations to cut the price of renewable electricity so we can produce green hydrogen as cheaply as possible and compete internationally.

https://windenergyireland.com/latest-news/5937-green-hydrogen-strategy-essential-for-ireland-to-meet-net-zero-emissions-targets

https://windenergyireland.com/policy/reports-position-papers

3.4.5 Other observations and recommended actions to assist in meeting the proposed sectoral carbon budgets

Much of the focus on potential uses of hydrogen in decarbonising the economy in Ireland so far has been on the Electricity sector, and on the Transport sector in particular heavy-goods vehicles and public transport. Buildings sector, including residential and commercial, and private transport policy currently encourages a switch to electricity as the sole energy source. Recently announced supports for taxis apply to grants will enable owners of small public service vehicles (SPSV), such as taxis and hackneys, to buy electric vehicles (EVs). It is recommended that supports for EVs should be extended to Hydrogen fuel cell EVs (FCEVs), as FCEVs are increasingly becoming available as detailed in the IERC paper Hydrogen in the Irish Energy Transition: Opportunities and Challenges, noted in section 3.4.3 above.

https://www.gov.ie/en/press-release/f1623-up-to-25000-for-taxi-drivers-to-buy-electric-vehicles/

3.4.5.1 Climate change adaptation

It is recommended that climate change mitigation measures should also take climate change adaptation into account. The development of policies and strategies to enhance the resilience of individuals and communities to climate change should consider what happens as a result of the more intense storms that are predicted to occur. During December 2021, storm Barra resulted in power outages of up to three days duration in Ireland, while storm Arwen, followed by storm Barra, resulted in power outages of more than 10 days in parts of Scotland and northern England. Over-reliance on electricity in these circumstances potentially leaves households and businesses in affected areas without heat, cooking facilities, communications, or a means of transport to leave the area. The availability and use of green hydrogen would assist in enhancing resilience, not as an either or scenario, but as a both electricity and green hydrogen energy supply and use.

3.4.5.2 Heat

It is recommended that the role of green hydrogen in providing lower cost decarbonisation options for citizens, including low income households, is considered in detail, as a “least burden and most opportunity pathway to decarbonisation” that facilitates participation in decarbonisation effort nationally.

Reducing greenhouse gas emissions in existing buildings in Ireland, including traditional buildings, can be achieved in two ways:

1. by using less energy combined with electric heat pumps (e.g. retrofit)
2. by using low carbon fuels (e.g. decarbonisation).

Current policy in Ireland is to link the reduction of greenhouse gas emissions in a single funding package for buildings using retrofit combined with electric heat pumps. There is a risk that the combined costs associated with having to carry out both energy efficiency retrofit and decarbonisation of home heating and energy systems simultaneously in order to receive partial grant aid is a disincentive / financial barrier to householders. Ideally, of course both actions should be carried out simultaneously. However, given the IPCC stated imperative to decarbonise as quickly as possible during the current decade, it is important to avoid time delays arising from complex retrofit planning and implementation. A “decarbonise first, as quickly as possible” approach is recommended as a stand-alone work package. This can be achieved using recently developed 100% hydrogen ready boilers, cookers, and heaters (see Appendix 2).

Retrofit actions to improve the insulation and thermal efficiency of 100% hydrogen heated buildings should be de-coupled from grant supports for boiler installation, but could follow as separate stand-alone work packages on a phased basis if necessary.

Policy and grant supports for decarbonised domestic and commercial heating should target zero emission technology, and should include supports for green hydrogen ready central heating boilers for use in domestic and commercial heating, together with supports for the early provision of a guaranteed green hydrogen fuel supply. Pilot projects should be advertised, promoted and initiated throughout Ireland, including areas not served by the existing natural gas grid.

In Ireland, regulation of the smoke, sulphur and moisture content of domestic solid fuels will be introduced before September 2022, so that the most polluting solid fuels will no longer be available on the Irish market. These regulations could be seen as providing a policy coherence and just transition opportunity to offer support for decarbonising home heating. Older and traditional housing stock often relies on open fires with back boilers for water and space heating. Supported provision of hydrogen ready central heating boilers at these and at other older housing stock currently relying on fossil fuel or solid fuel for heating would accelerate the decarbonisation of home heating and help in meeting or potentially improving on the proposed carbon budgets.

If the correct initiatives and green hydrogen supplies and price supports are put in place in Ireland, it might be a cheaper option to decarbonise 600,000 rural dwellings in a relatively short time frame. This would assist in meeting the first and second carbon budgets for the Buildings sector. Insulation and other energy efficiency retrofit could be carried out later, on a phased basis; this approach would take account of the current shortages in building materials, technical expertise and contractors. Buildings, including traditional buildings and protected structures that may be unsuitable for deep retrofit that are on the natural gas grid can be decarbonised by the progressive addition of green hydrogen to the distribution network.

Residential gas appliances (cookers, boilers) in Ireland are already configured to run on natural gas with blends of up to 20% hydrogen. Trials are now planned to test various blends of hydrogen / natural gas on Ireland’s gas network, the results of which will inform policy development and the regulatory framework for hydrogen blending and in future potential gas network repurposing to transport 100% hydrogen.

It is anticipated that gas distribution networks in the UK will be ready to transport up to 20% hydrogen blended with natural gas by 2023, and while it is expected that Ireland’s gas network will also be able to transport up to 20% hydrogen blend without major investment (and no customer/cost impact), further work is needed to develop a safety case for hydrogen blend and /or repurposing the gas network to 100% hydrogen, in line with CRU requirements.

3.4.5.3 Potential pathways to facilitate early and accelerating production of green hydrogen in Ireland

Eirgrid work programmes and approval processes may mean delays in the provision of grid connection for existing approved wind and solar farms, and potentially in the short term to proposed wind and solar farms.

It is recommended that it would be useful to collate information on the combined generating capacity of renewable energy projects in this situation, in order to facilitate direct wind to green hydrogen production. Given the Climate Action Plan 2021, the COP26 phase down fossil fuel use objective, and Ireland's membership of the Beyond Oil & Gas Alliance (BOGA), wind and solar projects should be facilitated to commence construction and to produce green hydrogen at the earliest opportunity to facilitate decarbonisation and emission reductions consistent with the proposed carbon budgets.

It is recommended that direct wind to green hydrogen production should commence in 2022, and that a target of at least 200MW electrolyser capacity should be operational by 2025.

4. Appendices

Appendix 1. Actions on green hydrogen listed in the Climate Action Plan Annex, December 2021

Appendix 2. Heat, hydrogen ready boilers, cookers and gas fires

Appendix 3. Current estimates and trends in H2 production costs

Appendix 1. Actions on green hydrogen listed in the Climate Action Plan Annex, December 2021

Action 169: develop renewable gas in the gas grid

Steps Necessary for Delivery	Proposed Output	Timeline	Lead
Test the technical feasibility of safely injecting green hydrogen blends in the gas grid	Completed assessment of the impacts on network operation, integrity, and end users' appliances	Q4 2022	GNI
Assess the potential for energy system integration between the electricity and gas networks including the production, storage and use of green hydrogen	Assessment of the potential for electricity and gas system integration published	Q1 2023	DECC
Develop a policy/regulatory roadmap for green hydrogen use in the natural gas grid.	Publish a policy/regulatory roadmap for green hydrogen use in the natural gas grid	Q1 2023	DECC

Action 268: Transition Dublin Metropolitan PSO bus services to low/zero emission bus fleet

Steps Necessary for Delivery	Proposed Output	Timeline	Lead
Complete pilot of hydrogen fuel cell double deck buses and review performance.	Complete and publish a review of pilot findings	Q4 2022	NTA

Action 294: Carry out a review of the supply of renewable transport fuels in Ireland, such as biofuels, advanced biofuels, e-fuels, synthetic fuels, biogas, and green hydrogen.

Steps Necessary for Delivery	Proposed Output	Timeline	Lead
Progress a study reviewing the profile, sustainability, and supply of renewable transport fuels in Ireland, such as biofuels, advanced biofuels, e-fuels, synthetic fuels, biogas, and green hydrogen.	Research report including Recommendations for sustainable biofuels policy development published	Q2 2022	D/Transport

Appendix 2. Heat, hydrogen ready boilers, cookers and gas fires

The Hy4Heat programme in the UK has completed a number of work packages on 100% hydrogen as a fuel for domestic hydrogen boilers and cookers, including hydrogen standards and certification, safety assessment, and appliance and meter development. Demonstration homes with appliances fuelled entirely by hydrogen were officially opened by UK Energy Minister in July 2021 – see https://www.hy4heat.info/

Hydrogen ready combi and system boilers are being developed by Baxi, part of the BDR Thermea Group, and has a range of demonstration projects across Western Europe, including in the EU, and the UK as part of the hy4heat work programme – see https://www.baxiheating.co.uk/the-future-of-heat

Bosch has developed two 30 kW boiler; the Combi (which produces instantaneous hot water) and the Regular (intended to support a hot water cylinder). The boilers are direct like-for-like replacements for existing natural gas boilers and provide heating and hot water in exactly the same way as their natural gas counterparts.

Worcester Bosch is a partner in two work packages of Hy4Heat; WP4 (domestic appliance development) and WP5b (commercial appliance development). Under WP4, we have developed the Greenstar 8000 Hydrogen-Ready gas condensing boiler. Under WP5b, we have developed and demonstrated the Regular appliance as a cascade solution, supporting commercial applications up to 480 kW. In September 2020, the first domestic hydrogen boiler demonstration was installed and commissioned at H21's HyStreet at DNV Spadeadam. It has operated for a year heating a typically constructed end-of-terrace house. A second appliance is being demonstrated at BEIS, NGN & Cadent's Hydrogen Home near Gateshead. In 2020, an appliance was also demonstrated in the Netherlands in a hydrogen network demonstration conducted by Stedin in the town of Uithoorn.

While the Prototype 1.0 appliances that have been certified and released for demonstration trials burn 100% hydrogen only, Prototype 2.0 appliances are hydrogen-ready; capable of burning natural gas including blends of up to 20% hydrogen, and also 100% hydrogen – see Worcester Bosch www.worcester-bosch.co.uk/hydrogen

The HyCookers Consortium comprises the UK's largest manufacturer of domestic cookers (GDHA) and an R&D consultancy (Enertek International Ltd). These two companies have worked collaboratively throughout the Hy4Heat programme with input from key suppliers to produce a range of three certified 100% Hydrogen gas cooking appliances comprising a hydrogen gas hob, a built-in oven/grill and a freestanding cooker.

The HyFires Consortium comprises the UK's three leading gas fire manufacturers supported by two major component manufacturers and an R&D consultancy. These six companies have worked collaboratively throughout the Hy4Heat programme to produce a range of three certified 100% Hydrogen gas fire models comprising a traditional open fronted coal effect gas fire, a glass fronted conventionally flued version and a glass fronted balanced flued model.

Appendix 3. Current estimates and trends in H2 production costs

Using renewable electricity to produce hydrogen currently costs in the order of $(USD) 3 to $8 per kg, with costs projected to fall to as low as USD 1.3 per kg by 2030 in regions with excellent renewable resources (Global Hydrogen Review, IEA 2021).

Hydrogen Council (February 2021) projections show that by 2030 the costs of renewable hydrogen production could be in the range of $2.3 per kilogram and $1.4 per kilogram (the range results from differences between optimal and average regions). Rethink Energy sees the cost of green hydrogen falling from about $3.70/kg to just over $1/kg in 2035, and around $0.75/kg by 2050 (https://hydrogen-central.com/hydrogen-clean-energy-10-trillion-spend-rethink-energy-research/). Some regions may be able to produce green hydrogen for $1.0 per kilogram by 2030 (https://hydrogen-central.com/ryze-hydrogen-green-hydrogen-prices-plummet-dithering-investors/ January 2022).