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An Ghníomhaireacht um Chaomhnú Comhshaoil

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Towards a Green Net National Product for Ireland

STRIVE

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2007-2013

SSTI Strategy for Science, Technology and Innovation

Comhshaol, Pobal agus Rialtas Áitiúil
Environment, Community and Local Government

Environmental Protection Agency

The Environmental Protection Agency (EPA) is a statutory body responsible for protecting the environment in Ireland. We regulate and police activities that might otherwise cause pollution. We ensure there is solid information on environmental trends so that necessary actions are taken. Our priorities are protecting the Irish environment and ensuring that development is sustainable.

The EPA is an independent public body established in July 1993 under the Environmental Protection Agency Act, 1992. Its sponsor in Government is the Department of the Environment, Community and Local Government.

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We license the following to ensure that their emissions do not endanger human health or harm the environment:

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- large scale industrial activities (e.g., pharmaceutical manufacturing, cement manufacturing, power plants);
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- the contained use and controlled release of Genetically Modified Organisms (GMOs);
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- Office of Environmental Enforcement
- Office of Environmental Assessment
- Office of Communications and Corporate Services

The EPA is assisted by an Advisory Committee of twelve members who meet several times a year to discuss issues of concern and offer advice to the Board.

EPA STRIVE Programme 2007–2013

Towards a Green Net National Product for Ireland

(2009-SD-LS-2)

STRIVE Report

Prepared for the Environmental Protection Agency

by

The Economic and Social Research Institute

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DISCLAIMER

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Executive Summary

Introduction

National governments devote considerable resources to measuring economic performance, for example as measured by gross domestic product (GDP) but less resource is devoted to measuring the enhancement or degradation of the environment associated with economic growth. Economic activity affects the environment both positively and negatively and conversely natural resources and a clean environment contribute to economic growth and well-being. To place decisions that affect the environment on a strong empirical foundation it is important that a set of Environmental Accounts are incorporated into the national accounts. This project is a step towards achieving that goal and builds upon an earlier Environmental Protection Agency (EPA)-funded research project 'Ireland's Sustainable Development Model' (Lyons and Tol [2010]). The key objective of the earlier project was to develop a sustainable development model (ISus) relating environmental pressure on key resources to relevant economic developments. This report documents the further development of that work, developing data and resources that contribute towards measuring Ireland's green net national product (GNNP). The project, through the ISus model, combines historical data and behavioural equations to predict future trends in environmental emissions to inform public debate on environmental policy options.

This report is broken into two distinct parts. The first part is an 'end-of-project report' for the 'Towards a Green Net National Product for Ireland' project and covers work on the development of both the ISus model and Environmental Accounts. The discussion in Part I also contains summaries of research papers that were published (mostly in peer-reviewed journals) during the course of the project. Part II of the report is the environmental policy analysis section and presents the latest environmental emissions projections from the ISus model (as of spring 2013) and a detailed discussion of four policy areas where public discussion is currently active: (i) climate, (ii) transport, (iii) agriculture, and (iv) waste.

Environmental Accounts: National, Regional and Distributional

The Economic and Social Research Institite (ESRI) Environmental Accounts have collated a wide variety of environmental data and classified the emissions by economic sector of origin. In most instances the data covers the years 1990–2010. This data will facilitate research about environment-economic issues, for example the environmental performance of specific economic sectors or economic analyses of particular pollutants. The Economic and Social Research Institute (ESRI) Environmental Accounts now include 20 gaseous emissions to air, 19 resource uses (energy), emissions of 9 metals; 7 persistent organic pollutants (POPs); 3 categories of particulate emissions; and 5 types of waste with 5 dispositions, each for 20 sectors of the economy. Environmental Accounts are critical for the ISus emissions projection scenarios model, as the ISus model uses the historical data in the accounts to estimate behavioural relationships between economic activity and each of the emission types (e.g. CO_2, hazardous waste). The Environmental Accounts are also a resource for estimating GNNP and are available to download from the ESRI's website.*

Analysis of some environmental issues makes more sense at a regional rather than a national level. For instance, while a summary of national water quality is useful for understanding current trends, more spatial detail is required to understand local idiosyncrasies and devise appropriate remediation measures. The regional capabilities of the ISus model were developed during the project such that emissions can now be mapped and analysed at a range of spatial levels, including by county, electoral division and river basin district.

* http://www.esri.ie/irish_economy/environmental_accounts/

The pressure households place on the environment and how they respond to policy measures will differ substantially depending on a host of circumstances, including those related to income, household composition, and location. This applies to the business sector equally. A core result from the research on the distributional analysis of environmental emissions is that a decomposition of emissions by household types shows that households will not be impacted equally by environmental policy measures designed to curtail emissions. However, it also shows that policies can be researched and tailored so that the worst polluting households can be specifically targeted and vulnerable groups protected. For instance, the main results show that on a per-person basis richer households in urban areas have the poorest emissions performance.

Environmental Expenditure

Environmental regulation is necessary to protect environmental quality; nonetheless, the business sector often argues that regulation, including environmental regulation, impacts negatively on competitiveness. The analysis of businesses' environmental expenditure finds that the impact of environmental regulation on business is nuanced. Energy taxes affect total factor productivity, employment, capital investment and profitability, but not necessarily negatively. The analysis supports the Porter Hypothesis that environmental taxes can encourage firms to innovate, which in turn can improve competitiveness and enhance productivity. Energy taxes have a positive effect on employment in some sectors, such as textiles and wood products sectors, where labour in these sectors is typically lower skilled and can be easily substituted for energy -ntensive capital. For most sectors, energy taxes show a positive effect on the return on capital.

Environmental Projections and Policy Analysis

Environmental emissions projection scenarios covering the period to 2030 are presented with the objective of contributing to discussions on environmental policies. The projections, developed using the ISus model, are based on macroeconomic and environmental policy assumptions and are not intended as forecasts of future environmental outcomes. The purpose of projections is to gauge how successful current policies and trends are likely to be in achieving policy targets and thereby contribute to a discussion of how environmental policy might be amended.* The environmental projections discussion focuses on four policy areas where public discussion is currently active: (i) climate, (ii) agriculture, (iii) transport and (iv) waste.

Climate Change

Ireland's actual greenhouse gas emissions for the period 2008–2012 are expected to be within the Kyoto Protocol target limit. However, the prospect for compliance in terms of actual emissions with other climate targets is much less positive. Installations with high greenhouse gas emissions will be regulated within the European Union Emission Trading Scheme (EU-ETS), whereas emissions from the remainder of the economy are subject to binding limits as part of the EU Commission's Effort Sharing Decision. The ISus baseline projection is that by 2020 non-ETS emissions will be roughly 5 per cent below 2005 levels, compared to a committed target of a 20 per cent reduction. Without dramatic change from existing practices it is difficult to envisage how the target will be achieved. While the 2020 emissions targets may be onerous, longer-term targets will be even more so considering the EU's agreed long-term objective of 80–95 per cent reduction in emissions by 2050 compared to 1990. Transitioning to a low-carbon economy is now a necessity and all sectors of the economy will be expected to play a role. Agriculture and transport, which account for roughly three-quarters of Ireland's non-ETS emissions, must lead the transition to a low-carbon economy.

* A forecast is a prediction of a future outcome whereas a projection is an assessment of a future outcome subject to underlying assumptions. For example, one of the underlying assumptions in this report is future energy prices (as outlined in Table 9.1), which are assumed rather than forecast and hence figures for future emissions are projections subject to the underlying assumptions rather than a forecast of a future outcome.

Sustainable Agriculture

The agriculture sector is promoting an expansion in output, which will support employment and rural development, as well as supply growing world food demand but the sector is potentially constrained by environment policy. The sector emits a large share of non-ETS emissions but any curtailment in Irish agricultural production to comply with domestic climate policy targets will not reduce global emissions. Production will move overseas whereas Ireland's dairy and beef production systems are among the most efficient worldwide in terms of carbon footprint. Preserving emissions-efficient production in Ireland is preferable from a global climate policy perspective and therefore seeking a special mechanism for managing agricultural emissions outside the non-ETS targets would be a desirable strategy.

There is considerable opportunity for the agriculture sector in the move to a low-carbon economy. Teagasc has identified significant carbon-abatement potential in the sector, which would facilitate an expansion in output. A further alternative for the sector is for it to become a major producer of renewable energy, through a variety of energy crops. With the majority of farm enterprises grass based, grass as an energy crop is highlighted as an area needing further research. Energy from grass is generally not a viable economic proposition at present but with energy potential that exceeds many of the usual energy crops it could be a long-term measure that helps in the transition to a low-carbon economy.

Expanding output also has implications for nutrient management. There is evidence that nutrient-management initiatives in agriculture are paying dividends, but the EPA's *State of the Environment* report provides proof that further improvement is still required, as nutrient losses from agriculture are still attributed as a major source of enrichment of surface and ground waters. Expanding output increases the amount of nutrients that must be managed so the threat to water quality remains an ongoing issue for the sector.

Sustainable Transport

Emissions from transport have more than doubled since the 1990s, growing by more than 4 per cent per annum on average. Emissions projections signal a continuing growth in emissions, not as high as in the past but strong growth nonetheless. That level of growth is unsustainable both for a country attempting to reduce emissions and also in terms of the impact on global climate. There are no simple near-term pragmatic solutions to reducing transport emissions dramatically. Transport is integral to both economic activity and social interaction and seriously curtailing transport activity (as opposed to transport emissions) is not a practical option. A carbon tax, which directly penalises use of the fuels from which emissions arise, is an efficient instrument to ration transport demand, but to make any meaningful progress of reducing emissions practical low-emission transport alternatives are necessary. Electric vehicles fall into that category, as does the development of renewable transport fuels for blending with, and as alternatives to, petrol and diesel. On the other hand, fuel rebates for specific sectors run counter to measures aimed at encouraging innovations in fuels, fuel efficiency and reducing emissions.

Waste Management

The economic downturn serendipitously contributed to reductions in waste generation and has helped Ireland meet waste-management policy targets. Economic conditions may lead to further reductions in the municipal waste stream for the next few years, but by the end of the decade waste generation will likely have recovered to 2010 levels. However, some of the improvements in waste management are likely to persist. For example, improvements made over time in recycling behaviour are likely to continue. How waste is treated in the future is likely to be substantially different than today with greater levels of recycling/recovery and a lower reliance on landfill. Waste-treatment capacity will have to evolve to enable this to happen, whether it relates to treatment of organics, dry-recyclables, or residual waste. The private sector will play an important role in delivering new waste collection and treatment capacity but the efficient management of the waste-management system will depend on the roles of regulatory authorities and new regional waste-management plans. One proposal within the new waste-management policy that should significantly improve matters in relation to illegal dumping and burning of waste is mandatory household collection. Nevertheless, for waste-management policy to work well, it is imperative that households and businesses face clear and effective incentives. Pricing structures for waste management must be simple and apply to all without exemption. Waste collectors should be required to apply pay-by-use tariffs (with effective enforcement of this requirement) and encouraged to operate simple and transparent pricing schemes.

1 Towards a Green Net National Product for Ireland

1.1 Introduction

The environment and the economy are interlinked. Natural resources and a clean environment contribute to economic growth and well-being. Economic activity affects the environment both positively and negatively; climate change is a well-recognised example of the latter. National governments devote considerable resources to measuring economic performance, for example as measured by gross domestic product (GDP), but less resource is devoted to measuring the enhancement or degradation of the environment associated with economic growth.

Within the national accounting framework GDP is the sum of the value added of the economy and is a measure of national income. When profit repatriation and net remittances from abroad are deducted, this equals gross national product (GNP), which is a further measure of income. Net national product (NNP) takes changes of wealth into account and equals GNP plus net investment in capital goods (i.e. gross investment minus depreciation). Up until this point all these measures from countries' national accounts are measures of the economic performance without reference to changes in natural resources, including environmental resources.

To place decisions that affect the environment on a strong empirical foundation, it has been proposed to include a set of Environmental Accounts into national accounts (Nordhaus and Kokkelenberg [1999]) following a well-established theoretical framework (Nordhaus and Tobin [1972]; Weitzman [1976]). Only a small number of countries have Environmental Accounts that have good coverage and are updated regularly (Pedersen and de Haan [2006]). In Ireland, the Environmental Accounts contain far less detail than the United Nations recommendations (United Nations et al. [2003]). This research project extends Ireland's Environmental Accounts and moves closer to developing a green net national product (GNNP) for Ireland: a measure of wealth creation that includes environmental wealth (Dasgupta and Maeler [2000]). A GNNP subtracts two things from NNP: first, NNP is corrected for environmental pollution and second NNP is corrected for degradation in natural resources, be it quantity, quality, or value.

This project, 'Towards a Green Net National Product for Ireland', builds upon an earlier Environmental Protection Agency (EPA)-funded research project 'Ireland's Sustainable Development Model (ISus)' (Lyons and Tol [2010]). The key objective of the earlier project was to develop a sustainable development model which could link environmental pressure on key resources to relevant economic developments. ISus is a simulation model that combines historical data and behavioural equations to predict future trends in environmental emissions. The ISus model projects future environmental emissions (e.g. to air) and natural resource use (e.g. energy), subject to assumptions on policy and economic growth conditional on scenarios for economic growth and environmental policies. In that regard ISus is a tool to analyse how policy affects environmental emissions, and also a tool that can be used for environmental-planning purposes. The current version of the model (v0.8) uses historical data for the period 1990–2010 to calibrate the model and estimate relationships, while projections are generated for the period 2011–2030. In the current project the ISus model was extended in a number of ways: to provide dimensions for regional Environmental Accounts, distributional Environmental Accounts, as well as elements related to energy and environmental expenditures. A synthesis report on the development of the ISus model and the data in the underlying Environmental Accounts are available in (Lyons and Tol [2010]). Further details on the model, data and supporting documentation is available on the Economic and Social Research Institute's (ESRI) website.[1]

This is an 'end-of-project' report for the 'Towards a Green Net National Product for Ireland' project and covers work on the development of both the ISus model and the Environmental Accounts. Additionally,

1 http://esri.ie/research/research_areas/environment/isus

the report contains the latest (as of spring 2013) environmental emissions projections using the ISus model and subsequently discusses a number of current environmental policy issues. Consequently, the report is divided into two parts. Part I is the ‘end-of-project report’ (Sections 2–7) and uses the work package titles from the original research proposal. These sections describe the research work undertaken, covering (i) developments in the national Environmental Accounts, (ii) regional Environmental Accounts, (iii) distributional Environmental Accounts, (iv) environmental protection expenditures, and finally (v) the development of an energy sub-model within ISus. The discussion in these sections also contain summaries of research papers that were published (mostly in peer-reviewed journals) during the course of the project. Part II (Sections 8–14) of the report is the environmental policy analysis section, which utilises the ISus model and the results of the analysis described in Part I. Part II presents the latest environmental emissions projections from the ISus model (as of spring 2013) and a detailed discussion of four policy areas where public discussion is currently active: (i) climate, (ii) transport, (iii) agriculture and (iv) waste.

Part I

2 National Environmental Accounts: Past and Future

At the beginning of this project the ESRI Environmental Accounts[2] covered, for 20 economic sectors, 20 emissions to air, 4 emissions to water, 1 emission to land, 19 resource uses, and 3 types of waste with 4 dispositions. During the project the accounts were revised substantially in a number of areas and new substances added in order to reflect changes in data availability and a changing regulatory framework for some substances. The ESRI Environmental Accounts now include 20 gaseous emissions to air, 19 resource uses (energy), emissions of 9 metals; 7 persistent organic pollutants (POPs); 3 categories of particulate emissions; and 5 types of waste with 5 dispositions. The sector disaggregation remains unchanged at 19 productive sectors and the residential sector (see Appendix I).

These accounts are critical for the ISus emissions projections scenario model. The ISus model uses the historical data in the accounts (currently updated to 2010) to estimate behavioural relationships between economic activity and each of the emission types (e.g. CO_2, hazardous waste) for all 20 economic sectors in the model. These estimated behavioural equations are used to project future emissions from each sector based on exogenous assumptions of macroeconomic performance of the economy. When making projections of environmental emissions the ISus model relies on the ESRI's macroeconomic projections of future economic performance within the Irish economy. Through this project the development of both the Environmental Accounts and the ISus model has helped integrate environmental and economic research at the ESRI and consequently mainstreamed environmental issues in the ESRI's analysis and discussion of the Irish economy.

2 The Environmental Accounts provide information on emissions and resource use and are designed to be consistent with the national accounts. The ESRI Environmental Accounts are described in detail in Lyons et al. (2009).

In addition to the use of the Environmental Accounts with ISus in the preparation of emissions projections, the ESRI Environmental Accounts are a resource for environmental research in their own right. The accounts have collated a wide variety of environmental data and classified the emissions by economic sector of origin. In most instances the data covers the years 1990–2010. This data will facilitate research of environment-economic issues, for example the environmental performance of specific economic sectors or economic analyses of particular pollutants. The ESRI Environmental Accounts are available to download from the ESRI's website.[3]

The remainder of this section outlines the major developments in the accounts during the course of the project.

2.1 Persistent Organic Pollutants, Heavy Metals and Particulates

In the previous version of the Accounts, dioxin emissions were based on research studies that developed a dioxin emissions inventory, with aggregate estimates of dioxin emissions to land, air and water.[4] In the intervening period the EPA developed a methodology that complies with their reporting obligations to the Convention on Long-range Transboundary Air Pollution (CLRTAP), and additionally provides more extensive and consistent data covering heavy metals and particulate emissions. Using the CLRTAP data, which reports emissions by process source, emissions are decomposed into economic sector of origin. Consequently, the Environmental Accounts' coverage of dioxin and furan emissions has improved substantially and heavy metal, and particulate and other POP emissions have been added. Persistent organice pollutants emissions include: polychlorinated biphenyls (PCB), hexachlorobenzene (HCB), Benzo(a)

3 http://www.esri.ie/irish_economy/environmental_accounts/

4 Hayes and Marnane (2003) and Creedon et al. (2010).

Table 2.1. Waste Accounts composition.

	Primary materials			Secondary materials		
Dispositions	**Hazardous**	**Biowaste[7] (organic)**	**BMW, non-Biowaste (non-organic)**	**Other, non-Biowaste**	**Soil & stones**	**Incinerator ash**
Landfilled	X	X	X	X	X	
Recycle/ Recovery	X	X	X	X	X	
Incinerated	X	X	X	X		
Used as fuel	X	X		X		
Unattributed	X	X	X	X	X	X

pyrene, Benzo(k)fluoranthene, and Indeno(1,2,3-cd) pyrene.[5] The heavy metal emissions added to the Environmental Accounts are: mercury, cadmium, lead, chromium, arsenic, zinc, copper, nickel, selenium. Particulate emissions are included as measurements of PM2.5, PM10 and total suspended particulates (TSP).

2.2 Waste Accounts

The Waste Framework Directive (2008/98/EC) introduced biowaste[6] as a new regulatory waste category. The classification of waste within the ESRI Environmental Accounts was extended to reflect this new regulatory category, both in the historical waste data and in projections to enable compliance with policy targets to be tracked. The re-classification extended the waste accounts from three types of waste with four dispositions to five types of waste with five dispositions, as shown in Table 2.1, where an 'X' denotes combinations that are present within the accounts. The 'unattributed' disposition category is a residual and includes uncollected household waste. For accounting purposes 'incinerated' waste is distinguished from waste that is 'used as a fuel' – though for most economic policy purposes the distinction will not be relevant.

2.3 Economic Accounts

Economic data was used to help analyse emissions and resource-use data in the Environmental Accounts. Subsequently, in ISus these series were used to project future emissions based on economic activity. In previous versions of ISus (v0.1–v0.5) a mix of economic data was used for this purpose: gross output where available, and value added (net output) elsewhere. The economic data used for this purpose has been revised and a consistent time series developed. The Central Statistics Office (CSO) does not publish time series of gross output and value added across the 19 productive sectors of the economy, but CSO data (e.g. Census of Industrial Production and Input-Output data) is used to prepare such estimates. The economic data now includes gross output, value added and employment

5 Polychlorinated biphenyls (PCB), which cover a broad family of synthetic organic chemicals known as 'chlorinated hydrocarbons', were used in hundreds of industrial and commercial applications. PCB production was banned by the Stockholm Convention on Persistent Organic Pollutants. Hexachlorobenzene (HCB) is a fungicide formerly used as a seed treatment and has also been banned under the Stockholm Convention on Persistent Organic Pollutants. Benzo(a)pyrene, Benzo(b) fluoranthene, Benzo(k)fluoranthene and Indeno(1,2,3-cd) pyrene are polycyclic aromatic hydrocarbons (PAHs) and mix more easily with oil than water. PAHs occur in oil and coal and are produced as by-products of fuel combustion (including biomass fuels). PAHs in the environment are found primarily in soil, sediment and oily substances, as opposed to in water or air.

6 Biowaste incorporates biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food-processing plants.

7 Biowaste partially overlaps the regulatory waste category of biodegradable municipal waste (BMW). The 'BMW, non-biowaste' category is the non-organic fraction of BMW. The organic fraction of BMW is included in biowaste. 'Other, non-biowaste' comprises materials that are non-hazardous, non-BMW, and non-biowaste. See McCoole et al. (2012) for further definitions of regulatory waste categories and Curtis (2012) for waste classifications used in the Environmental Accounts.

series across the 19 productive sectors. Gross output is generally a better indicator of economic activity and hence environmental pressure than value added, which is a better indicator of economic prosperity.

2.4 Decomposition of Air Emissions

Decomposition analyses of air emissions were completed in order to provide a better understanding of which processes drive emissions. An index decomposition analysis was used to split the historical trend in National Emission Ceiling Directive emissions[8] into four constituent parts: (i) population growth, (ii) per-capita income growth, (iii) structural economic change, and (iv) technological progress (Tol [2012]). Despite rapid economic change in the 1990–2009 period, emissions fell for three of the four pollutants, with ammonia being stationary. Falling emissions per-unit output was the main driver of the overall trend, except for ammonia where structural economic change was the main driver. If these historical trends continue, Ireland will keep emissions below its national emission ceiling, with the exception of nitrogen oxides (where emissions are likely to fall below the ceiling target by 2015). A decomposition analysis of greenhouse gas emissions (Llop and Tol [2011]) shows that different factors are driving emissions of carbon dioxide, methane and nitrous oxide. A primary driver of carbon dioxide emissions is, to a greater extent, final demand of other sectors. In the case of methane, the primary source of emissions relates to demand from other sectors for intermediate goods. Most methane is emitted from the agriculture sector, but demand for agricultural commodities (e.g. by food-processing sector) is driving sector output and emissions. For nitrous oxide (also primarily from the agriculture sector) there is no general rule of thumb with both intermediate and final demand driving emissions.

2.5 Emissions Trading Scheme

Climate policy distinguishes between greenhouse gases emitted from installations regulated by the EU Emissions Trading Scheme (ETS) and emissions originating from elsewhere in the economy (non-ETS). The regulatory tools employed to curtail emissions from these two sources differ and hence it would be useful to model and project ETS and non-ETS emissions separately. Technical energy criteria determine whether an installation should be regulated under the ETS, and hence the ETS sector does not match the NACE classification of economic sectors that is used within ISus. Some NACE sectors have a high share of ETS installations, whereas other NACE[9] sectors have few or no ETS installations. It is not practically feasible to model and project ETS and non-ETS emissions separately for each of the 20 sectors within ISus. Therefore, the ISus model continues to project emissions by sector without distinguishing between ETS and non-ETS shares. However, it is important from a policy perspective to present ETS and non-ETS projections, although National and Economic Social Council (NESC, 2012) warns that focusing on the ETS and non-ETS split might mislead people on the nature and scale of the climate policy challenge by suggesting emissions from ETS sectors are 'taken care of'. Nonetheless, ISus projections of greenhouse gas emissions are now disaggregated 'ex post' into ETS and non-ETS emissions for each of the 20 sectors within ISus. To do this, data on verified emissions of individual ETS installations published by the EPA are used and these installations categorised by ISus sector. It is assumed that ETS emissions by sector will grow at the same rate as those projected by ISus for the entire sector (i.e. combined ETS and non-ETS). There is no evidence to suggest how the growth in emissions from ETS installations within a sector differs from the growth in aggregate sector emissions. Non-ETS emissions are then calculated as the difference between projections of aggregate and ETS emissions.

2.6 Annual Updates

The ESRI Environmental Accounts are updated as new data becomes available and the full accounts are published annually on the ESRI's website.[10] Maintenance and updating of the Environmental Accounts include revisions to the historical series from

8 Sulphur dioxide (SO_2), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC), and ammonia (NH_3).

9 The Statistical Classification of Economic Activities in the European Community (in French: Nomenclature statistique des activités économiques dans la Communauté européenne).

10 http://esri.ie/irish_economy/environmental_accounts/

1990 as methodological rules and reporting are revised, for example, under the greenhouse gas emissions reporting to the United Nations Framework Convention on Climate Change (UNFCCC).

In addition to the annual maintenance and publication of the ESRI Environmental Accounts, an annual 'Environmental Review' report is published (Devitt et al. [2010]; Curtis [2012]). Part II of this report contains the latest Environmental Review. These reports present latest ISus emissions projections based on macroeconomic and environmental policy scenarios and are intended as a contribution to public discourse on environmental policy issues.

2.7 Summary

Over the course of the project the Environmental Accounts have been expanded extensively. Additional substances have been added and data for existing substances updated, as new data was published. The Environmental Accounts now represent a resource for researchers analysing the relationship between business and the environment. One instance where this has already occurred is in the estimation of the value of environmental damage both within sectors and across the economy (Woods [2012]). The Environmental Accounts were used with data from the environmental damage valuation literature to make a first approximation of GNNP. Between 1997 and 2007 environmental damage estimates across the economy were estimated to have decreased by roughly 30 per cent, largely driven by the rise of the services sector and improvements in emissions intensity of industry, with the latter particularly attributed to the implementation of an industrial licensing system by the EPA.[11] However, the loss of welfare due to pollution is relatively small, falling from 2.9 per cent of GNP in 1997 to 1.2 per cent of GNP in 2007. Overall, Wood's estimate of the gap between GNNP and NNP is relatively small, meaning that in current circumstances NNP is a reasonable approximation of GNNP in Ireland.

The ESRI Environmental Accounts now include emissions data for 44 substances plus resource use for 19 types of energy covering the main substances of policy concern. The modular design of ISus means that when data for additional emission types are added to the Environmental Accounts it can be easily incorporated into the ISus model. All emission types for which there is relatively comprehensive data have now been incorporated into the Environmental Accounts. Water resource use is still a significant gap in the accounts though in time the data collected through water metering will provide significantly better

11 A study of emissions from EPA licensed industry found that between 2001 and 2007 aggregate emissions declined by 22 per cent in the chemical sector, 28 per cent in the food and drink sector, 40 per cent for the pharmaceutical sector and by 45 per cent in the power generation sector (Styles and Jones [2010]).

information than is currently available.

3 Regional Environmental Accounts

Given different environmental footprints across income groups and industries, and given the uneven distribution of the population and industry across spatial units, spatial differences with respect to environmental issues would be expected. While for many environmental matters, such as greenhouse gas emissions, national accounts are perfectly adequate for most purposes, there are some purposes for which spatial disaggregation is useful. For many issues, such as air and water quality, national statistics are less informative as they impact only at a local or regional scale.

Analysing environmental issues at a regional level is more complicated for two reasons. Firstly, only limited data – particularly on the socio-economic drivers of environmental impacts – is available. Secondly, defining the appropriate spatial scale is not straightforward as data is often collected for different types of spatial units and the boundaries of these are often not coterminous. For example, river basin districts and hydrometric areas are defined on the basis of topography, while socio-economic data is collected for specific administrative units. As a consequence, spatial analysis requires a range of mappings of data between spatial units and also interpolation where data is not readily available.

3.1 Estimating Regional Emissions

Tol et al. (2009) construct regional estimates of the environmental pressures posed by Irish households and the environmental problems faced by them. The basic unit of analysis is the electoral division (ED), and the main data source is the CSO's Small Area Population Statistics (SAPS) from Census 2006. The approach adopted is to run classifying regressions of the Household Budget Survey to impute domestic energy use at ED level using equivalent data from the SAPS. Engineering relations are utilised to impute transport fuel use, and secondary data on household behaviour to impute waste arisings. By focusing solely on households this analysis does not construct spatially disaggregated data related to production activities. This issue is tackled in Leahy et al. (2009), who combine the approach of Tol et al. (2009) with the detailed analysis of the economic geography of Ireland in Morgenroth (2009). Morgenroth (2009) uses an approach that utilised a special tabulation from the CSO 2006 Census of Population Place of Work Anonymised Records (POWCAR) to establish the geographic distribution of employment at the two-digit NACE level at ED level. This analysis found that production activity (excluding agriculture) is more spatially concentrated than the population, which implies that environmental impacts from economic activity are also more spatially concentrated.

Leahy et al. (2009) construct labour satellite accounts from the Census for Industrial Production and the Annual Services Inquiry, with supplementary data from the Quarterly National Household Survey and the Census in order to calculate emissions per employee and sector, and value added per employee and sector. These are combined with the data on the number of employees per ED and sector established in Morgenroth (2009) to estimate emissions and value added per ED. While greenhouse gas emissions broadly follow the degree of economic activity, differences in emissions by sector and the different spatial distribution of sectors result in a different spatial pattern of emissions as compared to activity (see Fig. 3.1).

The resulting data was used to investigate the spatial incidence of a carbon tax: it found that at the household level commuting areas face the highest burden of a carbon tax (Leahy et al. [2009]). This arises because transport patterns are the key difference between households in commuting areas and those in city or rural areas more generally.

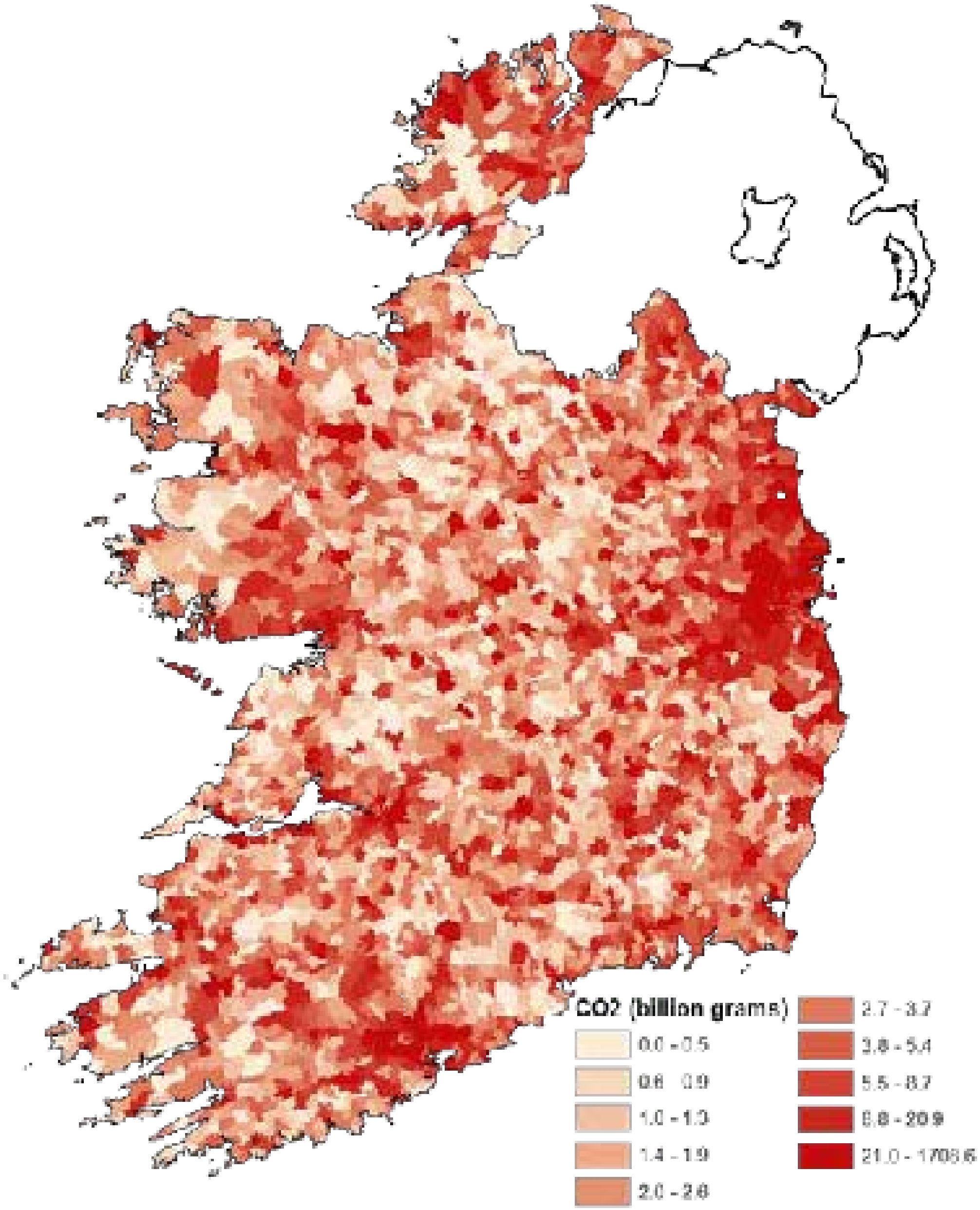

Figure 3.1. Carbon dioxide emissions by production activities.

Source: Morgenroth (2009)

3.2 Transport

The regional Environmental Accounts include emissions from transport. In the absence of additional changes of behaviour, greenhouse gas emissions are projected to grow by approximately 20 per cent between 2010 and 2020 (see Part II, Section 12). Thus, there is a need for closer consideration of the determinants of transport patterns. With respect to household travel it is noteworthy that there is a persistent trend to less sustainable travel patterns. For example, mode shares for public transport, and walking to work or school have consistently declined since the 1980s, as shown in Fig. 3.2.

In order to identify appropriate policies to improve the sustainability of transport and to predict future trends, it is necessary to consider the determinants of transport decisions. One important issue is the effect of availability of public transport. Naturally, where no public transport is available such modes could not be expected to be used. However, in practice it is possible to use a private mode of transport to access a public transport. In order to analyse this, it is useful to consider travel mode shares in small spatial units. Morgenroth (2012) models rail modal share for 3401 electoral divisions using 2006 and 2011 data. Explanatory variables include accessibility, which is measured as minimum drive time to the nearest railway station, measures of service quality and a number of socioeconomic variables. As expected, access to a railway service is found to be an important determinant of rail mode share. However, measures of service quality and in particular train frequency explain a larger portion of the variation in the data than accessibility, which suggests that an increase in service frequency would be a more effective policy to increase rail mode share than to build new rail lines. The analysis also finds that high levels of car ownership reduce the rail share, which concords with the finding in the literature.

3.3 Water Quality

Curtis and Morgenroth (2012) consider the marginal contribution of various catchment activities to lake water quality. The approach in this research is to

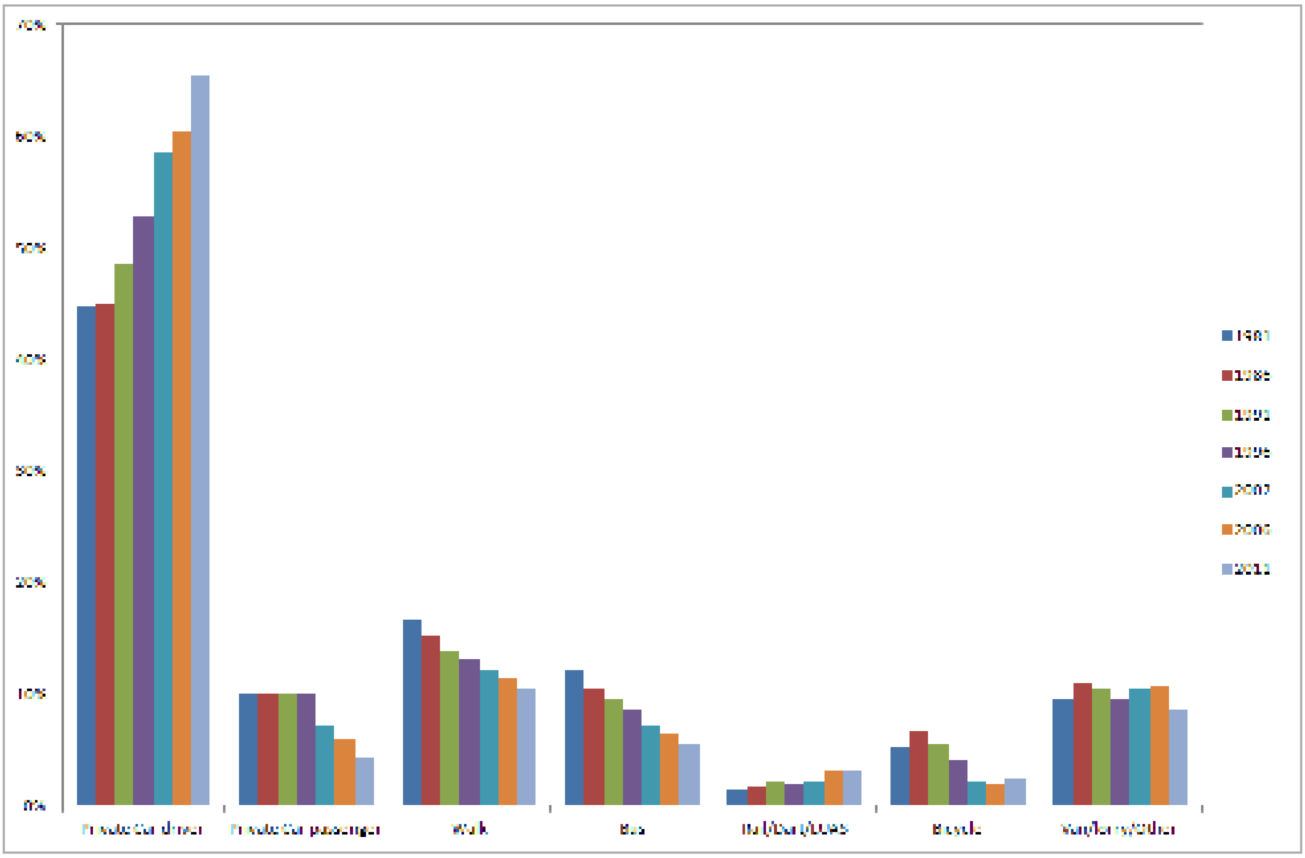

Figure 3.2. Trends in travel mode shares for commuting to work and school.

Source: Central Statistics Office Census, various issues map spatial data based on administrative boundaries to lake catchments using a simple spatial algorithm. This data is then used to estimate the effects on lake water quality using linear and quadratic models. This is a significant enhancement over previous research on catchment level statistical analyses, which were based on a relatively simple relationship between the share of catchment land in specific land uses and water quality. The analysis shows that the relationship is neither simple nor linear and that models of water quality need to incorporate all aspects of anthropogenic activity, though the non-availability of data will limit the extent to which this is practically possible. The empirical results show that the relationship between pollutant source and water quality is complex. For example, the marginal impact of urban populations on lake-water quality is found to be disproportionately greater for smaller towns. An implication for water policy in this instance is that growth in small towns will have a disproportionately greater impact on water quality than growth in larger towns given existing waste water-treatment systems. The results also show a clear relationship between the level of excreted phosphorus within catchments and lake-water quality. Not unexpectedly, the larger the phosphorus loading from livestock within a catchment, the proportionately greater is the marginal impact on water quality. Importantly, the analysis shows a means by which risk profiles for both sampled and unsampled lakes can be established.

3.4 Summary

Analysis of some environmental issues makes more sense at a regional rather than a national level. For instance, while a summary of national water quality is useful for understanding current trends, more spatial detail is required to understand local idiosyncrasies and devise appropriate remediation measures. The regional capabilities of the ISus model were developed during the project such that emissions can now be mapped and analysed at a range of spatial levels, including by county, electoral division, river basin district, and, as discussed above, by lake catchments.

4 Distributional Environmental Accounts

Households, as well as business sectors of the economy, differ – both in idiosyncratic and systematic ways. This is potentially very important for policymakers given that different household types/ sectors of the economy put different pressures on the environment and thus may be affected differently by environmental policies. An important distinction to make here is between indirect and direct emissions: direct emissions are those which a household has control over (by burning a coal fire for example), in contrast to indirect emissions which a household cannot control (for example, pollution from the manufacture of a kettle). This distinction is important when analysing what impacts policy changes could potentially have on different household types. Taxes or regulatory measures affecting indirect emissions fall more heavily on households that purchase a lot of goods and services, whereas the cost of measures affecting direct emissions relates mainly to how much energy a household uses for heating, lighting and other purposes. Each household has a different mixture of these types of spending, so the burden of environmental policy on different groups can vary depending upon how it is designed.

The aim of the work was to extend ISus, using micro-data at household level from the CSO, so that direct emissions by income decile and other household characteristics could be identified. The work was undertaken in three parts, with emissions decomposed by final demand sector, by intermediate goods (Hyland et al. [2012a]) and by household type (Lyons et al. [2012]). This is important as, firstly, Verde and Tol (2009) show that, for Ireland's household sector, direct emissions of CO_2 are larger than indirect emissions, and secondly, so that analysis can then focus on relationships between household activities and the environment. This section gives an overview of decomposition of emissions for the economy as a whole. This is followed by a decomposition of emissions at the household level, and finally a decomposition analysis of a carbon tax is presented.

4.1 Decomposition at Economy Level

Looking at an aggregate level, Hyland et al. (2012a) use input-output decomposition analysis to examine the drivers of greenhouse gas emissions from energy on the island of Ireland, comparing results for the Republic of Ireland and Northern Ireland. The analysis takes 19 sectors, looking at both the production and consumption side of the economies in order to determine the main sources of greenhouse gas emissions, though focusing primarily on the emissions of carbon dioxide. The analysis shows that the majority of greenhouse gas emissions can be attributed to a select few sectors, but that the inclusion of intermediate goods matters. When intermediate goods and final demand goods are analysed together, the emission intensity differences of the sectors is less prominent. The sector with the highest carbon dioxide intensity is fuel, power and water (i.e. power generation) for both the Republic and Northern Ireland. For Northern Ireland the transport sector and the manufacture of non-metallic minerals are second and third respectively. For the Republic of Ireland the second highest carbon dioxide intensity is the manufacture of non-metallic minerals (e.g. cement production) and third is the transport sector. The power generation sector of the Northern Ireland economy emits more CO_2 than the Republic, but this could be because 43 per cent of fuel used is coal in Northern Ireland compared to only 26 per cent in the Republic. The decomposition of emissions for the economies of Ireland and Northern Ireland are shown in Fig. 4.1 for production and Fig. 4.2 for consumption for each sector in the respective economies.

Figures 4.1 and 4.2 show that both the transport and power-generation sectors are important sources of emissions from both production and consumption but with several notable differences. For example, CO_2 emissions from consumption in the services sector are very large, but emissions from production in this sector are not prominent. This is fairly intuitive given

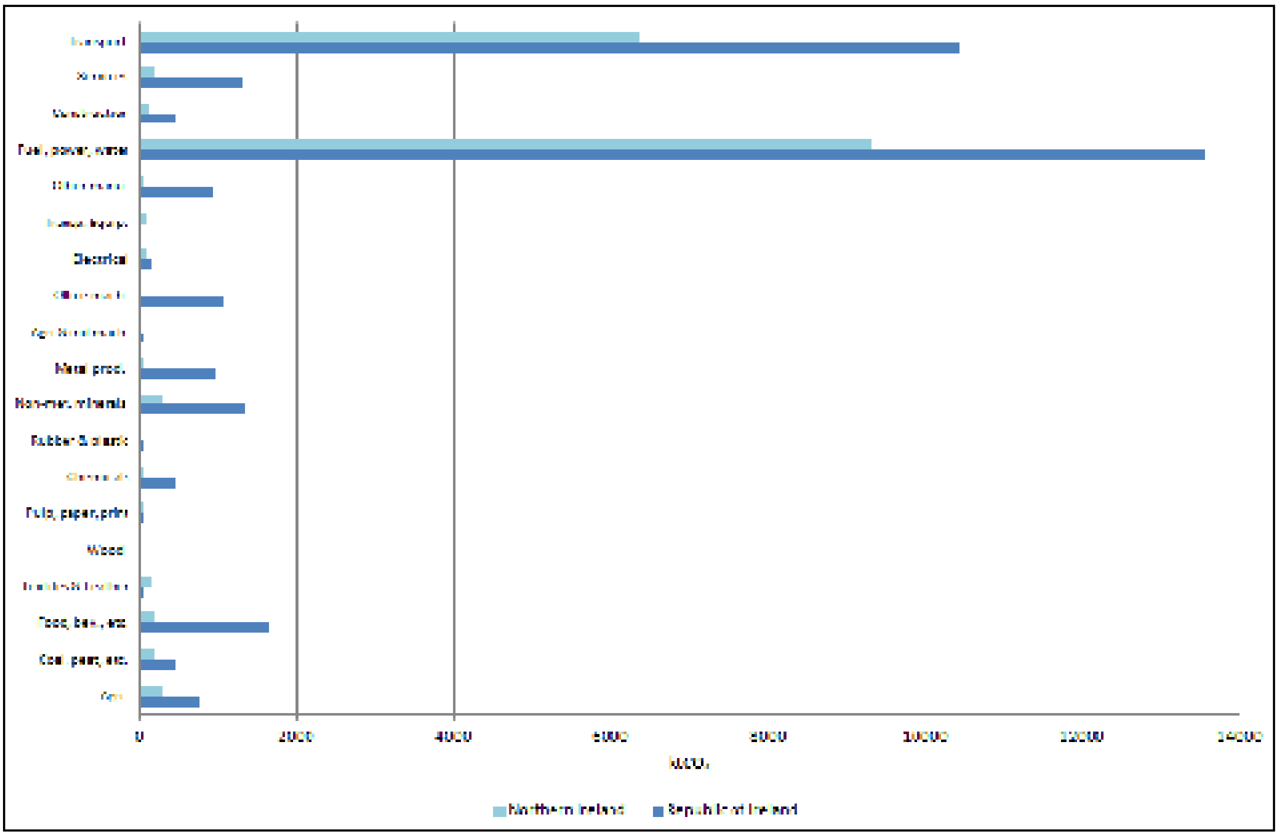

Figure 4.1. Energy-related emissions from production.

Source: Hyland et al. (2012a)

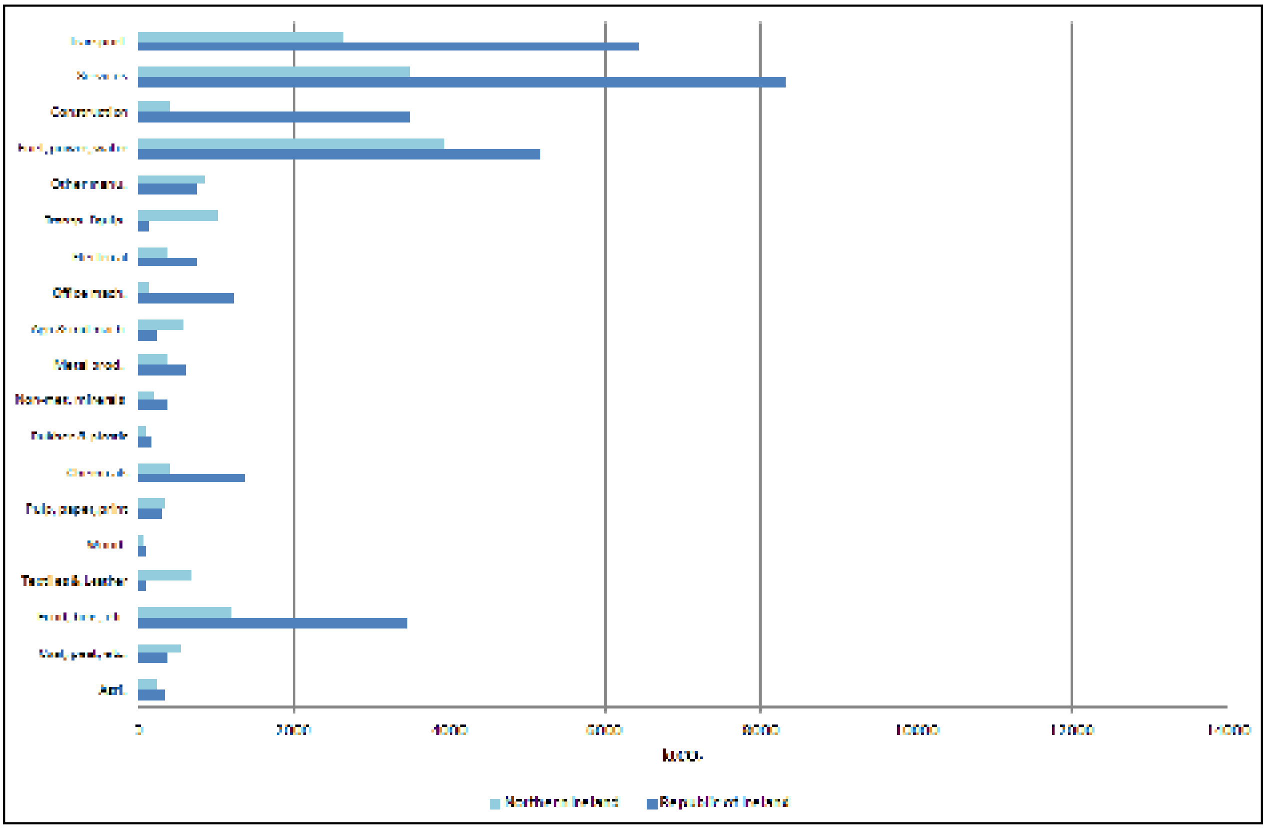

Figure 4.2. Energy-related emissions from consumption.

Source: Hyland et al. (2012a)

that hospitals, buses and schools use up a lot of fuel and energy when being demanded (consumed) over time by the public. In general, emissions from consumption (demand) are greater than emissions from production in Northern Ireland, while the opposite is true for the Republic of Ireland, but the differences are fairly minimal.

4.2 Decomposition at Household Level

Lyons et al. (2012) look at decomposing emissions at a household level for a range of household types. This paper aims to determine direct and indirect emissions for an average person by household type, across 41 emissions. All results analysed are for the year 2006, but it is likely that the results do not vary substantially over time as many household practices are slow to evolve. The household type categories used are location (urban and rural, the latter contains much of the commuter belt), income decile (10 deciles), household size (1 to 7+ person households), household composition (e.g. single adult, couple with two children, single parent) and number of disabled residents. The paper tests hypotheses on emissions across a range of household types, including:

- That rural households have higher direct emissions due to more frequent use of private transport and longer journeys whereas urban households may emit more by indirect means through the use of public transport services;
- That richer households have higher emissions than poorer households due to being able to afford more energy use (or that richer households offset increased emissions by investing in ‘green technology’);
- That if economies of scale in consumption are present then households with more people would, on a per capita basis, emit less than those with fewer residents.
- That household composition matters in relation to emissions:
  - That retired households emit more than a working household, per person, as they are potentially at home more during the day;
  - That a single parent may not be able to afford as much energy consumption as a household where two working adults reside, leading to fewer household emissions;
  - That households with children emit less (per head) if economies of scale in consumption are present.

Three sets of results are summarised here: for (i) greenhouse gas emissions, (ii) air pollutants and (iii) metals.

As an overview, Fig. 4.3 shows the split of direct and indirect emission sources for households. The majority of emissions are emitted indirectly; however, the most important greenhouse gasses are also emitted directly. For example, roughly 1 per cent of methane (CH_4) comes from direct sources; 8 per cent of nitrous oxide (N_2O) and roughly 33 per cent for carbon dioxide (CO_2) from fossil fuel is contributed by direct sources. Direct emissions of POPs (for example, dioxins and PCBs) and of polycyclic aromatic hydrocarbons (for example indeno(1,2,3)pyrene and benzo(a)pyrene, the greatest source of which is from combustion in the residential sector) contribute over 90 per cent of the total emissions.

Looking at the household level for greenhouse gas emissions (CO_2, CH_4, N_2O and HFCs), the patterns which emerge are very similar across emissions. Only the results for carbon dioxide (CO_2) will be presented here (Fig. 4.4) as this is the greenhouse gas which households emit the most. Figure 4.4 shows that an average person in an urban household emits more CO_2 than an average person in a rural household, contrary to our hypothesis. The richer the household, the higher both total and indirect emissions compared to poorer

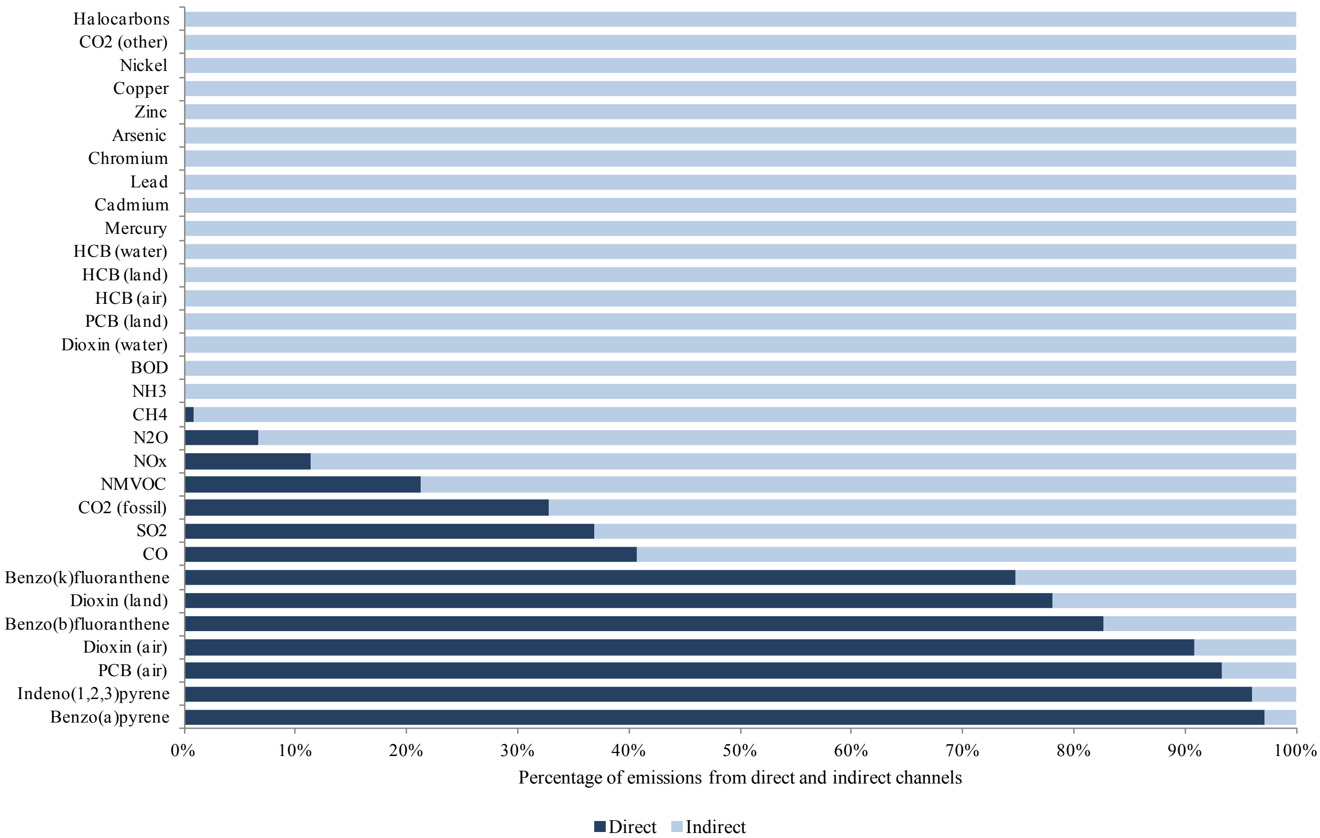

Figure 4.3. Emissions from households by direct and indirect channels (%).

Source: Lyons et al. (2012)

households per person. The richer deciles also pollute more by direct means, but the differences between the income groups are not as pronounced as for pollution by indirect means. The larger the household the lower the emissions per person, which is intuitive given economies of scale in consumption: a meal is only cooked once whether it be for one, two or five people in the household. The only anomaly is for a retired aged single adult; for a single adult it is expected that total emissions are higher than a for a couple per person (given economies of scale in consumption); however, this is not the case. This could be due to an average couple having a higher income than an average single retired person.

As an example of other air pollutants,[12] Fig. 4.5 shows the distribution of carbon monoxide (CO) emissions per average person for different household types. Direct sources of carbon monoxide emissions are car exhausts, whereas indirect source include emissions from power-generation plants. Per capita, the lowest emitters of CO are a couple with at least four children; the highest emitters are working-aged single households. This may be caused by economies of scale in consumption. While per-person emissions are mainly from indirect sources for most households, direct emissions also play a significant role. The patterns are similar to those analysed for the greenhouse gases – where richer households emit more on a per capita basis than poorer households. Larger

12 Other air pollutants include sulphur dioxide (SO_2) and non-methane volatile organise compounds (NMVOC).

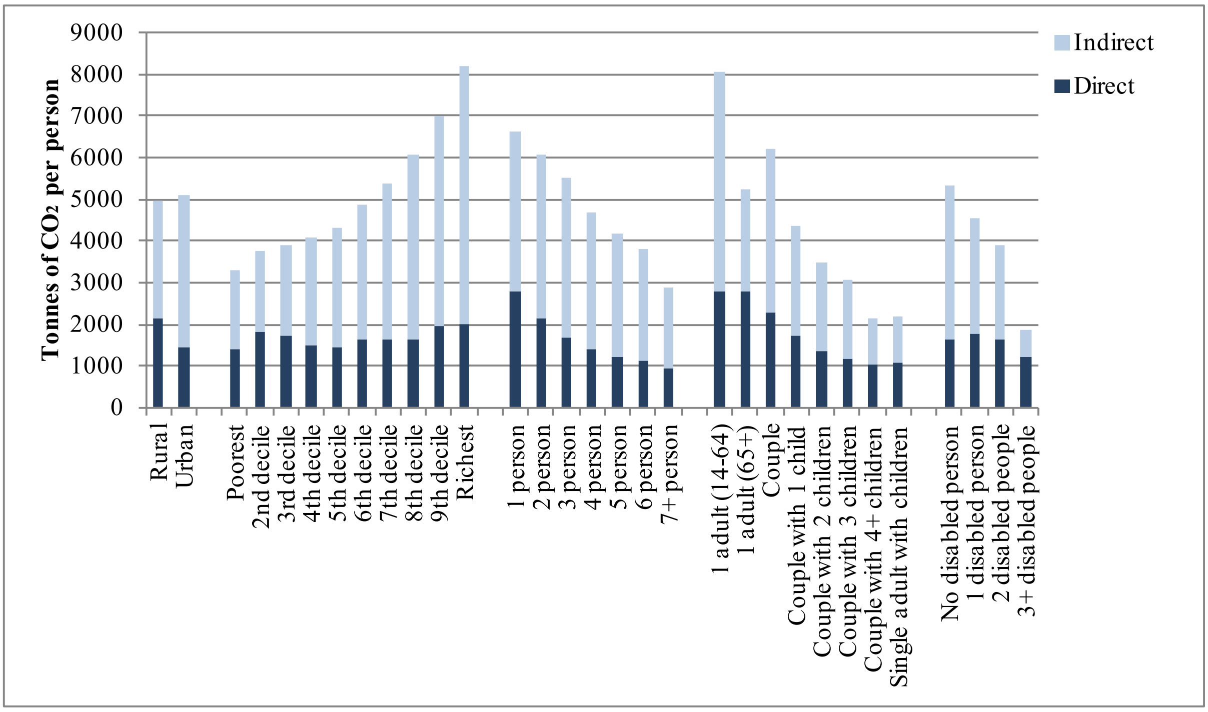

Figure 4.4. Direct and indirect emissions of carbon dioxide (CO_2) per person by household type.

Source: Lyons et al. (2012)

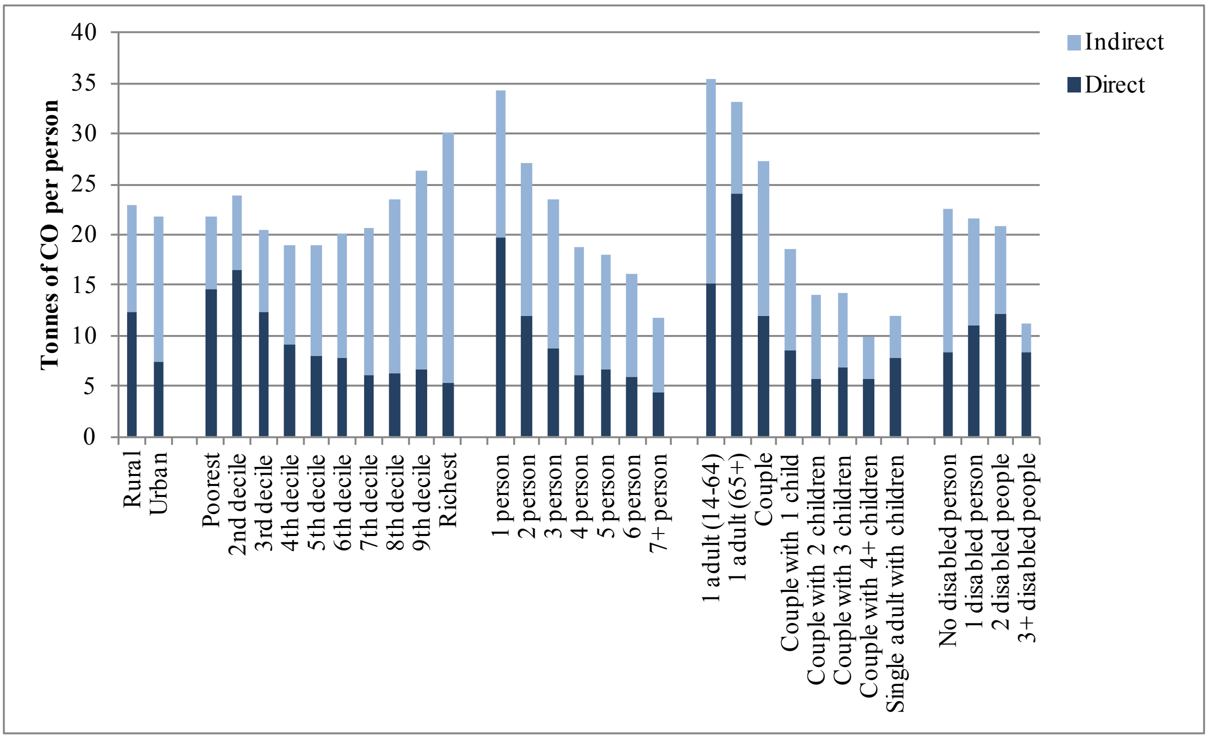

Figure 4.5. Direct and indirect emissions of carbon monoxide (CO) per person by household type.

Source: Lyons et al. (2012)

households also pollute less than smaller households on a per-capita basis. A significant difference between richer households and rural households, lower-income and smaller households is that per-person emissions are greater from *direct* sources than indirect sources (which is the opposite scenario to that of the greenhouse gases). There is also a small difference between air pollutants and greenhouse gases for the urban–rural split. An average rural household pollutes more CO and SO_2 than an urban household, whereas the urban household was the largest emitter of greenhouse gases (and also non-methane volatile organic compounds [VOC]).

The metal emissions of lead, mercury, cadmium, chromium, zinc, copper and nickel all exhibit the same pattern between household types; a joint graphic for lead, mercury and cadmium is shown in Fig. 4.6. Data is only available for metal emissions via indirect channels by households, so no direct pollution is shown. Indirect metal emissions are mainly a result of fossil fuel combustion – for example, pollution from coal-fired power stations, and industrial processes such as pulp and paper manufacturing; lead and cadmium are also present in cigarettes.

The patterns shown in Fig. 4.6 for metal emissions are very similar to those of the greenhouse gas emissions: the average urban household pollutes more than its rural counterpart on a per-person basis and the rich emit far more than poorer households. Per-person emissions decrease with household size; however, households composed of one, two or three residents have roughly the same emissions before the total declines with four or more residents. On a per-person basis, a single working-aged adult pollutes more than other household compositions and a couple with at least four children and a single parent pollute the least of the household compositions.

Having looked at individual pollutants, Lyons et al. (2012) also examine the relationship between emissions and both household size and income. Household income and size are analysed as these household types have a clearer policy focus than location or household composition.[13] Figure 4.7 depicts the relationships that direct and indirect emissions have with income:

13 The incidence of a carbon tax, for example, would tend to be correlated with household income and size (through higher consumption), rather than household composition or location.

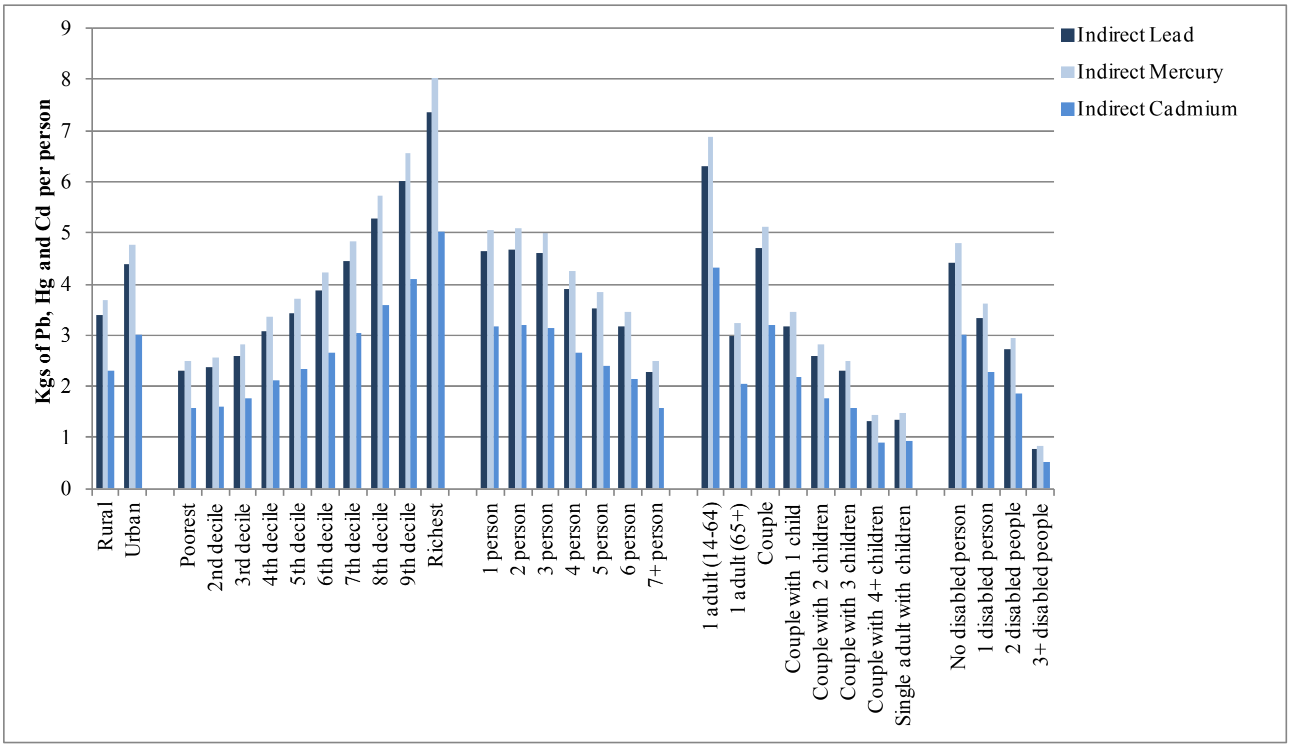

Figure 4.6. Indirect emissions of lead (Pb), mercury (Hg) and cadmium (Cd) per person by household type.

Source: Lyons et al. (2012)

the emissions ratio of the richest decile to the poorest decile. For each emission, this is per-person pollution emitted directly (indirectly) for the richest household income decile divided by per-person pollution emitted directly (indirectly) for the poorest income decile. Therefore, an emission with a high ratio is one where emissions are strongly related to income, whereas low ratios indicate emissions with little association with income. Hexachlorobenzene (HCB) (emitted to water) is shown to have the lowest ratio both indirectly and directly: higher-earning households cause 2.6 times the per capita indirect emissions than low-earning households. Indirect emissions are affected by income (all ratios are above one), but there is little difference between each substance. Looking at direct emissions, only NO_x and CO_2 (from fossil fuels) have a ratio of more than 1 and only N_2O and SO_2 have a ratio greater than 0.5: thus it may be sensible for any policy to target the price of these four emissions and not the rest given there is little relation between income and direct emissions.

Figure 4.8 depicts the emissions ratios relative to household size, showing that the pollutants have an average ratio of 0.68 for indirect emissions. Again, oxides of nitrogen (NOx) have the highest direct emissions ratio and PCB the lowest. Size ratios are generally lower than the income ratios discussed above; in Fig. 4.8 no emission has a ratio over 0.7; however, in Fig. 4.7 all indirect emissions ratios and two of the direct emissions ratios are over 1. Income has a much stronger association with household emissions per person than household size does.

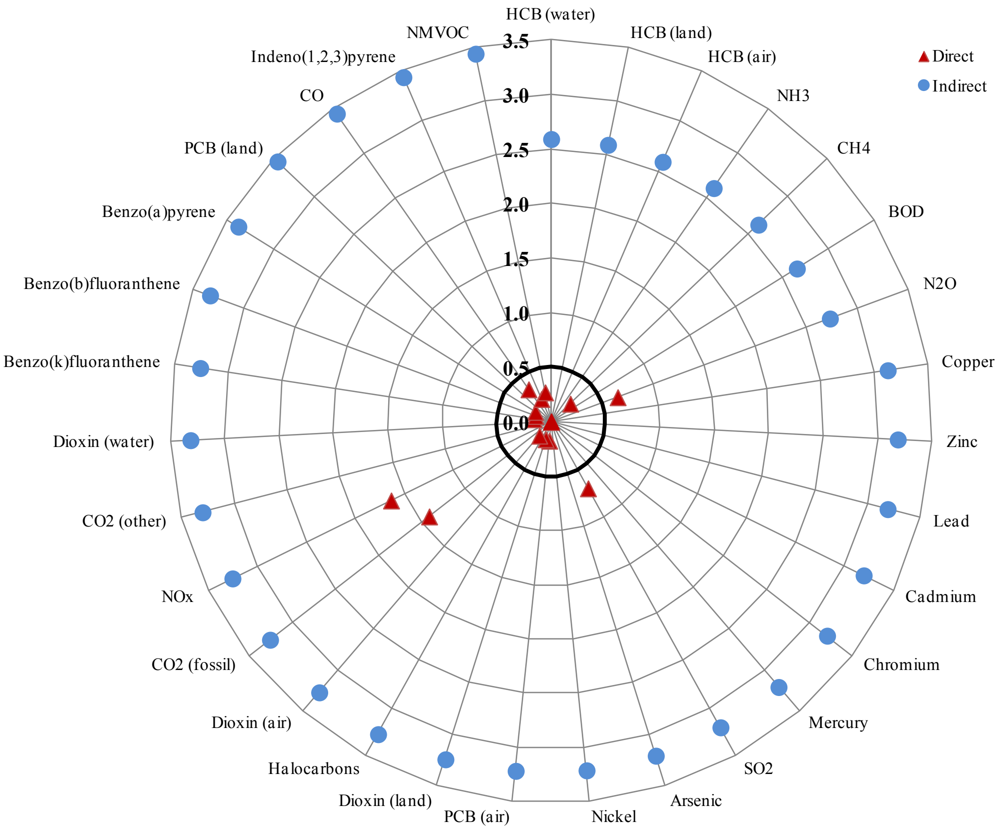

Figure 4.7. Income intensity of emissions: ratio of household emissions per person for those in the highest income decile to those in the lowest decile by substance.[14]

Source: Lyons et al. (2012)[15]

14 For each emission, this is per-person pollution emitted directly (indirectly) for the richest household income decile divided by per-person pollution emitted directly (indirectly) for the poorest income decile.

15 Reprinted from Lyons, S., Pentecost, A and Tol, R., ‘Socioeconomic distribution of emissions and resource use in Ireland’, *The Journal of Environmental Management*, vol. 112, pp. 186–98, © 2012, with permission from Elsevier.

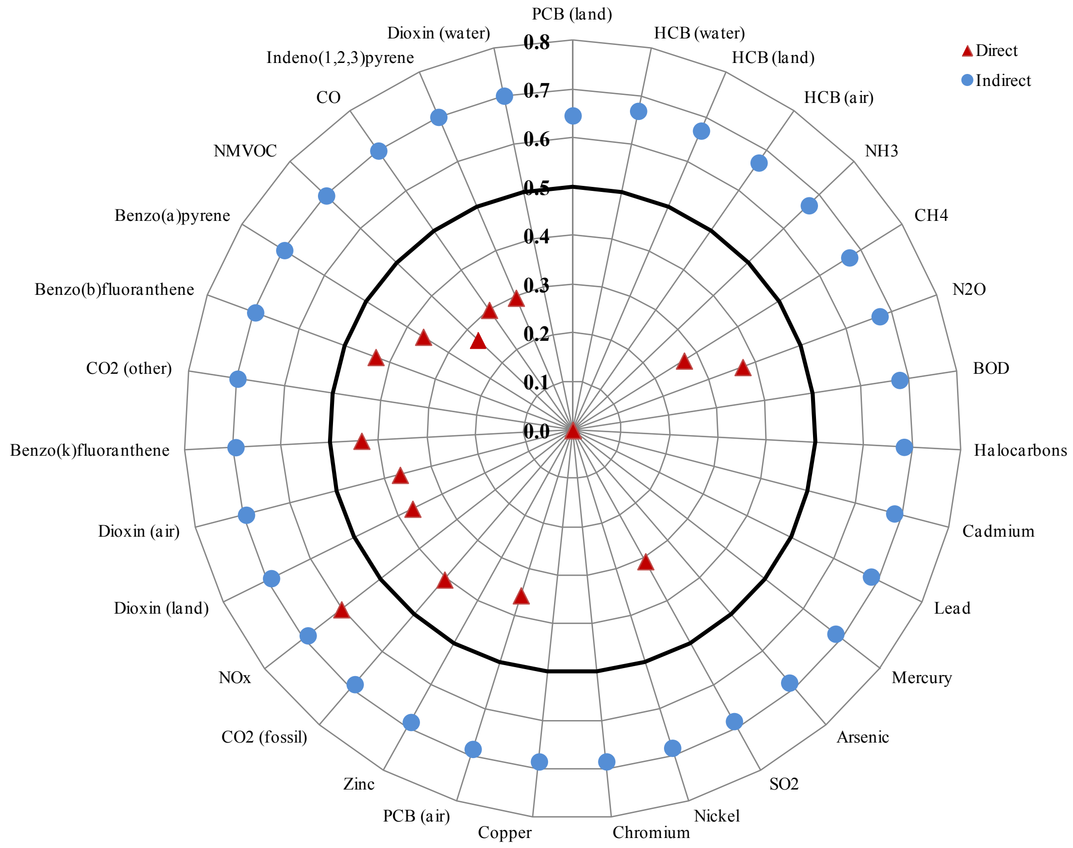

Figure 4.8. Household size intensity of emissions: ratio of household emissions per person, from the largest households (6 persons) to those in the smallest (one person) by substance.[16]

Source: Lyons et al. (2012)[17]

Implications of a Carbon Tax

One of the main advantages to looking at household characteristics is that policymakers can determine which household types are most affected by existing policies and also see any possible effects of change in policy:[18] for example, implementing a carbon tax or introducing water charges. Knowing the distributional effects of a policy can help inform measures to protect poorer households from facing the brunt of the burden, for example some of the tax evenue could be recycled to reduce income tax (Conefrey et al. [2008]).

Hennessy and Tol (2011) analyse the impact of the reform in vehicle registration tax (VRT) and motor tax in 2008 from a system based on engine size to one based on emissions. Their analysis anticipated correctly a large shift from petrol to diesel cars, as diesel is a more efficient fuel and thus cheaper to run.[19] There was also a substantial impact on tax revenue as car purchasers shifted to cars in the lower taxation bands. The analysis, which was subsequently borne out in reality, showed that financial incentives can bring about change in behaviour but that it can have unexpected impacts also. There was a large drop in Exchequer revenue from vehicle related

16 For each emission, this is per-person pollution emitted directly (indirectly) for the largest household size divided by per person pollution emitted directly (indirectly) for the smallest household size.

17 Reprinted from Lyons, S., Pentecost, A. and Tol, R., 'Socioeconomic distribution of emissions and resource use in Ireland', *The Journal of Environmental Management*, vol. 112, pp. 186–98, © 2012, with permission from Elsevier.

18 Leahy et al. (2011) analyse the effects of VAT increases on different household types and this analysis would be the same for a flat rate carbon tax – it would be regressive.

19 Their analysis is based on data from the old taxation system related to engine size before the implementation of the emissions based taxes. The research was initially published in working paper format (Hennessy and Tol [2010a]; Hennessy and Tol [2010b]).

taxes following the new taxation system but this also coincided with the collapse in the car market affected by the economic recession.

In their paper, di Cosmo and Hyland (2011) look at the wider macroeconomic context and assess what potential impact a carbon tax would have on economic growth and employment levels. Using a number of scenarios they find that the decline in sector demand (and thus CO_2 emissions) is greater in some sectors than others due to varying elasticities of demand. For example, in the residential sector the price elasticity of demand for gas was estimated at -0.32, which means that households' demand is likely to be moderately responsive to a carbon tax.

In addition to reducing emissions, a carbon tax generates significant revenue for the Exchequer, projected at €612 million by 2015 (di Cosmo and Hyland [2011]). Previous research suggested that a carbon tax is contractionary (e.g. Lu et al. [2010]), whereas the analysis by Hyland et al. (2012a) finds that the contraction in final demand is greatest in sectors where the price elasticities of demand are highest (food, beverage and tobacco sector) and the sectors that have the most intensive carbon fuel mix (textiles and leather and agriculture, forestry and fishing). So while a carbon tax can be contractionary, the impact will not be uniform across the economy.

4.3 Summary

The pressure households place on the environment and how they respond to policy measures will differ substantially depending on a host of circumstances – including those related to income, household composition, and location. This applies equally to the business sector. In devising policy it is important to understand how different sorts of households and business are likely to be affected and to respond to new policy measures, both in terms of anticipating the environmental response (e.g. lower emissions) and being aware of welfare issues. The work on distributional accounts contributes to that understanding. When implementing environmental policy, it is important that policymakers ensure that the polluter is made to pay while being careful not to leave some sectors/ households unexpectedly adversely affected.

A core result from the analysis is that a decomposition of emissions by household types shows that households will not be affected equally by environmental policy measures designed to curtail emissions. However, it also shows that policies can be researched and tailored such that the worst polluting households can be specifically targeted and vulnerable groups can be protected. For instance, the main results show that on a per-person basis richer households in urban areas have the poorest emissions performance.

5 Environmental Expenditure Accounts

Understanding how Irish companies respond to environmental regulation will enable future policies to be best designed or facilitate the use of measures employed to counter those aspects of regulation that can hinder business. The industrial sector will be expected to invest significantly in the next few years to contribute to the national non-ETS emissions target. An analysis of historical environmental expenditures allows the examination of how firms are likely to respond to the challenge.

Several economic positions have been put forward on the likely impact of environmental policies, such as increased taxes for emissions, on firms. On the one hand, taxes create an additional cost to firms and this may constrain production possibilities and reduce profits. They may also encourage relocation to where environmental standards are low and regulatory costs are small. The Porter Hypothesis (Porter [1991]; Porter and van der Linde [1995]), however, contends that taxes will encourage firms to innovate, which in turn can improve competitiveness and productivity.

Haller and Murphy (2012) analyse data for 1491 Irish manufacturing companies to explain the key factors influencing firms when deciding on both capital and non-capital environmental expenditure (including investment in pollution-control equipment). Only 22 per cent of firms reported any environmental expenditure, of which just 5 per cent reported investment in capital for pollution control. An initial conclusion is that the majority of Irish industrial firms do not have a history of actively curtailing their environmental emissions. At the sector level, firms in chemical manufacturing reported the highest values of environmental expenditure, whereas firms in the wood products sector reported the highest expenditure on capital for pollution control. The office and data machinery sector has the lowest shares of capital and non-capital environmental expenditure.

Using regression analysis, Haller and Murphy (2012) find that larger, exporting and more energy-intensive firms are more likely to incur environmental expenditure. For capital investment in pollution-control equipment, larger and older firms are likely to invest more than smaller and newer firms. The chemical and wood products sectors are the highest spenders on environmental expenditure, reflecting their potential for environmental harm. Likewise, the food and beverage sector has significant expenditure on environmental protection. Reflecting a lower potential for environmental harm, the metal-processing sector has a low likelihood of investment in environmental protection. Integrated Pollution Prevention Control (IPPC)-licensed firms were less likely to invest in capital for pollution control in 2006, but this may be because most put measures in place at an earlier stage when they first became subject to licensing. In general, the results are intuitive given that larger, older and exporting firms are likely to be more efficient and have more resources and thus are able to exploit economies of scale effectively. These firms may also be subject to external pressure and must be seen to be proactive in their efforts to reduce pollution either by customers or shareholders.

Commins et al. (2011) investigate the impact of energy taxes on firms across the EU between 1996 and 2007 and test four hypotheses. Using firm-level micro-data their paper focuses on employment levels, investment behaviour, returns to capital (profits) and productivity. The results show that total factor productivity growth is positively associated with energy taxes in some sectors – for example, pulp and paper, motor vehicles and office machinery, but negatively associated for others, such as textiles, quarrying and wood products. This result is consistent with the Porter Hypothesis. The weighted average across all sectors for the EU shows a positive and significant effect.

A second hypothesis investigated by Commins et al. (2011) is that taxes weaken incentives to use capital with high-energy intensity, causing firms to switch to more labour-intensive production. Firms can also choose to relocate production to countries with less expensive regulations. Figure 5.1 presents the results graphically: a positive value denotes an increase in employment from energy taxes and vice versa. The sectors affected most positively by an energy tax are the textiles/apparel and the wood products sectors. Labour in these sectors is typically lower skilled and can easily replace capital (intensive in energy). Sectors where energy taxes affect employment levels negatively include electricity and gas, motor vehicles and construction. The large effect for the air transport sector likely reflects sector restructuring due to the growth of low-cost airlines than an effect of energy taxes. The overall weighted European average is negative and significant: energy taxes reduce employment.

Commins et al.'s third hypothesis is that energy taxes affect capital investment, and that firms substitute labour for capital. The Porter Hypothesis suggests the opposite: with energy taxes, innovation will occur and thus investment in new, more efficient and productive technology. Figure 5.2 again shows different results for different sectors, indicating that there is no single 'rule' that explains how firms respond to environmental taxes. The tobacco sector exhibits the largest fall in investment associated with energy taxes; however, the authors note that this sector was already in decline for reasons other than energy taxes. Other sectors which see lower investment in the presence of energy taxes include construction and leather. Sectors where there was an increase in investment include metal mining, gas extraction and basic metals. The weighted average shows a positive and significant effect on investment from energy taxes across Europe, with an elasticity of 0.138.

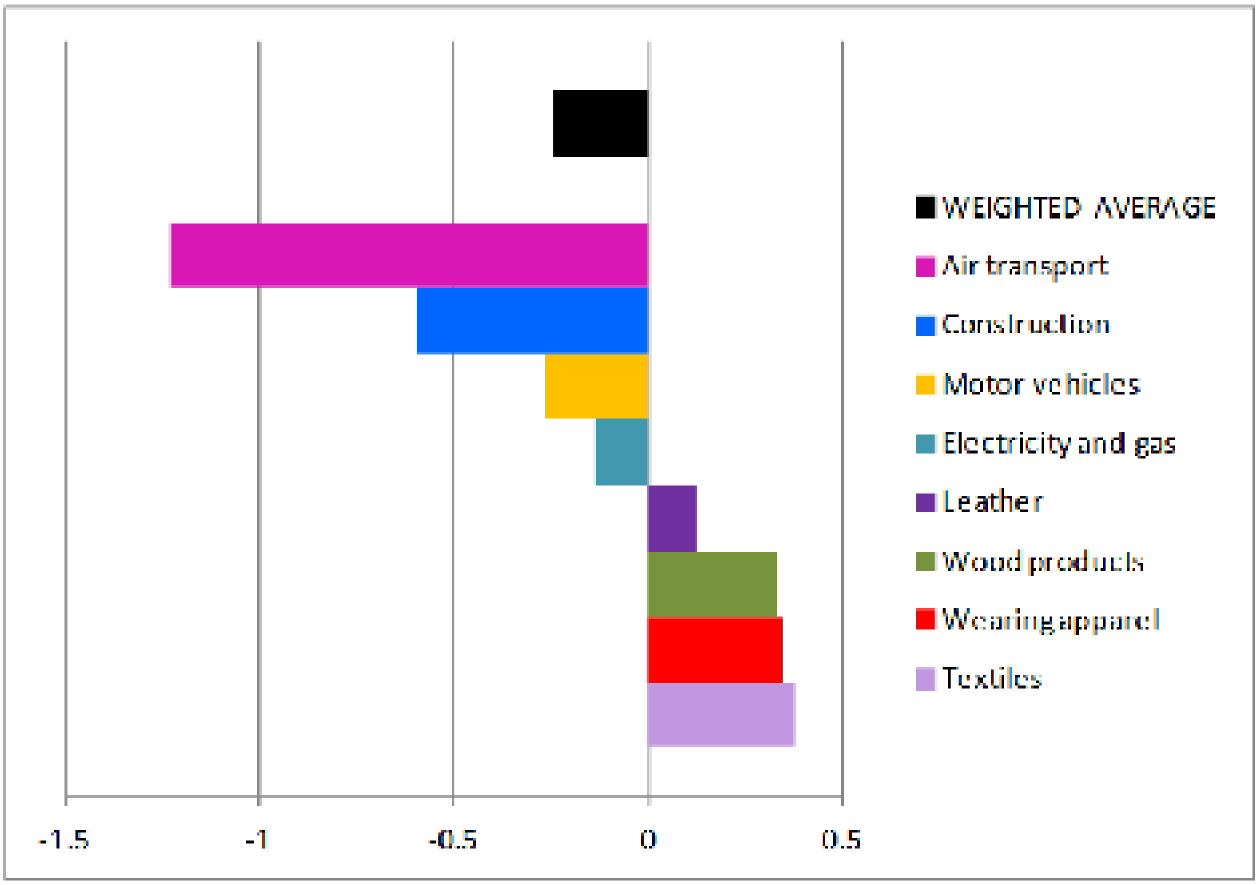

Figure 5.1. Average partial effects of 1% rise in energy taxes on firms' employment by sector.

Source: AMADEUS database

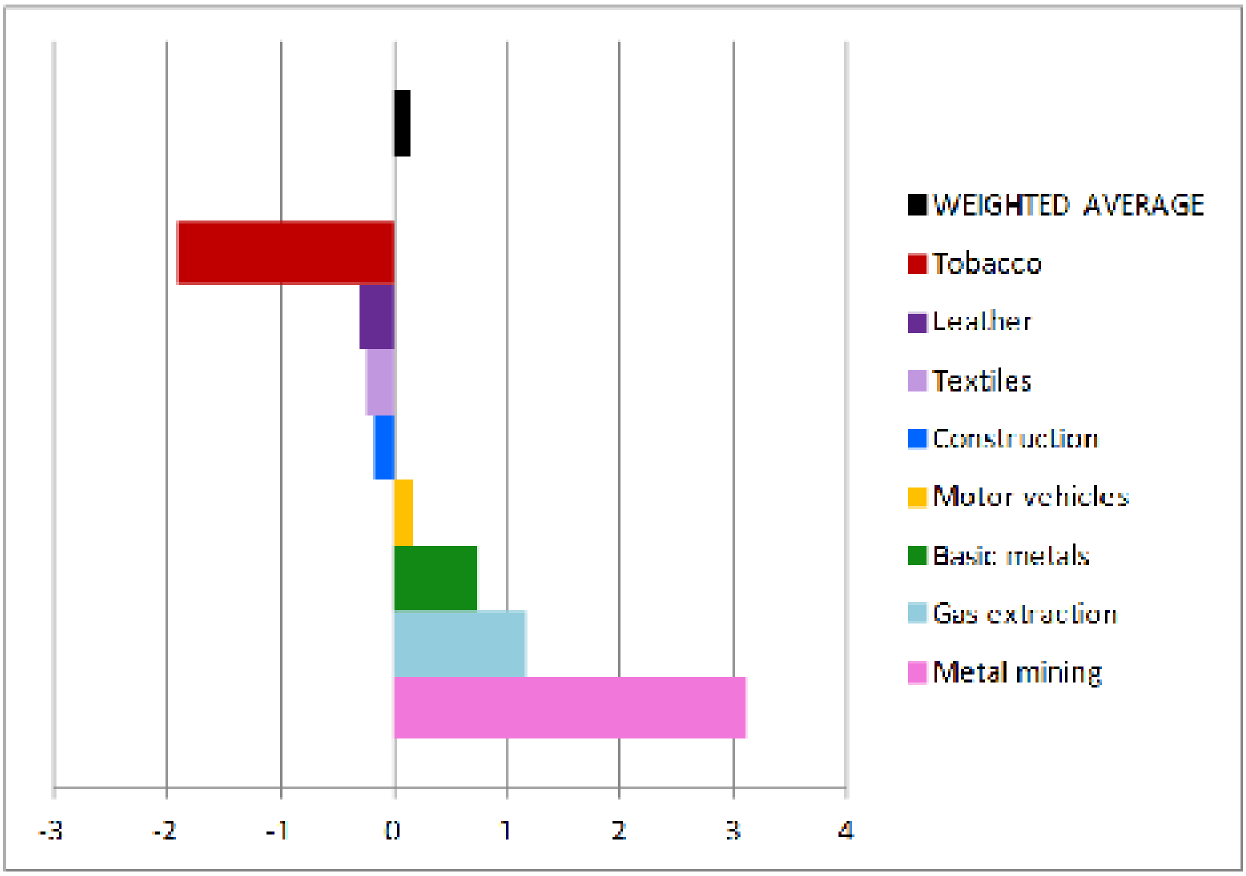

Figure 5.2. Average partial effects of 1% rise in energy taxes on firms' investment by sector.

Source: AMADEUS database

A final hypothesis investigated by Commins et al. (2011) is that the return on capital employed (i.e. profitability) is expected to fall when energy taxes increase based on the assumption that taxes are an additional cost of business. For most sectors, however, results show a positive effect of energy taxes on the return to capital. The overall weighted European average shows a positive and significant effect from energy tax rises on return to capital. This suggests that firms are generally able to pass on the higher costs to customers to cover the increase in tax and take advantage of improved productivity.

5.1 Summary

Environmental regulation is necessary to protect environmental quality; nonetheless, the business sector often argues that regulation, including environmental regulation, impacts negatively on competitiveness. The analysis of businesses had two main findings. In Ireland environmental expenditure is more likely to occur among larger, exporting and energy-intensive firms. With respect to the impact of environmental regulation on business, the picture is nuanced. Energy taxes affect total factor productivity, employment, capital investment and profitability, but not necessarily negatively. The analysis supports the Porter Hypothesis that environmental taxes can encourage firms to innovate, which in turn can improve competitiveness and enhance productivity. Energy taxes have a positive effect on employment in some sectors, such as textiles and wood products sectors, where labour in these sectors is typically lower skilled and can be easily substituted for energy intensive capital. Nonetheless, the overall weighted European average is negative and significant: energy taxes reduce employment, whereas energy taxes show a positive effect on the return on capital for most sectors.

6 Energy and the Environment

Energy is a major source of air pollution, particularly greenhouse gas emissions, and consequently the modelling of energy demand is a critical element of emissions projections. One objective of this project was to integrate ESRI research on energy and the environment. Earlier versions of the ESRI Environmental Accounts incorporated historical fuel use based on energy balance data compiled by Sustainable Energy Authority of Ireland (SEAI), whereas, future energy demand projections were modelled within the ESRI's macroeconomic model, HERMES. During the course of this project the energy-demand sub-model has been redeveloped as an integral component of ISus.[20] Another element of the project was estimating micro-econometric models of demand for energy-using equipment, including cars and household appliances. The information gleaned from such models helps in understanding how energy and environmental taxes are likely to affect demand.

6.1 Energy Demand Model

The first element of the ISus energy sub-model is a structural econometric model that estimates the demand for major fuels (e.g. coal, gas, oil, etc) in five aggregate sectors of the economy: (i) household, (ii) industry, (iii) commercial and public, (iv) transport and (v) agriculture. These five sectors match the sectors modelled in HERMES[21] and the HERMES projections of sector growth are used as drivers for future energy demand. The second element of the energy model is the electricity-generation sector. Owing to the variability of energy demand and technical constraints of power generation, it is necessary to model electricity separately through a dedicated model. Previously, ISus relied on Ireland's Electricity Dispatch Model (IDEM) to determine electricity fuel mix and associated emissions. Today, both in Ireland and elsewhere, PLEXOS is the standard model for analysing electricity markets among energy regulators, utilities, and researchers.[22] To better integrate energy and environmental research ISus now also utilises data from published PLEXOS electricity dispatch scenarios. This approach provides a consistency with external modelling scenarios for macroeconomics and electricity. The third element of the energy model entails attributing fuel demand and associated emissions to the full sectoral breakdown in the ISus model. ISus is used to present an analysis of the impact on Irish emissions of a proposed EU Commission policy to support the EU-ETS allowance price in Section 10 below.

6.2 Vehicles

The transport sector is one of the biggest consumers of energy; between 1990 and 2007 energy use in the transport sector grew by 181 per cent and in 2007 it accounted for 43 per cent of Irish final energy demand (Howley et al. [2009]). Transport-related taxes were reformed in recent years to try to curb these large increases in energy demand and emissions. An analysis of major transport decisions, such as the choice of which car to buy, can help inform how effective policy reforms are likely to be in changing behaviour.

Hennessy and Tol (2011) developed a model of the stock of private cars by engine size and fuel, fuel efficiency, distance driven and age distribution of private cars in order to predict the impact of the 2008 policy changes of vehicle registration and motor tax. The model projects that the number of private cars in Ireland will be nearly 2.4 million by 2025 but that the composition of cars will change in response to the changes in vehicle registration and motor taxes enacted in 2008. The tax reforms incentivised more emissions-efficient cars, which in turn incentivised a switch to the most efficient fuel, i.e. diesel. Figure 6.1, from Hennessy and Tol (2010b), projects how the new tax structure is likely to affect the national stock of cars fuelled by either petrol or diesel compared to the pre-2008 tax structure. Diesel-fuelled cars are likely to grow dramatically in number with a decline in petrol-fuelled cars. Average emissions

20 di Cosmo and Hyland (2012) describe the energy demand model.

21 HERMES is ESRI's macroeconomic model of the Irish economy.

22 See, e.g. CER (2012).

of new vehicles fell from 166g/km in 2008 to 129g/km in 2011 (Rogan et al. [2011]; Howley et al. [2011]), leading to significantly lower emissions. As the national vehicle fleet is gradually replaced by newer more fuel-efficient vehicles the effect on aggregate emissions will be more pronounced.

The difficulty of effectively reforming vehicle taxes to reduce transport emissions echoes the complexity of the choice for a car buyer deciding whether a petrol or diesel car is most cost efficient. The conundrum for the car buyer is that diesel cars are more expensive to buy, but cheaper to run than petrol cars. Thus, those who drive greater distances should opt for diesel as the cheaper running costs make up for a higher buying price; once the owner has 'broken even' on cost, diesel fuel is then cheaper and more efficient. Hennessy and Tol (2011) concluded that the 2008 tax reform substantially reduced the break-even distance for medium-sized diesel cars, but had little effect for smaller cars. This divergence is ultimately related to the differences in mileage distribution; that is, those who drive more will put a greater weight on efficiency. As a consequence, those who drive longer distances than the break-even point will choose diesel over petrol.

The complexity of changing transport practices is also illustrated in a paper by Driscoll et al. (2012b), which examines transport mode choice for a range of journey purposes. As one would expect, the paper finds that location, demographic characteristics and availability of public transport affect mode choice. In addition, the determinants of mode choice differ depending on the purpose of the journey. This implies that it would be misleading to generalise the results from studies considering only one journey purpose (e.g. work commuting) to other journey types (e.g. shopping). Notwithstanding that, another result was that regular car commuters are more likely to rely on the car as the mode of choice for other journey purposes. The implication is that car owners may consider additional use of other modes for non-commuting journeys if reliance on the car for work commuting is diminished.

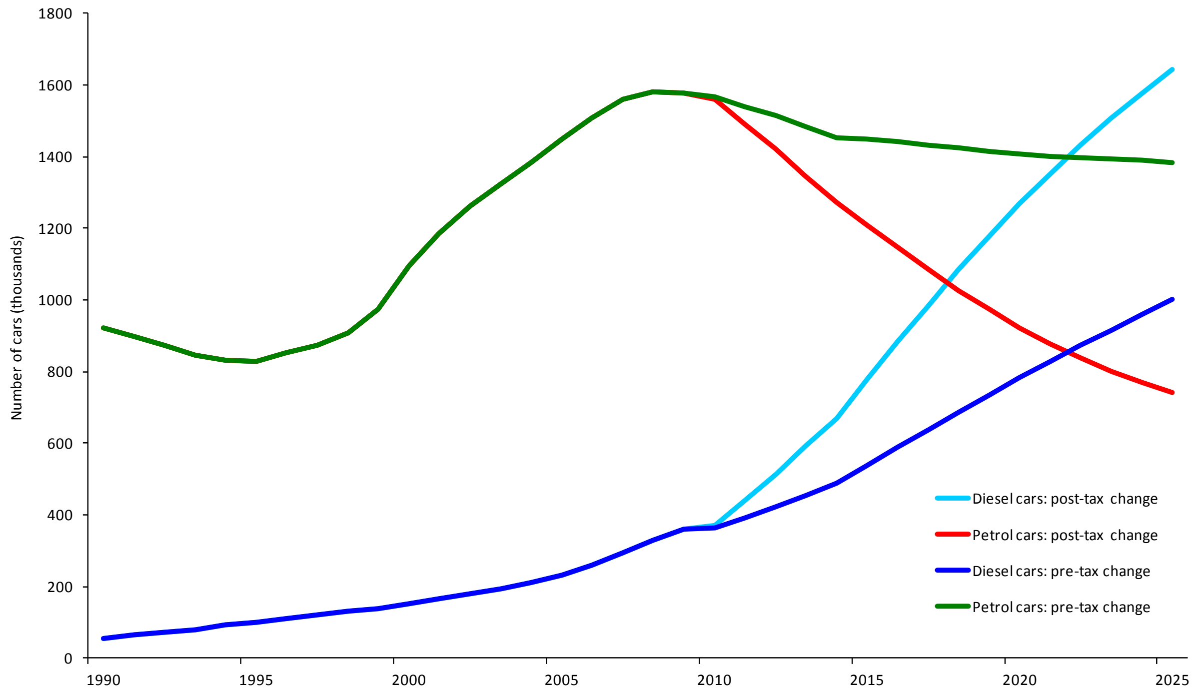

Figure 6.1. Impact of 2008 tax reform on the number of diesel and petrol cars.

Source: Hennessy and Tol (2011)

6.3 Electric Vehicles

The national target for electric vehicles is that 10 per cent of all vehicles in the transport fleet will be powered by electricity by 2020.[23] This target is likely to represent some 200,000 vehicles by that year. At present the number of electric vehicles is relatively low, with just 163 new all-electric vehicles registered during 2012.[24] Based on current low level of sales NESC (2012) conclude that the policy targets are unlikely to be achieved. Two analyses investigating demand for electric vehicles shed light on the potential efficacy of current measures to increase the stock of electric cars (Hennessy and Tol [2011]; Driscoll et al. [2012a]).

Hennessy and Tol (2011) run a number of scenario analyses to determine how effective the electric vehicle target will be in reducing CO_2 emissions from private vehicles. They estimate that if the electric vehicle stock reaches 10 per cent of the total car stock, the associated emissions (from electricity generation) would account for between 2 and 3 per cent of total vehicle emissions. This captures the extent to which electricity generation is less carbon intensive than direct combustion of fossil fuels in cars. The second analysis by Driscoll et al. (2012a) simulates the likely market shares for electric vehicles available on the Irish market in 2012 based on a model of car-purchasing decisions, which is a function of vehicle characteristics. The simulated market shares are very low, with electric vehicles at just 1 per cent of all new cars sold under a pricing scenario that includes a €5000 government grant and exemption from VRT. Their analysis suggests that to significantly increase the market share would require incredibly generous grant incentives.

In summary, electric vehicles have the potential to make a contribution to reducing transport emissions, without necessarily curtailing transport demand. However, demand for electric vehicles has been minimal and – based on an assessment of what vehicle characteristics Irish motorists demand in their car purchases – their numbers are unlikely to increase substantially without a dramatic change in motorists' perceptions of electric vehicles. Moreover, the current low motor tax on electric vehicles means that a dramatic increase in electric vehicles would bring a significant reduction in Exchequer tax revenue. Once they become relatively common the necessity for generous electric vehicle purchase incentives might no longer exist and the taxation of vehicles will need to be balanced against Exchequer revenue requirements.

6.4 Household Appliances and Resource Use

Households are among the biggest users of energy, with household emissions accounting for one-sixth of total EU emissions (Commission of European Communities [CEC] [2011b]). In Ireland emissions from the household sector have varied between 16 and 18 per cent of non-ETS emissions since 2008 (EPA [2012c]). Similar to other sectors of the economy, the household sector needs to curtail its emissions significantly if Ireland is to achieve its contribution to the EU's 20-20-20 climate and energy target, which is a 20 per cent reduction in 2020 non-ETS emissions compared to 2005. Increasing household energy efficiency is one channel that may help achieve an improvement. A number of studies investigating households' behaviours in matters that affect energy use offer insight on where and how households might be encouraged to improve energy efficiency (Leahy and Lyons [2010]; Lyons et al. [2010]; Hyland et al. [2012b]).

One study investigated the determinants of domestic ownership of energy-using appliances and factors affecting the level of domestic energy usage in Ireland (Leahy and Lyons [2010]). Many of the results of the analysis are intuitive. Larger houses and more recently built properties are more likely to have a greater number of appliances, as are households with a greater number of members. In general, higher levels of income are associated with a greater number of appliances and presumably energy use. A result of the analysis that was less intuitive was that local authority housing dwellers use more energy than those who own their homes or those who rent privately. A number of reasons could be proffered for this including that these properties are poorly insulated and not energy efficient. Given the large local authority housing stock, energy efficiency improvements in local authority housing is likely to aggregate to significant energy savings and reductions in emissions.

23 http://www.transport.ie/pressRelease.aspx?Id=61

24 http://www.cso.ie/en/releasesandpublications/er/vlftm/vehicleslicensedforthefirsttimedecember2012/, accessed 11/1/2013

Building Energy Rating (BER) certificates are designed to inform participants in the property market of a dwelling's energy efficiency. A BER is based on the efficiency of the space and water heating, ventilation, insulation and lighting fixtures. Energy-efficient dwellings (higher BER rating) should have lower energy operating costs. Hyland et al. (2012b) investigate whether energy efficiency in the form of published building energy ratings (BER certificates) affect sales and rental prices, i.e. whether potential buyers or renters are willing to pay extra for more energy-efficient homes with lower running costs. The key result from the analysis is that there is a positive association between BERs and both house prices and rents, indicating that both buyers and sellers value energy efficiency. A BER is measured on a 15-point scale from A1 to G and Hyland et al. (2012b) find that each rating decline along the BER scale is associated with a reduction in price of 1.0 per cent. The effect on price is weaker in the rental market. One implication this result has for developing policies and incentives for domestic energy efficiency is that households do internalise the cost of energy in their housing decisions. It implies that households see the value of improving energy efficiency, whether through retro-fitting insulation or other measures. While there is a public benefit in terms of emissions reduction from improvements in household energy efficiency this research questions the necessity of using public monies to fund investment in domestic energy efficiency measures where the benefit is a private one and, based on Hyland et al.'s analysis, households are willing to pay for the benefit.

In another study of household-resource use Lyons et al. (2010) analyse ownership of water-using appliances and mains water connections. This information becomes pertinent in studying the effect of household water charges on household welfare. One of the more policy-relevant findings is that the number of water-using appliances in households (and by inference water use) is positively correlated with income, dwelling value, larger households, higher social status, having a detached dwelling, owner occupiers, and rural dwellers. While there are exceptions, on average households with potentially the greatest water use are households that are likely to have the resources to pay for that water.

6.5 Summary

The ISus model now incorporates an energy sub-model, which means that emissions associated with electricity generation, transport and other fuel use are modelled and projected within the model itself. In addition to the development of the energy model a number of ancillary studies related to energy use were completed, and these provide important insights on households' behaviours with respect to purchasing decisions for vehicles, and household energy efficiency. The papers' findings are useful in two regards. First, they provide information on parameters for further development of models on household energy use and vehicles and, second, they provide information that is relevant to developing effective policy instruments in these areas.

7 Summary

The report thus far summarises the work completed in the work packages of the 'Towards a Green Net National Product for Ireland' research project. Significant progress has been achieved in moving 'towards' developing an estimate of a green net national product (GNNP). The ESRI Environmental Accounts now have the most comprehensive data about emissions and resource use by economic sector in Ireland. This information is a necessary requirement for the development of green national accounts. It has already facilitated the first estimate of GNNP (Woods [2012]). Woods estimates that the cost of environmental damage across the economy between 1997 and 2007 decreased by roughly 30 per cent, with much of the improvements associated with the relative growth of the services sector and improvements in emissions intensity of electricity generation, with the latter particularly attributed to the implementation of the industrial licensing system by the EPA (Styles and Jones [2010]). However, the overall loss of welfare due to pollution is relatively small, falling from 2.9 per cent of GNP in 1997 to 1.2 per cent of GNP in 2007.

An important objective of the research is to develop the ISus model as a tool to analyse how policy scenarios affect future environmental emissions. In Part II of this report the latest version of the ISus model (v0.8) is used to present projections on environmental emissions, conditional on macroeconomic and environmental policy scenarios. These projections are used as a basis to discuss current environmental policy issues.

Part II

8 Introduction

The objective of this part of the report is to contribute to current discussions on environmental policies. It discusses ISus emissions projection scenarios covering the period to 2030 and analyses a number of current environmental policy issues. ISus projections are based on macroeconomic and environmental policy assumptions and are not intended as forecasts of future environmental outcomes. The purpose of projections is to gauge how successful current policies and trends are likely to be in achieving policy targets and thereby contributing to a discussion of how environmental policy might be amended.[25] During the course of this project, 'Towards a Green Net National Product for Ireland', and a predecessor project 'Ireland's Sustainable Development Model' (Lyons and Tol [2010]) the ESRI published a number of reports presenting ISus emissions projections that have contributed to public discussion on environmental policy (FitzGerald et al. [2008]; Bergin et al. [2009b]; Devitt et al. [2010]; Lyons and Tol [2010]; Curtis [2012]). Part II of this report is the ESRI's latest contribution to that policy debate.

The next section presents the underlying macroeconomic assumptions upon which the projections are based. The subsequent sections focus on four areas of policy: (i) climate, (ii) transport, (iii) agriculture and (iv) waste. It is in these four areas that public discussion on environmental policy is currently most active.

25 A forecast is a prediction of a future outcome whereas a projection is an assessment of a future outcome subject to underlying assumptions. For example, one of the underlying assumptions in this report is future energy prices (as outlined in Table 9.1), which are assumed rather than forecast and hence figures for future emissions are projections subject to the underlying assumptions rather than a forecast of a future outcome.

9 The Macroeconomic Scenario

The ISus model's projections rely on an assumed scenario for macroeconomic growth, which was prepared by the ESRI in November 2012 utilising its macroeconomic model, HERMES. The scenario is based on the HERMES model scenarios documented in Bergin et al. (2009a) and Bergin et al. (2010), but updated with current assumptions on government finances and the international economy. Assumptions on the international economic environment are based on NIESR (2012) but with international projections updated to incorporate the energy price assumptions, as outlined in Table 9.1.

Table 9.1. Energy price assumptions.

	2010	2010–2015	2015–2020	2020–2025	2025–2030
	value, €/MWh	% average annual change			
Oil	37.6	7.5	0.6	0.2	0.9
Gas	17.3	14.4	2.7	-0.9	1.8
Coal	10.0	6.7	0.5	1.0	0.3
Peat	12.0	0.0	0.0	0.0	0.0

Given the impact of domestic austerity measures, the poor performance of the UK economy, as well as the ongoing debt crisis in Europe, medium-term economic projections are subject to considerable uncertainty. Compared to the last ISus projection in June 2012 (Curtis [2012]) the underlying growth assumptions have been revised downwards. Nonetheless, moderate annual growth is projected, averaging 2.5–3.5 per cent in the years to 2020. The main macroeconomic indicators are presented in Table 9.2. With growth in population, employment and incomes anticipated there will be a direct effect in terms of higher emissions and waste generation. What is less certain is the exact timing of that growth. If growth is lower than projected, the main effect on environmental emissions will be that the projected growth in emissions will be delayed.

All sectors of the economy are projected to grow through the rest of the decade, with the exception of the construction sector, which is expected to continue to contract in the short term but to recover significantly after 2015. Output in the agricultural sector is anticipated to grow substantially, especially after the abolition of milk quotas in 2015, and following the Food

Table 9.2. Economic gross output and population as observed and projected.

	2010	2010–2015	2015–2020	2020–2025	2025–2030	2010–2015	2015–2020	2020–2025	2025–2030
	Observed	Baseline projection				Baseline projection			
	Billion euro per annum*					Real change per year, %			
Agriculture	6.6	7.6	8.1	8.5	8.5	3.3	1.8	0.0	0.0
Industry	119.8	137.6	175.7	208.5	240.9	5.8	4.1	2.9	3.0
Construction	21.2	18.0	26.2	32.1	35.4	-1.4	8.7	2.3	2.1
Services	171.4	174.6	190.2	220.5	246.1	0.8	2.7	2.9	1.8
Transport	10.6	11.3	12.7	14.4	16.3	2.4	2.5	2.5	2.5
Total	329.6	349.1	412.9	484.0	547.2	2.7	3.6	2.8	2.3
Population	4.429	4.456	4.552	4.685	4.807	0.3	0.5	0.6	0.5
Output per person	74.4	78.3	90.7	103.3	113.8	2.4	3.1	2.2	1.8

*Billion euro (constant 2004 basic prices) with the exception of population (million) and output per person (thousand euro).

Harvest 2020 strategy.[26] Agricultural output projections come from Teagasc's FAPRI model, providing projections to the year 2021. After 2021 a conservative assumption is that there will be no growth in emissions from the sector. The transport and industrial sectors are projected to experience relatively strong growth but the effect of that growth on emissions differs significantly between the sectors. Emissions from transport are projected to grow, whereas emissions from the industry sector are projected to decline. The remaining sections of the report examine where the main environmental pressures over the coming two decades are likely to arise.

26 DAFF (2010).

10 Climate Change

Intergovernmental Panel on Climate Change (IPCC) reports have documented indicators of global climate change and highlighted its potential effect on sea-level, extreme weather events, water stress, and biodiversity among other topics. Such is its potential impact, climate change is widely acknowledged as one of the great challenges facing humankind. Ireland actively supports and is committed to European and international efforts, under the United Nations Framework Convention on Climate Change (UNFCCC), to address climate change and lessen its impacts. There are a range of national energy and climate policies in place that are contributing to achieving Ireland's committed targets. As noted above, for the non-ETS sector the primary overarching climate target for Ireland under EU 20-20-20 is a 20 per cent reduction in non-ETS emissions compared to 2005, which is part of the EU's Effort Sharing Decision that established binding annual greenhouse gas emission targets for member states for the period 2013–2020. The challenge for the ETS sector is being compliant in a situation where the EU-wide cap on allowances is set to decrease by 1.74 per cent annually. The EU Commission is also actively considering options to achieve even greater emissions reductions, support the carbon price, and tackle the structural supply–demand imbalance in emission allowances (CEC [2012c]).

Considerable work has been undertaken in Ireland on climate change relating to climate policy, the effect of climate change, and climate change adaptation.[27] This report focuses on some immediate concerns of climate policy, which include how Irish emissions are likely to compare against committed policy targets, as well as how policy proposals currently under consideration will have an impact in Ireland. In the next section, ISus baseline projections of greenhouse gas emissions are presented, with the discussion particularly focusing on non-ETS emissions targets. The subsequent section undertakes a scenario analysis of the impact of an EU Commission proposal to support the price of carbon by delaying ('back-loading') auctioning of ETS allowances in the third phase of the EU-ETS starting 2013. The Commission's proposal, coupled with the UK's proposed carbon price floor, is most likely to affect the electricity-generating sector directly, and consequently the price of electricity to Irish consumers.

27 For instance, see EPA funded research on these issues at: http://www.epa.ie/search/results.jsp

10.1 Climate Scenarios

In addition to the macroeconomic scenario outlined in Section 9, there are additional assumptions related to agriculture, energy, carbon tax, and the EU-ETS allowance price that are also relevant for the climate projections. Emissions from livestock are based on exogenous projections of livestock numbers produced by Teagasc in December 2012.[28] The livestock projections assume that the Food Harvest targets for dairy, beef, sheep and pig sectors will be achieved. This is on the basis that milk quotas will be removed in 2015 and that beef production with a low level of profitability will be replaced by milk production. Sheep and pig output is also projected to expand. The emissions calculated based on the livestock projections do not incorporate the benefits of any emission-abatement technologies that may be developed and implemented.[29] Among the uncertainties in the livestock projections is whether beef cow numbers decline as assumed or whether they remain near current levels and the intensity of fertiliser use, which is dependent on animal stocking rates that may change as milk and beef productions systems evolve. Teagasc's projections cover the period to 2021, and no change in emissions beyond 2021 is assumed.

The SEAI baseline assumptions relating to energy are followed. For example, it is assumed that the coal-fired electricity-generation plant at Moneypoint will

28 Teagasc use the FAPRI model to develop livestock projections. See: http://www.teagasc.ie/topics/economics/fapri.asp for further details about the FAPRI model.

29 We use the latest EPA emission factors for livestock emissions. Teagasc have indicated that there is a 1.1 million tonne of CO_2 abatement potential within the agriculture sector (Schulte et al. [2012]). How much of that abatement potential will be realised depends on the extent to which farmers fully implement the abatement practices as specified.

Table 10.1. Greenhouse gas emissions as observed and as projected per gas and per sector.

	2010	2010–2015	2015–2020	2020–2025	2025–2030	2010–2015	2015–2020	2020–2025	2025–2030
	Observed	Baseline projection				Baseline projection			
	Million tonnes CO_2eq per year[a]					Change per year (%)			
CO_2, energy	39.9	39.1	39.6	40.5	42.9	-0.7	1.1	0.1	2.0
CO_2, process	1.4	1.3	2.3	3.4	4.5	2.7	12.7	6.4	6.2
CO_2, land use[b]	-1.1	-1.2	-1.5	-1.9	-2.2	4.3	4.5	3.6	3.1
CH_4	11.6	11.7	11.9	12.1	12.1	0.1	0.7	0.0	-0.1
N_2O	7.9	7.9	8.2	8.3	8.3	0.4	0.8	0.0	0.1
F-gases	0.6	0.7	0.6	0.5	0.4	-2.3	-1.0	-2.4	-2.3
Agriculture[c]	18.8	19.0	19.7	20.1	20.2	0.5	0.9	0.1	0.1
Industry	17.9	17.6	17.2	15.8	15.4	-1.1	0.5	-2.8	1.4
Construction[d]	2.3	2.1	3.1	4.2	5.3	0.6	9.1	5.2	5.2
Services	3.0	2.4	2.2	2.2	2.2	-6.0	0.0	0.6	-0.3
Transport	11.6	12.2	13.2	15.0	17.5	1.5	2.3	2.9	3.3
Residential	7.8	7.3	7.3	7.4	7.5	-1.6	0.3	0.4	0.4
Total (incl. sinks)	60.3	59.5	61.1	62.9	66.1	-0.4	1.3	0.3	1.6
ETS[e]	17.4	17.1	17.8	17.5	18.3	-0.6	1.9	-1.5	2.7
non-ETS[e]	42.9	42.4	43.2	45.4	47.8	-0.3	1.0	1.0	1.1

[a] Levels are in million metric tonnes of carbon dioxide equivalent, using the IPCC AR2 global warming potentials; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; F-gases = HFC_{23}, HFC_{32}, HFC_{34}a, HFC_{125}, HFC_{143a}, HFC_{152a}, HFC_{227ea},CF_4, C_2F_6, cC_4F_8 and SF_6; ETS = EU Emissions Trading System. [b] The impact of land use (e.g. forestry sinks) is included as allowed for under Article 3.3 of the Kyoto Protocol, however, this not currently allowed for compliance with the targets set under the EU Commission's Climate and Energy Package. [c] Assumes implementation of the Food Harvest 2020 strategy.[d] Note that cement production (an industry) and construction (a service) are here listed together as construction. [e] Under the Kyoto Protocol 2008–2012, Ireland was required to limit total national greenhouse gas emissions to 314.2 million tonnes of CO_2 equivalent. For 2013–2020 there are separate targets for the ETS and non-ETS sectors.

be replaced in 2021 with combined cycle gas turbine power plants and that onshore wind-generating capacity grows from 1602 MW in 2011 to 2159 MW in 2030. The carbon tax is assumed to remain at a nominal value of €20/tonne until 2020 and rise thereafter, reaching roughly €60 by 2030. For the EU-ETS allowance price, we assume that it will decline by 7 per cent on average over the years 2010–2015, though rise by 10 per cent per annum thereafter. These are important baseline assumptions and are not necessarily forecasts of likely out-turns in these parameters.

Based on these assumptions the projection for greenhouse gas emissions from the entire economy (ETS and non-ETS) is that emissions will decline by an average of 0.4 per cent per annum in the first half of this decade but rise by an average of 1.3 per cent per annum in the latter half of the decade (see Table 10.1. Greenhouse gas emissions as observed and as projected per gas and per sector.). The longer-term projection to 2030 is continuing growth in greenhouse gas emissions.[30] It is projected that actual emissions will comply with the Kyoto Protocol target of 314.18 Mt CO_2eq for the five-year commitment period 2008–2012.[31] On the ETS side of the economy the emissions profile reflects the assumptions on installed electricity-generating capacity: for instance, the decommissioning of the coal-fired plant at Moneypoint significantly reduces emissions. From a domestic policy perspective, non-ETS emissions are of more immediate urgency. Non-ETS emissions are also projected to decline in the period to 2015 by 0.3 per cent per annum and subsequently to grow by roughly 1 per cent per annum. Overall, by 2020 we project that non-ETS

30 This incorporates an assumption of no change in livestock emissions beyond 2021.

31 This equates to an average of 62.84 Mt CO_2eq per annum over the period (i.e. 13 per cent above the baseline estimate).

emissions will be approximately 5 per cent below 2005 levels, compared to a committed target of 20 per cent below. Previous projections, including EPA (2012d), suggested that Ireland would exceed its binding annual emission limits under the EU Commission's *Climate and Energy Package* sometime between 2015 and 2017. In our baseline projection, annual emission limits will be exceeded from 2016.

In the services sector a net decline in emissions in excess of 0.7 million tonnes (mostly due to lower gas and oil demand) is projected. Unlike recent emissions reductions, this decline is not attributable to the economic downturn, as the sector is expected to grow with emissions declining. Most of the reduction in emissions is expected to arise in the start of the decade with modest growth in emissions thereafter.

Following historical trends, emissions from transport are expected to continue to grow rapidly. Much of the growth in emissions is attributable to freight transport and diesel-fuel consumption in passenger cars.[32] The strong growth projections reflect a 'business as usual' scenario and represent the potential scale of emissions in the future unless there is radical change in transport, both commercial and domestic. A significant growth in market share for both electric cars and renewable transport fuels would be needed to change this emissions profile, as well as a change in commuting behaviours.

Much of the projected growth profile in emissions from the industrial sector is related to the assumptions surrounding fluorinated greenhouse gases (F-gases). Both within Ireland and Europe F-gas emissions have increased dramatically over the past few decades. The main uses of F-gases are in refrigeration and air-conditioning systems, fire protection, and electrical switching equipment as well as in foams and aerosols. In many instances F-gases replaced ozone-depleting substances. The EU Commission has published a proposal to repeal the existing F-gas regulation in favour of a regulation that prohibits the use of F-gases with a high impact on climate, introduces a quota for placing hydrocarbons on the market, and encourages alternative technologies (CEC [2012b]). In previous ISus projections F-gas emissions were projected to grow by in excess of 10 per cent per annum (e.g. Curtis [2012]). When the new regulation is finalised and implemented the F-gas emissions will be curtailed significantly, with a 79 per cent reduction from 2015 levels envisaged by 2050. For the purpose of this baseline projection, a reduction in F-gas emissions to roughly 2010 levels in 2014, the first year that the regulation will apply, and a further step reduction in 2015 when further elements of the regulation become effective is imposed. Thereafter, it is assumed that as equipment is phased out and with technological innovation that emissions will gradually decline. Overall, for the industrial sector roughly static greenhouse gas emissions are projected.

32 The aviation sector (domestic) is still classified as being part of the non-ETS sector within ISus and is part of the non-ETS projections in Table 10.1. Greenhouse gas emissions as observed and as projected per gas and per sector. International aviation emissions are excluded.

This baseline projection of greenhouse gas emissions differs in a number of areas from Curtis (2012), the most recent published ISus projections. One area of difference is that in the interim period the method of projecting non-ETS emissions has been revised substantially. The revision relates to an improvement in the disaggregation of ETS and non-ETS projections across the sectors, which was discussed in Section 2. Further, in the June 2012 report it was assumed that future F-gas emissions would continue on their strong historical growth trend. As discussed above, the current baseline incorporates an assumption that the proposed regulation on F-gases will significantly constrain emissions from 2014. In the June 2012 report emissions associated with implementation of Food Harvest 2020 were discussed as part of a scenario analysis, rather than within the baseline projection. Food Harvest 2020 is discussed in Section 11 below.

10.2 European Union Emission Trading Scheme, 'Back-loading' Allowances Scenario

During 2008–2011, the first four years of the second Kyoto period, the ETS experienced a surplus of 955 million allowances and international credits compared to actual emissions (CEC [2012c]). The surplus is equivalent to roughly 12 per cent of the demand for allowances. With an increasing supply of allowances and international credits as well as low demand, allowance prices have followed a strong downward trend since mid-2011, reaching prices as low as €5. The European Commission estimates that the potential

Table 10.2. EU-ETS allowance prices, €/tonne

Scenario	Description	2013	2014	2015	2016	2017	2018	2019	2020
Baseline	Political inaction	4	4	5	5	6	6	8	8
Scenario I	Back-load 900 Mt & no cancelling	8	9	10	8	8	7	7	6
Scenario II	Back-load 900 Mt & cancel 700 Mt	10	12	14	12	11	11	10	12
Scenario III	Back-load 900 Mt & cancel 900 Mt	10	12	14	12	12	12	14	15

Source: Point Carbon (2012)

surplus in allowances during the entirety of Phase 3 will be in the order of 2 billion allowances, though the exact magnitude of the surplus will depend on energy mix, energy efficiency and the speed of economic recovery. This structural imbalance in allowances supply will maintain a downward pressure on the price of carbon and will weaken the ETS as a mechanism for reducing emissions, which is particularly relevant in the context of the EU's agreed long-term objective of 80–95 per cent reduction in emissions by 2050 compared to 1990.

To deal with the structural imbalance in the supply of allowances, the EU Commission has tabled a draft amendment to 'back-load' the auction of allowances.[33] Under the proposal, 900 million allowances will be held back from auction in the years 2013–2015 when demand is expected to remain very low, and 900 million additional allowances auctioned in 2019–2020. The anticipated effect of the proposal is that the market price of ETS allowances will be higher than would have been the case otherwise (initially at least) but no change in the planned aggregate supply of allowances. Where this is likely to have the greatest impact in Ireland is on the price of electricity, as power generation companies must purchase allowances from the ETS marketplace to match their actual emissions, whereas most other sectors will receive free allowances. The ISus model is used to estimate the likely effect on Irish emissions of the Commission proposal.

If implemented, the Commission proposal should have the effect of increasing the price of ETS allowances, which is a European-wide price. Irish ETS companies are price takers in this market and for the purpose of the scenarios forecasts of the EU allowance prices published by Point Carbon (2012) in response to the Commission proposal are used. On the basis of Point Carbon's forecast allowance price, the effect on Irish electricity prices is modelled and the ISus model used to project energy demand and emissions. In addition to the Commission's proposal, Point Carbon also forecast allowance prices for variants of the Commission's proposal. One variant is that of political inaction with no change from the planned allowance auctions in 2013–2020. This is used as the scenario baseline. A second is that 700 of the 900 million back-loaded allowances will be cancelled in 2019–2020 (Scenario II), and a third variant is that all 900 million of the back-loaded allowances will be cancelled in 2019–2020 (Scenario III). These scenarios and the assumed ETS allowance prices are shown in Table 10.2.

Developing a scenario on the potential impact of the Commission's proposal incorporates assumptions on future fossil fuel prices, future ETS allowance prices as per Table 10.2, as well as assumptions surrounding the UK's policy of a carbon price floor (HM Treasury [2011]). The relevance of the UK's proposal to introduce a carbon price floor from 1 April 2013 is through its effect on generation mix and electricity prices in the Single Electricity Market (SEM) for the island of Ireland. The proposed floor starts at £16 per tonne of carbon dioxide and follows a linear path to a target of £30 in 2020. Electricity dispatched within Northern

33 http://ec.europa.eu/clima/news/articles/news_2012111401_en.htm, accessed 7/12/12.

34 The prices in the table are hypothetical scenario prices. The baseline political inaction price of €4 average for 2013 is similar to actual allowance prices in January and February 2013.

Table 10.3. EU-ETS 'back-loading' scenario results for 2020.

	Year	Electricity demand (RoI)	Electricity price	ETS €/tonne	UK carbon floor price €/tonne	Power generation GHG emissions
Baseline (2020=100)	2020	100.0	100	8	39	100.0
Scenario I	2020	100.0	100	6	39	101.0
Scenario II	2020	99.8	102	12	39	94.6
Scenario III	2020	99.8	103	15	39	96.6

Ireland will be subject to the carbon floor price[35] and based on the electricity market rules will be reflected in the Public Service Obligation (PSO) levy payable by all customers north and south. This issue is described in greater detail in Curtis et al. (2013), whereas the overview results are presented in Table 10.3.[36]

Back-loading is likely to increase ETS prices initially but lead to lower ETS prices in 2020 compared to the baseline (Scenario I), as allowances withheld in previous years are auctioned in 2020. In Scenarios II and III back-loaded allowances are cancelled giving support to the ETS price compared to the baseline. Changes in the ETS allowance price will affect Irish electricity prices, as determined within the SEM, but Irish prices will also be affected by the UK carbon floor price because electricity generated within Northern Ireland will be subject to the carbon floor price. The change in the ETS price across scenarios and its relativity to the UK carbon floor price affects the mix of fuels used in generation, which in turn affects domestic emissions in two ways. First, a higher price of carbon prioritises more carbon-efficient-generating plants, *ceteris paribus*.

Second, domestic emissions are affected by *where* in the SEM electricity is dispatched. Emissions associated with electricity generation in Northern Ireland are attributed to Northern Ireland regardless of where the electricity is consumed. As the gap between the ETS and the UK carbon floor prices vary, the mix of plants being dispatched will change. In some instances, the Republic of Ireland will be a net exporter of electricity to Northern Ireland and sometimes a net importer. Under Scenario I, the projected demand for and price of electricity in the Republic is similar to the baseline but Republic of Ireland emissions are projected to be 1 per cent higher than the baseline. This occurs because the Republic exports electricity to Northern Ireland. In all scenarios in Table 10.3, the Republic is a net exporter of electricity to Northern Ireland; this can be easily justified as the ETS price is strictly lower than the UK carbon floor.[37] The difference in the ETS price between the baseline and Scenario I are reflected in the emissions: lower carbon prices don't affect the price of electricity in the Republic (which is similar to the baseline), but Republic of Ireland exports electricity to Northern Ireland and the emissions generated by the Republic generation mix are projected to be 1 per cent higher than the baseline. A change in the ETS price, however, will change the amount of electricity exported to Northern Ireland. As a consequence, the emissions produced by the Republic will change as well. Comparing Scenario III with the baseline is useful for understanding the emission dynamics associated to different carbon prices. Under the baseline scenario exports to Northern Ireland are

35 The difference between the ETS and the carbon floor price will be payable to HM Revenue.

36 The baseline energy projections in Curtis et al. (2013) differ from the projections consistent with SEAI's assumptions on energy mix in electricity generation and compliance with energy policy targets. The power generation emissions underlying the projections in in 2020 project a lower fossil fuel mix and consequently that greenhouse gas emissions from power generation will be lower. The different fuel mix projections relate to differences in assumption surrounding the ETS carbon price and the UK carbon floor price and the consequent effect on the merit order of electricity-generating plants.

37 The projections in Table 10.1, which are consistent with SEAI assumptions on energy mix in electricity generation and compliance with energy policy targets, assume that the Republic will be a net electricity exporter to Northern Ireland in 2020. See also footnote 34.

equivalent to 7 per cent of domestic electricity demand though this falls to 4 per cent under Scenario III as the gap between the ETS and carbon floor prices narrows. The lower emissions associated with Scenario III are due to a higher carbon price, which drives a number of changes. Electricity prices rise but, because of low-price elasticity of demand, there is a negligible change in electricity demand. On the electricity supply side, the fuel mix used in generation changes plus exports to Northern Ireland decline, leading to lower emissions overall.

The direct impact of the EU Commission's proposal to 'back-load' ETS emission allowances on the electricity market and emissions is likely to be relatively small compared to the impact of the UK carbon price floor on the SEM. The difference between the ETS allowance price and the UK carbon floor price will affect the mix of plants that are dispatched and consequently affect the extent to which the Republic is exporting electricity to Northern Ireland (but remaining responsible for the associated emissions). Insofar as Irish electricity customers are paying for the price support afforded by the UK carbon price floor it would be preferable that that revenue went to the Irish rather than the UK Exchequer. In that regard consideration should be given to matching the UK carbon floor within the Republic of Ireland. A second reason for considering matching the UK carbon floor price is to avoid electricity market distortions that the presence of a carbon floor in one part of the SEM would introduce. The results presented here are specific to the year 2020. Results from the intermediate years are complicated by constraints on interconnection and renewables generation and are discussed in detail in Curtis et al. (2013).

10.3 Summary

Ireland's actual greenhouse gas emissions for the period 2008–2012 are expected to be within the Kyoto Protocol target limit. The prospect for compliance in terms of actual emissions with other climate targets is much less positive. Installations with high greenhouse gas emissions will be regulated within the EU-ETS, whereas emissions from the remainder of the economy are subject to binding limits as part of the EU Commission's Effort Sharing Decision. The ISus baseline projection is that by 2020 non-ETS emissions will be roughly 5 per cent below 2005 levels, compared to a committed target of a 20 per cent reduction. Without a dramatic change from existing practices it is difficult to envisage how the target will be achieved. While the 2020 emissions targets may be onerous, longer-term targets will be even more so considering the EU's agreed long-term objective of 80–95 per cent reduction in emissions by 2050 compared to 1990. Transitioning to a low-carbon economy is now a necessity and all sectors of the economy will be expected to play a role. Agriculture and transport, which account for roughly three-quarters of Ireland's non-ETS emissions, must lead the transition to a low-carbon economy. Opportunities to improve the emissions performance of both sectors are discussed in the next two sections.

11 Sustainable Agriculture

A sustainable agricultural sector is one that is inherently profitable and does not pollute soil, water or air. From both financial and environmental perspectives the sector faces significant challenges in this regard. With direct income payments in 2010 ranging from 47 to 202 per cent of family farm income across the main enterprises, the sector is not on a strong financial footing (Department of Agriculture, Food and the Marine [DAFM] [2012]). On environmental matters nutrient losses from agriculture are attributed as a major source of excess nutrients in surface and ground waters (EPA [2012a]). Greenhouse gas emissions from agriculture account for over 42 per cent of non-ETS emissions (EPA [2012b]) and are expected to grow with the implementation of the Food Harvest 2020 strategy, which will coincide with a requirement for the entire non-ETS sector to reduce emissions.

The agriculture sector is operating in a difficult policy environment with conflicting expectations. Agricultural policy is promoting an expansion in output and value added, which will support employment and rural development, as well as supply growing world food demand. Environmental policy, especially related to water, places a responsibility on all sectors to avoid activities that pollute, which means that agricultural expansion necessitates significant abatement measures. However, it is climate policy that is most at cross purposes from an agricultural perspective. The agricultural sector is responsible for a large share of non-ETS emissions for which there is a committed policy target of annual reductions up to 2020. Nevertheless, any curtailment in Irish production to comply with the climate policy target will not reduce global emissions, as production will move overseas. With agriculture accounting for over 42 per cent of non-ETS emissions it is difficult to determine within existing climate mechanisms how Ireland's non-ETS emissions targets will be achieved without a significant contribution from the agricultural sector.

There has been major investment in agriculture to address the challenges facing the sector. The Food Harvest 2020 strategy is aimed at improving profitability and employment in the sector and will also contribute to supplying the growth in global food demand. The Beef Technology Adoption Programme and Sheep Technology Adoption Programme are two initiatives aiming to improve profitability at farm level. The objective of Teagasc's Agricultural Catchments Programme is to evaluate the effectiveness of water-protection measures, which ultimately supports sustainable production. While water quality in Ireland is generally good, there is a problem of excessive nutrients, for which agriculture is considered part responsible (EPA [2012a]). While measures currently being implemented to improve efficiency of manure and fertiliser applications are having positive results (Wall et al. [2012]), it will take time to achieve the sustainable management of nutrients especially in the context of expanding output. The agriculture sector, as well as the other sectors of the economy, has been tasked with developing a low-carbon roadmap that will tackle the problem of high greenhouse emissions. The emissions intensity of agriculture has improved over the past decade and ongoing investment is likely to result in continuing improvement, but emissions targets for the agricultural sector need to be examined to ensure they make sense at domestic, European and global level. Achieving a low-carbon sector, while imminently desirable, is a long-term goal. The scale of the environmental challenges means that incremental improvements, while welcome, may not be sufficient.

11.1 Nutrient Management

Farm-level nutrient management is a longstanding topic of research in Irish agriculture (e.g. Mounsey et al. [1998]) and a component of good agricultural practice guidelines. The decline in recent years in the proportion of soils tests with excessive nutrients (e.g. Wall et al. [2012]) is evidence that the research and management focus is paying dividends. The EPA's *State of the Environment* report provides proof that further improvement is still required, as nutrient losses from agriculture are still attributed as a major source of enrichment of surface and ground waters (EPA [2012a]).

Under the Nitrates Action Plan farmers are currently required to comply with nutrient-spreading limits on a whole-farm basis. This means that an entire farm holding can be nitrates compliant but simultaneously allow excessive levels of nutrients to be spread on individual fields. In the case of nutrients leaching to water it matters more what occurs at individual field level than the average across the entire farm. If agriculture is to be sustainable it has to move to field-level nutrient management.[38] Field-level nutrient management is not cost-free but the on-farm financial return is positive, as effective nutrient management can result in substantially lower levels of inorganic fertiliser purchases (Hyde and Carton [2005]). Even though field-level nutrient management is financially advantageous to farmers, it is not widely practised. As in all sectors, not all individual decisions are taken on an economically or technically optimal basis. Farmers are slow to break with tradition or long-held farming practices, regardless of new information on what constitutes best practice. In addition, excessive nutrient applications may also be considered in some quarters as an insurance policy against low yields or the fertiliser potential of manure may be discounted.

The knowledge and capacity to implement field-level nutrient planning efficiently is already available in existing research and farm advisory services. Progressive farmers are already using field- and plot-level nutrient demand-planning to manage their fertiliser costs efficiently. The challenge is to make it standard practice rather than the exception. A regulatory requirement to implement field-level nutrient management planning is one policy option available to accelerate its adoption. Such a policy would impose costs on farmers but there would be a positive return on investment from Year I and an added environmental dividend in terms of minimising diffuse pollution of waterways.

11.2 Bioenergy

Energy crops have long been advocated as an alternative to fossil fuels and as a means to reduce greenhouse gas emissions. But when energy crop production expanded worldwide in response to rising fossil fuel prices the apparent sustainability of bioenergy crops was brought into question. Among the issues that arose were negative impacts of land-use change, declining food production and increased food prices, and in some instances no net reduction in greenhouse gas emissions. The EU responded with sustainability criteria for energy from renewable sources, which relate to greenhouse gas savings, land with high biodiversity value, land with high carbon stock and agro-environmental practices (EP and CEU [2009])). Even with these more stringent criteria, there is still potential for the agricultural sector to be a more significant energy supplier. This is recognised in the government's most recent renewable energy strategy (Department of Communications, Energy and Natural Resources [DCENR] [2012]). To date policy has focused on more conventional bioenergy crops such as coppice willow or miscanthus, where establishment grants have been provided. Grassland accounts for roughly 90 per cent of agricultural land, and if a small proportion of that resource were used for bioenergy production it would make a significant contribution to renewable energy targets.

In October 2012 the EU Commission introduced a new proposed directive relating to renewable energy fuels and policy targets (CEC [2012a]). A key element of the proposed directive is to limit the use of food-based biofuels to meet the 10 per cent renewable energy target of the Renewable Energy Directive (2009/28EC) and to stimulate the development of alternative biofuels from non-food feedstock, such as waste or straw. The proposal favours the development of fuel from residual materials by counting the contribution of such feedstocks to the policy target at four times their energy content. The proposed Directive does not preclude the development of grass as a feedstock and allows the contribution of energy from a grass feedstock (as non-food cellulosic material) towards the policy target to be counted at twice its energy content.[39] In addition, grass feedstock would not incur proposed penalties associated with land-use change that may arise with other energy crops because no land-use change occurs.

38 And even to sub-field or plot level nutrient management.

39 See Annex IX of the proposed Directive. While grass would not typically be considered as a primary cellulosic energy crop, as compared to miscanthus or willow for example, in Ireland in most instances the use of grass as a fuel would not require landuse change (unlike miscanthus or willow).

Food security is a growing policy issue internationally. National agricultural policy sponsors UN and Food and Agriculture Organization of the United Nations initiatives on malnutrition, whereas domestically it supports the expansion of production in light of growing international food demand. Producing unprofitable food is not sustainable and doesn't make sense but many farm enterprises are currently unprofitable. As noted above, direct-income payments to farmers range from 47 to 202 per cent of family farm income across the main enterprises, with beef enterprises most reliant on direct payments (DAFM [2012]). It does not make sense to expand unprofitable production. In those instances energy crop production may in certain circumstances be more financially viable.[40] Research suggests that conventional energy crops are already more profitable than beef, with a premium of about €135 per hectare per year for willow and €185 for miscanthus compared to beef (Clancy et al. [2008]). But only a very small proportion of farmers are willing to investigate the production of willow or miscanthus (Connolly et al. [2006]). Between 2007 and 2011 just over 3,000 hectares were planted under the Bioenergy Scheme, which is a grant scheme to support the establishment of miscanthus and willow energy crops (NESC [2012]). Among the reasons for the low take-up of energy crops are concerns about 'locking-in' land to energy crop production for up to 20 years and underlying farmer attitudes towards non-conventional agricultural crops (NESC [2012]). Grass as an energy crop is not subject to the same concern. Farmers already have knowledge, expertise, and infrastructure to grow grass and make silage. Also important is that additional on-farm investment would generally be negligible and producing grass as an energy crop would integrate with existing farm enterprises. Fields used for energy crops could be used for stock grazing after silage harvests.

Grassland can be used to produce biomethane. As an example of its energy potential, just 10 per cent of Irish grasslands could fuel over 55 per cent of the Irish private car fleet (Smyth et al. [2009]). Nizami et al. (2012) describe how grass can be used to produce biomethane for use as a transport fuel. In brief, it entails using grass silage that is subsequently processed via anaerobic digestion to produce a biogas, which can be cleaned to natural gas standard. The concept of grass as an energy crop is being considered in many countries, including Austria, Belgium, Finland, The Netherlands and the UK (Cropgen [2007]; Gerin et al. [2008]). A number of reports in Ireland have also advocated grass as an energy crop, where it is argued that it is among the energy crops best suited to Irish circumstances (Curtis [2006]; Murphy and Power [2009]). Biomethane from grass compares favourably to other energy crops on a gross energy basis, including sugarcane and palm oil (Smyth et al. [2009]). The energy return per hectare used for transport biofuel production is also very favourable for grass. On a comparable energy basis, rapeseed for biodiesel requires four times the land necessary than if growing grass/silage for biogas, whereas wheat or sugar beet for ethanol production require 2.5 and 1.5 times the land area of grass (Murphy and Power [2009]). Additionally, grass for energy has the potential to meet the most stringent of the EU sustainability criteria of a 60 per cent reduction in greenhouse gas emissions (Korres et al. [2010]).

Currently the economics of grass biomethane do not make it financially viable. On-farm investment to produce grass/silage as an anaerobic digester feedstock may be negligible but significant capital investment is required for the anaerobic digestion infrastructure itself. Reports on the financial viability of grass feedstock anaerobic digester plants is mixed but it is potentially most viable as a transport biofuel (Smyth et al. [2010]). A number of German studies have found that grass biogas can be profitable when using larger anaerobic digestion plants, for plants in receipt of agricultural subsidies, and for plants with lower feedstock costs (Prochnow et al. [2009]; Blokhina et al. [2009]; Rösch et al. [2009]). A UK study found that a grass biogas plant would struggle to break even (Holliday et al. [2005]). However, there are a number of environmental factors that are not normally priced in the business decision. The first is the potential double dividend associated with reduced greenhouse gas emissions. Grass biomethane could displace fossil transport fuels, which has obvious benefits in terms of greenhouse gas emissions and scope to meet

40 Teagasc's FAPRI livestock projections assume that beef production with a low level of profitability will be replaced by milk production.

climate policy targets.[41] If there is a switch from beef production into grass-for-energy production, emissions will decline both from agriculture and transport. Grass biomethane production also has potential synergies with waste management in the agri-food sector, particularly abattoir wastes. Management of these wastes is always a challenge for the sector but using the waste as a feedstock provides an energy bonus, would improve the economics, and is a sustainable treatment option.[42]

Currently, the economics for grass methane production are not favourable but as a transport biofuel it has a potentially excellent energy balance compared to alternative fuel options. The environmental benefits are real and could improve the greenhouse gas emissions performance of both the agriculture and transport sectors. The proposal here is not to promote grass as the best renewable energy option but to highlight both its energy potential and its synergy with existing farming enterprises. Considerable additional research is still required to assess its feasibility with respect to its integration with existing grass-based farm enterprises; its viability in marginal grassland areas; and its environmental and biodiversity impacts. At best grass biomethane may be a long-term measure possibly limited to fleet vehicles but developments of this nature are required to move to a low-carbon economy. Such a development requires leadership, collaboration and support from the business sector and government, as well as favourable economics.

11.3 Food Harvest 2020[43]

The implementation of Food Harvest 2020 has the potential to contribute to an additional 1 million tonnes of greenhouse gas emissions per annum by 2020, as well as generate significant additional nutrient emissions (Curtis [2012]). Teagasc have suggested that total abatement potential from carbon mitigation measures in Irish agriculture could amount to 2.5 million tonnes, with 1.1 million tonnes attributed to the agriculture sector in accordance with UNFCCC reporting methodology (Schulte et al. [2012]). Teagasc's analysis considered 10 abatement measures that are applicable to Irish farming systems but noted that the figures represent estimates of total potential abatement that can be realistically achieved following full implementation of abatement measures wherever biophysically possible. The realised abatement depends on the extent to which individual farmers fully implement the required practices: consequently, the net outcome is difficult to predict.

Greenhouse gas emissions are just one aspect of Food Harvest 2020 that represents a test for environmental sustainability. Hamell (2012) outlines some of the other environmental challenges facing the Irish agricultural sector, including biodiversity loss, water use and ammonia emissions. Intensification of production may have adverse implications for biodiversity and ecosystem services, which have specific targets under the national biodiversity plan (DAHG [2011]). Ammonia emissions, which are virtually all from agriculture and contribute to eutrophication, acidification and biodiversity-decline, have been below the national emission ceiling since 2003, but they will become problematic if livestock numbers increase to their pre-2000 levels. Since the publication of the Food Harvest 2020 report and subsequent public consultation, a revised environmental analysis of its implementation incorporating suggestions from the EU Commission is being finalised. This analysis will consider environmental characteristics, including biodiversity, flora and fauna, groundwater, surface water, soil, air quality, landscape and climatic factors including greenhouse gas emissions; other emissions; population; human health; cultural heritage; and material assets.

The issue of the impact of Food Harvest 2020 on greenhouse gas emissions is complicated by the interface between Ireland's climate targets, global food security and the potential for carbon leakage. Ireland's dairy and beef production systems are among

41 Grass biomethane will generally not be price competitive with fossil transport fuels but renewable energy targets, such as the Biofuels Obligation, will support a demand for biomethane and other competitor renewables.

42 Smyth et al. (2011) examine the potential for co-digestion of slaughter waste (belly grass) in regional grass biomethane plants in Ireland.

43 DAFF (2010).

the most efficient worldwide in terms of carbon footprint (Leip et al. [2010]). Preserving or even expanding emissions-efficient production in Ireland would be preferable from a global climate policy perspective. Given agriculture's large share of non-ETS emissions and Ireland's committed targets under the Effort Sharing Decision even to maintain the current level of emissions from the agriculture sector may be too high for Ireland to achieve its annual emission limits to 2020. Consideration should be given to seeking, at EU level, a special mechanism for managing agricultural emissions within Europe.

12 Sustainable Transport

Between 2007 and 2011 transport emissions declined by 22 per cent, a decline that is attributed to the economic downturn, changes in VRT and motor tax, and the implementation of the Biofuels Obligation Scheme (EPA [2012c]). Nonetheless, transport emissions remain stubbornly high and have accounted for roughly one-fifth of total greenhouse gas emissions over the years 2007–2011. Without significant change in transport policy the baseline ISus projection for transport emissions is one of growth in absolute emissions and as a share of total emissions, as shown in Table 10.1 above. It is widely recognised that reducing transport emissions will be difficult but that a substantial reduction will be required to achieve compliance with policy targets on greenhouse gases and other air emissions (NESC [2012]; EPA [2012a]). There are no simple near-term solutions to dramatically reduce transport emissions. Conventional policy measures will not be sufficient to bridge the gap to the policy targets without a large adverse impact on competitiveness and growth. Instead, more substantial changes in transport are needed, such as a transition to electric cars or grass biomethane. Wider issues of spatial planning and settlement also have an impact on transport demand and need to be considered initiatives to improve transport sustainability.

12.1 Electric Cars

As discussed in Section 6, the outlook for the use of electric cars is not immediately positive: based on the current low level of sales (NESC (2012)), it is unlikely that the policy target for 2020 will be achieved. Reluctance to purchase electric vehicles may relate partly to the limited (though expanding) recharging network or the characteristics of the electric vehicles (Driscoll et al. [2012]), both of which are issues that ultimately can be resolved. There is a large environmental benefit from having a significant share of the car fleet powered by electricity. As noted above in Section 6, if 10 per cent of the car stock was electric, the associated emissions (from electricity generation) would account for between 2–3 per cent of total vehicle emissions (Hennessy and Tol [2011]).[44] Achieving such an emissions reduction by conventional policy instruments (e.g. transport-related taxes) would have major adverse economic impacts.

The initial policy target was over-ambitious in timing but not unreasonable in terms of its ultimate objective. In an analysis of a transition to a low-carbon economy in the longer term (beyond 2020) Ó Gallachóir et al. (2012) conclude that electric vehicles will be one of the key technologies. The policy attention with respect to electric cars should be focused on facilitating adoption when it is economically efficient. There is no clear prescription on what needs to be done to increase the stock of electric vehicles to be a significant share of the car fleet or when this will be practicable. Technical progress is continuing, so policy initiatives need to be flexible and regularly reviewed.

12.2 Vehicle Registration Tax and Motor Tax

Vehicle registration tax (VRT) and motor tax were rebalanced in 2008 to incentivise the use of low-CO_2 emission vehicles. At that time technological improvements in emission performance of vehicles was being offset by a general preference among Irish motorists towards larger vehicles, which generally had higher emissions (Ó Gallachóir [2009]). The rebalancing of VRT and motor tax had a significant impact on the market. Average emissions of new vehicles fell from 166g/km in 2008, to 145g/km in 2009, 134g/km in 2010 and 129g/km in 2011 (Rogan et al. [2011]; Howley et al. [2011]). This demonstrates the effectiveness of changing financial incentives. However, it is the quantity of fuel consumed that ultimately determines the effect on total emissions. Fu and Kelly (2012) conclude that the VRT and motor tax changes principally supported a shift toward diesel

44 Emissions associated with electric vehicles occur in the generation of electricity, which are ETS emissions, unlike the rest of transport emissions.

and more fuel-efficient cars and exhibited relatively little impact on aggregate carbon emissions.

A second outcome of the rebalancing of VRT and motor tax was a reduction in Exchequer revenue. Allowing for the effect of the recession, the impact of rebalanced VRT was an estimated 33 per cent reduction in revenue or €166 m (Rogan et al. [2011]). Motor tax revenue is also likely to have declined. While VRT and motor tax are labelled as 'environmental taxes', they are integral elements of general Exchequer revenue, financing general government services. It is not practically feasible that a single policy instrument can deliver two policy objectives: generate substantial share of Exchequer revenue and also discourage a polluting activity. This dichotomy is not sustainable and the rebalancing of the motor tax rates in Budget 2012 recognised that dilemma. Motor tax rates in the two lowest tax-emissions bands, which account for 90 per cent of new cars, were increased by 44 and 55 per cent compared to increases in the remaining bands of between 7 and 9 per cent. This was clearly a policy change to preserve Exchequer revenue because as a flat annual tax it has no effect on the fuel consumed by the existing car fleet.

In straitened financial times the Exchequer cannot forego revenue from vehicle taxation, which is an important and significant source of income. The current design of VRT and motor tax with the dual objectives of generating Exchequer revenue and incentivising lower CO_2 emissions does not work effectively. These taxes have a relatively small impact on current emissions levels (Fu and Kelly [2012]). However, over time as a greater proportion of the national vehicle fleet becomes more fuel efficient, the impact on carbon emissions will be greater. It is the fuel, rather than the vehicles themselves, that is the source of the environmental emissions, and a carbon tax on the fuel is more effective in terms of carbon-emission reductions, tax revenue and welfare (Fu and Kelly [2012]). At present, 91 per cent of new cars are accounted for in just two of seven emission bands (NESC [2012]). Budget 2013 announced a further rescaling of VRT and motor tax and expanded the number of tax bands from 7 to 12. Though nominally an environmental measure, an important objective of the rescaling the vehicle taxation bands is the maintenance of Exchequer revenue, a view that is echoed in NESC (2012). The carbon tax should be considered the primary mechanism to incentivise use of lower emission fuels, which is also more equitable in the sense of the 'polluter pays' principle.[45] However, economic competitiveness must be balanced against setting a carbon tax at a level that would be necessary to keep Ireland in compliance with the Effort Sharing Decision targets.

12.3 Transport Fuel Rebates

Under the EU Directive 2003/96/EC (CEC (2003)) on Restructuring the Community Framework for Taxation of Energy Products, member states may give fuel tax rebates for essential fuel users, including haulage vehicles in excess of 7.5 tonnes. Fuel rebates are available to hauliers in 5 of the 27 EU member states and they effectively reduce the price of fuel for eligible vehicles. As fuel prices have increased by over 30 per cent since 2009 it is not surprising that there were calls for the introduction of a fuel rebate in Ireland by the haulage industry and this was also supported by the Oireachtas Joint Committee on Transport and Communications (2012). The benefits of such a scheme are to lower the price of fuel to eligible vehicles, which could result in lower transport costs relative to the base case of not introducing the rebate and thereby improve competitiveness.[46] This is argued to be particularly relevant for an island nation. Furthermore, the Irish Road Hauliers' Association (IRHA) argued that the rebate would result in a Exchequer benefit of roughly €300 million, due to the elimination of the practice of refuelling abroad by Irish hauliers while in transit and from increased fuel tourism by foreign hauliers in Ireland.[47] Morgenroth and Hyland (2012) find that such a rebate is likely to result in a substantial loss to

45 The extension of the carbon tax to solid fuels, as announced in Budget 2013, is a welcome development. This means that turf and coal, which have the highest carbon content, have the same tax treatment as other fuels.

46 In early January 2013 road diesel was already approximately 11 per cent cheaper than road diesel in the UK – source: petrolprices.com and pumps.ie

47 http://www.irha.ie/images/stories/source/euroct12.pdf, accessed 3/12/12.

the Exchequer, estimated at roughly €76 million per annum. They highlight that the shift in fuel purchases from abroad to Ireland will result in increased emissions being attributed to Ireland as the emissions associated with a fuel purchase are counted in the country where that purchase takes place. Budget 2013 announced a rebate on diesel excise for hauliers effective on 1 July 2013 and acknowledged that the relief would cost the Exchequer €76 million. From an environmental perspective discounting the cost of fuel does not make sense. The high price of diesel, including excise and carbon taxes, acts as an incentive to achieve greater fuel efficiency and utilise alternative fuels such as biogas. It is also uncertain whether the price reduction will be passed on to exporters and consumers in Ireland. We therefore concur with the NESC (2012) that, in general, exemptions and reliefs should not be applied. They serve no useful purpose other than delaying or distorting adjustments that will inevitably occur within the industry.

12.4 Green Diesel

The Irish Petroleum Industry Association (IPIA) estimates that 12 per cent of the road diesel market is supplied by illegal laundered 'green' or 'marked' diesel and that there are at least an estimated 120 sites engaged in practices throughout Ireland (IPIA [2012]). The Irish Business and Employers Confederation (IBEC) estimate that the illegal fuel trade costs the Exchequer at least €155 million per annum.[48] In addition, there are environmental consequences: the process itself generates a tar-like sludge as a by-product, and this is usually dumped on roadsides and leaches into soils and groundwater. Recovery and remediation costs of fuel laundering sludge have totalled many million euro in the past few years, with the cost incurred by just Louth County Council being roughly €1 million in 2011 (IPIA [2012]). The current system for the management of green diesel does not work: it causes a loss of revenue to the Exchequer, clean-up costs and environmental damage. A new licensing system was introduced in 2012 to track fuel movements within the legitimate oil industry and a new fuel marker dye was also introduced to make laundering more difficult. While this may improve matters, given the large differential of roughly 50 cent per litre between green and road diesel, the incentive for criminal gain persists.

The system of dyeing diesel and operating a dual-pricing for diesel should be abolished. Instead, a single price for diesel should apply, and a system of tax rebates should be implemented where required. Abolishing green diesel has been proposed previously and the Minister for Finance indicated that implementing such a system would entail an excessive administrative burden and likely be vulnerable to exploitation by criminals (Noonan [2011]). The current system is already being exploited by criminals and given that the State operates repayment systems for VAT, and a system for the Single Farm Payment, which covers almost all farmers, the additional administrative burden may not be excessive. The availability of green diesel in Northern Ireland would undermine a rebate system in the Republic. However, developing rebate systems in tandem in both jurisdictions would benefit both Exchequers. Other countries, for example Germany, operate a single price system for diesel fuel but operate a rebate system for relevant users, such as farmers. Implementing such a system here would have environmental benefits, reduced enforcement effort, and provide a significant net benefit to the Exchequer.

12.5 Biogas

The agricultural sector has the capacity to be a major supplier of renewable transport biofuel, as discussed in Section 11 above. Neither the fuel source (i.e. grass) nor the fuel (i.e. biogas) is widely used in transport and consequently it is unlikely to happen without significant support from major stakeholders, including government, transport and energy sectors. However, the environmental benefit could be on a scale to transform the emissions profile from both transport and agriculture significantly, and is therefore worth exploring in more depth. Similar to electric vehicles, this is a long-term option that might be part of a wider transition to a low carbon economy.

48 http://www.ibec.ie/ibec/press/presspublicationsdoclib3.nsf/wvSectorNews/AA9877C94794DA8380257A8B00383BD5, accessed 3/12/12.

In addition to the challenges related to farmer participation and securing capital investment a further obstacle will be developing a distribution network for transport biogas. Utilising the natural gas grid has already been provisionally examined (Smyth et al. [2010]) but the absence of a retail market for transport biogas is possibly a greater challenge than developing a charging network for electric cars. Given the inertia of the residential sector with respect to new transport fuels, any significant development of biogas as a transport fuel might initially be best served by targeting commercial vehicle fleets.

13 Waste Management

The economy benefits from effective waste-management systems, though high waste-management costs in the past have been perceived as a threat to international competitiveness (Forfás [2006]; Forfás [2010]). Having an environmentally sound waste-management system enables domestic businesses to focus on their primary activity, whereas it is also a positive factor for international companies considering foreign direct investment in Ireland. In recent years attention has begun to focus on improving the sustainability of waste-management practices. At EU level a number of strategy and policy documents propose a resource-efficient economy incorporating high levels of materials reuse and recycling (CEC [2005]; CEC [2008]; CEC [2010]; CEC [2011a]). The Government's new waste-management policy (Department of the Environment, Community and Local Government [DECLG] [2012a]) builds on the these European policy frameworks as well as the National Waste Prevention Programme and National Hazardous Waste Management Plan. The *National Waste Report* (McCoole et al. [2012]) already reports significant improvements in sustainability measures (e.g. recycling performance) though much of the gain has been attributed to the economic downturn of recent years, whereas waste initiatives under the National Waste Prevention Programme have been shown to reduce costs and improve competitiveness (EPA [2012e]). This section reports ISus waste scenario projections, which enables the assessment of the effectiveness of existing policy measures against a number of policy targets. How measures announced in the new waste policy (specifically mandatory household collection and the expansion of 3-bin household collection), will affect the streams of waste processed through the waste-management system will also be discussed.

13.1 Waste Scenarios

A summary of ISus baseline scenario projections for waste generation is presented in Table 13.1. As usual in the modelling, the baseline projections capture the effects of macroeconomic and demographic change only. They do not take possible future policy effects into account; such effects are examined via scenarios. In general, with the current economic climate the levels of most waste streams are expected to trend downwards in the short run. Household waste is expected to continue to decline, averaging a 2 per cent fall per annum from 2010–2015. High levels of unemployment and pressures on discretionary spending are curtailing spending on food, clothing and other products, which is ultimately reflected in lower levels of waste generated. The projected trends in the regulatory category of biodegradable municipal waste (BMW) are similar to the trend for growth in municipal solid waste (MSW), which is a further decline in waste generation in the next few years followed by growth in the second half

Table 13.1. Waste arisings as observed, and projected for municipal solid waste (MSW), biodegradable municipal waste (BMW), household waste, biowaste, hazardous waste, and construction and demolition waste (C&D).

	2010	2010–2015	2015–2020	2020–2025	2025–2030	2010–2015	2015–2020	2020–2025	2025–2030
	Observed	Baseline projection				Baseline projection			
	Million tonnes per year					Change per year, %			
MSW*	2.85	2.77	2.88	3.32	3.74	-0.8	2.3	2.9	2.2
BMW*	1.81	1.78	1.87	2.15	2.42	-0.5	2.4	2.9	2.2
Household waste*	1.69	1.59	1.60	1.82	2.08	-2.0	2.0	3.0	2.5
Biowaste**	1.35	1.36	1.45	1.63	1.80	0.4	2.2	2.3	1.9
Hazardous	0.29	0.32	0.43	0.53	0.62	6.6	5.0	3.3	3.3
C&D waste***	3.34	2.77	3.55	3.90	3.83	-2.9	6.0	-0.1	-0.5

* Includes managed and uncollected; ** Biowaste projections exclude Harvest 2020 Strategy ambitions; ***C&D figures are for soil and stones and other C&D waste, including both materials with reported and unreported dispositions.

of the decade. Biowaste[49] is projected to increase throughout the projection period. Construction waste is expected to decline by 3 per cent per annum for the next couple of years. Hazardous waste, mostly emanating from the industrial sector, is projected to increase reflecting an expectation of growth in output from the sector. Roughly half of the hazardous waste generated in 2010 was exported for treatment (McCoole et al. [2012]). With a projection of increased levels of hazardous waste in the future the sustainability associated with shipping these materials abroad for treatment needs to be reassessed.

As the economy begins to grow, particularly after 2015, waste generation is projected to trend upwards again, averaging 2–2.5 per cent per annum for the household and municipal waste streams. The economic downturn has affected waste generation differently in the household and commercial sectors. In the commercial sector we project that waste generation is static or already growing. Household waste generation is projected to decline in the first half of the decade, after which it is projected to grow, reaching 2010 levels by 2020.

There is increasing policy attention directed towards waste prevention, but where waste does arise the policy objective is to maximise recycling and recovery. Projecting which treatment technologies will be employed in the future is subject to greater uncertainty than the waste-generation projections. Ultimately, factors such as waste infrastructure and prevailing waste-management prices will affect how waste is managed. Nonetheless, projecting a possible waste-disposition scenario provides an indication of the level of waste-management capacity required for the future, as well as an indication of performance against some waste-management policy targets. Table 13.2 gives a scale of the main waste-treatment operations. While considerable policy attention is directed towards municipal waste streams, municipal waste accounts for only about 15 per cent of all waste streams managed. Landfill remains a significant final treatment option but recycling and recovery are growing. Almost 1.5 million tonnes of municipal waste was landfilled in 2010 with over 1 million tonnes recycled/recovered. It is expected that the quantity of material sent to landfill will decline for a number of reasons. The increase in the landfill levy, which will be €75 per tonne from July 2013, is driving diversion from landfill. On the basis of existing behaviour and waste-policy recycling and recovery of waste will increase, with in excess of an additional 100,000 tonnes of municipal waste recovered/recycled per annum projected by 2020. It is likely that recycling targets will increase following the forthcoming European Commission Review of the Waste Framework Directive and Packaging Directive and with subsequent future domestic policy initiatives the amount of waste recycling could be substantially higher by 2020. The development of municipal waste incineration capacity will also result in a switch in final treatment option. The Carranstown incinerator was commissioned in 2011 and it is assumed that it will operate at full capacity in 2012. The projection also assumes that the Poolbeg facility will operate from

Table 13.2. Waste management as observed, and projected for landfill, incineration, and recycling/recovery.

	2010	2010–2015	2015–2020	2020–2025	2025–2030	2010–2015	2015–2020	2020–2025	2025–2030
Observed		Baseline projection				Baseline projection			
		Million tonnes per year				Change per year, %			
Landfill & mining/ mineral waste	5.56	5.63	5.91	6.69	7.48	1.3	1.1	2.4	2.2
Municipal landfill	1.50	1.31	0.81	0.93	1.16	-3.9	-8.1	5.6	3.8
Incinerate	0.50	0.69	1.34	1.51	1.57	9.7	13.1	0.8	0.9
Recycle/ recovery (excl. Agric)	4.60	4.42	5.48	6.15	6.50	0.8	4.4	1.2	1.1
Municipal recycle/ recovery	1.08	1.07	1.12	1.29	1.46	-0.4	2.4	2.9	2.2

49 Biowaste is defined here as 'biodegradable garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises and comparable waste from food processing plants.'

2016. Landfill capacity is also declining. The *National Waste Report* (McCoole et al. [2012]) notes that at current fill rates 15 of the 28 active landfills in 2010 would reach capacity within three years and that waste will have to be transported longer distances, making recovery a potentially more economic option.

The economic downturn contributed to reductions in waste generation in recent years and as such contributed to positive progress against policy targets. As the economy recovers and waste streams begin to trend upwards again (as outlined in Table 13.2), some of the gains against policy targets may be lost. One target of particular policy focus in recent years has been the Landfill Directive target. The 2010 target was achieved with 872,000 tonnes of BMW landfilled compared to maximum of 916,000 tonnes permitted. Reaching the stricter targets of 610,000 tonnes in 2013 and 427,000 tonnes in 2016 will be much more difficult. ISus projections are that BMW generated will continue to decline gradually before rising again in the latter half of the decade. Therefore, with practically the same level of BMW generation in 2013 as 2010 but with the maximum permitted BMW that can be landfilled 30 per cent lower than 2010 (i.e. 610,000 tonnes) substantial capacity expansion in BMW treatment is required. The EPA's pre-treatment guidelines for landfill (EPA [2009]) and the Waste Management [Food Waste] Regulations 2009 (DEHLG [2009]) are regulatory instruments that should help drive that expansion in waste-treatment capacity, whereas the high landfill levy supports the financial model for investment in such a capacity. The ISus projection scenario assumes that the Poolbeg incinerator will be built and commissioned by 2016 and if that transpires it will contribute to achieving the much more stringent Landfill Directive target for 2016.

Three other policy targets that are nominally related are:

- Recycling of 35 per cent of municipal waste by 2013;[50]
- A diversion of 50 per cent of overall household waste away from landfill by 2013;[50]
- Fifty per cent reuse and recycling of household paper, metals, plastic and glass by 2020.[51]

In 2010 42 per cent of municipal waste was recycled/recovered, so compliance with the 35 per cent target is unlikely to be an issue in the future. In the past few years there has been a dramatic increase in the amount of household waste diverted from landfill, reaching almost 41 per cent in 2010, and there is a strong likelihood that the target of 50 per cent will be reached by the 2013 deadline or shortly thereafter. If additional incinerator capacity is commissioned it is likely that diversion of household waste from landfill will significantly surpass the 50 per cent target. The Waste Framework Directive target of 50 per cent reuse or recycling of household waste is reported achieved in the National Waste Report 2010.

13.2 A Resource Opportunity

In July 2012 the DECLG published a revised waste-management policy (DECLG [2012a]). From an economic perspective, the most significant element of the policy was the decision to preserve the existing market structure for household waste collection, maintaining side-by-side competition between waste collectors and free market access. Elsewhere, the policy represents a significant change from the status quo with a range of initiatives proposed for licensing, enforcement, and waste management – including a customer charter and mandated service levels. The proposal that all householders will be obliged to demonstrate that they are availing of an authorised waste collection service or are otherwise managing their waste in an environmentally acceptable manner will be a vital tool in helping to eliminate fly-tipping, littering and backyard burning of waste. Though often localised, the pollution associated with these activities can be long lived and damage both visual amenity and environmental quality. In 2010 almost half a million households did not have a household waste-collection service (McCoole et al. [2012]), though presumably many of these households disposed of their waste via the conventional waste-management infrastructure such as civic amenity sites and landfills. A policy of a

50 *Changing Our Ways*, DELG (1998).

51 Article 11(2)a of Waste Framework Directive, EP and CEU (2008).

universal or mandatory household collection will have a significant effect on the total tonnage of waste streams collected and on treatment capacity requirements, an issue which is explored later. There are a number of other proposals in the policy, economic in nature that have the potential to significantly affect waste-management outcomes, which are discussed below.

The policy signalled the intention to introduce a household waste-collection waiver scheme and alternative support schemes for low-income households. The nature in which support schemes are implemented will affect a household's decisions on waste, including its presentation for collection, segregation as well as the total quantity generated. If the support scheme is implemented as a fee waiver, recipient households will not face the incentives to reduce waste, and to maximise the segregation of waste streams (e.g. dry recyclables, organics). The support schemes obviously need to address the protection of affordability for vulnerable households, but to achieve best environmental outcomes all households should face the same incentives to minimise and segregate waste. It is our view that income supports for waste collection service should be implemented through the tax and welfare system. All households should face the full cost of waste-management service and be uniformly incentivised to minimise, recycle and segregate waste, but low-income households can be protected separately via cash transfers and tax credits.

Another element of the new policy is a proposal that waste collectors will be required to operate pricing structures that incentivise waste reduction and segregation by households. Effective enforcement will be critical to ensure this. The literature is quite clear that pay-per-use pricing is the most effective in this regard, and that within pay-per-use schemes weight-based-charging has achieved the most environmentally sustainable outcomes (e.g. Scott and Watson [2007]). Pay-per-use means that there is a cost to households every time a bag is taken or bin emptied and excludes the commonly used flat fee for specific volume waste bin. Pay-per-use schemes that are volume based (e.g. per-bin lift) encourage storage of waste until bins or bags are full, potentially leading to treatment problems for the putrescible fraction. Weight-based charging is possibly the most transparent pricing scheme, with the price facing households in the same unit (i.e. tonnes) as prices for waste treatment and disposal options. Weight-based charging possibly also entails the truest application of the polluter pays principle. Devising pricing structures to encourage waste segregation with low contamination is difficult. If households face differentiated prices for segregated waste collected, the risk of contaminated segregated streams is higher. If dry recyclables are the lowest priced waste, the likelihood of contamination with wet or other wastes increases.[52] As much as 10 per cent (and sometimes higher) of materials in dry recyclables bins are contaminants and up to 20 per cent in brown bins.[53] To prevent this, it may be worth considering a bonus and penalty system for good and bad performance on segregation. The incentive in that instance is to segregate correctly. To effectively incentivise waste reduction and segregation, pricing structures must be simple. Households should be able to calculate the cost of their waste actions easily when they put materials in their segregated waste bins. Flat annual service fees for provision of service plus a per unit fee (e.g. €/kg) are easily understood. Where there is an additional 'per-lift' charge it is more difficult for households to calculate the marginal cost. Furthermore, per-lift fees potentially encourage cross-contamination of segregated waste streams, as households attempt to minimise the number of bin-lifts.

Existing proposals to extensively roll out household brown bin collection is endorsed in the new policy document, where the document states that 'the regulatory impact analysis on draft household Food Waste collection regulations confirms the value of separate "brown bin" collections' (DECLG [2012b]). There are clear benefits associated with separate collection of organic waste in terms of its treatment and subsequent use, as well as waste-management policy targets. Whether such benefits justify the cost of implementing a 3-bin collection service ultimately to all households in settlements exceeding 500 persons, is less clear.[54] The regulatory impact analysis already acknowledges a poor voluntary compliance by private

52 Dry recyclables collections are free for most but not all households with such a service.

53 RPS (2009).

54 DECLG (2012b) analyses extending collection to settlements of 3000 and 5000 in population, whereas Indecon (2012) proposes extending collection to all households in settlements exceeding 500 in population.

waste collectors with permit conditions requiring an organic bin collection. Prohibitive costs, diminishing or eliminating profitability, may be one reason for the poor voluntary response. It is difficult to substantiate the extent to which that is true, though it is likely to vary spatially and by waste collector. Equally, there are waste collectors that provide brown bin collections at a lower price than their residual bin, suggesting that it can be profitable in at least some instances.[55]

Independent of the cost of provision of a brown bin collection, it is instructive to estimate the effect of the new policy's provisions for brown bin collection in settlements of various sizes and for mandatory waste collection service for all households. Both provisions will substantially affect the tonnage of waste collected kerbside. A baseline for comparison is the 2010 *National Waste Report*, which reports that 773,000 tonnes was collected in black bins, 264,000 tonnes in green bins and 64,000 tonnes in brown bins, as shown in Table 13.3. Moreover, using *National Waste Report* data on the number of households with each type of collection service we estimate the relative share of waste collected in black, green and brown bins for 1-bin, 2-bin and 3-bin collection services, as shown in Table 13.4.[56] Using these shares we present a number of scenarios on the effect of implementing universal household collection and the widespread roll-out of brown bin collection. With the implementation of mandatory household collection, an estimated 0.5 million additional households will receive a waste-collection service. Previously waste from some of these households entered the waste-management system via civic amenity sites and landfills but the EPA estimate that there was some 265,000 tonnes of uncollected waste that did not enter the conventional waste-management system in 2010 (McCoole et al. [2012]). Assuming the type of collection service that the additional 0.5 million households utilise is in proportion to the share of 1-bin, 2-bin and 3-bin collections in 2010, the segregated streams collected are shown in Scenario I in Table 13.3.[57] Under that scenario of universal mandatory collection, total waste collected directly from households is estimated to increase by over 440,000 tonnes. Given that scale of increase, mandatory household collection will require waste collection companies to invest in additional collection capacity. Under this scenario of mandatory household collection service, it is estimated that an additional 25,000 tonnes will be collected in brown bins in areas where the brown bin service is already provided, an increase of 39 per cent. The brown bin collection of 89,000 tonnes in Scenario I is a possible baseline to compare the effect of rolling out 3-bin collection to all population centres.

Environmental Protection Agency waste-characterisation data suggests that organic and garden waste constitutes almost 23 per cent of total household waste (McCoole et al. [2012], Appendix H.1). Based on *National Waste Report* data on the number of households on 1- 2- and 3-bin collection and the total waste collected in these bins it can be inferred that of households with 3-bin collection only 17 per cent of household waste is deposited in the brown bin.[58] Therefore, there is scope to increase the amount of waste collected in the brown bin. Increasing the share of organic waste that is collected in brown bins (where brown bin service is currently available) from 17 to 22 per cent would increase brown bin collections by an estimated 26,000 tonnes (Scenario II versus Scenario I). On the basis of the policy for mandatory household waste collection service (Scenario I) and measures to educate households to increase the level of organic waste deposited in brown bins (Scenario II) the total amount of material collected in brown bins could increase by 80 per cent compared to current levels, rising to some 115,000 tonnes.

55 In autumn 2012 in Dun Laoghaire/Rathdown Panda waste collector's prices for brown bin collection were lower in terms of annual service charge, per lift charge, and per kilo charge than its prices for black bin collection, http://www.panda.ie/household/dun-laoghairerathdown/prices.html

56 The methodology used in the scenario analysis presented in Table 13.3 differs from the approach used in Indecon (2012), which makes assumptions on the growth in participation rates for brown bin collection. The methodology here assumes an average tonnage in 3-bin collections across all households on 3-bin collection compared to making assumptions on both the participation rate for presentation of the third bin and then average weight of weight in the third bin conditional on bin presentation.

57 Without data on the location of households not participating in waste collection, it is difficult to gauge what collection service will be available to uncollected households under a mandatory collection scenario.

58 The percentage of household waste collected in the brown bin may be significantly higher is specific locations (e.g. see RPS [2009]) but the figure of 17 per cent represents an inferred average across all 3-bin households.

Table 13.3. Household waste-collection scenarios.

	Scenario: Description	1-bin	2-bin	3-bin	Black bin	Green bin	Brown bin
		%	%	%	Tonnes (000)		
	National Waste Report 2010	5[a]	61[a]	34[a]	773	264	64
I	Mandatory collection service with bin service in proportion to existing shares	5	61	34	1,087	367	89
II	Mandatory collection service with bin service in proportion to existing shares & in households with brown bin collection the proportion of waste deposited in the brown bin increasing from 17 to 22%	5	61	34	1,061	367	115
III	Brown bin collection in settlements exceeding 5000[b] persons, balance households on 1-bin and 2-bin collection in proportion to relative shares in 2010	3	40	57	1,020	374	150
IV	Brown bin collection in settlements exceeding 5000[b] persons, balance households on 2-bin collection	0	43	57	1,008	386	150
V	Brown bin collection in settlements exceeding 3000[b] persons, balance households on 2-bin collection	0	40	60	1,000	386	157

Note: the percentages in this table refer to percentages of occupied households, as distinct from percentage of the population.

a In 2010 the percentages are of households on waste collection service. In Scenarios I–V the percentages are of all households, including uncollected households in 2010.

b The analysis here is confined to extending collection to households in settlements exceeding populations of 3,000 and 5,000 persons, similar to that discussed in DECLG (2012b). The regulatory impact analysis undertaken by Indecon (2012) covers settlements exceeding 500 in population.

Table 13.4. Bin shares in household waste collection, 2010.

Collection scheme	Black bin %	Green bin %	Brown bin %	Total %
1-bin	100	0	0	100
2-bin	75	25	0	100
3-bin	58	25	17	100

Source: Inferred from National Waste Report 2010 data on household bin collections; and waste tonnages collected by bin types

There are three further scenarios (III–V) presented in Table 13.3 related to the roll-out of brown bin collections. The policy document is not specific on the extent of the roll-out, saying ‘within population centres of a given size and will be introduced on a phased basis over a 4-year period’ (p. 10). The Regulatory Impact Analysis on household waste collection discusses settlements exceeding 3,000 and 5,000 people (DECLG [2012b]).[59] Census 2011 reports 57 per cent of private households in settlements exceeding 5000 persons, and 60 per cent of households in settlements exceeding 3000 persons.[60] In 2010 approximately 24 per cent of all households had a brown bin collection service.[61]

Scenario III looks at a roll-out of brown bins to 57 per cent of households, with the balance of households on 1-bin and 2-bin collection in proportion to relative shares in 2010. Under this scenario an additional 35,000 tonnes of waste will be collected in the brown bin collection.[62] Based on data from existing 2-bin and 3-bin collections, the provision of a brown bin collection is also likely to increase the tonnage of dry recyclables collected. Under this scenario the switch of recyclables from the black to green bin is relatively small at 7,000

59 Indecon (2012) discusses settlements exceeding population of 500.

60 In terms of persons, as opposed to households, Census 2011 reports 56 per cent of the population reside in settlements exceeding 5000 persons, and 58 per cent in settlements exceeding 3000 persons.

61 34 per cent of households with a collection service have a brown bin.

62 Scenarios I, III, IV and IV assume that 17 per cent of household waste is deposited in the brown bin, whereas organic waste comprises an average of 23 per cent of household waste.

tonnes. However, if all 1-bin collections are replaced with a minimum of 2-bin collection the tonnage of green bin collections would increase by a further 12,000 tonnes, which is presented as Scenario IV in Table 13.3.

Scenario V extends the roll-out of brown bins to 60 per cent of households, with remaining households on a 2-bin service. In this instance the marginal increase in brown bin collections is 7,000 tonnes compared to Scenarios III and IV. Overall, the potential effect of a roll-out of brown bin collections from households in settlements exceeding 3–5000 persons is a total brown bin collection in the order of 150,000 tonnes. If the baseline for comparison is Scenario I the marginal collection from the roll-out of 3-bin collection to all major population centres is approximately 60,000 tonnes, which is equivalent to total collection in 2010. However, there is further scope for additional brown bin collection within existing brown bin collections. At present in 3-bin collections about three-quarters of organic waste is collected in brown bins but educating households to increase this proportion could have a significant effect in aggregate, in the case of Scenario II, by as much as 26,000 tonnes.[63]

Both mandatory household collection and the further roll-out of 3-bin collection should make a significant impact on the tonnage of segregated organic waste collected if they are enforced effectively. However, it should be noted that based on existing experience with 3-bin collections that up to 20 per cent[64] of the brown bin constitutes contaminants, which makes its treatment more difficult. Nonetheless, based on 2010 waste streams the two policies have the potential to increase source segregation of organic and garden waste to 150–200,000 tonnes.[65] The diversion of this waste from landfill will make significant inroads towards the Landfill Directive targets. There is also scope for even greater segregation and diversion. The upper bound estimate of 200,000 tonnes collected assumes that the organic fraction (incl. contaminants) of household waste deposited in the brown bin increases from 17 to 22 per cent but the share of organics in collected household waste stream can be substantially higher.[66]

Separate collection of organic wastes facilitates greater treatment options and the diversion of this material from landfill. The policy announcement focuses on the collection mechanism, i.e. the roll-out of brown bins, whereas the analysis here has shown that significant increases in organic waste collection can be achieved without expansion of the brown bin collection. Increasing the efficiency of brown bin collection where it already exists and subsequently expanding brown bin collections may offer a more cost-efficient approach than dramatically increasing the number of households with brown bin collection immediately. But the cost efficiency of waste treatment also depends on the level of contamination of brown bin waste with non-organic materials. Quality brown bin waste (i.e. without contaminants) facilitates greater treatment options that potentially include recovery (e.g. compost for landscaping or land spreading). Accordingly, there is a balance to be achieved between maximising the quantity of material collected in brown bins versus the quality of that material.

13.3 Backyard Burning

A further potential benefit of the mandatory household bin collection policy is a reduction in dioxin emissions from household sources. A proportion of households, especially those not participating in a collection service, burn their household waste. The emissions associated with uncontrolled burning of waste, such as dioxins, are persistent, bioaccumulative and toxic; and many are carcinogenic and mutagenic. The introduction of a policy for mandatory household waste collection has the potential to dramatically reduce or eliminate this source of toxic emissions. Duffy et al. (2012) estimate emissions associated with burning of household waste in fireplaces or backyard bonfires. The ISus baseline scenario assumes that emissions from this source remain at 2010 levels, i.e. no change. If disposal behaviour changes with the introduction of the mandatory household waste collection service and burning of household waste is eliminated, dioxin

63 In Scenario IV if waste deposited in brown bins increased from an average of 17 per cent of household waste to 22 per cent, the total waste collected in brown bins would increase from 150,000 t to 194,000 t.

64 RPS (2009).

65 See Table 13.3 and footnote 61 for scenario assumptions.

66 See Appendix D, RPS (2009) for composition statistics on a variety of 2-bin and 3-bin collection routes.

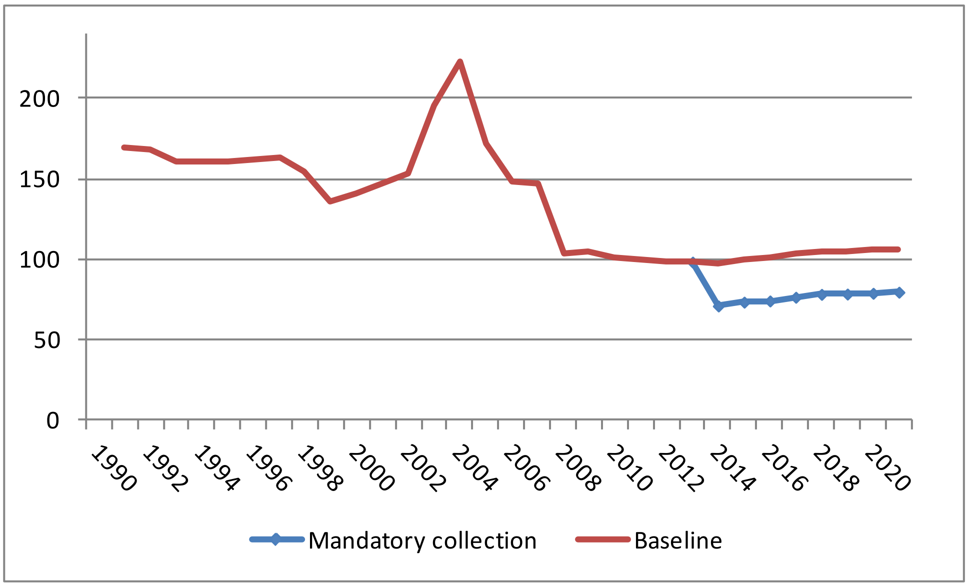

Figure 13.1. Dioxin emissions (all sources) and universal household waste collection, index 2010=100.

Source: Duffy et al. (2012) and ISus

emissions could fall by an as much as 20–25 per cent, as shown in Figure 13.1.

13.4 Summary

Ireland's performance on waste management continues to improve and the new policy announcement for mandatory household collection will further improve matters, especially in relation to illegal dumping and burning of waste. To maintain progress it is imperative that households and businesses face clear and effective incentives. Pricing structures for waste management must be simple and apply to all without exemption and to this end waste collectors should be required to apply pay-by-use tariffs (with effective enforcement of this requirement) and encouraged to operate simple and transparent pricing schemes. Economic conditions may lead to further reductions in the municipal waste stream for the next few years, but by the end of the decade waste generation will likely have recovered to 2010 levels. The management of this waste stream in the future is likely to be substantially different than today, with greater levels of recycling/ recovery and a lower reliance on landfill. Waste treatment capacity will have to evolve to enable this to happen, whether it relates to treatment of organics, dry-recyclables, or residual waste. The private sector will play an important role in delivering new waste collection and treatment capacity but the efficient management of the waste-management system will depend on the roles of regulatory authorities and the new regional waste-management plans.

14 Conclusions

14.1 Climate Change

Every year since 2005 total greenhouse gas emissions have declined, mostly by 1–2 per cent per annum and with a more dramatic decline of 9 per cent in 2009. Consequently, Ireland's actual greenhouse gas emissions for the period 2008–2012 are expected to be within the Kyoto Protocol target limit. The recent trend therefore has been in the right direction but compared to future policy commitments the reduction in emissions is much smaller than is required. Under the EU Commission's Climate and Energy Package Ireland has annual binding targets for non-ETS emissions culminating in a target for 2020 of emissions 20 per cent below 2005 levels. For the future, our baseline model projects a reversal in the trend, with a growth in greenhouse gas emissions that may lead to Ireland breaching its binding annual emission limits for non-ETS emissions possibly as early as 2015. The ISus baseline projection is that in 2020 emissions will be 5 per cent below 2005 levels, rather than the target of 20 per cent below. These ISus projections are not forecasts of environmental outcomes and are based on various assumptions about economic activity and policy, as discussed earlier in the report. Nonetheless, we can conclude that if existing practices and policies are continued broadly as today, actual emissions will exceed committed climate policy targets. Any shortfall in annual emission reductions will have to be achieved in the subsequent year plus a penalty factor of 8 per cent. Compliance with the Effort Sharing Decision targets is feasible through the purchase of either Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanism credits or surplus emissions reductions from other member states.

To reach Irish climate policy targets, including the EU's agreed long-term objective of 80–95 per cent reduction in emissions by 2050 compared to 1990, the country needs to move to a low-carbon economy. Being a low carbon economy is a longer-term goal but will not be achieved without urgent and concerted action across all sectors. This report highlighted opportunities in the agriculture and transport sectors but these will not be realised in a business and regulatory environment that is not conducive to change.

14.2 Sustainable Agriculture

The agriculture sector is promoting an expansion in output, which will support employment and rural development, as well as supply growing world food demand, but the sector is potentially constrained by environment policy.

The agriculture sector emits a large share of non-ETS emissions for which there is a committed policy target of annual reductions up to 2020. However, any curtailment in Irish agricultural production to comply with the climate policy target will not reduce global emissions. Production will move overseas whereas Ireland's dairy and beef production systems are among the most efficient worldwide in terms of carbon footprint (Leip et al. [2010]). Teagasc have suggested that there is significant carbon-abatement potential in the sector that would facilitate expanding output but even if most of that abatement is realised (which is not guaranteed) it is difficult to see within existing climate mechanisms how Ireland's non-ETS emissions targets will be achieved without a substantial net reduction in emissions from agriculture. However, preserving emissions-efficient production in Ireland is preferable from a global climate policy perspective, and therefore seeking a special mechanism for managing agricultural emissions outside the non-ETS targets would be a desirable strategy.

Expanding output also has implications for nutrient management. There is evidence that nutrient management initiatives in agriculture are paying dividends, but the EPA's *State of the Environment* report provides proof that further improvement is still required, as nutrient losses from agriculture are still attributed as a major source of enrichment of surface and ground waters. Expanding output increases the amount of nutrients that must be managed so the threat to water quality remains an ongoing issue for the sector. The environmental analysis of Food Harvest 2020, which is currently under way, should address how water quality and other environmental issues will be managed in the context of expanding output.

There is considerable opportunity for the agriculture sector in the move to a low-carbon economy. The sector has the potential to be a major producer of renewable energy, through a variety of energy crops. The energy potential of grass as an energy crop was highlighted and though it is not currently a viable economic option, the associated environmental benefits are real and could improve the greenhouse gas emissions performance of both the agriculture and transport sectors. Additional research is still required to assess its feasibility and at best it may be a long-term measure but developments of this nature are required to move to a low carbon economy.

14.3 Sustainable Transport

Emissions from transport have more than doubled since the 1990s, growing by more than 4 per cent per annum on average. That level of growth is unsustainable both for a country attempting to reduce emissions and also in terms of the impact on global climate. ISus baseline emissions projections signal a continuing growth in emissions, not as high as in the past but strong growth nonetheless. There appear to be no simple near-term pragmatic solutions to reduce transport emissions dramatically. Adjustments to conventional policy measures will not be sufficient to bridge the gap to the policy targets. Innovative policy measures will be needed to change transport behaviours and patterns. In the long term, expanding the share of electric cars in the national car fleet has the potential to make a contribution. However, demand for electric cars has been weak so far and it may take time for technical progress and market development before electric vehicles make significant inroads into transport emissions. Policy analysis to date suggests that the effects of transport policy measures can vary widely from what was initially expected, and consequently that initiatives need to be flexible and policymakers should be ready to adapt to new information.

The experience with rebalancing VRT and motor tax in recent years shows that people respond to financial incentives. Equally, the decline in average emissions of new cars also shows the effectiveness of EU measures to improve fuel efficiency. Transport is integral to both economic activity and social interaction and seriously curtailing transport activity (as opposed to transport emissions) is not a practical option. Given the budgetary crisis it is also clear how important vehicle taxation is to general Exchequer revenues. A carbon tax that directly penalises use of the fuels from which emissions arise, is an efficient instrument to ration transport demand, but to make any meaningful progress of reducing emissions practical low-emission transport alternatives are necessary. Electric vehicles fall into that category, as does the development of renewable transport fuels for blending with, and as alternatives to, petrol and diesel. A policy of transport fuel rebates for the haulage sector runs counter to measures aimed at encouraging innovations in fuels, fuel efficiency and reducing emissions. The discussion here has focused on fuels and technology as a means to reduce emissions but the management of planning and spatial development, which also drives transport demand, has a role to play in improving transport sustainability.

14.4 Waste Management

The economic downturn serendipitously contributed to reductions in waste generation and has helped Ireland meet waste-management policy targets. Some of the gains are likely to persist, for example, improvements made over time in recycling behaviour are likely to continue. But as the economy returns to growth, waste generation will increase. But the return to growth will not be uniform; in particular, the household sector may lag behind other parts of the economy in terms of increasing waste generation. With the policy of mandatory collection of household waste, uncollected waste should be considerably reduced with more waste collected and treated within the conventional waste-management system. The policy of brown bin collection for all urban areas should facilitate better treatment of organic waste and diversion from landfill. This is likely to require additional infrastructure, particularly related to waste collection. In the longer term more waste will be recycled and there will be much less reliance on landfill. To maintain compliance with the increasingly stringent targets from the Landfill Directive, and because of changes in the waste-management market driven by higher landfill levy, additional treatment capacity will be required. It is most likely that the private sector will play a leading role in the provision of additional collection and treatment capacity. Local authorities and the EPA will continue to play an important role in the licencing and enforcement of waste-management policy.

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Acronyms and Annotations

BER	Building Energy Rating (BER)
BMW	Biodegradable municipal waste
CEC	Council of European Community
CLRTAP	Convention on Long-range Transboundary Air Pollution
CDM	Clean Development Mechanism
CSO	Central Statistics Office
DECLG	Department of the Environment, Community and Local Government
ED	Electoral division
EPA	Environmental Protection Agency
ETS	EU Emissions Trading Scheme
GDP	Gross domestic product
GNNP	Green net national product
GNP	Gross national product
HCB	Hexachlorobenzene
IDEM	Ireland's Electricity Dispatch Model
IPEC	Intergovernmental Panel on Climate Change
IPIA	Irish Petroleum Industry Association
IRHA	Irish Road Hauliers' Association
JI	Joint Implementation
MSW	Municipal solid waste
NESC	National and Economic Social Council
NNP	Net national product
PCB	Polychlorinated biphenyls
POP	Persistent organic pollutants
POWCAR	Population Place of Work Anonymised Records
PSO	Public Service Obligation
SAPS	Small Area Population Statistics
SEAI	Sustainable Energy Authority of Ireland
SEM	Single Electricity Market
STAP	Sheep Technology Adoption Programme
TSP	Total suspended particulates

UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
VRT	Vehicle registration tax

Appendix 1

Table A.1. Substances in ESRI Environmental Accounts.

Variable	Description (years available, source, measurement unit)
CO_2 from fossil fuel	Carbon dioxide emissions from fossil fuels 1990–2010 (EPA) thousand tonnes
CO_2 other	Carbon dioxide emissions from non-fossil fuels 1990–2010 (EPA) thousand tonnes
CH_4	Methane emissions 1990–2010 (EPA) thousand tonnes
N_2O	Nitrous oxide emissions 1990–2010 (EPA) thousand tonnes
HFC23	
HFC32	
HFC134a	
HFC125	Halofluorocarbon emissions 1990–2010 (EPA) tonnes of CO_2 equivalent
HFC143a	
HFC152a	
HFC227ea	
CF_4	
C_2F_6	Perfluorocarbon emissions 1990–2010 (EPA) tonnes of CO_2 equivalent
cC_4F_8	
SF_6	Sulphurhexafluoride emissions 1990–2010 (EPA) tonnes CO_2 equivalent
SO_2	Sulphur dioxide emissions 1990–2010 (EPA) thousand tonnes
NOx	Oxides of nitrogen 1990–2010 (EPA) thousand tonnes
CO	Carbon monoxide 1990–2010 (EPA) thousand tonnes
NMVOC	Non-methane volatile organic compounds 1990–2010 (EPA) thousand tonnes
NH_3	Ammonia 1990–2010 (EPA) thousand tonnes
Dioxins	Dioxin emissions PCDD/PCDF 1990–2010 (CLRTAP) g ITEC
PCB	Polychlorinated biphenyl emissions 1990–2010 (CLRTAP) kg
HCB	Hexachlorobenzene emissions to air 1990–2010 (CLRTAP) kg
Benzo(a)pyrene	Emissions 1990–2010 (CLRTAP) Mg
Benzo(b)fluoranthene	Emissions 1990–2010 (CLRTAP) Mg
Benzo(k)fluoranthene	Emissions 1990–2010 (CLRTAP) Mg
Indeno(1,2,3)pyrene	Emissions 1990–2010 (CLRTAP) Mg
Mercury	Emissions 1990–2010 (CLRTAP) Mg
Cadmium	Emissions 1990–2010 (CLRTAP) Mg
Lead	Emissions 1990–2010 (CLRTAP) Mg
Chromium	Emissions 1990–2010 (CLRTAP) Mg
Arsenic	Emissions 1990–2010 (CLRTAP) Mg
Zinc	Emissions 1990–2010 (CLRTAP) Mg
Copper	Emissions 1990–2010 (CLRTAP) Mg
Nickel	Emissions 1990–2010 (CLRTAP) Mg
Selenium	Emissions 1990–2010 (CLRTAP) Mg
Primary Peat	Use – difference from transformation of input to output 1990–2010 (SEAI) thousands of tonnes of oil equivalent
Peat	Use - final energy 1990–2010 (SEAI) thousands of tonnes of oil equivalent

Variable	Description (years available, source, measurement unit)
Gas	Use 1990–2010 (SEAI) thousands of tonnes of oil equivalent
Coal	
Crude Oil	
Gasoline	
Kerosene	
Diesel	
Fuel Oil	
LPG	
Other Oil	
Hydro	Use 1990–2010 (SEAI) thousands of tonnes of oil equivalent
Wind	
Biomass	
Landfill Gas	
Biogas	
Other Renewables	
Electricity	
PM2.5	Particulate matter less than 2.5µm in diameter 1990–2010 (CRLTAP) Gg
PM10	Particulate matter less than 10µm in diameter 1990–2010 (CRLTAP) Gg
TSP	Total Suspended Particulate emissions 1990–2010 (CRLTAP) Gg
HazWasteLandfill	Hazardous waste into landfill 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
HazWasteIncinerate	Hazardous waste into incineration 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
HazWasteUseAsFuel	Hazardous waste used as a fuel 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
HazWasteRecycle	Hazardous waste into recycling 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
HazWasteUnattrib	Hazardous waste unattributed 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
Non-BioLandFill	Non-hazardous, Non-BMW landfilled waste 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
Non-BioIncinerate	Non-hazardous waste, Non-BMW incinerated 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
Non-BioUseAsFuel	Non-hazardous waste, Non-BMW used as fuel 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
Non-BioRecycle	Non-hazardous waste, Non-BMW recycled 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
Non-BioUnattrib	Non-hazardous waste, Non-BMW not attributed 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BioWasteLandfill	Biowaste landfilled 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BioWasteIncinerate	Biowaste incinerated 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BioWasteUseAsFuel	Biowaste used as fuel 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BioWasteRecycle	Biowaste recycled 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BioWasteUnattrib	Biowaste unattributed 2001, 2004, 2006, 2008 (EPA National Waste Reports) tonnes
BMWnonBioLandfill	BMW non-biowaste landfilled 1998, 2001–2010 (EPA National Waste Reports) tonnes
BMWnonBioIncinerate	BMW non-biowaste incinerated 1990–2010 (EPA National Waste Reports) tonnes
BMWnonBioRecycle	BMW non-biowaste recycled 1998, 2001–2010 (EPA National Waste Reports) tonnes
BMWnonBioUnattrib	BMW non-biowaste unattributed 2002–2010 (EPA National Waste Reports) tonnes
Soil&StonesLandfill	Soil & stones landfilled 1990–2010 (EPA National Waste Reports) tonnes
Soil&StonesRecycle	Soil & stones recycled 1990–2010 (EPA National Waste Reports) tonnes
Soil&StonesUnattrib	Soil & stones unattributed 1990–2010 (EPA National Waste Reports) tonnes

An Ghníomhaireacht um Chaomhnú Comhshaoil

Is í an Gníomhaireacht um Chaomhnú Comhshaoil (EPA) comhlachta reachtúil a chosnaíonn an comhshaol do mhuintir na tíre go léir. Rialaímid agus déanaimid maoirsiú ar ghníomhaíochtaí a d'fhéadfadh truailliú a chruthú murach sin. Cinntímid go bhfuil eolas cruinn ann ar threochtaí comhshaoil ionas go nglactar aon chéim is gá. Is iad na príomh-nithe a bhfuilimid gníomhach leo ná comhshaol na hÉireann a chosaint agus cinntiú go bhfuil forbairt inbhuanaithe.

Is comhlacht poiblí neamhspleách í an Ghníomhaireacht um Chaomhnú Comhshaoil (EPA) a bunaíodh i mí Iúil 1993 faoin Acht fán nGníomhaireacht um Chaomhnú Comhshaoil 1992. Ó thaobh an Rialtais, is í an Roinn Comhshaoil, Pobal agus Rialtais Áitiúil.

ÁR bhFREAGRACHTAÍ

CEADÚNÚ

Bíonn ceadúnais á n-eisiúint againn i gcomhair na nithe seo a leanas chun a chinntiú nach mbíonn astuithe uathu ag cur sláinte an phobail ná an comhshaol i mbaol:

- áiseanna dramhaíola (m.sh., líonadh talún, loisceoirí, stáisiúin aistrithe dramhaíola);
- gníomhaíochtaí tionsclaíocha ar scála mór (m.sh., déantúsaíocht cógaisíochta, déantúsaíocht stroighne, stáisiúin chumhachta);
- diantalmhaíocht;
- úsáid faoi shrian agus scaoileadh smachtaithe Orgánach Géinathraithe (GMO);
- mór-áiseanna stórais peitreail;
- scardadh dramhuisce.

FEIDHMIÚ COMHSHAOIL NÁISIÚNTA

- Stiúradh os cionn 2,000 iniúchadh agus cigireacht de áiseanna a fuair ceadúnas ón nGníomhaireacht gach bliain.
- Maoirsiú freagrachtaí cosanta comhshaoil údarás áitiúla thar sé earnáil - aer, fuaim, dramhaíl, dramhuisce agus caighdeán uisce.
- Obair le húdaráis áitiúla agus leis na Gardaí chun stop a chur le gníomhaíocht mhídhleathach dramhaíola trí comhordú a dhéanamh ar líonra forfheidhmithe náisiúnta, díriú isteach ar chiontóirí, stiúradh fiosrúcháin agus maoirsiú leigheas na bhfadhbanna.
- An dlí a chur orthu siúd a bhriseann dlí comhshaoil agus a dhéanann dochar don chomhshaol mar thoradh ar a ngníomhaíochtaí.

MONATÓIREACHT, ANAILÍS AGUS TUAIRISCIÚ AR AN GCOMHSHAOL

- Monatóireacht ar chaighdeán aeir agus caighdeáin aibhneacha, locha, uiscí taoide agus uiscí talaimh; leibhéil agus sruth aibhneacha a thomhas.
- Tuairisciú neamhspleách chun cabhrú le rialtais náisiúnta agus áitiúla cinntí a dhéanamh.

RIALÚ ASTUITHE GÁIS CEAPTHA TEASA NA HÉIREANN

- Cainníochtú astuithe gáis ceaptha teasa na hÉireann i gcomhthéacs ár dtiomantas Kyoto.
- Cur i bhfeidhm na Treorach um Thrádáil Astuithe, a bhfuil baint aige le hos cionn 100 cuideachta atá ina mór-ghineadóirí dé-ocsaíd charbóin in Éirinn.

TAIGHDE AGUS FORBAIRT COMHSHAOIL

- Taighde ar shaincheisteanna comhshaoil a chomhordú (cosúil le caighdéan aeir agus uisce, athrú aeráide, bithéagsúlacht, teicneolaíochtaí comhshaoil).

MEASÚNÚ STRAITÉISEACH COMHSHAOIL

- Ag déanamh measúnú ar thionchar phleananna agus chláracha ar chomhshaol na hÉireann (cosúil le pleananna bainistíochta dramhaíola agus forbartha).

PLEANÁIL, OIDEACHAS AGUS TREOIR CHOMHSHAOIL

- Treoir a thabhairt don phobal agus do thionscal ar cheisteanna comhshaoil éagsúla (m.sh., iarratais ar cheadúnais, seachaint dramhaíola agus rialacháin chomhshaoil).
- Eolas níos fearr ar an gcomhshaol a scaipeadh (trí cláracha teilifíse comhshaoil agus pacáistí acmhainne do bhunscoileanna agus do mheánscoileanna).

BAINISTÍOCHT DRAMHAÍOLA FHORGHNÍOMHACH

- Cur chun cinn seachaint agus laghdú dramhaíola trí chomhordú An Chláir Náisiúnta um Chosc Dramhaíola, lena n-áirítear cur i bhfeidhm na dTionscnamh Freagrachta Táirgeoirí.
- Cur i bhfeidhm Rialachán ar nós na treoracha maidir le Trealamh Leictreach agus Leictreonach Caite agus le Srianadh Substaintí Guaiseacha agus substaintí a dhéanann ídiú ar an gcrios ózóin.
- Plean Náisiúnta Bainistíochta um Dramhaíl Ghuaiseach a fhorbairt chun dramhaíl ghuaiseach a sheachaint agus a bhainistiú.

STRUCHTÚR NA GNÍOMHAIREACHTA

Bunaíodh an Ghníomhaireacht i 1993 chun comhshaol na hÉireann a chosaint. Tá an eagraíocht á bhainistiú ag Bord lánaimseartha, ar a bhfuil Príomhstiúrthóir agus ceithre Stiúrthóir.

Tá obair na Gníomhaireachta ar siúl trí ceithre Oifig:

- An Oifig Aeráide, Ceadúnaithe agus Úsáide Acmhainní
- An Oifig um Fhorfheidhmiúchán Comhshaoil
- An Oifig um Measúnacht Comhshaoil
- An Oifig Cumarsáide agus Seirbhísí Corparáide

Tá Coiste Comhairleach ag an nGníomhaireacht le cabhrú léi. Tá dáréag ball air agus tagann siad le chéile cúpla uair in aghaidh na bliana le plé a dhéanamh ar cheisteanna ar ábhar imní iad agus le comhairle a thabhairt don Bhord.

Science, Technology, Research and Innovation for the Environment (STRIVE) 2007-2013

The Science, Technology, Research and Innovation for the Environment (STRIVE) programme covers the period 2007 to 2013.

The programme comprises three key measures: Sustainable Development, Cleaner Production and Environmental Technologies, and A Healthy Environment; together with two supporting measures: EPA Environmental Research Centre (ERC) and Capacity & Capability Building. The seven principal thematic areas for the programme are Climate Change; Waste, Resource Management and Chemicals; Water Quality and the Aquatic Environment; Air Quality, Atmospheric Deposition and Noise; Impacts on Biodiversity; Soils and Land-use; and Socio-economic Considerations. In addition, other emerging issues will be addressed as the need arises.

The funding for the programme (approximately €100 million) comes from the Environmental Research Sub-Programme of the National Development Plan (NDP), the Inter-Departmental Committee for the Strategy for Science, Technology and Innovation (IDC-SSTI); and EPA core funding and co-funding by economic sectors.

The EPA has a statutory role to co-ordinate environmental research in Ireland and is organising and administering the STRIVE programme on behalf of the Department of the Environment, Heritage and Local Government.

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An Ghníomhaireacht um Chaomhnú Comhshaoil

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