The Macroeconomic Implications of Carbon Budgets for Ireland

John FitzGerald, Second Draft, 14th September 2021

1. Introduction

The task of decarbonising Ireland is a major challenge, and it will affect all aspects of our lives. Achieving a successful outcome will take time, but there is a strong commitment to making major progress by 2030, reducing emissions by 51% compared to 2018 levels. The payoff for this transformation of our economy will be Ireland's contribution to halting global warming by 2050. It will have other potential benefits in terms of biodiversity and human health. However, to make it happen will require a major increase in investment in decarbonising the economy, redirecting resources that could have been used for investment to reach other goals, and also resources that could have been used to fund household consumption and other current government expenditure. Obviously, there will be significant implications for employment, output and the competitiveness of the economy.

In addition, the necessary economic changes will have implications for those working in different sectors, for different households and companies. It will be the role of public policy to ensure a just transition, ensuring that the burdens and benefits of the transformation in our economy are shared fairly across society.

This note considers the economic implications of undertaking the necessary policy measures to meet our climate goals. It first outlines a macro-economic framework for this analysis. It then considers the likely effects on different sectors of the Irish economy of possible measures needed to meet our carbon budgets. Finally, it brings together the different strands of the analysis to provide a necessarily incomplete picture of the potential implications for employment, competitiveness and for different sectors in society.

2. Macroeconomic Framework

If the world is to reach the goals set in the Paris agreement, a step change in climate investment will be taking place across the world over the coming decade. The benefits will accrue in Ireland and elsewhere in a rapid reduction in emissions of greenhouse gases. However, as in Ireland, this redirection of resources to necessary investment is likely to be only partly offset by a reduction in expenditure on fossil fuels. In the medium term, the difference between the cost of the investment and the savings on fuels will have to be met by redirecting resources from other uses in the economy.[1]It is this reduction in resources for other uses which will represent the cost of the necessary changes in our economies. In some countries and some economic sectors, the fuel savings may be close to the cost of the investment, whereas in others the net "cost" will be quite significant. This process will play out across the world economy, as outlined in in a paper by Pisani-Ferry, 2021.[2]

The analysis of Pisani-Ferry and others suggests that internationally investment in tackling climate change could amount to 2% or more of GDP in the countries that take action. If there is widespread

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[1] In terms of timing, the investment will come first, followed by energy savings once the new capital stock is in operation. In the medium term what is important for GDP is the difference between the investment costs and the discounted savings over time.

[2] https://www.piie.com/publications/policy-briefs/climate-policy-macroeconomic-policy-and-implications-will-be-significant This paper also provides a brief summary of the literature on the macro-economic effects of tackling climate change. Rather similar analysis is also available in publications such as https://www.bruegel.org/2021/08/how-much-investment-do-we-need-to-reach-net-zero/

implementation of the Paris Agreement goals across the world, a 2% rise in investment, with no direct effect on savings, will result in a rise in interest rates. In turn this will slow investment elsewhere in the economy, with potential longer-term impact on output. The potential rise in interest rates will also affect governments that are highly indebted and will make borrowing by governments to finance the investment less attractive, suggesting a need to rely on taxation to fund the necessary investment. In turn, a higher level of interest rates is likely to adversely affect employment growth in the medium term.

The additional investment, through increasing the demand for investment goods such as solar panels and wind turbines, will lead to increased output and employment in the affected sectors. However, the funding of the investment will also see a reduction in investment elsewhere or a reduction in consumption. To the extent that the investment results in a reduction in expenditure on fossil fuels the negative effects of the funding will be limited in countries that don't produce fossil fuels. Obviously, those employed in producing fossil fuels and related products and services are likely to see a major reduction in employment. However, to the extent that the investment is not offset by savings in expenditure on fuel, there will have to be cutbacks either in other investment or in consumption. This reduction in other expenditure will see small losses of employment spread across many sectors.

The long-term effects on economies will obviously depend on their structures and how efficiently they tackle the challenge. While output in many economies may not be greatly affected, as climate friendly investment substitutes for other forms of expenditure, there will still be real costs for individuals, governments, and society from the need to use resources for climate goals rather than meeting the existing needs of household and government consumption. There will also be real gains for sectors that are important in the decarbonisation process.

To the extent that the savings on fuel do not support a commercial case for the necessary investment to eliminate carbon emissions, governments will have to take action to ensure that the investment takes place. This support can take a number of different forms: subsidies to make the investment attractive to households and companies; taxes can be raised on carbon emissions and related activities to make the necessary investment commercially viable; or the state can regulate to require the private sector to undertake the necessary investment.

If the state opts for subsidies, their cost will have to be funded by increased taxation. In turn, that taxation will reduce private expenditure elsewhere. To the extent that additional taxes are used to incentivise the necessary investment, the reduction in disposable income will also reduce private expenditure elsewhere, but the tax revenue will be available to the government to offset that deflationary effect. Finally, where the private sector is required to undertake the necessary investment by regulation, the result will also be a reduction in private expenditure elsewhere.

Thus, to a significant extent the necessary investment to tackle climate change will substitute for other expenditure. The changed composition of expenditure will have implications for employment, with some sectors gaining and some losing expenditure. The ESRI research, using the I3E model, is well placed to cast light on this issue, as does the UCD research, which has examined the sectors most likely to gain from the increased employment. Nonetheless, at an aggregate level the effects are not likely to be very large, given the offsetting nature of the changes in expenditure. However, if a substantial share of the investment goods were imported this would have a negative effect on national income.

Where there could be bigger effects is if the level of output in the economy changes as a result of the necessary changes in the structure of demand. The innovation, driven by the need to develop new technologies, could have a long-term positive effect on world output. However, there are a number of ways in which there could also be a significant negative impact on output. For example, where parts of the capital stock are written off prematurely (e.g. fossil fuel electricity generation stations, and fossil fuel cars) there is likely to be a loss of productive capacity.

Possibly more important, if much of the investment has to be directly or indirectly funded by the state necessitating higher taxation, there will be an additional loss of output. As first shown internationally in Pigou, 1928, this additional loss of output is due to the shadow price of public funds exceeding the revenue actually raised: taxes tend to reduce output by more than the amount actually raised in tax, while the spending of the taxes may not provide offsetting benefits.[3] Honohan and Irvine, 1987, showed a very high shadow price of public funds in Ireland in the 1980s. Partly as a result of the insights of that paper the tax system was subsequently reformed so that today the shadow price of public funds is much lower than in the 1980s.

The latest estimate of the shadow price of public funds is incorporated in the Public Expenditure Guidelines, 2019. In turn this work builds on Department of Jobs Enterprise and Innovation, 2018. The Public Expenditure Guidelines set the standard assumption for Irish state funded investment projects: the loss of output from raising taxes is assumed to be 130% of the revenue raised. Thus, if much of the investment is financed by taxation, rather than directly by the private sector, this will be a clear drag on the economy until the transition to a net-zero carbon economy is completed.

Finally, there may be some cases where output is directly affected by action on climate change. As discussed later, one such example are the necessary changes in the agricultural and food processing sectors, which will directly reduce output in Ireland. This will be likely to have a permanent effect on the productive capacity of the economy.

If, as is suggested in Pisani-Ferry, the world needs to undertake additional investment over the coming decade in tackling climate change amounting to 2% of national income, this will be quite feasible to achieve, being within the range of similar investment surges in the past. However, redirecting the resources needed from existing consumption and investment to necessary climate investment will still cause some pain.

Because the overall output effects from switching national expenditure will probably be relatively limited, so too will be the overall worldwide employment effects. However, fossil fuel intensive sectors and economies will obviously suffer severely from the transition. Also, there will be some losses in employment spread over other sectors of the economy as national expenditure is redirected to climate investment. The output and employment gains, which may substantially offset the losses, will be spread over a more diverse range of sectors.

Because the major costs of transitioning to a carbon neutral economy and society will arise from the necessary investment in new technologies, once that investment surge has been completed, the costs are likely to fall dramatically. However, if the world is to successfully decarbonise, the

[3] An example is a tax on labour. Higher taxes may cause workers to drop out of the labour market, especially those with significant child-care costs. In turn, this reduces output, while not producing tax revenue. The tax revenue is paid by those remaining in work, reducing their expenditure. It is this additional direct loss of output from people dropping out of the labour market due to the tax that makes the cost of public funds higher than the actual amount of revenue raised.

necessary investment surge is likely to continue for the next twenty years. Thus, financing the transition will substantially fall to the current generation.

3. Illustrative Policy Measures Needed in Ireland

Detailed analysis of the least cost pathway to decarbonising Ireland has been undertaken for the energy sector by the UCC MAREI Institute using the TIM model and, for agriculture by Teagasc. This work has identified a series of detailed measures that will be needed across all sectors of the economy if Ireland is to reduce its emissions of greenhouse gases by 51% by 2030. Obviously, with such forward looking modelling there is considerable uncertainty about the costs of future technologies and the scale of their adoption. However, the scenarios prepared provide a vital first step in identifying the types of investment and other action needed to decarbonise Ireland. In turn, it provides a basis for assessing the macroeconomic impact of the transition to a net-zero economy and society.

In considering the macro-economic effects of the transition in Ireland no account is taken of what happens outside of Ireland, As discussed above, effective world and EU action could see a rise in interest rates, with consequential effects on output and employment in Ireland. However, these effects are beyond the scope of this analysis. Instead, this analysis concentrates on the direct impact on the Irish economy of the action to be taken in Ireland to meet Ireland's climate change target for 2030. The external environment, including interest rates, is assumed to remain unchanged in the face of the climate action taken in Ireland.

In this Section some of the key measures from the UCC scenarios are identified and their possible cost and economic implications are discussed. In the case of investment that is commercially justifiable, this investment should take place even without major policy measures or state support. However, in many cases policy measures by the state will be essential if the investment is to take place.

Much of the investment in developing renewable electricity may end up costing consumers very little because of the saving on future expenditure on fossil fuels. However, for other investment, such as retrofitting dwellings, the future savings on fossil fuels are unlikely to offset the cost of the necessary investment. In the latter case state intervention, through a dramatic increase in the carbon tax or, more likely, a direct subsidy (funded out of general taxation), will be required to ensure that the investment takes place. As discussed above, because the costs to society are likely to be higher where the funding requires state subsidies backed by taxation, there will be additional costs for society and an additional loss of output and employment.

For this reason, for each of the measures considered here an assumption is made about the extent of the state support needed, support that will have to be met by higher taxation. The macroeconomic effects of higher taxation to fund the related subsidies are set out in Bergin et al., 2017 and Bergin *et al.*, 2013.

A key feature of the measures to decarbonise Ireland will be a major programme of investment in new technologies. The investment will occur before the resulting savings in reduced expenditure on fossil fuel energy are realised. At a project level, the funding of the investment could be delayed by borrowing. However, at the economy level, assuming full employment, at least initially the investment will have to be funded by reduced expenditure elsewhere. For the state, it is simplest to assume that increased expenditure must be financed by increased taxation. Even if it were assumed that the state borrowed to finance the investment, over time this borrowing and the related interest would have to be funded through increased taxation in the future. Also, as discussed above, effective world action to tackle climate change is likely to raise the cost of borrowing.

Table 1 sets out the implied average annual investment by sector between 2026 and 2030 under the different scenarios modelled by UCC-MAREI. In the case of the two scenarios where agricultural emissions are cut by 33% and energy emissions by 61% and where agricultural emissions and energy emissions are both cut by 51% (A51-E51,) the effects are shown compared to the base case of what the EPA terms "With Additional Measures" WAM. The effects on agriculture are treated separately.

Table 1: Average Annual Investment, 2026-2030, € million, base year prices

	Base	Change compared to WAM	
	WAM	A33-E61	A51-E51
Transport	4066	4186	804
Supply	136	89	188
Services	864	433	205
Residential	1272	2246	1610
Power	2309	1026	804
Industry	0	470	470
Total	8646	8450	4081

Source: UCC-MAREI Modelling

As shown in Table 1, the increase in average annual expenditure on energy related investment under the A51-E51 scenario is estimated to be around €4 billion, just under 2% of GNI* for 2020. Under the A33-61 scenario the increase in investment would be €8.5 billion, around 4% of GNI*, a very substantial stimulus. As discussed above, the bulk of the boost to domestic demand from this investment would be offset by a reduction in other forms of investment or a reduction in consumption. Thus, it is not readily apparent what would be the ultimate effect on output and employment.

To date the investment in renewable electricity has, if anything, saved electricity consumers money (di Cosmo, 2014 and IWEA, 2018). Here it is assumed that this continues to be the case over the period to 2030, despite the very demanding targets set for the sector. The cost of the increased investment would be offset in the long term by savings in expenditure on fossil fuels. This assumption needs to be tested by further analysis.

In the case of transport, between two thirds and three quarters of the investment relates to passenger transport (primarily cars). In the base case there is assumed to be substantial deployment of electric vehicles along the lines of the existing Climate Action Plan. In the base (WAM) scenario it is assumed that the deployment of EVs occurs on a purely commercial basis. Any cost premium for EVs is assumed to be offset by savings in the cost of fossil fuels over the lifetime of the vehicle.

In the A51-E51 scenario deployment of electric vehicles is assumed to be slightly higher than in the base case, involving an additional €800 million a year in investment, primarily by the household sector.

However, in the A33-E61 scenario the stock of Electric cars by 2030 is assumed to be around 800,000 higher than in the A51-E51 scenario. To reach this number of EVs it would be necessary to scrap early 800,000 old fossil fuel cars. If the scrapped cars had a residual value of €10,000 each (absent this particular action on climate change) the loss to the household sector would be at least €8 billion or around €1.8 billion a year between 2026 and 2030. This would represent a real loss to the affected households as, while the new EVs which they would have to buy would be much less costly to run, this would not offset the loss from the early scrappage of their existing car.

While regulation could force early scrapping, given the large loss which it would impose on generally poorer households with older fossil fuel cars, this would be difficult to achieve and could be widely seen as unfair. Given the commitments to a just transition, the households' loss on early scrappage, here assumed to be €8 billion over the period 2026-2030, would have to be met by the state through some form of scrappage scheme. In turn this would require the state to raise an additional €1.8 billion a year in taxation over the period 2025-2030. Given that Ireland does not produce cars there would be no offsetting bonus in terms of new car output.[4]

In the case of the household sector, the A51-E51 scenario assumes households will spend an additional €1.6 billion a year on retrofitting their houses and in the A33-E61 scenario they are assumed to spend €2.2 billion a year. With full retrofits costing around €40,000 to €50,000 each dwelling, these figures are broadly consistent with the numbers assumed in the Department of Housing's recent publication *Housing for All.*

While this investment will substantially reduce each affected household's expenditure on energy through switching to electricity (for more efficient heat pumps), they will still have a significant bill for electricity for heating. A paper by Coyne and Denny, 2021, using detailed Irish data, shows that even after a major retrofit to bring a house to at least a B2 standard, Irish households continue to spend more on energy than would be predicted by engineering models.

In 2018 households with gas central heating spent around €1000 a year and oil households spent closer to €1500 a year on fuel for heating. While all expenditure on fossil fuels will end if a heat pump is installed, there will still be a significant bill for the albeit limited amount of electricity used by the heat pump. Even for oil households, the likely savings in fuel costs from a retrofit will go nowhere near paying for the cost of a full retrofit. Even without discounting, the fuel cost savings would take many decades to recoup the capital cost.

This suggests that the targets for retrofit will not be met unless the state pays for the bulk of the costs. In any event the state will have to pay for retrofitting the social housing stock which it owns. If two thirds of the cost of the retrofits assumed here were to fall on the state, this would require the spending of between €1 billion and €1.5 billion a year over the period 2026-2030 to achieve the necessary target on retrofits.

In the case of industry both scenarios assume that CCS is installed in cement plants in 2030 at a cost of €2.4 billion or around €500 million a year over the period 2026 to 2030. As it is not expected that cement plants in other jurisdictions will have to make a similar investment, this would have a major adverse impact on the competitiveness of the sector. The likely effect would be the closure of cement production in Ireland, reducing emissions of CO2 by around 3 million tonnes. However, as there would be no impact on consumption of cement, the emissions would just be shifted to a neighbouring jurisdiction.

This would be an inappropriate way to reduce the headline numbers for emissions and it would have obvious costs in terms of lost output and employment, with no reduction in European emissions of greenhouse gases. As a result, if the CCS were to go ahead it is likely that the state would have to carry a significant part of the cost.

[4] Also there is likely to be some reduction in output and employment in the car maintenance sector.

The two other areas of additional investment identified by UCC-MAREI are relatively small and no assumption is made on the extent to which state support would be required to make them happen.

The final area where major action is needed for Ireland to meet its targets under the legislation is the agricultural sector. Given the target to reduce emissions of all gases by 51% by 2030, the minimum reduction in agricultural emissions is 33%. Anything less than that would leave an impossible task for the energy sector if Ireland is to meet the target for 2030 of reducing all emissions of greenhouse gases by 51%. As it is, reducing energy emissions by 61% by 2030, to complement the 33% reduction in agricultural emissions, is a major task, as is reflected by the fact that the marginal abatement cost for carbon dioxide is at least €2000 a tonne under this scenario, according to the UCC-MAREI work.[5] (The carbon tax for 2030 is due to hit €100 a tonne and the price for carbon in 2050 assumed in the Public Expenditure Guidelines is €256 a tonne.)

As recommended by the CCAC in previous Annual Review Reports, a limited reduction in livestock numbers may come at limited cost in terms of farm income. In particular, if it is targeted at the beef sector, the costs for the agricultural sector would be quite low. This reflects the fact that, on average, farmers market income in the sector is very low, with their main income source being CAP payments. However, as Teagasc 2021 shows, the cuts needed to meet the national target in the Climate Action and Low Carbon Development Act for 2030 are much more substantial. Furthermore, all of the recent increase in emissions has come from expansion in the dairy herd, so there are also fairness issues to be addressed within agriculture as to how the required reduction in emissions is achieved.

Teagasc have identified some technical improvements that could reduce methane emissions over the coming decade by over 10%, far short of the lower bound figure of 33%. As in other sectors, technical solutions are being developed which may substantially reduce methane emissions in the future at much lower cost and to a much greater extent than is feasible under current technologies. However, these will not be ready for deployment until the 2040s and, in the interim, the only way to reduce emissions by a large amount is by reducing activity and output specifically in the ruminant animal sector. Diversification into alternative activities needs to be encouraged, but experience shows this is likely to be a slow process at best.

As the Teagasc 2021 paper shows, to reduce agricultural emissions by 33% by 2030 it will be necessary to have a substantial reduction in livestock numbers. Current technical solutions can at best reduce methane emissions by around 10%. Moving to a 51% reduction in agricultural emissions would require a further dramatic reduction in livestock numbers or a dramatic new breakthrough in GHG mitigation technology that could be quickly commercialised and adopted by farmers. The latter is not anticipated till the 2040s.

The dairy sector is the one major area of agricultural activity that is very profitable, as is reflected in the rapid growth in the dairy cow population and output in recent year. Thus, once the scope for reducing cattle numbers in the beef sector is exhausted, reducing the dairy cow population will be expensive in terms of income and output losses.

In the agricultural sector labour is much less mobile out of the sector, especially given the age structure. Farmers generally leave the sector through retirement or death. Thus, if incomes are hit, farmers will be much less likely to move to work in other sectors, producing alternative output to replace lost agricultural output. In addition, milk is the one profitable area of farming in Ireland. The

[5] This is the marginal cost – the cost of reducing emissions in the most difficult case. The cost of most of the necessary measures would be lower than the marginal cost, generally much lower.

only other use for the land and agricultural capital, which would hold out the prospect of significant income, would be forestry.

In addition to losses in agriculture from reducing production, there will be significant losses in output, income and employment in the food processing sector. This sector relies on a steady input of materials – animals and milk – from the agricultural sector. The value added and employment in the food processing sector also takes place in regions of the country where there is much less alternative economic activity. This makes it particularly important to those regions

Table 2: Impact of Cutting Emissions on the Agricultural Sector, € million

	2019 Base	Cut in emissions of	
		-33%	-55%
Farm Income	3511	-878	-1931
Gross output	8367	-1673	-3347
Milk Output	2609	-731	-1565

Source: Teagasc

Table 2 shows an estimate of the impact on the agricultural sector of cutting emissions by 33% or 55% by 2030. These results are derived from graphs in Donnellan and Hanrahan, 2021. (They simulated the effects of a 55% reduction rather than 51%, but the difference between the two is likely to be sufficiently small that we can use the 55% cut results in conjunction with the earlier results for a 51% cut in emissions.) Because the resources used in agriculture, especially the labour resources, are not likely to be deployable elsewhere, the loss of farm income is likely to result in a permanent reduction in national income.[6]

Table 2 shows that in the case of a 33% reduction in emissions, the related reduction in activity would see a drop in farm income of just under €900 million or 25%. For a 55% reduction, farm income would fall by 55% or just under €2 billion. The figures for the effect on gross output, including milk output are also important because the output of the agricultural sector is a vital input into the food processing sector.

Generally, in the food processing sector, if the volume of inputs is reduced, there will be a related fall in value added, wages and employment. In addition, as Donnellan and Hanrahan, 2021 point out, additional value added and employment is generated in distributing and exporting the food produced by the sector.

In the long run, if there is a major fall in output and labour in the food processing sector, the capital and labour in the sector can probably be redeployed elsewhere in the economy. However, such redeployment will take time and stranded capital assets, as a result of a fall in output, would represent a significant cost.[7] Also, the short run disruption arising from a major fall in output would severely impact on the work force for a number of years before alternative activity develops in the relevant locations.

To estimate the knock-on impact of these cuts in output on the food processing sector and the rest of the economy a model, such as I3E, is needed. Donnellan and Hanrahan have used some evidence

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[6] By contrast, while it may be unprofitable to retrofit a house, the investment in the retrofit will generate output and investment mitigating the loss of national income and output.

[7] There has been substantial investment in recent years underpinning the expansion of the dairy sector and these capital assets would be stranded.

on marginal employment effects to provide the preliminary estimates shown in their Table, replicated here as Table 3.

Table 3: Output and Employment Impacts of Agricultural GHG Emission Reduction Scenarios: Marginal Employment Coefficients

	Scenario C -20%	Scenario D -33%	Scenario E -40%	Scenario F -55%
	Change in Output Value €m relative to BAU			
Milk	-478	-557	-1,400	-3,028
Cattle	-255	-541	-1,124	-1,347
Total	-733	-1,098	-2,524	-4,375
	Implied Change in Total Economy Employment (persons)			
Milk	-2,877	-3,352	-8,425	-18,223
Cattle	-2,876	-6,102	-12,678	-15,193
Total	-5,753	-9,454	-21,103	-33,415

Source: Donnellan and Hanrahan, 2021

An alternative simplistic approach is to assume that output and employment in the food processing sector falls in proportion to the fall in the volume of agricultural inputs available. Table 4 sets out the implications of such assumptions for value added, employment and wages in the food processing sector.

Table 4: Meat Processing, Dairy Processing and other Foodstuffs Production and Employment, € million

	2017	Change in Emissions	
	Base	-33%	-55%
Gross output	19,843	-3969	-7937
Value added	6,130	-1226	-2452
Wage bill	1,468	-294	-587
Employment	33,852	-6770	-13541

Source: The 2017 base data come from Eurostat Structural Business Statistics

Because many farmers fall into the lower half of the income distribution, and because the alternative income sources available to them are strictly limited, a major permanent fall in their income would be likely to have significant social consequences. Thus, it would probably fall to the State to replace much of that lost income through some combination of extensification payments and buy-out schemes. As shown in Table 2, depending on the scenario this would add between €900 million and €1,900 million to government expenditure (between just under 0.5% and 1% of GNI*) over the period 2026-2030.

Obviously not all of the lost income might need to be replaced by state support as there would be some movement to take up alternative sources of income. However, unlike the case of support for investment costs, the loss of income by farmers would be ongoing for the period they would have continued in business. While many of them are older and likely to retire over the subsequent decade, the necessary compensation would also probably need to continue at a reducing rate for some time after 2030. This would magnify the costs of the compensation shown in Table 5.

In addition, the state would have to fund training and support for those workers who lost their jobs in the food processing sector to help them transition to alternative employment. However, in a fully employed economy that support would be temporary rather than permanent, as in the case of support for farm income. No account is taken of these potential costs in Table 5.

Table 5: Summary of Possible Increased Government Expenditure to Support Necessary Climate Investment, average annual expenditure 2026-203, € million 2020 prices

	A33-E61	A51-E51
Transport	1.8	
Residential	1.5	1.0
Industry	0.5	0.5
Agriculture[8]	1.0	2.0
Total	4.8	3.5
% of GNI*	2.3	1.7

Table 5 shows an estimate of the possible additional state expenditure over the period between 2026 and 2030 required to ensure that the 2030 target for emissions reduction is achieved and that the incidence of the costs of adjustment are fairly distributed across society. The costs shown in the case of agriculture are an underestimate, as no allowance is made for the costs of supporting workers losing their jobs in food processing to transition to other sectors. In addition, no allowance is made for any additional costs arising from the need to ramp up investment in the power and services sectors.

The macro-economic effects of raising taxation to fund this additional expenditure needs to be assessed using a suitable macroeconomic model. The negative effects of raising taxation by the necessary substantial amount then needs to be offset against the stimulus to demand from the higher investment funded, directly or indirectly, out of that taxation.

4. Conclusions

As discussed above, depending on the scenario chosen by the government, meeting Ireland's target for reducing emissions by 51% by 2030 will require very substantial additional investment. In the case of the A33-E61 scenario it would amount to around 4% of GNI* and in the case of the A51-E51 scenario it would be closer to 2% of GNI* over the period 2026-2030.

Because much of the investment in tackling climate change would be financed by reducing investment elsewhere or reducing consumption, the ultimate output effects are unclear. (The I3E model analysis may throw some light on this issue). However, they are likely to be significantly smaller than the size of the investment shock.

However, even if output were relatively unchanged, society would face short-term losses in welfare from having to reallocate significant resources to tackling climate change. In return, these welfare losses would be much more than offset in the long term by the halting of the momentum of climate change.

[8] As noted above, this would be just the cost for the period 2026-2030. However, unlike in the case of support for investment, this support would probably need to continue for some time, albeit declining as those affected reach retirement.

The negative effects on output are likely to be more acute in the case of the transport sector in the A33-E61 scenario. In the case of agriculture, the negative effects in the A51-E51 scenario will arise primarily from a direct reduction in potential output, which would be permanent, given the current absence of competitive diversification opportunities. In the case of the early scrappage of fossil fuel cars, the costs would be temporary: once the costs of writing off the fossil fuel cars are met, thereafter there would be no further loss of output as EVs would be the cheap option.

The UCC research shows that the costs of the path to decarbonising Ireland set out in the recent climate legislation are likely to reach a peak in the period 2026-2030. UCC estimate the marginal abatement cost for reducing carbon dioxide emissions over the period 2026-2030 lies in the range €500 to €2000 a tonne. However, after the major investment surge over those five years the marginal abatement cost is likely to be much lower in the 2040s and the 2050s. This picture mirrors the scenarios undertaken by the UK Climate Change Committee which also show costs peaking in the late 2020s.

This note provides a crude preliminary approach to integrating the wide range of evidence assembled on the likely macroeconomic effects of the carbon budgets needed to underpin the commitment to reducing emissions of greenhouse gases by 51% by 2030. The analysis in this note is based on a range of untested assumptions that require further research. Also, the interpretation of the research used in this study needs to be clarified with the authors of that work.

Finally, the results quoted here tell only part of the story. To provide a complete picture the effects of the additional investment on the economy needs to be combined with the reduction in expenditure elsewhere in the economy to fund that investment. As outlined here, part of that funding is likely to come from an increase in taxation. When taken together the effect on national income and employment is likely to be negative, but the size of the change is likely to be substantially smaller than some of the macroeconomic shocks that the economy has suffered in recent decades.

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