



Rialtas na hÉireann
Government of Ireland

Revising the Shadow Price of Carbon used in Public Sector Economic Appraisal

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MARCH 2024

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Irish Government Economic and Evaluation Service

Rationale for Valuing Emissions in Public Sector Economic Appraisal

Ireland has committed to achieving ambitious but challenging legally-binding greenhouse gas (GHG) emission reduction targets, with key milestones in 2030 and 2050. It is therefore imperative that the assessment of public investment projects include an appropriate valuation of the cost that society will bear in dealing with the greenhouse gas emissions any project might give rise to or the benefits to society of a project that mitigates emissions. The best method of achieving this is through the use of an appropriate shadow price of carbon.

A shadow price is the monetary value assigned to an abstract or intangible commodity which is not generally traded in the marketplace. Unlike a regular commodity, an individual project may not have to pay any direct cost for the greenhouse gas emissions it may give rise to. However, since the country as a whole has legally binding targets to reduce greenhouse gas emissions, the cost of these increased emissions will be a burden on society. Since the increased emissions contribute to climate change, they may also impose an additional cost on society in adapting to climate change and the damage costs caused by increasing weather variability. Conversely, a project may result in reduced emissions, which will contribute to the achievement of our climate targets and benefit society.

To ensure that these future burdens (or future benefits) are taken into account, the amount of emissions a project may give rise to (or reduce) needs to be quantified and valued. This then allows the evaluator of the project to determine if this burden outweighs any benefits the project may bring, or vice versa.

The use of a shadow price of carbon has become a standard part of Government project evaluation frameworks globally. It also sees some use in the private sector and its use is mandatory for multilateral development agencies such as the World Bank. It was introduced into the Infrastructure Guidelines in 2009 and has subsequently been modified periodically.

Previous Review of the Shadow Price of Carbon

In 2019, the Department of Public Expenditure, NDP Delivery and Reform (DPENDR) reviewed the methodology used to derive the shadow price of carbon and updated the values applied to public sector economic appraisal under the Infrastructure Guidelines (previously the Public Spending Code).

As part of the 2019 review, it was decided that a marginal abatement cost, also known as a target consistent approach for valuing emissions, was the most appropriate methodology for deriving the

shadow price of carbon. This based the shadow price of carbon on the estimated abatement costs associated with reaching Ireland's emissions reduction targets.

The 2019 revision of the shadow price of carbon set out two separate schedules of values for the shadow price of carbon, depending on whether an appraisal is valuing emissions in the Emissions Trading System (ETS) or the sectors outside of the Emissions Trading System (non-ETS). Both of these schedules were based on a target consistent approach for valuing emissions i.e. the ETS value was calculated using the EU ETS emissions reduction target and the non-ETS value using Ireland's EU Effort Sharing Regulation reduction target.

Further detail on the 2019 review of the shadow price of carbon can be found [here](#).

Rationale for 2023 Review

Since 2019, Ireland's climate targets at both national and EU level have increased significantly in ambition.

As part of the European Green Deal, with the European Climate Law, the EU has set a binding target of achieving climate neutrality by 2050. To put Europe on the trajectory to meet this target, the EU has committed to reducing emissions by 55% by 2030, based on 1990 levels. In particular, this has impacted Ireland's legally binding non-ETS target under the Effort Sharing Regulation (ESR), which has increased from a 30% to a 42% reduction in GHG emissions in the non-ETS sector by 2030.

At a national level, Ireland has committed to achieving a 51% reduction in greenhouse gas emissions by 2030, compared to emission levels in 2018, which represents one of the most ambitious greenhouse gas emissions reduction targets in the world. Furthermore, the Climate Action and Low Carbon Development (Amendment) Act 2021 set Ireland's commitment to achieve climate neutrality by 2050 in law. This Act requires the Government to adopt a series of economy-wide carbon budgets on a rolling 15-year basis. The first carbon budget programme came into effect on 6 April 2022. These economy-wide budgets have been translated into specific targets for each relevant sector, known as [sectoral emissions ceilings](#).

In this regard, the National Development Plan committed the DPENDR to revising the shadow price of carbon in the Infrastructure Guidelines in light of Ireland's enhanced climate ambition. This commitment was echoed in the Government's Climate Action Plan¹.

¹ <https://www.gov.ie/en/publication/7bd8c-climate-action-plan-2023/>

The aim of the review is to align the shadow price of carbon in the Infrastructure Guidelines with the national ambition on climate action, as set out in the Climate Action & Low Carbon Development (Amendment) Act 2021.

Methodology

In deriving the new shadow price of carbon, this review endeavoured to strike the appropriate balance between practicality and accuracy, and taking account of the structure of Ireland's climate targets. The Department therefore believes that this shadow price of carbon trajectory represents the most appropriate values for use in economic appraisal under the Infrastructure Guidelines. However, the shadow price of carbon will need to be reviewed frequently as compliance with our carbon budgets and progress towards net-zero become more evident.

Target Consistent Approach

As part of this review, DPENDR has considered whether a target consistent approach continues to be the most appropriate method for valuation. Our research has indicated that other countries and multilateral agencies at the forefront of the low carbon transition are relying on this method. The UK Government has used a marginal abatement cost approach to value emissions in policy appraisal since 2009². New Zealand³ and France's Value for Climate Action Commission⁴ also used target-consistent approaches to derive the shadow price of carbon they recommend for use in public economic appraisal. Therefore, we are confident that this method remains appropriate and hence this review will not revisit this aspect of the methodology.

Carbon Budgets and Sectoral Emissions Ceilings

A carbon budget represents the total amount of emissions that may be emitted in the State during a five-year period, measured in tonnes of carbon dioxide equivalent. The carbon budgets provide for a reduction of 51% of greenhouse gas emissions by 2030 relative to 2018.

The first carbon budget programme comprises carbon budgets for the following periods: 2021-2025; 2026-2030 and 2031-2035, with the carbon budget for 2031-2035 being provisional:

² <https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation>

³ [CBAx Tool User Guidance: Guide for departments and agencies using Treasury's CBAx tool for cost benefit analysis - October 2022](#)

⁴ <https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/fs-the-value-for-climate-action-final-web.pdf>

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

These economy-wide budgets have been translated into specific targets for each relevant sector, known as sectoral emissions ceilings. A sectoral emissions ceiling is the maximum amount of greenhouse gas emissions that are permitted in a sector of the economy during each 5-year carbon budget.

Table 1: Sectoral Emissions Ceilings

| Sector | 2018 Baseline (MtCO2eq.) | Sectoral Emission Ceilings for each 5-year carbon budget period (MtCO2eq.) | | Indicative Emissions in Final Year of 2021- 2025 carbon budget period (MtCO2eq) | Indicative Reduction in Emissions in Final Year of 2021-2025 budget period compared to 2018 | Emissions in final year of 2026- 20230 carbon budget period (MtCO2eq) | Reduction in Emissions final year of 2026- 2030 carbon budget period compared to 2018 |
|--|--------------------------|--|------------|---|---|---|---|
| | 2018 | 2021-2025 | 2026-2030 | 2025 | 2025 | 2030 | 2030 |
| Electricity | 10 | 40 | 20 | 6 | ~40% | 3 | ~75% |
| Transport | 12 | 54 | 37 | 10 | ~20% | 6 | ~50% |
| Built Environment - Residential | 7 | 29 | 23 | 5 | ~20% | 4 | ~40% |
| Built Environment - Commercial | 2 | 7 | 5 | 1 | ~20% | 1 | ~45% |
| Industry | 7 | 30 | 24 | 6 | ~20% | 4 | ~35% |
| Agriculture | 23 | 106 | 96 | 20 | ~10% | 17.25 | ~25% |
| LULUCF | 5 | XXX | XXX | XXX | XXX | XXX | XXX |
| Other (F-Gases, Waste & Petroleum refining) | 2 | 9 | 8 | 2 | ~25% | 1 | ~50% |
| Unallocated Savings | | | -26 | | | -5.25 | |
| TOTAL | 68 | XXX | XXX | XXX | XXX | XXX | XXX |
| Legally binding Carbon Budgets and 2030 Emission Reduction Targets | - | 295 | 200 | - | - | 34 | 51% |

Source: DECC

TIMES Ireland Model (TIM)

Modelling to calculate the marginal abatement cost associated with the agreed sectoral emissions ceilings was undertaken by UCC MaREI using the TIMES Ireland Model (TIM), which is an optimisation model of the Irish energy system.

The TIMES-Ireland Model (TIM) that UCC has developed can inform future possible decarbonisation pathways for the Irish energy system. Information on the current Irish energy system, constraints, such as emissions constraints, and technological projections are fed into the model, which then finds the least-cost pathway for energy supply and demand in Ireland consistent with meeting the emissions reduction target. It accounts for all the linkages in the system, such as sector coupling and trade-offs.

Key inputs include primary energy resource availability and costs, the technical and cost evolution of new mitigation options, maximum feasible uptake rates of new technologies and climate policy targets. The model outputs give the lowest-cost configuration of the energy system (in terms of investment in and operation of energy technologies and fuel mix) which meets future energy demands at the lowest cost, while respecting technical, social and policy constraints.

A limitation of TIM is the sole focus on energy and process emissions. Non-energy related emissions from agriculture and land-use are very significant emitters in Ireland. The scenario used to value the shadow price of carbon therefore assumes that agriculture meets its sectoral emissions ceiling outside of this model, with TIM solving for the marginal cost of abating energy related emissions.

Further information on the TIM can be found [here](#).

For this review of the shadow price of carbon, new scenarios were developed to derive marginal abatement costs that align with our enhanced climate ambition. Individual sectoral carbon budgets for the amalgamated period 2021-2035 (periods 1-3) were used to constrain the model. The total carbon budget available for Ireland's energy sector from 2021-2050 was held constant at 379 MtCO₂.

A 30% contingency was added to each of the individual 15-year sectoral budgets, to give each sector some flexibility, and to allow trade-offs between sectors. This flexibility margin in individual sector budgets was not carried over into the all-energy budget. Hence, the sum of budgets for individual sectors is a larger sum than the constraint applied to the sum of sectors. All constraints apply simultaneously, and none of them are breached in the reported scenario. This allows for economic optimisation between sectors, and almost completely removes the variances in marginal abatement cost between sectors.

Policy Questions

Following the conclusion of the modelling, a number of key policy questions were considered in terms of the most appropriate way to translate the modelled marginal abatement costs into a practical shadow price of carbon for use in public economic appraisal.

1. One Value vs Separate ETS and Non-ETS Values

When revising the shadow price of carbon in 2019, the decision was made to value greenhouse gas emissions in the non-ETS differently from greenhouse gas emissions in the ETS by using two separate schedules of values. Up to this point ETS price estimates had been used to value emissions in all sectors.

It was felt that available market projections and the EU's reference scenario provided robust values for the shadow price of carbon to be used in the ETS sector. However, these projections were considered to undervalue mitigation costs in the non-ETS. If used to value emissions in the non-ETS sector the net result would be less decarbonisation than is optimal.

Furthermore, using separate pricing schedules reflected the distinction made in EU regulation between emissions in these sectors. Since Ireland's legally binding climate targets are based on emissions in the non-ETS sector, under-pricing these emissions would increase the risk that Ireland fail to reach these targets. Consequently, the cost of compliance borne by society or the cost that society will bear to exercise mitigation options would increase.

However, certain developments since the 2019 revision of the shadow price of carbon have led us to reconsider the appropriateness of valuing ETS and non-ETS emissions differently.

While the reduction of emissions in the ETS sector has, up to this point, only been subject to the overall EU wide ETS emissions target, Ireland now has an economy-wide 51% emissions reduction target in 2030 and net-zero by 2050. These targets do not differentiate between emissions in the ETS/non-ETS. Marginal abatement costs should ideally be compared across the entire economy to determine the least cost pathway for Ireland to reach these targets.

In addition, the extreme price volatility in the ETS sector at present further brings into question the reliability of using these projections as an emissions valuation methodology. Since the previous revision of the shadow price of carbon, the ETS allowance price has increased rapidly, reaching €50/tCO₂ in summer 2021 and continuing to climb, reaching an all-time high of €100/tCO₂ in February 2023. This price level is significantly higher than the 2021 and 2023 shadow prices from the 2019 review for both the ETS and non-ETS sectors.

Providing one shadow price of carbon for all emissions also has practical benefits, in that it simplifies the calculation required for an appraisal and should ensure a greater level of consistency across appraisals. One economy-wide price should also remove the risk of inefficiencies and transfers between the ETS and non-ETS sectors.

The UK appraisal framework does not have a separate price for emissions covered by the UK ETS and those emissions outside the UK ETS. However, it does include provisions for appropriate adjustments to be made to account for any existing carbon pricing in the market prices of goods or services in order to avoid double counting. Prior to the 2021 revision of the UK carbon values, the UK did use separate carbon values for the ETS and non-ETS sectors, on the basis that different targets in each sector implied that emissions in the two sectors were essentially different commodities and that the carbon values need to reflect this. This distinction ceased from 2030 where a single carbon value for all emissions was assumed⁵.

On the basis of the above points, the shadow price of carbon has been updated to provide one value for all greenhouse gas emissions, rather than valuing greenhouse gas emissions in the ETS and non-ETS sectors differently.

2. Post-2050 Shadow Price of Carbon

The Infrastructure Guidelines does not currently provide guidance on how the shadow price of carbon should be applied post-2050. The modelling undertaken as part of this review of the shadow price of carbon only provided marginal abatement costs out to 2050. There is much uncertainty surrounding the period post-2050 and the assumptions required to estimate marginal abatement costs for this period. In the UK, BEIS note that the way in which variables in their model interact over time in the complex, dynamic global climate, economic and social system is both uncertain and, in some areas, unknown. However, as some project proposals will have impacts beyond 2050, it is important that any emissions impacts beyond 2050 resulting from these projects are included during the project appraisal.

Given such uncertainty, the UK simply apply a real annual growth rate of 1.5% to the 2050 value to derive values for the post-2050 period. The Value for Climate Action Commission in France applied an annual growth rate of 4.5%, which is equal to the discount rate, between 2050 and 2060, with the

⁵ The UK assumed that beyond 2030 there would be a fully working global carbon market, thus implying a single carbon value for economic appraisal over the 2031-2050 period that reflects the costs required to achieve the EU long term target of limiting dangerous climate change to 2 degree centigrade.

shadow value of carbon held stable after 2060. The reasoning behind this is that, though the stock of capital required to meet net-zero targets has already been constituted in the 2050-2060 period, the value of carbon should continue to grow to guard against any return of emissions or risk of delay in achieving the net-zero target. After 2060, it is reasoned that the relative weight of climate externalities in comparison to other externalities should not continue to increase over time, given the stability of carbon sinks and the stability of the abatement technology costs.

In New Zealand, the shadow price is calculated out to 2050, with an annual growth rate of 3% applied each year thereafter for situations where a longer term shadow price is required than the 2050 price. This growth rate is lower than the standard public sector discount rate.

Taking the above into consideration, it was decided to apply a 4% annual growth rate, in line with discount rate, to provide values between 2050 and 2055. This has the effect of keeping the shadow price of carbon constant in real terms post-2050.

Shadow Price of Carbon

Applying the proposed approach to the policy questions outlined above to the modelling outputs provided by UCC MaREI, the following schedule of shadow price of carbon values was derived:

| Shadow Price of Carbon € ₂₀₁₈ tCO ₂ | |
|---|-----|
| 2024 | 322 |
| 2025 | 335 |
| 2026 | 349 |
| 2027 | 363 |
| 2028 | 377 |
| 2029 | 392 |
| 2030 | 408 |
| 2031 | 424 |
| 2032 | 441 |
| 2033 | 459 |
| 2034 | 477 |
| 2035 | 496 |
| 2036 | 516 |
| 2037 | 537 |
| 2038 | 558 |
| 2039 | 580 |

| | |
|------|------|
| 2040 | 604 |
| 2041 | 628 |
| 2042 | 653 |
| 2043 | 679 |
| 2044 | 706 |
| 2045 | 735 |
| 2046 | 764 |
| 2047 | 794 |
| 2048 | 826 |
| 2049 | 859 |
| 2050 | 890 |
| 2051 | 926 |
| 2052 | 963 |
| 2053 | 1001 |
| 2054 | 1041 |
| 2055 | 1083 |