Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

codema
Sustainable Dublin

Baseline Emission Inventory for

Dublin City Sustainable Energy Action Plan 2010-2020

Version 1.0

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Dublin City Sustainable Energy Action Plan 2010-2020

Report prepared in association with Dublin City Council by

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September 2008

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Contents

Introduction

Dublin City Council (DCC) in association with Codema is committed to delivering an *Action Plan on Energy for Dublin.*

There are several reasons for this energy action plan:

The first reason is to save energy because of its cost, driven primarily by the price of a barrel of crude oil, which rose from $30/bbl in 2004 to over $100/bbl in 2008 and which it is predicted will continue to rise. Fuel costs affect every business in the city (including DCC itself with an annual energy bill of circa €20m in 2007); they also affect every commuter and every household. The most vulnerable citizens are being hardest hit, for example those who experience difficulty in heating their homes adequately.

The second reason concerns human wellbeing which, in addition to being a significant end in itself, is an important driver of competitiveness as Dublin endeavours to attract and develop world class companies here. Those who have to commute long distances to work, for example, or take long detours to drop off their children at schools or crèches, come under additional stresses from rising transport fuel costs, and their wellbeing suffers.

The third reason for preparing an action plan on energy is to reduce Dublin's carbon footprint in the context of the global problem of climate change. Cities have a central role to play in tackling climate change, particularly as cities bear a disproportional responsibility for causing it. In fact, cities consume 75 per cent of the world's energy and produce 80 per cent of its greenhouse gas emissions [1].

There are thus three drivers of this energy action plan encompassing the economic, social and environmental dimensions. These three dimensions are inseparable and interlinked and they combine both local and global issues. They are further discussed in the next chapter under the overarching framework of sustainable development.

In 2006 Dublin City consumed 22 terawatt-hours of primary energy in the form of oil, gas, electricity and renewable energy and, in the process, emitted 5 million tonnes of carbon dioxide (CO_2). The consumption can be divided between four major sectors: residential 35%, services 22%, manufacturing 20% and transport 23%.

The type of actions that are considered in this plan in order to reduce the energy consumption and associated CO_2 emissions fall under two general headings: (a) energy efficiency and (b) alternative energy sources.

Energy efficiency is about getting more from less and the best opportunities for improving energy efficiency can be found in the housing and transport sectors. For example, insulation of homes and new technology heating systems can significantly reduce energy consumption in the residential sector. Efficient forms of transport, such as the LUAS, DART; bus and rail, consume far less energy per passenger journey than commuting by single occupancy car. In both of these areas peoples' behaviour and attitude to energy usage has the biggest impact on their energy consumption and carbon footprint.

The second type of action that can reduce Dublin's carbon footprint is to replace conventional fossil fuels, such as oil and gas, with innovative renewable energy sources, such as solar panels and wind or ocean energy.

Dublin City Council has already taken a pro-active approach to sustainable energy since the start (in 2006) of the process for developing this energy action plan:

- Since November 2007, by means of a variation to the current City Development Plan, the City Council has been promoting higher standards of energy efficiency and increased use of renewable energy in new building developments by insisting on a high energy rating which will be increased further to an A3 minimum BER rating in January 2009

- In May 2008 the Council adopted a Climate Change Strategy focussed on reducing the 5 million tonnes of CO_2 emitted each year in Dublin. The strategy addresses five areas, namely energy, planning, transport, waste management and biodiversity

- The City Council is also leading by good example in its own offices and services and in a number of best practice demonstration projects, including:
    - New low-energy apartments in York Street
    - The Dublin District Heating project
    - Renewable hydro-electricity at Vartry works
    - Wind turbines at Father Collins Park
    - Workplace travel plan for Council's own staff

Looking to the future, Dublin is already leading an Intelligent Energy European project, called 'MINUS 3%' [2], which aims to reduce energy consumption in city administrations by 3% per year, culminating in an annual energy saving of 33% by 2020.

In addition to these local priorities, this *Action Plan on Energy for Dublin* is in accordance with the Irish national targets for reducing energy consumption and associated CO_2 emissions, as set out in the Government's Energy White Paper – *'Delivering a Sustainable Energy Future for Ireland'* [3] and in the current *Programme for Government* [4].

The action plan supports and reinforces the *1st National Energy Efficiency Action Plan for Ireland 2007-2020* that, first, sets out the path to achieving a 20% (33% for the public sector) reduction in energy demand by 2020 and, second, serves as Ireland's response to the requirements of Article 14(2) of the EU *Energy End-Use Efficiency and Energy Services Directive* (2006/32/EC).

The methodology employed, as detailed in the following chapters, examines the current energy consumption in the four main sectors: residential, services, manufacturing and transport. Models are created for each sector in order to evaluate a range of potential actions in terms of capital cost, energy savings and reduction of CO_2 emissions. A menu of options is presented that permits the balancing of business and environmental objectives within an overall human wellbeing approach.

This Consultation Draft presents the issues, costs and benefits of Dublin's options for improving sustainable energy use. It follows on from the pre-draft consultations that have been carried out since the start of the process in mid-2006.

The first step in developing this report was the *Dublin Seminar on Sustainable Energy Action Plans* at the Civic Offices in October 2006. This brought together experts, stakeholders and decision makers from Dublin, along with the partners in the EU 'SECURE' project [5] from Denmark, Sweden and Estonia.

Next, pre-draft consultations with key stakeholders and the general public were facilitated over the following months. About 50 organizations were consulted, including DCC and Government departments and agencies, engineering consultants, third level institutions, Dublin's Residents Associations and Comhairle na n'Óg.

The present Consultation Draft provides a comprehensive starting point for the debate among policymakers, stakeholders and citizens on Dublin's future energy strategy. It is the businesses, communities and individual citizens who consume energy at home, at work and travelling in between that are critical for the ultimate success of this energy action plan.

Figure 1.1: Computer Image of Father Collins Park in North Dublin which has a Focus on Sustainability and Includes Five Wind Turbines to Power the Sports Facilities

Background

Framework

The sustainable development concept, defined by Brundtland in 1987 as: '*development which meets the needs of the present without compromising the ability of future generations to meet their own needs*' [1], provides the overarching framework for this energy action plan.

Sustainability "captures the important ideas that development has economic, social and environmental dimensions which together can contribute to a higher quality of life" [2]. These three aspects of sustainable development are inseparable and interlinked and they combine both global and local issues.

Economic Dimension

Dublin competes primarily against other city-regions in a globalised economy for trade, investment and people. As the capital city, Dublin captures a large proportion of Ireland's population and economic activity. It follows that the success of Dublin remains critical to the performance of the Irish economy.

Dublin's position in Europe is highly rated regarding the indices of growth, wealth and an attractive business environment, particularly to foreign investors, as assessed by the European Regional Economic Growth Index (EREGI). Dublin, rating 4th in 2007, remains one of Europe's economically most attractive cities [3].

Ranking criteria	%	Rank	2006	2007
		1	London	London
Absolute Growth	15	2	Paris	Munich
Percent Growth	30	3	**Dublin**	Paris
R & D	15	4	Madrid	**Dublin**
		5	Stockholm	Stockholm
		6	Barcelona	Luxemb'g
Wealth (GDP)	20	7	Munich	Helsinki
		8	Helsinki	Stuttgart
Business Environm.	15	9	Zurich	Oslo
EU Participation	5	10	Luxemb'g	Madrid

Table 2.1: Ranking of Top 10 European Cities in EREGI for Years 2006 and 2007, together with Criteria (left column)

On a broader worldwide basis there are several rankings. One of the best known is the Global Competitiveness Index (GCI), produced by the World Economic Forum. For the most recent year reported (2006 – 2007), Ireland performs well: ranking 22nd out of a list of 131 countries worldwide. The GCI provides an overview of factors that are critical to driving productivity and competitiveness [4].

The Irish economy is highly dependent upon imported energy, especially oil. This brings a risk, because oil prices are rising – irreversibly. Those economies that invest in energy efficiency measures and practices today will gain a competitive advantage in the future. Already, the more energy-intensive sectors are exposed to the impact of high oil prices, which rose from $30/bbl in 2004 to over $100/bbl in 2008 and which will continue to rise.

Today's energy costs are determined to a large extent by the international price of a barrel of crude oil. The price of crude oil on the world's commodity markets is volatile and subject to political and climatic events.

The underlying factors are three-fold:

(i) World supply, which is reaching a plateau in the case of liquid fuel production (see box on Peak Oil)

(ii) Demand for energy, which is ever increasing in the developed countries and is rising very rapidly in India and China

(iii) The long-term price elasticity of demand for oil in relation to the real price of oil. One analysis concludes that a 25% rise in prices reduces demand by 1%, and such a figure is very low [5]

Clearly there are risks associated with Ireland's very high dependency on imported fuels, especially oil. In addressing the security of supply risk this action plan focuses first on improving energy efficiency, i.e. getting more from less, and second, on creating new and innovative sources of renewable energy that are appropriate to the urban context.

Peak Oil

"The peak of oil discovery was passed in the 1960s, and the world started using more than was found in new fields in 1981. The gap between discovery and production has widened since. Many countries, including some important producers, have already passed their peak, suggesting that the world peak of production is now imminent. The transition to decline threatens to be a time of great international tension. Petroleum Man will be virtually extinct this Century and Homo Sapiens faces a major challenge in adapting to his loss. Peak Oil is by all means an important subject"

Colin Campbell ASPO's founder of ASPO (Association for the study of Peak Oil and Gas) [6]

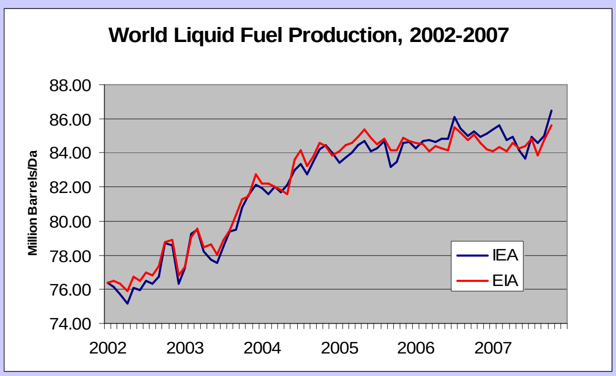


Figure 2.1: World Liquid Fuel Production Plateau [7]

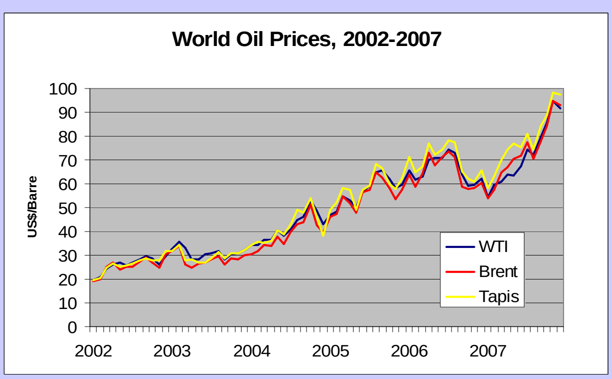


Figure 2.2: World Oil Price Increases [7]

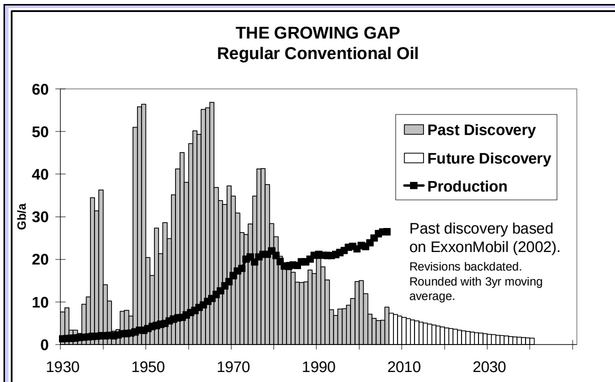


Figure 2.3: The Growing Gap between Oil Production and Discovery [7]

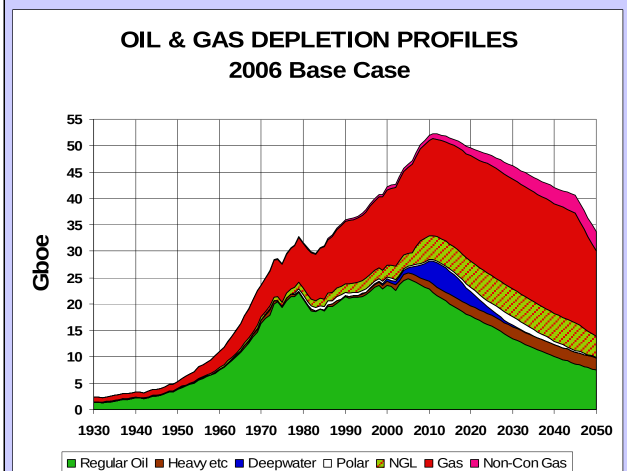


Figure 2.4: World Oil & Gas Depletion Profiles: ASPO 2006 Base Case [7]

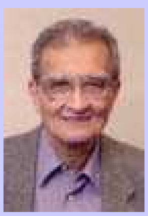
Peak Oil is the term given to the point in time when the maximum rate of global petroleum extraction is reached, after which the rate of production declines. There is some discussion among the experts as to the year in which Peak Oil will occur but all are agreed that it is inevitable.

Ultimately, Peak Oil will impact on the price of oil, through the forces of supply and demand. The IXIS Corporate and Investment Bank has extrapolated global oil consumption to 108 million barrels/day by the year 2015 compared with a predicted production capacity of just 100 million barrels/day, leaving a shortfall of 8 million barrels/day. Given the low elasticity of demand for oil, IXIX CIB predicts an oil price forecast of $380/barrel for 2015 [5].

Social Dimension

Human Development

The Human Development approach, adopted by the UN, is about people. Its point of departure is essentially about expanding people's real choices and substantive freedoms and cultivating the capabilities that enable them to lead the lives that they value [8].

> *"Human development, as an approach, is concerned with what I take to be the basic development idea: namely, advancing the richness of human life, rather than the richness of the economy in which human beings live, which is only a part of it."* [9]
>
> 
>
> **Prof. Amartya Sen,**
> **Professor of Economics, Harvard**
> **Nobel Laureate in Economics, 1998**

In the Human Development Report 2007 –2008 *Fighting Climate Change: Human Solidarity in a Divided World*, Sen examines the apparent conflict between economic development and environmental sustainability. He concludes that economic growth and environmental protection are mutually compatible objectives. This approach is significant; it implies that the two ambitions of poverty reduction through economic growth, on the one hand, and ecology and environmental preservation, on the other hand, are not on a collision course, as is commonly thought. When we consider the crucial ingredients of our quality of life – our health as well as our wealth - it is clear that development has to be environment-inclusive [10].

The next steps are for a greater public participation in the climate change debate, and for better communication and public dialogue that can make us more aware of the need for environment-oriented thinking. The need for such public deliberation is considered by Sen to be as important in dealing with climate change and environmental dangers as it is in tackling more traditional problems of deprivation and continuing poverty [10].

Wellbeing

The Irish *Discussion Paper on Wellbeing and Competitiveness*, published by the National Competitiveness Council [11] refers to the United Nations Human Development Index (HDI) as an objective measure of wellbeing. The HDI provides a composite measure of three key dimensions of human development: life expectancy, educational attainment and adjusted real income [9].

> *"An environment that supports high levels of wellbeing is also becoming an important driver of competitiveness as Ireland endeavours to attract and develop world-class companies here"*
>
> **Don Thornhill, Chairperson, National Competitiveness Council [11]**

Ireland ranks high in the world for human development: 5th out of the 177 countries listed in the UN's Human Development Index. The poorest countries of the world and the most vulnerable are mostly in the African continent. These will suffer first and most, although they have contributed least to the problem, but no country however wealthy or powerful will be immune to the impacts of global warming.

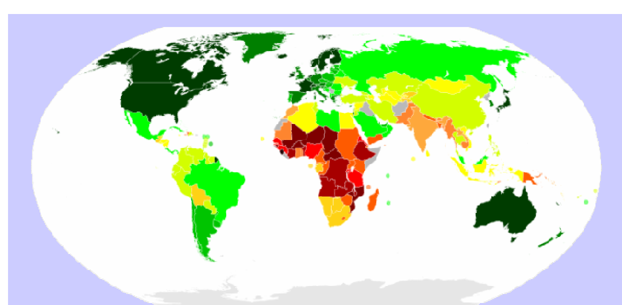


Figure 2.5: Global Human Development Index map (green=high; yellow=medium; red=low) [8]

The Irish economy is now shifting from manufacturing to services [12], which has implications for Dublin as an international city region. As already pointed out, there is a growing importance placed on quality-of-life issues, for several reasons, e.g. attracting inward investment and the ability for firms to retain key staff. This underlines the need for continuing investment in Dublin and the critical role of land use, planning and transport which, in turn, relates to energy consumption and CO_2 emissions.

Environmental Dimension

Stabilization of CO_2 Emissions

The rich countries of the world will need to commit to around 80% cuts in carbon emissions by 2050 to avoid the 5-degree rise in temperatures that scientists have forecast for the end of the century if we continue to produce at the present rates of growth. The basis for this conclusion is summarized in the table below.

Basis of Stabilization

- CO_2 levels in the atmosphere have risen from 280ppm in 1850, before the Industrial Revolution, to 430ppm today – and are increasing at a rate of 2.5ppm/year, leading to 750 to 800ppm by the end of the century under business-as-usual
- The probability, based on risk analysis, is that this business-as-usual scenario has a 50:50 chance of a 5 degree C rise in global temperature by the end of this century
- Stabilization at 500ppm, which is the target that is considered necessary to avoid serious negative impacts, requires a cut by about 50% in all greenhouse gases (GHGs) by 2050
- This would imply – as a matter of simple arithmetic – a commitment to per capita emissions by 2050 of around 2 tonnes CO_2 equivalent as a world average, with little scope for significant deviation
- For developed countries, with the highest emissions, the target represents an 80% cut in emissions
- Stern estimates a one-off step rise in cost of 1 to 2% GDP for stabilization

Lord Nicholas Stern, Economist, speaking at the SAS Premier Business Leadership Series, London 30th April 2008 [13]

This assessment is based upon the report of the Intergovernmental Panel on Climate Change (IPCC), which has found unequivocal evidence of dangerous trends of global warming due to the increase of greenhouse gases (GHG) in the Earth's atmosphere that is attributed to human activities [14].

Global Impacts of Climate Change

CO_2 is the greenhouse gas that has the strongest effect on climate change and this CO_2 comes mainly from the combustion of fossil fuels for energy use. Due to the release of these gases the climate has already started to change and will continue to do so, yielding increased global average temperatures, higher sea levels and changes in weather patterns leading to more extreme events with risk of extended periods of extensive flooding.

Temperature

The greenhouse gases in the atmosphere, as the name implies, trap the sun's warmth and cause the temperatures of both the land and the sea to increase. Over the past 100 years the Earth has warmed by 0.7°C and there is strong evidence that the process is accelerating.

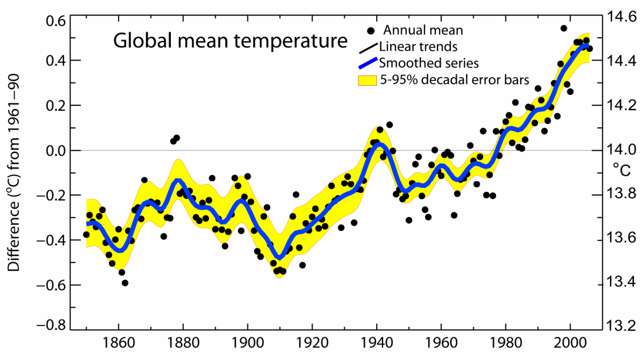


Figure 2.6: Trends in Mean Global Temperature 1850 to 2005 [14]

There are five key areas where climate change is likely to cause negative impacts [8]:

- Agricultural production and food security
- Water stress and water insecurity
- Rising sea levels and exposure to climate disasters
- Ecosystems and biodiversity
- Human health

Sea Levels

An increase in sea-water temperature directly causes physical expansion of the body of water with associated rise in sea levels. Many of the world's major cities are threatened with flooding and hundreds of millions of people could be displaced.

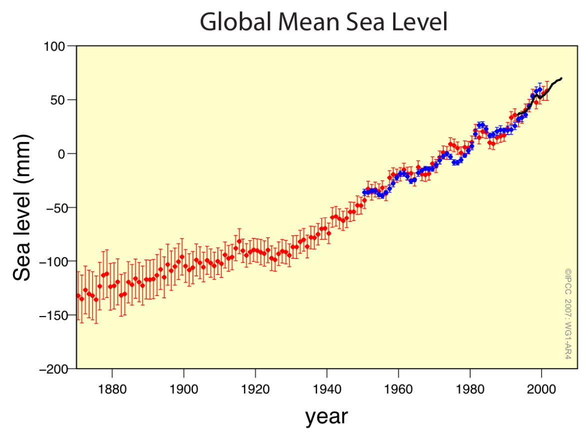


Figure 2.7: Trends in Global Mean Sea Level 1850 to 2005 [14]

Global Temperature Projections to 2100

The Intergovernmental Panel on Climate Change (IPCC) has developed a number of scenarios that describe temperature projections to 2100, which could arise from plausible future patterns of population growth, economic growth, technological change and associated CO_2 emissions.

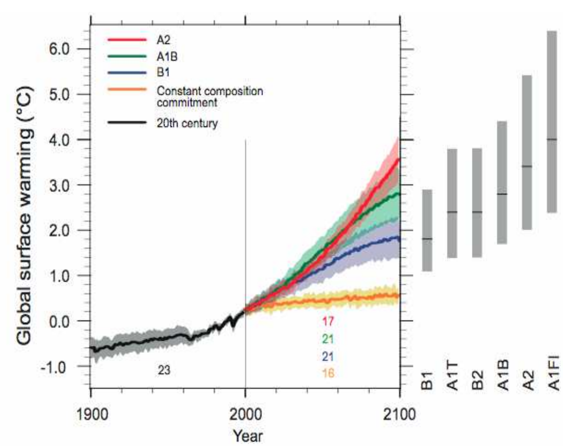


Figure 2.8: Projections in Global Warming to 2100 [14]

IPCC Scenarios:

- A1 scenarios assume rapid economic and population growth combined with reliance on fossil fuels (A1F1), non-fossil energy (A1T) or a combination (A1B).
- A2 scenario assumes lower economic growth, less globalisation and continued high population growth.
- B1 and B2 scenarios contain some mitigation of emissions, through increased resource efficiency and technology improvement (B1) and through more localised solutions (B2).

Figure 2.9: Rajendra Pachauri, Chairman of the IPCC and 2007 joint Nobel Peace Prize winner, Presenting the IPCC Scenarios at the Institute of International and European Affairs on Carbon Day (1st June 2007) [14]

On an international scale, Ireland performs poorly on a CO_2 emissions per capita basis: 17 tonnes CO_2eq compared with the EU27 average of 10.5 tonnes CO_2eq. Globally, Ireland ranks 44th out of the 56 countries listed in the Climate Change Performance Index 2008, that evaluates trends and policies in addition to emissions levels [15].

Impacts

Economic and Social Impacts

There will be significant economic and social consequences facing Ireland as the global economy adjusts to higher energy prices and the process of weaning the economy off its over dependence on fossil fuels [16].

The cost of policies and measures for meeting Ireland's legally binding commitments on climate change will be met by every business, household and individual in the country. The Exchequer will also have to allocate additional financial resources to fund carbon abatement measures. The European Commission's impact assessment estimates that the direct economic costs for Ireland will be between 0.47% and 0.63% of GDP – or about €1 billion/year by 2020. These are costs that will be reflected in electricity bills [17].

For the more vulnerable sectors of society the problems of fuel poverty (the inability to heat one's home adequately) will be exacerbated unless suitable supports and actions are put in place to reduce the impact of higher home heating costs. In 2006, 288,800 households received fuel benefit payments from the Department of Social and Family Affairs and this number is likely to increase due to the increasing fuel prices over the last two years.

This report will contribute to reducing the negative impacts of energy use and climate change while also taking full advantage of the opportunities to improve Dublin's competitiveness through innovation, improved efficiencies and more sustainable energy use. There will also be substantial benefits in terms of security of energy supply and sustainability.

Environmental Impacts

Although the physical impacts of climate change for Ireland are less severe than in other regions of the world, the flooding that occurred in August 2008 demonstrated vividly the type of impacts that Ireland can expect.

The research carried out by Irish scientists reflects the conclusions of the IPCC: that the effect of greenhouse gas emissions caused by human activities will impact negatively on the physical environment and that the impacts will intensify in the medium to long term. Much greater adaptation measures against changing weather patterns and rising sea levels will be required during the present century.

Temperature

The climate will continue to warm, particularly in the summer and autumn seasons, with possible increases of 3 to 4°C towards the end of the century. The greatest warming will occur in the south and east of the country.

Satellite data shows that the sea has been warming at a rate of 0.3 – 0.4°C per decade over the past 25 years for most of the Irish territorial waters, with trends up to 0. 7°C per decade for the Irish Sea [18].

The increases in temperature will have some benefits for Ireland. For example there will be a longer and warmer growing season, and demand for heating energy in winter will decrease significantly: 10% by 2060 and 22% by 2100.

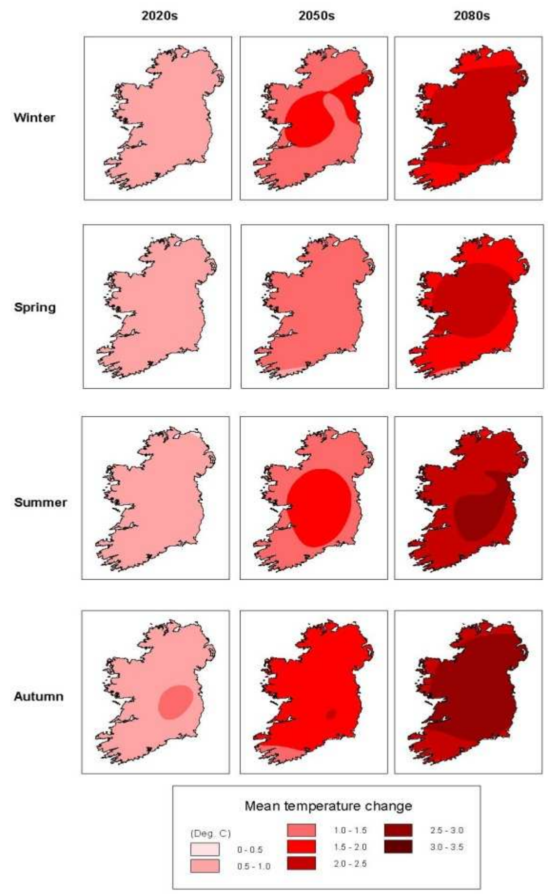


Figure 2.10: Mean Seasonal Temperature Increases Projected for 2020, 2050 and 2080 [19]

Rainfall

Wetter winters will bring a 5-10% increase in rainfall by mid-century and 15-25% increase by 2100 [18].

Summers will be correspondingly dryer, especially in the east and south, leading to water shortages in Dublin in the summer months unless demand is reduced and/or new sources of supply are found.

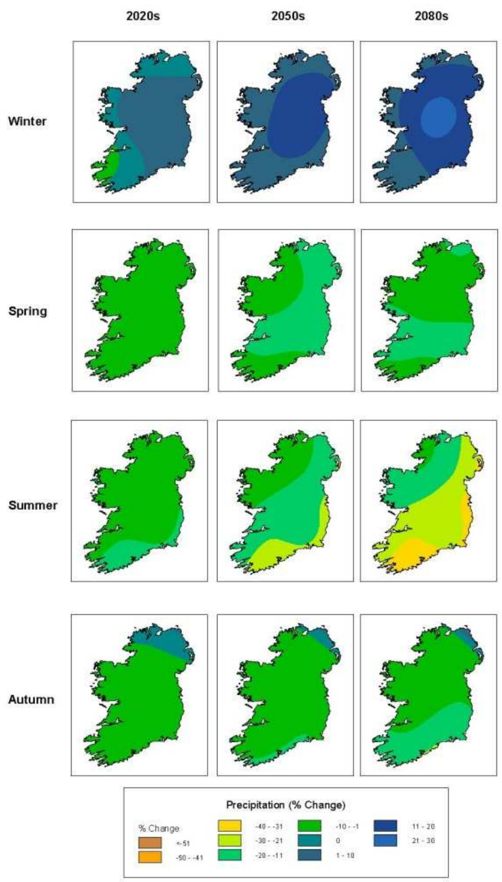


Figure 2.11: Mean Seasonal Precipitation Changes Projected for 2020, 2050 and 2080 [19]

Risk of Flooding

The mean sea level in the Irish Sea is rising at a rate of about 2.7 cm per decade [18]. This trend, if it continues, is consistent with the IPCC prediction of a rise of 0.18 – 0.59m rise by the end of the century. Recent research suggests that the rise in sea level may actually be greater than predicted as glaciers and ice caps are melting at increasing rates [20].

Ocean modelling results indicate an increase in storm surge events around the Irish coast, with extreme wave heights also likely to increase. Additional to this are the changes in precipitation leading to a rise in winter stream flows and increasing the risk of flooding [18].

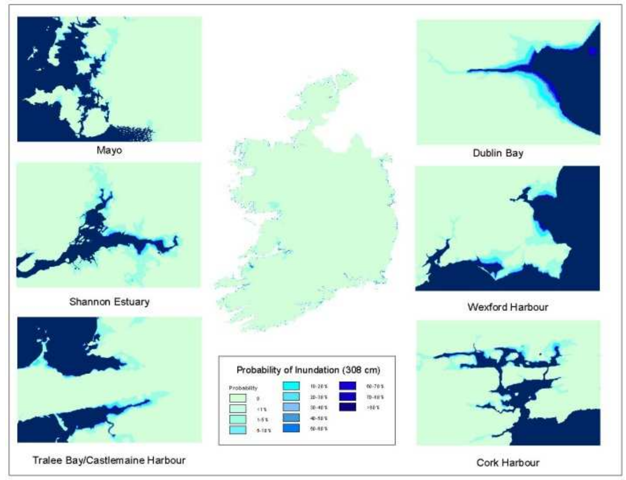


Figure 2.12: Probability of Coastal Inundation Associated with a Sea Rise of 0.48 m and a Storm Surge of 2.6 m [21]

Conclusions

As Ireland's capital city and an international city region, Dublin ranks highly when assessed by global indices for economic competitiveness and for human development. However, Ireland ranks poorly in terms of greenhouse gas (GHG) emissions.

The *Action Plan on Energy for Dublin* aims to maintain Dublin's competitive advantage and quality of life while at the same time reducing the city's carbon footprint.

The sustainable development concept, with its interlinked economic, social and environmental dimensions, provides the overarching framework for this report, which seeks to balance business and environmental objectives within a human wellbeing approach.

The concrete actions set out in this plan for Dublin are also contributing to national and European policy objectives for sustainable energy and reduction of GHG emissions and is aligned with the Irish and EU energy efficiency action plans.

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Analysis of Residential Sector

Introduction

In Dublin, the residential sector accounts for 7.8 TWh primary energy consumption per annum and 1,570 ktonnes of CO_2 making the sector the largest consumer of energy and producer of CO_2 emissions.

However, the sector offers the most significant potential for savings, which are both relatively low cost and easy to achieve.

Many of the products, technologies and expertise necessary to improve the energy efficiency of our homes are readily available on the market. This is evident in new housing, where compliance with more stringent building regulations is required. Achieving these savings will also have a positive effect on the wider economy and the environment through job creation.

Achieving improvements in the existing housing stock lies in the hands of the homeowners, the local authority, the building industry and central government. Levels of knowledge among homeowners regarding energy use are often very low and people often have limited access to capital for home improvements. Energy conservation and reduction of CO_2 from dwellings is not high on the agenda; this is evident from many recently constructed dwellings. The introduction of the EU Energy Performance of Buildings Directive will, to some extent, help to address this issue, but if savings targets are to be achieved, greater action at both a local and national level needs to be taken.

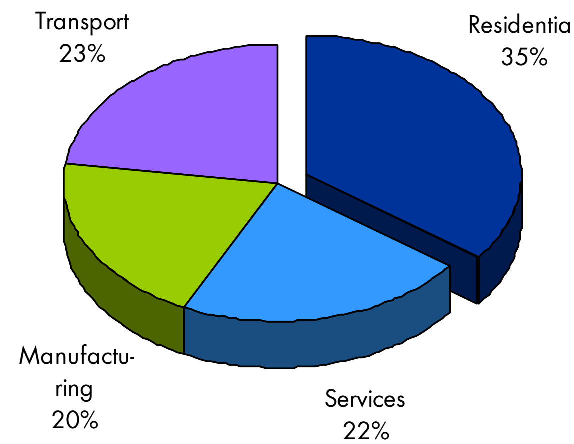

Figure 3.1: Primary Energy Consumption in the City of Dublin by Sectors in 2006

Sector	Primary Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Residential	7.8	1,570
Services	4.8	1,120
Manufacturing	4.4	990
Transport	5.0	1,240
Total	22.0	4,920

Table 3.1: Primary Energy Consumption and CO_2 Emissions in the City of Dublin in 2006

Methodology

The current housing stock situated within the Dublin City Council area was analysed in detail. Several data sources were used to gather the necessary information, including the Central Statistics Office, the Department of the Environment, Heritage & Local Government, ESRI (Economic and Social Research Institute), Codema, Sustainable Energy Ireland, data provided by informed organisations and estimates where no official data was available.

The housing stock was examined by built form (i.e. detached, semi-detached etc.), age profile, floor area and building fabric. Fuel mix was also considered although detailed information on the breakdown was not available for Dublin City. The fuel mix was estimated based on best available data.

Rates of construction of new dwellings and demolition of older dwellings were also examined. While there are some projections for rates of construction within Dublin City, estimating the rate of demolition was a more difficult task. Figures used are again based on best available data.

This information was then used to create a model of Dublin City Housing for the period 2006 to 2020. Based on the DEAP (Dwelling Energy Assessment Procedure), this model allows us to estimate the effects of our future actions, regarding the residential sector in Dublin City.

Analysis

Characteristics of Existing Housing Stock

Dublin City's housing profile differs within the residential sector when compared with the Greater Dublin Area (GDA) and the national housing profile.

Built Form

The housing stock comprises of detached, semi-detached, terraced houses and apartments. The type of unit affects the amount of energy consumed. For example, a detached dwelling has a greater wall and roof area exposed to the exterior than a terraced house, which is exposed on only two sides. Apartments have even less exposed area due to the nature of their construction.

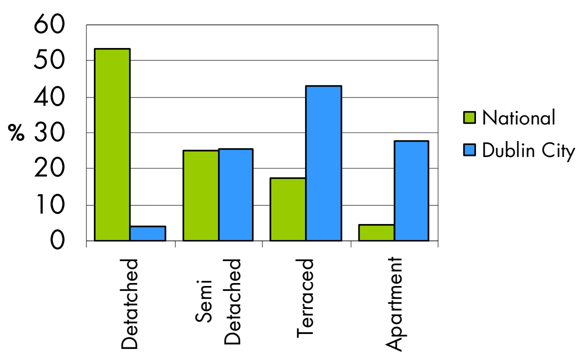

Figure 3.2: Percentage of Dwelling Types: National versus Dublin City

The proportion of apartments in the housing stock of Dublin City is significantly higher, at 27.7%, than the national profile, at 4.5%. Dublin City also has fewer detached units, at 4.1% in comparison with the national average of 53.5%. Terraced housing accounts for the greatest proportion of housing units at just over 80,000 units, 43% of the total [1].

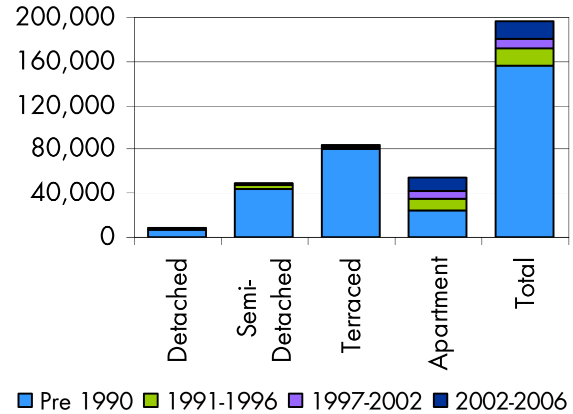

Figure 3.3: House Numbers per Unit Type

The average floor area of housing units has increased nationally by 15%. Apartment and semi detached floor areas are up 58% and 23% respectively from pre 1990 sizes while detached and terraced floor areas are down 7% and 5% respectively from pre 1990 sizes [2].

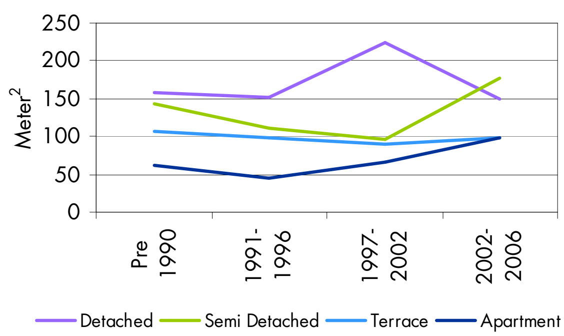

Figure 3.4: Average Floor Area Trends in Dublin City

Age Profile

At the end of 2006 there were 190,061 dwellings in Dublin City [1]. A breakdown of this shows that:

- Apartments are the fastest growing choice of new built, at 75% in the 2002 to 2006 period.
- Pre 1990 units are by far the most common with 80% of total unit numbers.

The vast majority of dwellings in Dublin City were constructed before 1960 (Figure 3.5), accounting for 63% of the total housing stock. Just over 80% of dwellings were constructed before 1991; the year building regulations were first introduced. This means that out of 190,061 dwellings in Dublin City 152,048 dwellings were constructed before the introduction of regulations concerning conservation of fuel and energy [3].

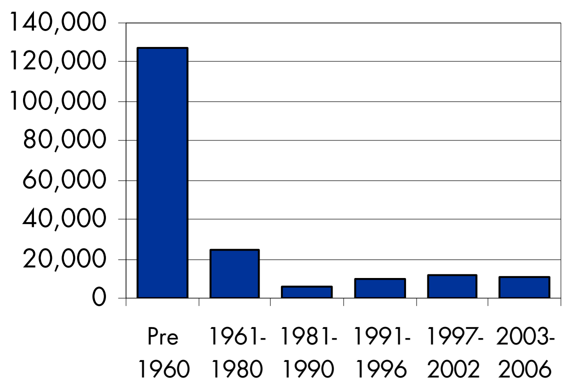

Figure 3.5: Age Profile of Existing Housing Stock

Building Fabric

The Irish National Survey of Housing Quality reports that energy efficiency is strongly affected by dwelling age [4]. The study found that 63% of dwellings built before 1940 have no wall insulation, 40% have no roof insulation and double-glazing was also less common. The report also found that 35% of homeowners who had been at their address for more than five years had undertaken some form of home improvement. The most common measures were window repairs, 22%, external doors, 19%, adding or replacing a central heating boiler, 15%. Only 3% of homeowners added wall insulation and 7% added roof insulation.

Behaviour

Emphasis on energy efficiency in the residential sector generally focuses on building fabric and use of renewable energy. However recent research has shown that user behaviour plays a significant role in determining the final energy consumption. Research conducted by Codema [5] has shown that for a group of identical apartments, with similar types of domestic appliances, annual energy use may differ by as much as a factor of 3. In a recent study titled *"An Investigation of Energy User Awareness and Behaviour in the Residential Sector"* [6] it was observed that the majority of participants were unaware of the significance and impact of different types of energy use in the home. In order to reduce energy consumption, 70% of participants considered reducing small power energy, such as switching off lights and not leaving appliances on standby, as more important than adjusting their heating controls. This indicates that there is a lack of awareness amongst householders with regard to the impact of different energy saving actions.

The study also assessed the impact of the Power of One campaign. The aim of the campaign was to generate awareness of user behaviour at the householder level and was run on a nationwide basis. It was found that an average of 57% of participants said they were familiar with the campaign, with awareness highest amongst private renters and homeowners, and lowest among local authority renters. As part of the Power of One campaign, eight families participated in the "Power of One Street". Power of one street energy experts performed an energy survey at each of the eight homes to determine what changes were most needed both on the home itself and, more importantly, regarding the behaviours of its inhabitants. The householders were challenged to make those changes and motivated to stick to a programme. An average saving of 19.3% was recorded as a result of the Power of One Street.

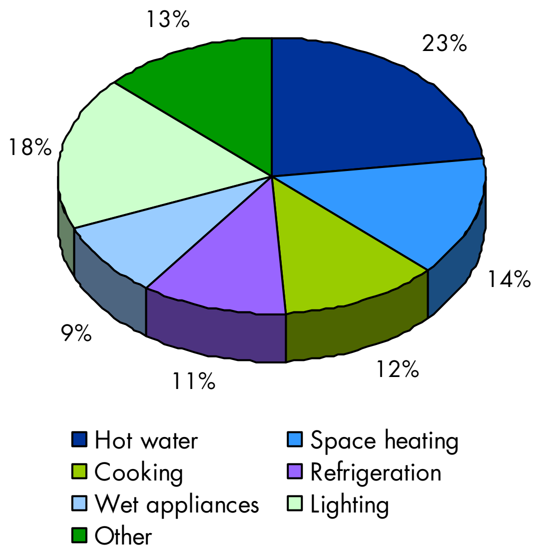

Figure 3.6: Energy Demand within a Residential Unit (National Example)

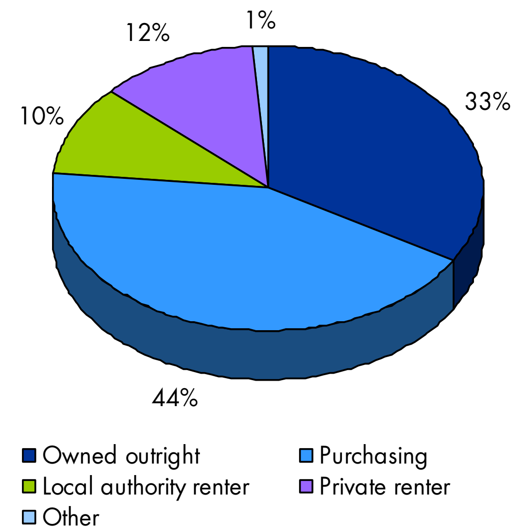

Figure 3.7: Tenure Types for Dublin City

Tenure

There is a high proportion of rented accommodation in Dublin City. Energy efficient materials and technologies are generally not a priority in rented accommodation as the landlords motives tend to be more related to capital cost and return on investment, while the running costs of energy are paid by the tenant. The Irish National Survey of Housing Quality [4] also found that energy use tended to be greater in higher-income households, younger households and newer dwellings

Fuel Mix

Dublin City has a higher prevalence of natural gas than nationally due to a high penetration of the gas network. However, the use of electricity for the provision of space heating and domestic hot water in Dublin is above the national average [4]. Solid fossil fuels account for less then 1% of primary heating systems [4] with most new apartment developments and many housing units built without any provisions for solid fuel burning appliances. Energy consumption in the residential sector can broadly be divided into two fuel categories: (1) that which is derived directly from electricity (appliances, lights, electrical storage heating etc) and (2) that which is derived by other sources (gas, oil, coal).

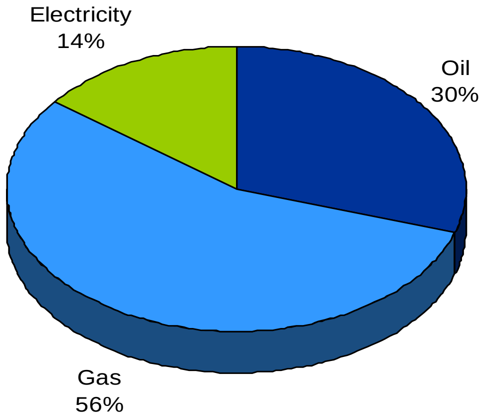

Figure 3.8: Dublin Residential Sector Fuel Mix

CO_2 Emissions

CO_2 is emitted as a by-product of combustion and causes an accumulation of green house gasses in the atmosphere. The fuel type has an effect on the amount of CO_2 released.

Fuel Type	CO_2 kg/kWh
Electricity	0.643
Natural Gas	0.203
Heating Oil	0.272
Wood Pellets	0.025

Table 3.2: CO_2 Emissions per Fuel Type

Demolition

As Dublin City no longer has any major green field sites to develop, the additional new dwellings will be accommodated through the demolition of old buildings and higher density in new construction. Both of theses measures will help to contribute to the future energy efficiency of Dublin housing. The average demolition rate between 1996 and 2005 was estimated 1,269 units per year. This estimate is based on the difference between the annual increase in dwelling numbers, and the number of new units constructed per year in Dublin City [3].

Demolition rates have a significant effect on the overall energy consumption figure. For the purpose of calculations in this report, it is assumed that all demolitions are of the pre 1960 dwellings.

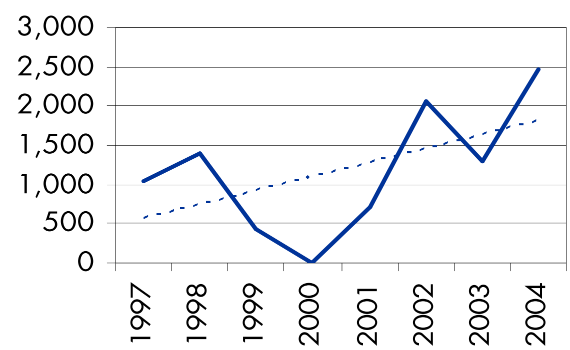

Figure 3.9: Demolitions Numbers in Dublin City

Characteristics of New Housing

The Dublin City Development Plan 2005–2011 identifies 13 key Framework Development Areas with development principles that include economic, social, cultural, environmental, urban form and spatial objectives. Five of the Framework Plan Areas are very large, each with over 500,000 m^2 of new-built residential / commercial development [7].

These five large schemes together make up about 3 million square meters of new development that offers significant potential for energy efficiency and carbon dioxide abatement over the buildings' lifespan of 60 years or more – but only if the present opportunities are taken up.

	Residential [m^2]	Commercial [m^2]
Poolbeg	370,000	130,000
Heuston	153,000	352,000
Grangegorman	120,000	274,000
Parkwest	125,000	300,000
North fringe	952,000	143,000
Total	1,720,000	1,199,000

Table 3.3: Proposed New Developments

For example, the House of Tomorrow standard for housing, of which there are about 1,200 dwellings already constructed or under construction in 20 different schemes around Dublin City and County, is at least 40% more energy efficient than current practice. These examples serve as valuable reference points for better energy efficient in Dublin's new buildings.

New building completions in Dublin City have dramatically increased over the last three years. It is very difficult to predict what will happen in the future. Current market conditions combined with a lack of greenfield sites would indicate that the trend might return to more moderate levels of construction. The ESRI recently suggested that 71,000 new homes would be constructed per annum, nationwide between 2006 and 2011, reducing to 50,000 to 60,000 per annum until 2016, with Dublin accounting for about 30% of total completions [8].

Applying these numbers to Dublin City on a pro rata basis suggests that between 2007 and 2020 81,648 new housing units will be constructed. This corresponds to approximately 6,084 units per year.

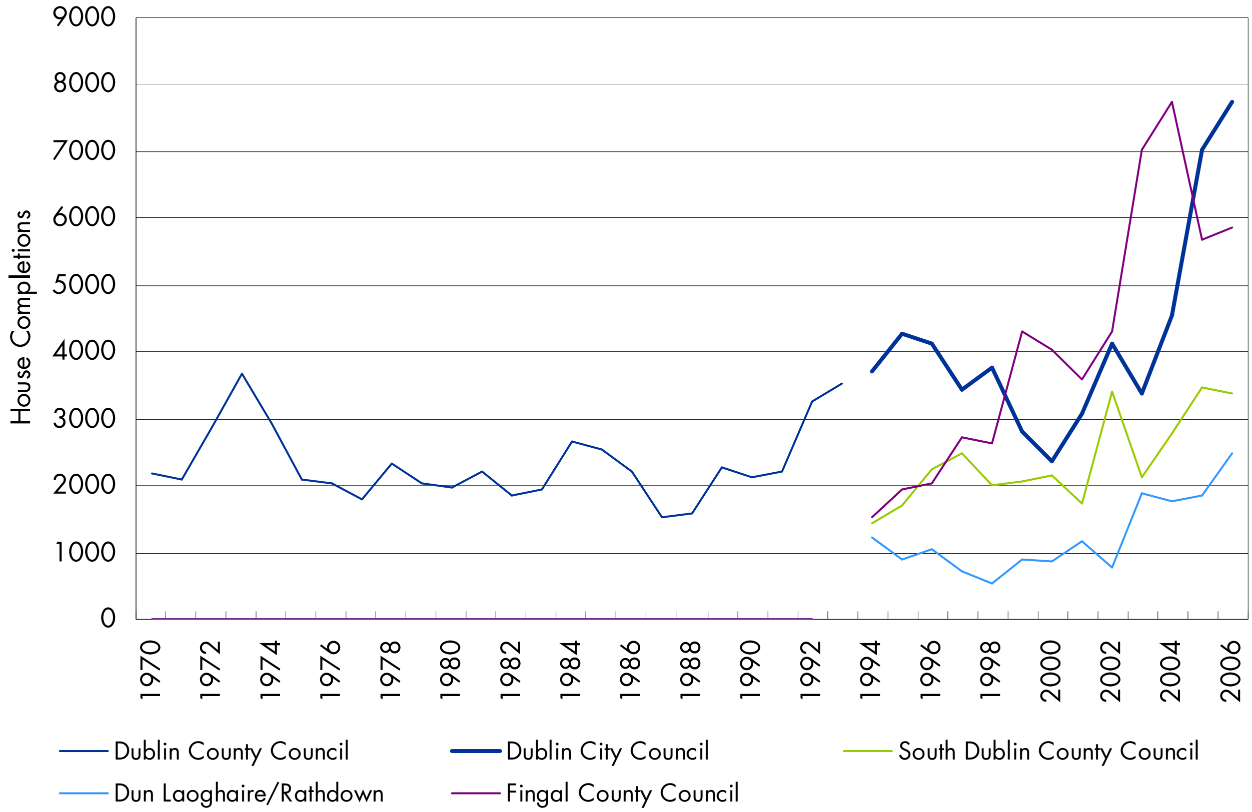

Figure 3.10: New House Completions in the Dublin Region [3]

Dublin City Council Leading by Example

York Street Apartments

The redevelopment of York Street apartments, off Stephen's Green, is a very important and high profile housing project for Dublin City Council. This scheme was designed by Sean Harrington Architects who address issues of environmental sustainability in building design. This best practice scheme was awarded funding under the House of Tomorrow programme for its low energy design, energy efficient and renewable energy features.

Low Energy Design:

The York Street Apartments are designed to address issues of environmental sustainability in building design. Low energy design helps combat fuel poverty through a well insulated building fabric and a highly efficient heating system combined with solar panels. A target of a 51% reduction in energy and carbon dioxide and a 70% reduction in running costs was set at the outset of design.

Community Heating System:

The redevelopment includes 66 new council apartments arranged in five blocks with communal spaces on the ground floor. Each block has a group heating system which provided space heating and domestic hot water. The system is powered by solar thermal panels with back-up from highly efficient condensing gas boilers at peak loads.

Energy Conservation:

The development has a highly insulated building fabric and passive solar gains are maximised through south facing glazed balconies. Building materials with a low environmental impact were used where possible.

Green Roofs:

Green roofs help to reduce the vegetated footprint that was destroyed when the original buildings were constructed. Green roofs have many advantages such as aesthetic and the mitigation of storm water runoff. Special attention was also given to the re-use of masonry and timber from the existing building.

Building Energy Rating:

The Building Energy Ratings (BER) of the York Street apartments range from A3 to B2. These are excellent ratings and can be mainly attributed to the high level of thermal insulation, the community heating, attention to detail in reducing thermal bridging and the use of increased south facing glazing and reduced north facing glazing.

Figure 3.11: York Street Apartments (Image Courtesy of Sean Harringtons Architects)

Energy Consumption Data

The energy calculations in this report are based on the Dwelling Energy Assessment Procedure (DEAP). DEAP is the national methodology for assessing the energy performance of dwellings [9]. The procedure takes account of the energy used for space heating, water heating, ventilation and lighting, less savings from energy generation technologies. For standardised occupancy, it calculates annual values of delivered energy consumption, primary energy consumption, CO_2 emissions and costs; both total consumption and consumption per square meter of floor area. The procedure also calculates the Carbon Dioxide Emission Rate (CDER) of the dwelling and the corresponding Maximum Permitted Carbon Dioxide Emission Rate (MPCDER). Both rates are used in assessing compliance of new dwellings with the Building Regulations Technical Guidance Document Part L.

It should be noted that DEAP tends to overestimate the energy consumption of older dwellings. This is a result of the assumptions which the calculation is based on. DEAP assumes that the dwelling is maintained at a constant indoor temperature for a set time period. While this will hold true for newer dwellings, which are adequately insulated, it will not generally be valid for older dwellings. Older dwellings tend to have lower average indoor temperatures than estimated by DEAP and hence consume less energy. DEAP does not account for electricity consumed by general domestic appliances; an appropriate adjustment was made to each calculation.

For the purposes of the calculations in this report, a sample dwelling was created that best represents a typical Dublin dwelling based on analysis of the current housing stock. This sample dwelling is a terraced house with a floor area of 113m^2, an exposed wall area of 100m^2 and a window area of 24m^2. A number of central heating systems are considered, natural gas boilers, electrical storage heating, wood pellet boilers and district heating.

A range of building specifications are applied to this sample dwelling. These specifications are defined to best represent the various dwelling ages in Dublin City. In total eight different specifications were created as outlined in Table 3.4, ranging from the existing pre 1960s dwellings to future dwellings constructed in the 2010 to 2020 period.

Dwelling Year of Construction		Pre 1960	1961-1980	1981-1990	1991-1996	1997-2002	2003-2006	2007-2009	2010-2020
Building Fabric (Estimated U-value)									
	Wall	1.25	1.01	0.51	0.51	0.4	0.25	0.2	0.18
	Roof	0.6	0.54	0.44	0.31	0.28	0.16	0.12	0.09
	Floor	0.7	0.7	0.6	0.6	0.4	0.2	0.18	0.18
	Window	3.5	3.5	3	3	2.5	1.8	1.8	1.4
Ventilation (ach)		1	1	1	0.8	0.8	0.6	0.5	0.5
Heating Controls		Basic	Basic	Basic	Basic	Basic	TRV	TRV	TRV
Thermal Bridging		0.15	0.15	0.15	0.15	0.11	0.11	0.11	0.08
Low Energy Lighting		33%	33%	33%	33%	33%	33%	50%	100%
Efficiency of Heating System		70%	70%	70%	75%	75%	90%	90%	90%

Table 3.4: Specification of Dublin City Housing Stock for Housing Model

codema
Sustainable Dublin

These specifications were created using data gathered by Codema and from the Irish National Survey of Housing Quality [4]. Each specification reflects the standard and quality of the housing stock depending on the year of construction. These values are estimated average values corresponding to the dwellings age. The specifications for future housing developments are based on the assumption that all dwellings constructed between 2007 and 2009 achieve a B1 building energy rating and all dwellings constructed after 2009 achieve an A3 energy rating, as required under variation number 22 of the Dublin City Development Plan 2005 to 2011 [10].

The impacts of energy efficient refurbishment measures are also considered. These measures range from simple, cost effective measures such as energy efficient lighting and attic insulation to the more expensive and more disruptive measures such as internal dry lining. These measures are applied, in that order, to the dwelling specifications in Table 3.5.

Adoption of renewable energy and district heating is also considered; this is principally for new dwellings constructed between now and 2020. It is assumed that these measures will be adopted on a phased basis, resulting in 40% of dwellings having some share of renewable energy (based on solar water heaters and wood pellet boilers) by 2020, and 30% of new dwellings connected to a district heating network (based on large new developments outlined in new housing section above).

Ground floors are also an area of significant heat loss but in general can only be insulated at the time of construction; for this reason they are not included in the model. If a ground floor were to be insulated during a refurbishment it would first need to be excavated. Future developments in insulation may address this issue but at present there is no simple solution. In the case of raised timber ground floors insulation may be possible if there is adequate access to the void beneath the floor.

Refurbishment Opportunities Considered
1. 100% low-energy lighting for all dwellings
2. A minimum roof U-value of 0.16 W/m²k (250mm fibreglass or equivalent)
3. A minimum wall U-value of 0.40 W/m²k
4. A minimum window U-value of 2.0 W/m²k
5. A minimum boiler efficiency of 90%
6. Renewable energy in the form of solar water heaters and wood pellet boilers

Table 3.5: Energy Efficient Refurbishment Measures for Existing Housing stock

Dublin City Residential Baseline - 2006

The energy intensity of an average Dublin dwelling is shown in Figure 3.12. There was a reduction in energy consumption from 1991 to 1996, corresponding to the introduction of building regulations. However, the energy increased again during the 1997 to 2002 period. The different colour bands represent the different contributions of houses and electrically heated apartments

The data highlights the increase in the number of apartment blocks being built and the prevalence for electrical storage heating within these blocks and its associated 40% energy efficiency in terms of primary energy. Apartment units with electrical storage heating achieve very poor building energy ratings. An increase in average floor size, a shift in behavioural patterns to increased energy use and higher comfort levels contribute to the overall rise in energy intensity.

In Dublin, the residential sector accounts for a total energy consumption of 7.8 TWh per annum, or 15.4 MWh per person. Sustainable Energy Ireland's 2006 Provisional Energy Balance [11] reports the national residential energy consumption at 34.4 TWh per year; this would indicate that Dublin City accounts for approximately 20% of the national energy consumption in the residential sector, while only accounting for 13% of the dwellings. However, if only dwellings constructed before 1991 are considered then Dublin City accounts for 22% of these dwellings, of which 80% were constructed before 1960. This would indicate that the energy consumed by Dublin City dwellings is greater than the national average due to the large number of pre 1960 dwellings.

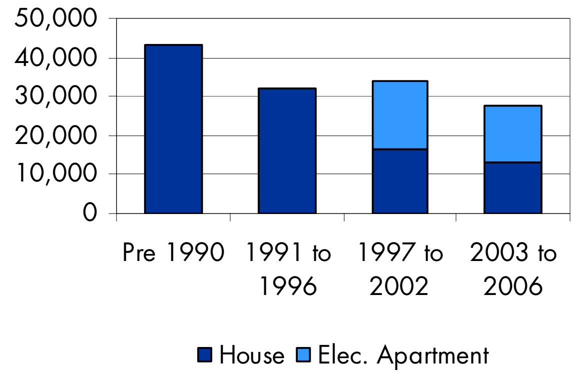

Figure 3.12: Energy Intensity of an Average Dublin City Dwelling (kWh/year)

Year of Construction	Number of Dwellings	Energy Consumption per unit (kWh/yr)	Total Energy Consumption (kWh/yr)
pre 60	127,708	43,725	5,584,032,300
61-80	24,027	41,373	994,069,071
81-90	6,259	36,966	231,370,194
91-96	9,884	32,155	317,820,020
97-02	6,820	28,479	194,226,780
electric Apartment	5,041	41,935	211,394,335
2003-06	5,936	22,372	132,800,192
electric Apartment	4,387	34,488	151,298,856
Total	190,062		7,817,011,748

Table 3.6: Energy Consumption of the Residential Sector in the City of Dublin

CO_2 Emissions Data

The CO_2 emissions of the residential sector in Dublin are calculated as shown in Table 3.7. Again it should be noted that DEAP tends to overestimate the CO_2 emissions of older dwellings. The carbon intensity of the current housing stock is shown in Figure 3.13; the different colour bands represent the different contributions of houses and electrically heated apartments.

The residential sector accounts for total CO_2 emissions of 1,570 ktonnes per year, or 3.1 tonnes per person per year.

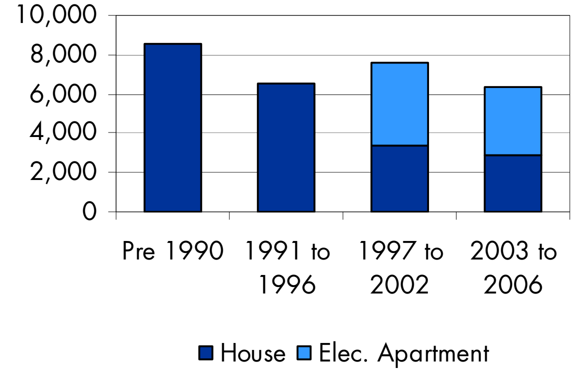

Figure 3.13: CO_2 Intensity of the Average Dublin City Dwelling (tonnes/year)

Year of Construction	Number of Dwellings	CO_2 Emissions per unit (kg/yr)	Total CO_2 emissions (kg/yr)
pre 60	127,708	8,673	1,107,611,484
61-80	24,027	8,239	197,958,453
81-90	6,259	7,426	46,479,334
91-96	9,884	6,538	64,621,592
97-02	6,820	5,863	39,985,660
electric Apt	5,041	9,987	50,344,467
2003-06	5,936	5,003	29,697,808
electric Apt	4,387	8,213	36,030,431
Total	190,062		1,572,729,229

Table 3.7: CO_2 Emissions of the Residential Sector in Dublin

Scenarios to 2020

There are many factors that will determine the future energy consumption and CO_2 emissions of the residential sector within Dublin City. The rate of construction of new energy efficient housing and the demolition of older inefficient units will have a significant effect. Levels of energy efficient refurbishment, the integration of renewable technologies and the development of a district heating network will all shape the future trends of the City.

In projecting this future trend to the year 2020, three scenarios are considered. These scenarios highlight the consequences of action versus inaction.

Business As Usual

Business As Usual is the continuation of current building practices in relation to the new housing stock and no action on existing housing stock. This means that all new dwellings constructed between 2007 and 2020 will be constructed to Building Regulations Part L 2005. No energy efficient refurbishments are made to the existing housing stock.

Scenario 1: Low cost refurbishment and new building standards

Existing Housing Stock
Low cost refurbishment of the existing housing stock consists of two actions; installing low energy light bulbs in every house in the city by 2008 and installing extra attic insulation in every house by 2011. This is completed on a phased basis tackling the older housing units first.

New Housing Stock
All new housing units are subject to improved building standards. All new units constructed prior to 2009 must be of a B1 standard and an A3 thereafter. New housing units will also incorporate renewable energy for space heating and hot water; this is introduced on a phased basis, starting at 10%, culminating to 50% of units by 2020. Scenario 1 also sees the introduction of district heating and group heating systems providing space heating and domestic hot water for 11% of dwellings by 2020.
In addition to these actions it is assumed that a 20% reduction, due to user behaviour improvement, can be achieved. This is introduced on a phased basis between 2008 and 2020.

Scenario 2: Complete refurbishment of existing stock and new building standards

Existing Housing Units
A complete refurbishment of the existing housing stock. This involves low energy light bulbs, attic insulation, wall insulation, high efficiency boilers and energy efficient windows for all existing units that require them. This is completed on a phased basis between 2007 and 2017. Once all energy efficient refurbishment opportunities are exhausted then renewable energy is considered for the existing stock introduced on a phased basis resulting in 40% of housing units using renewable energy for space heating and domestic hot water by 2020.

New Housing Stock
All new housing units are subject to improved building standards. All new units constructed prior to 2009 must be of a B1 standard and an A3 thereafter. New housing units will also incorporate renewable energy for space heating and hot water; this is introduced on a phased basis, starting at 10%, culminating to 50% of units by 2020. Scenario 2 also sees the introduction of district heating for existing dwellings providing space heating and domestic hot water for 30% of dwellings by 2020.
A 20% reduction, due to user behaviour improvement, is also assumed.

Opportunities for Energy Efficiency

Business As Usual

If we carry on "business as usual", this will result in a 16% increase in energy consumption, and a 17% increase of CO_2 emissions by 2020. This means that by 2020 the annual energy consumption of the residential sector will exceed 9 TWh per year, emitting over 1,800 ktonnes of CO_2. This growth is caused by the annual increase in housing units.

Scenario 1

Low cost refurbishment actions and improved building standards offer savings of 18% and 20% of energy and CO_2 respectively. Of this, low energy lighting and attic insulation account for a small part of the savings, while improved building standards and user behaviour account for the remainder. If the reduction in energy consumption due to improved user behaviour was omitted, energy consumption under Scenario 1 would continue to rise, thus highlighting the importance of actions targeting wasteful energy behaviour. This also highlights that improving building standards alone will not achieve significant reductions in energy and CO_2 compared with current consumption levels.

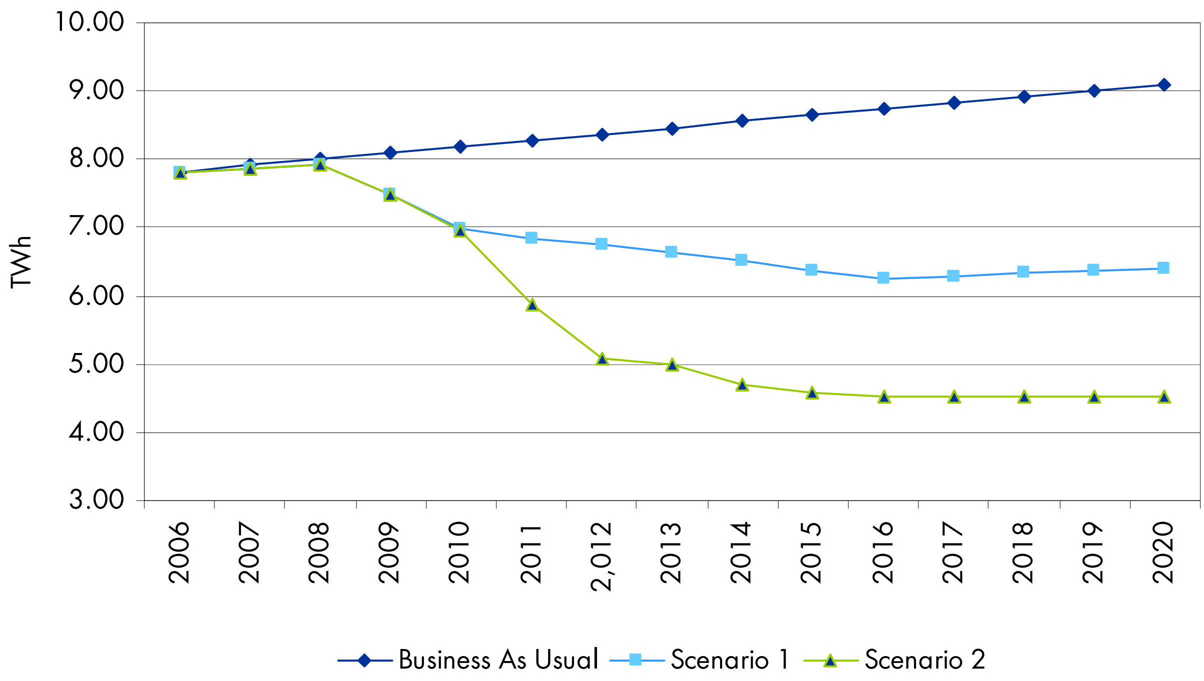

Figure 3.14: Dublin City Energy Consumption 2006 – 2020 (1269 Demolitions per Annum)

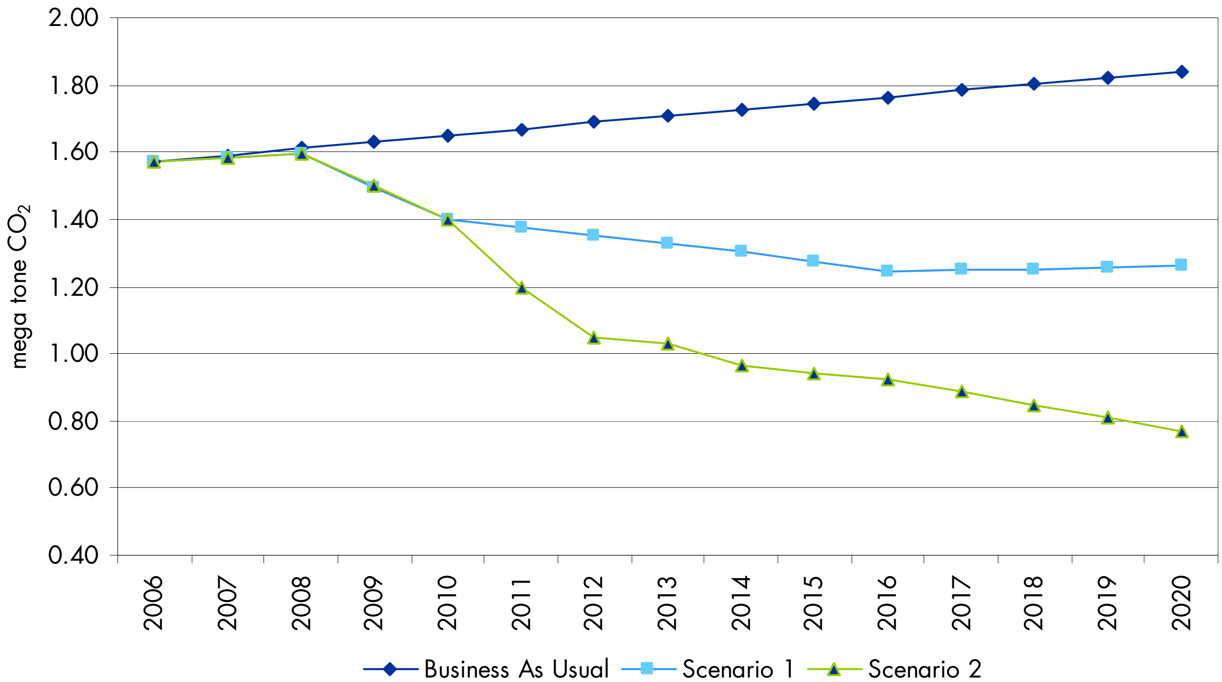

Figure 3.15: Dublin City CO_2 Emissions 2006 – 2020 (1269 Demolitions per Annum)

Scenario 2

In order to achieve significant reductions in energy and CO_2 emissions, refurbishment actions as in Scenario 2 must be considered. In Scenario 2 a 42% reduction in energy consumption and a 51% reduction in CO_2 emissions are possible. In addition to the actions adopted in Scenario 1, Scenario 2 also include boiler upgrades, wall insulation, window replacement along with renewable energy and district heating for existing dwellings.

	Energy savings	CO_2 savings
Business As Usual	+16%	+17%
Scenario 1	-18%	-20%
Scenario 2	-42%	-51%

Table 3.8: Energy and CO_2 Savings Opportunities

The most significant energy savings are gained by changes in user behaviour, followed by actions such as boiler upgrades, wall insulation, improved building regulations and attic insulation. Together, user behaviour and boiler upgrades account for 53% of the potential savings in the residential sector.

In respect to CO_2 emissions user behaviour again offers the most significant savings, followed by boiler upgrades, wall insulation and improved building regulations. The benefits of renewable energy are highlighted in Figure 3.14 and Figure 3.15. Scenario 2 in 2020 shows that energy consumption has stabilised at 4.6 TWh per year, but the associated CO_2 emissions are falling at a rate of 40 ktonnes per year. This continuing reduction in CO_2 is a direct result of the use of renewable energy technology.

Figure 3.16 and Figure 3.17 show the contribution of each action in achieving the reduction in energy consumption and CO_2 emissions indicated in the scenarios outlined above.

The proportion of savings resulting from renewable energy and district heating, indicated in Figure 3.16

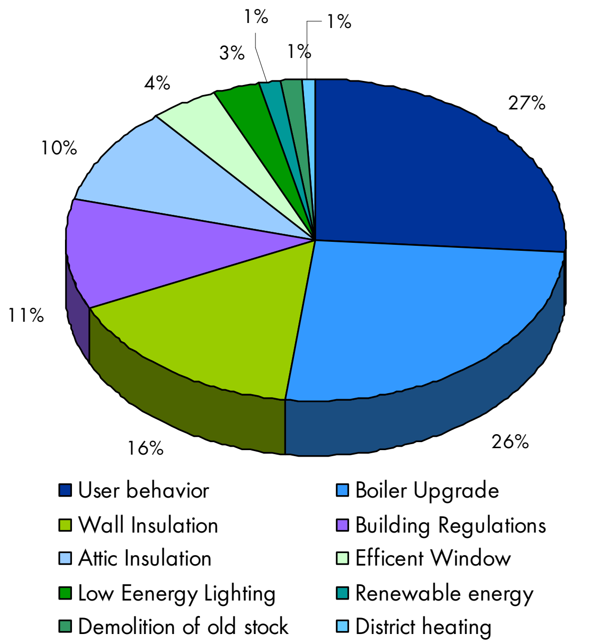

Figure 3.16: Contribution of Each Action to Possible Energy Savings (cumulative savings 2006 to 2020)

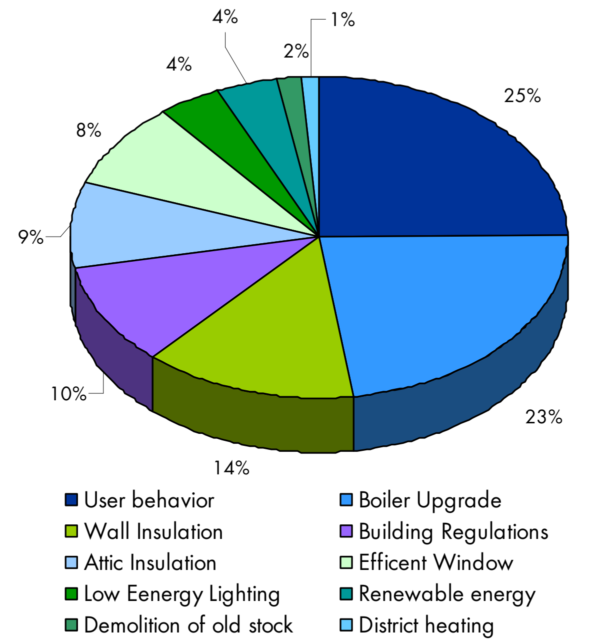

Figure 3.17: Contribution of Each Action to Possible CO_2 Savings (cumulative savings 2006 to 2020)

is quite small. This is due to the phasing of the model. Renewable energy for new dwellings is introduced on a phased basis from 2008 onwards, culminating in 50% of units having a share of renewable energy in 2020. For existing dwellings, renewable energy was introduced at a much later date, phased in from 2017 at 10% per year, totalling 40% by 2020. The average pre 1990s dwelling with renewable energy installed, after building fabric measures have been completed, offers a possible savings of 13% in energy and 60% in CO_2 emissions.

Building Energy Rating (BER)

The BER system was introduced to Ireland by the EPBD (Energy Performance of Building Directive) Working Group. It is based on a calculation of the energy required to meet standardised conditions (space heating, water heating, ventilation and lighting) within the house.

The basis of the BER rating is "primary energy". This takes account of energy used at the house and also the energy required at the processing and delivery stages, e.g. in electricity production and distribution losses.

The energy requirement is calculated using the national Dwelling Energy Assessment Procedure (DEAP). DEAP was published by SEI in June 2006 for demonstrating compliance with the CO_2 emission requirements under the amended *Building Regulations (Amendment) Regulations 2005 (S.I. 873 of 2005)*, published 30th December 2005 and the related *Technical Guidance Document L (May 2006 edition).*

The certificate is based on an "A to G" building energy rating scale. As the rating system must ultimately apply to all newly constructed houses and to all existing houses for sale or rent, the scale must cover houses of widely different energy efficiencies and calculated energy uses– from modern low energy houses to older, poorly insulated houses using inefficient heating systems. Accordingly, the A – G ratings on the scale is sub-divided in to 3 categories; A1, A2, A3; B1, B2, B3 etc. This is done to ensure that each point on scale does not represent too wide a bandwidth.

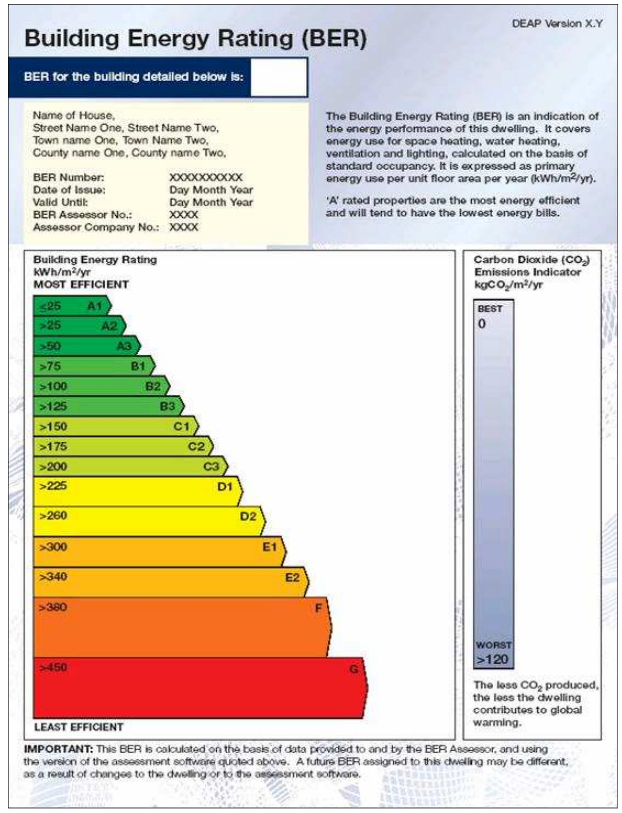

Figure 3.18: BER Certificate [12]

- BER of new houses commencing on or after 1 January 2007.
- BER of new Non-Domestic Buildings commencing on or after 1 July 2008.
- BER of existing buildings, when offered for sale or letting, on or after 1 January 2009.

Building Energy Rating of Dublin City Dwellings

Existing Dublin City Housing Stock

The housing stock was analysed in terms of performance on the Building Energy Rating (BER) scale, as introduced under the Energy Performance of Building Directive. The BERs of the existing housing stock are quite poor with the vast majority of the houses falling into the E1 category on the A to G scale as shown in Figure 3.19.

This is due to the poor energy efficiency of the majority of the existing housing stock, particularly houses constructed pre 1990. Much of the post 1990 housing stock falls into the C1 to D2 range. The better performers tend to be the gas heated houses and apartments with the majority of electrical heated apartments falling into the D1 to E1 range. It should be noted that while not indicated in the figure, there is a small number of A and B rated dwellings in Dublin City as well as F and G.

This chart is based on averaged data for Dublin City and therefore it gives only a broad picture of the current situation.

Business As Usual

Business As Usual offers a shift in BER to the B3 range but there are still significant numbers of E1 rated houses. The B1 shift is mainly made up of newly constructed houses with the corresponding reduction in E1 rated dwellings due to the demolition of older houses. The Business As Usual Scenario does not address the poor energy performance of the existing stock. The numbers of dwellings in the C1 to D2 range remains unchanged.

Scenario 1

Scenario 1 offers a significant rise in A3 and B1 rated houses. This is due to the introduction of improved building standards in the Dublin City Council area under variation number 22 of the Dublin City Development Plan 2005 to 2011 [10]. However, there are still a large number of E1 and D2 rated houses. There is a slight shift to better ratings due to refurbishment measures, such as low energy lighting and attic insulation, but a considerable gap remains between the energy efficiency of the new housing and the existing housing. As in the Business As Usual Scenario the main reduction in E rated dwellings is due to demolition older housing.

Scenario 2

Scenario 2 offers much greater energy savings in the existing housing stock. By 2020 the majority of the existing E1 houses would become B3 to C2 rated houses. There are a small number of dwellings that are still E1 and D2 rated. They are generally electrically heated apartments constructed between 1997 and 2006. Although these apartments are adequately insulated the installation of electrical storage heating leads to high consumption of primary energy due to the relatively inefficient generation of electricity in Ireland (40%). Retrofitting opportunities such as connection to a district-heating scheme are also limited due to the absence of a wet central heating system.

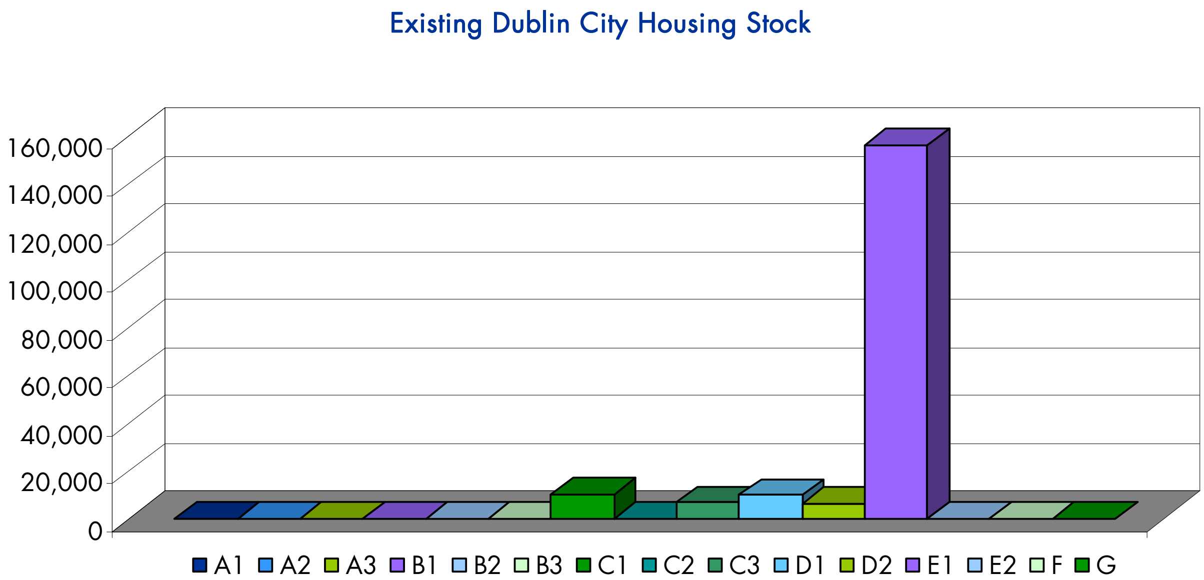

Figure 3.19: Building Energy Ratings of Existing Dublin City Housing Stock

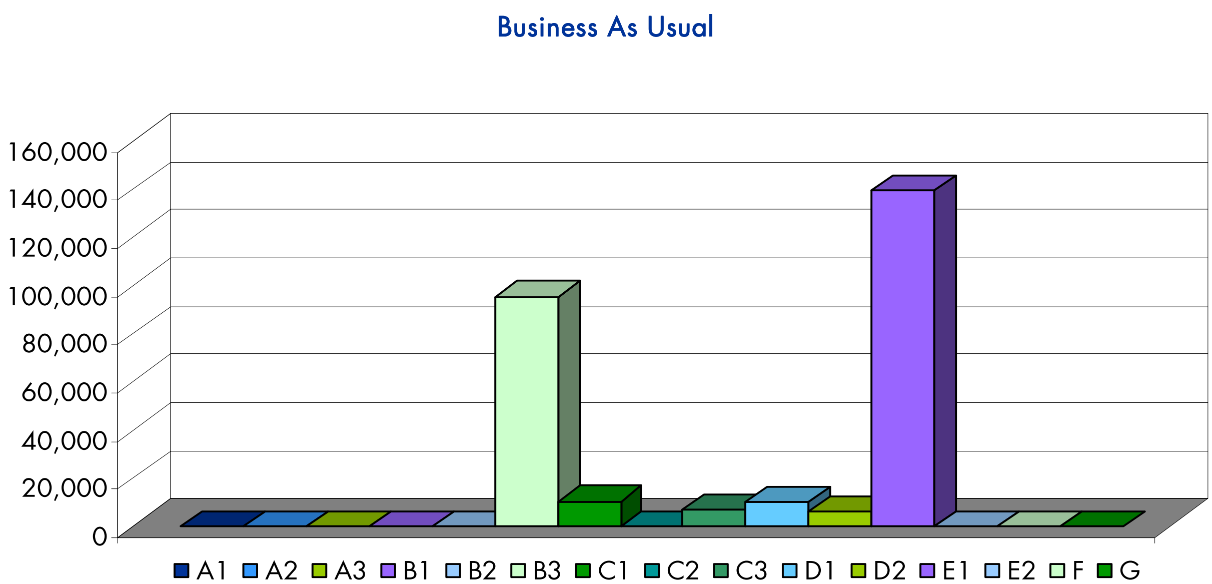

Figure 3.20: Building Energy Ratings of Dublin City Housing Stock 2020 - Business As Usual

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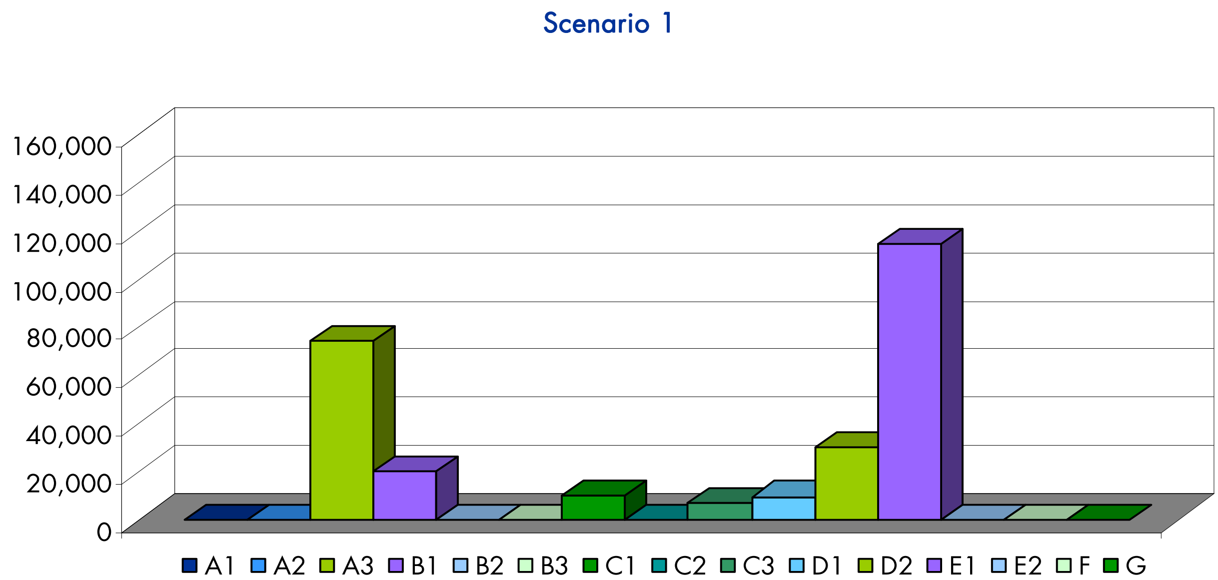

Figure 3.21: Building Energy Ratings of Dublin City Housing Stock 2020 - Scenario 1

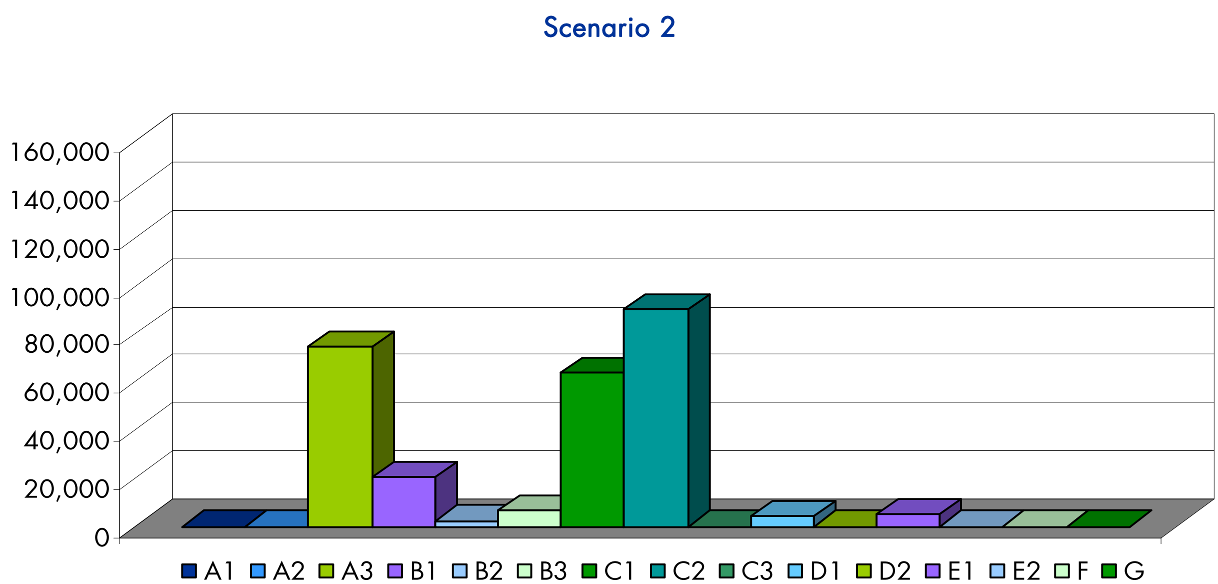

Figure 3.22: Building Energy Ratings of Dublin City Housing Stock 2020 - Scenario 2

Financial Analysis

Introduction

Scenario 1 and Scenario 2 include a total of ten individual actions. The overall effect of these actions depends very much on the degree and order in which they are introduced. In Table 3.9 the timeline, on which the Scenario 1 and Scenario 2 calculations are based, is presented. The actions with the green timelines are ones that are currently being implemented, such as improved building regulations and the Power of One campaign in the case of user behaviour. Elements of what will form part of a wider Dublin district heating system are also under construction. The actions with the blue timelines are new actions proposed by this action plan. It can be assumed that due to recently introduced laws a shift towards low energy lighting is currently taking place.

This section will look at the costs and benefits of the implementation of these proposed actions. All cost and benefits are calculated based on the same 2008 to 2020 timeline.

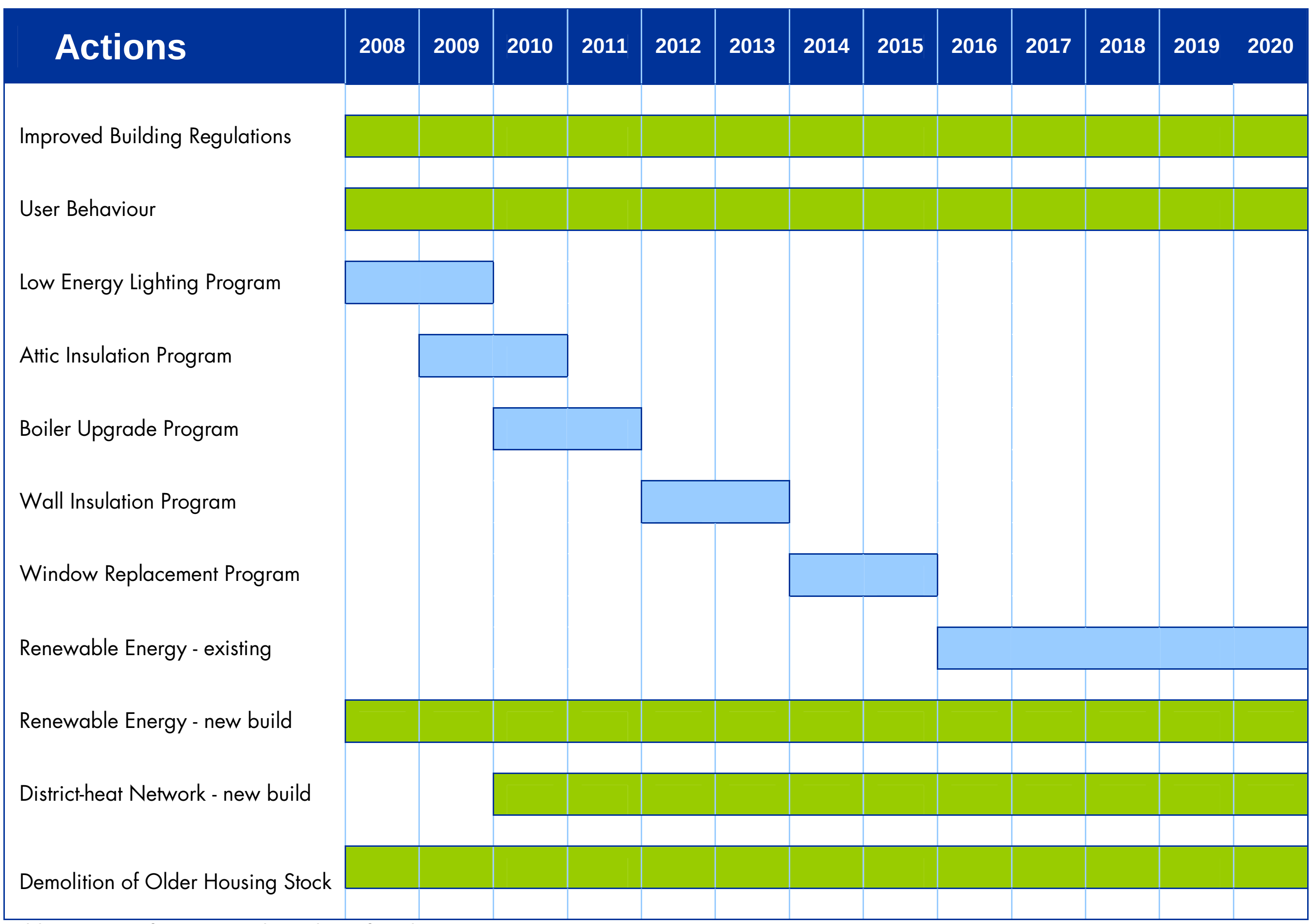

Table 3.9: List of Actions and Timeline of Implementation

Details of Proposed Actions

User Behaviour

The Power of One Street campaign recorded an average saving of 19.3% in energy consumption due to changes in user behaviour. In Scenarios 1 and 2 it was assumed that a reduction of 20%, for both energy consumption and CO_2 emissions, is possible. This is introduced on a phased basis, beginning at 5% in 2008 and ending in 20% in 2020. Capital cost is loosely based on the Power of One campaign.

Possible Savings:	Energy	11,691 GWh
	CO_2	2,288 ktonnes
Capital cost:	€37 million	
Cost savings:	€617 million	
Homeowners	€560 million	
Carbon Credits	€ 57 million	

Boiler Upgrade

It is assumed that all boilers in existing dwellings have a minimum average efficiency of 70% for pre 1990 dwellings, which in reality is optimistic. In Scenario 2 these boilers are upgraded to 90% efficiency or a modern condensing boiler. Boiler upgrades would result in approximate savings of 1.1 TWh of energy and 187 ktonnes CO_2 emissions per year. It should be noted that these CO_2 emissions are calculated for natural gas only as it is the main fuel source in Dublin City (electrical heating is also included for some apartments). If home heating oil was accounted for in this model, the estimated CO_2 savings would be slightly greater due to the higher emissions caused by burning heating oil.

The capital cost of the boiler upgrade program is based on a cost of €2,500 per boiler installed. This cost also includes provisions for small auxiliary works that may be necessary. The cost savings to the homeowner are based on savings estimated by the DEAP methodology, over the period 2008 to 2020. The cost savings for carbon credits are based on a cost of €25 per tonne of CO_2 saved.

Possible Savings:	Energy	11,591 GWh
	CO_2	2,138 ktonnes
Capital cost:	€424 million	
Cost savings:	€410 million	
Homeowners	€356 million	
Carbon Credits	€ 53 million	

Wall Insulation

Wall insulation also offers a significant saving opportunity, however in reality this may be much more difficult to achieve due to high costs and disruption caused to the home owner by some insulation methods. There are three main methods of insulating existing walls, (i) cavity wall pump fill, (ii) internal dry lining and (iii) external insulation. The type of insulation that is suitable depends on the wall construction, these are generally: cavity wall, hollow block and solid wall.

The simplest and most cost effective method of wall insulation is cavity wall pump fill. This applies as the name suggest to walls which have a cavity between an internal and external layers of block or brick work and does not apply to hollow block walls. In this method insulation is pumped into the wall cavity externally resulting in very little disturbance to the occupant.

Where hollow block or solid walls are concerned internal dry lining or external insulation may be considered. Internal dry lining is the most popular option but it is expensive and disruptive to the occupant. It will to some extent reduce the internal floor area and the dwelling will also require redecoration after dry lining. External insulation is not as popular in Ireland and if applied will change the facade of the dwelling.

There is a considerable difference between the cost of cavity pump fill insulation and internal dry lining. To somehow account for this difference an average cost of €3,250 per unit was assumed.

Possible Savings:	Energy	7,093 GWh
	CO_2	1,304 ktonnes
Capital cost:	€543 million	
Cost savings:	€266 million	
Homeowners	€233 million	
Carbon Credits	€ 33 million	

Building Regulations

Improved building standards have a very positive effect on the overall energy consumption and related CO_2 emissions of the future housing stock. This calculation is based on the proposed improvement in regulations proposed by Dublin City Council where developments above 10 dwellings constructed between 2008 and 2009 are constructed to a B1 standard and developments constructed from 2010 onwards are to be constructed to an A3 standard.

It is estimated that the cost of achieving a B1 rating is an extra €10,000 per unit, and an A3 costing an extra €15,000 per unit.

Possible Savings:	Energy	4,979 GWh
	CO_2	953 ktonnes
Capital cost:	€347 million	
Cost savings:	€221 million	
Homeowners	€197 million	
Carbon Credits	€ 24 million	

Energy Efficient Windows

Efficient windows are very important for both energy conservation and thermal comfort. Many older dwellings have already replaced single glaze windows with modern double glazed windows; this was accounted for in the calculation. Window replacement tends to be quite disruptive and also relatively expensive. Window replacement was estimated at €12,000 per unit or €500 per meter squared.

Possible Savings:	Energy	1,993 GWh
	CO_2	367 ktonnes
Capital cost:	€1,975 million	
Cost savings:	€70 million	
Homeowners	€61 million	
Carbon Credits	€ 9 million	

Attic Insulation

Considerable savings can also be achieved through attic insulation. Attic insulation is one of the most cost effective energy savings actions that can be applied to a dwelling. The savings indicated here are comparative as it is assumed that the majority of dwellings already have some form of attic insulation. However the condition of such insulation is unknown. Poorly fitted or damaged insulation products will not perform as well as theoretical estimations. Capital costs are estimated based on insulating horizontal roofs only at a cost of €560 per unit.

Possible Savings:	Energy	4,356 GWh
	CO_2	802 ktonnes
Capital cost:	€96 million	
Cost savings:	€188 million	
Homeowners	€168 million	
Carbon Credits	€ 20 million	

Low Energy Lighting

Small but not insignificant savings can be achieved by the reduction of low energy light bulbs in all dwellings. An average cost of €75 per unit is assumed.

Possible Savings:	Energy	1,404 GWh
	CO_2	381 ktonnes

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Capital cost:		€14 million
Cost savings:		€88 million
	Homeowners	€79 million
	Carbon Credits	€10 million

Renewable Energy

It is important to understand the necessity to conserve energy before considering renewable energy. Installing renewable products into dwellings that do not have adequate levels of insulation or inefficient central heating systems will result in a poor performance.

In Scenario 2 it is assumed that by 2020 40% of existing dwellings and 50% of new dwellings will use renewable sources to provide energy for space heating and domestic hot water. This level of renewable penetration would result in an estimated 4% reduction in CO_2 emissions from the residential sector, almost 367 kilotons of CO_2 per year. The renewable system is based on 3m^2 of solar water heater and a wood pellet boiler for each of the dwellings. Renewable energy is applied after all other refurbishment measures and only for the period 2017 to 2020, in the case of existing dwellings, hence savings indicated may appear less than expected. The capital cost is based on a unit cost of €5,200 for the solar system and €6,500 for a wood pellet boiler system.

Possible Savings:	Energy	619 GWh
	CO_2	784 ktonnes
Capital cost:		€1,296 million
Cost savings:		€106 million
Homeowners		€ 87 million
Carbon Credits		€ 20 million

District Heating

A districting heating network will be a very important piece of infrastructure for the future sustainability of Dublin. District heating offers great flexibility in the fuel used to provide heat to future dwellings and therefore offers the possibility of being a CO_2 neutral source of hot water. This is also extremely important considering the security of supply issues that Dublin and Ireland are facing in the coming years. The savings here are based on a district heating network supplied by gas powered CHP. If the network is supplied with renewable heat sources, very significant reductions in CO_2 would be achieved. In this model district heating was introduced to new housing only, supplying 22,500 housing units by 2020. The model does not take account of the district heating contribution to the commercial sector. The capital costs are based on an installation cost of €1,908. This is based on fees indicated in "District Heating for Dublin, 2007 Feasibility Study" [13].

Possible Savings:	Energy	414 GWh
	CO_2	146 ktonnes
Capital cost:		€43 million
Cost savings:		€24 million
Homeowners		€21 million
Carbon Credits		€ 4 million

Demolition Rate

The demolition rate for all above calculation is assumed to be 1,269 units per year, which was the average demolition rate between 1996 and 2005. However as Dublin City no longer has any major green field site to develop it is possible that this rate will increase. If the demolition rate is extrapolated to 2020 according to the trend indicated in Figure 3.6, the average demolition rate will be approximately 3,857 units per year. The effect of the demolitions on the overall outcome is very significant due to the removal of very energy intensive housing units, which are replaced with more energy efficient units.

The effect of embodied energy or the energy required for construction is not considered in this analysis. The capital cost is based on a demolition cost of €20,000 per unit.

Possible Savings:	Energy	573 GWh
	CO_2	116 ktonnes
Capital cost:	€355 million	
Cost savings:	€29 million	
Homeowners	€26 million	
Carbon Credits	€ 3 million	

Action	Primary Energy Savings TWh	CO_2 Savings ktonnes	Cost Savings million €	Costs of Action million €	Benefits to Cost Ratio
Refurbishment					
Low energy lighting program	1.40	381	€88.2	€14.2	6.2
Attic Insulation program	4.36	802	€187.6	€96.4	1.9
Wall insulation program	7.09	1,304	€265.5	€543.0	0.5
Boiler upgrade program	11.59	2,138	€409.8	€424.1	1.0
Window replacement program	1.99	367	€69.9	€1,974.6	0.0
Renewable energy	0.62	784	€106.4	€1,295.6	0.1
District-heat network in new city districts	0.41	146	€24.3	€42.8	0.6
Demolition of older housing stock	0.57	116	€29.3	€355.3	0.1
Improved Building Regulations	4.98	953	€221.0	€347.0	0.6
User behaviour	11.69	2,288	€616.6	€37.0	16.7
Total	44.71	9,280	€2,019	€5,130	0.4

Table 3.10: Costs and Savings of each Proposed Action calculated over the 2008 to 2020 Period

Capital Cost versus Potential Savings

The following charts display the capital cost of each program next to the potential savings, calculated over the period 2008 to 2020. Over this period, four of the suggested actions offer a net benefit to the city in terms of euros saved. These actions include, low energy lighting, user behaviour, attic insulation and boiler upgrades. The remaining actions will cost more than they will save over the proposed time period.

It is important to remember that all cost savings are based on the DEAP based model generated for this report. Actions such as renewable energy and district heating are phased in towards the end of the 2008 to 2020 period, and are therefore only active for latter years. For example low energy lighting is introduced in 2008; therefore the benefit is accumulated over 12 years. Renewable energy measures for existing dwellings are introduced in 2017; hence the benefit is calculated over 4 years. This approach was adopted to try and realistically reflect Dublin City in 2020 if such programs were adopted.

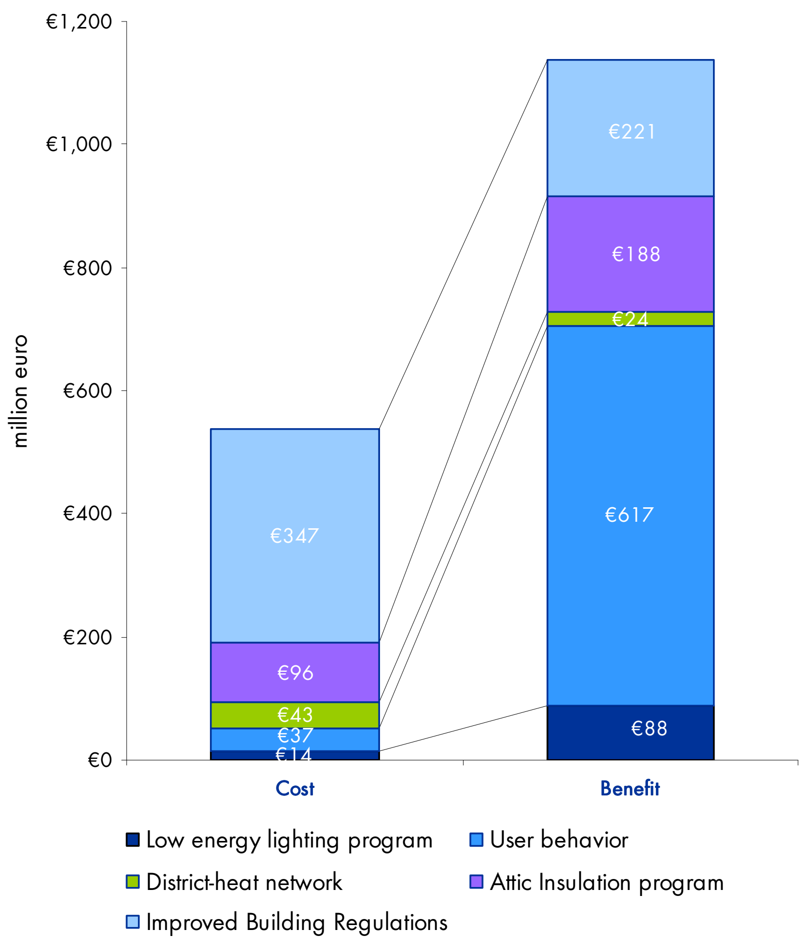

Figure 3.23: Cost-Benefit-Analysis of Actions Costing less that €347 million

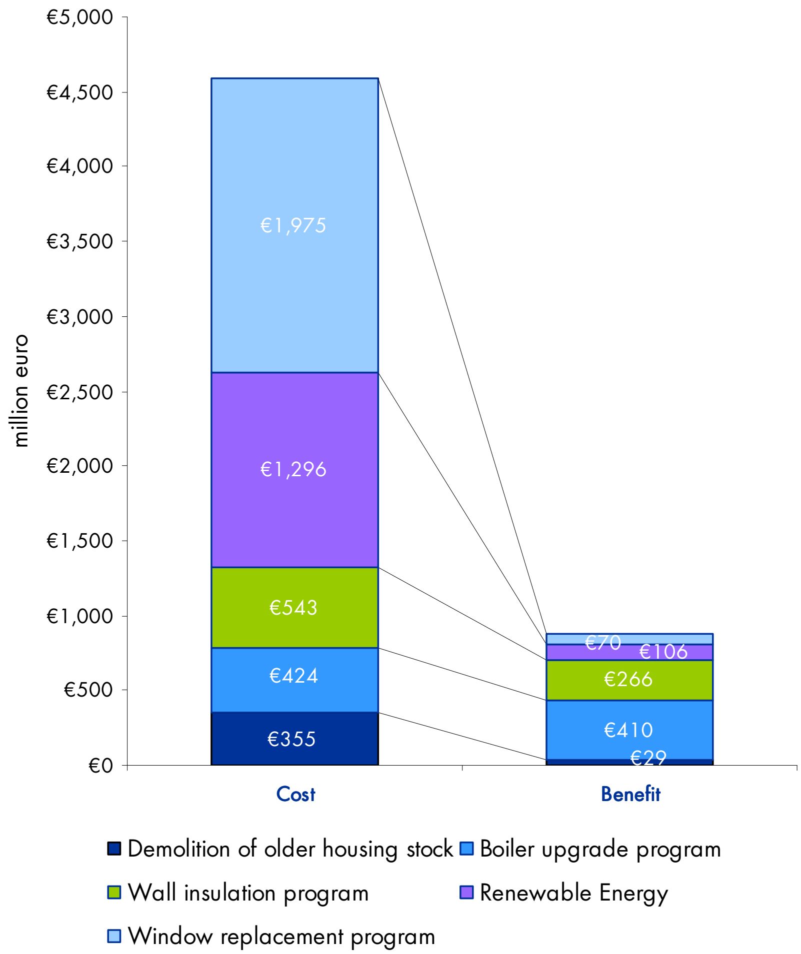

Figure 3.24: Cost-Benefit-Analysis of Actions Costing greater that €347 million

Conclusions

- In 2006 the energy consumption for the residential sector in the City of Dublin was 7.8 TWh and associated CO_2 emissions were 1,570 ktonnes.
- The residential sector accounts for 35% of the primary energy consumption and 32% of CO_2 emissions of Dublin City.
- Pre 1980 housing stock accounts for 84% of the energy consumed in the residential sector.
- New apartments are high energy consumers due mainly to electrical storage heating systems which have poor conversion efficiency (~40%) from primary fuels.
- The residential sector offers the greatest potential for energy (42%) and CO_2 (51%) savings.
- The refurbishment of the existing housing stock is essential if the potential savings are to be realized.
- Approximately 80% of the current Dublin City housing stock would achieve an E1 rating on the building energy rating scale.

Description		Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Current Situation	Energy Consumption / CO_2 Emissions 2006	7.8	1,570
Business As Usual	Business As Usual – 2020	9.1	1,841
Scenario 1	Low cost refurbishment and new building standards	6.4	1,262
Scenario 2	Complete refurbishment of existing stock and new building standards	4.5	771

Table 3.11: Current Situation and Scenarios for the Primary Energy Consumption and CO_2 Emissions

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Analysis of Commercial Sector

Introduction

The services and manufacturing sectors in Dublin City employ over 260,000 people and used 9.2 TWh of energy in 2006.

It is responsible for 42% of the total energy consumption in Dublin City, the biggest consumer when combined.

All calculations are in primary energy which takes into account the losses in delivery and production of energy. In Ireland the production of electricity has high CO_2 emissions due to the fuel mix in generation. Thus any activity that uses large amounts of electricity will consequently have large amounts of associated CO_2.

Manufacturing

This sector accounts for only 6% of total employees in Dublin City but consumed 20% of the energy and emitted 990 ktonnes of CO_2 in 2006. Its fuel use is dominated by electricity which accounts for 77% of fuel use. Future trends for the sector show an eventual decline of 20% in energy and CO_2 emissions by 2020 due to a shift towards a service based industry in Dublin City [1].

Services

96% of all services in Dublin City can be classed as small or medium enterprises (SMEs) employing 249 people or less [2].

The sector consumed 4.8 TWh of energy in 2006 and emitted 1,120 ktonnes of CO_2. 72% of the sectors energy needs are met by electricity. In a Business As Usual model the future trend to 2020 is for a 30% rise in energy and CO_2 emissions.

Two scenarios were examined in order to reduce this growth. The first involves a change over to low energy lighting and an implementation of a business wide energy behavioural program. With these implemented in 100% of activities it is shown that there is a possible saving of 15% in energy (18% in electricity) and a 15% saving in CO_2. The second scenario builds on the first and includes improvements to building fabric and heating, ventilation and air conditioning (HVAC); this produces savings of 21% in energy and 21% in CO_2 emissions.

The services construction industry remains buoyant compared to the residential market and growth is predicted year on year for the foreseeable future [1].

Sector	Primary Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Residential	7.8	1,570
Services	4.8	1,120
Manufacturing	4.4	990
Transport	5.0	1,240
Total	22.0	4,920

Table 4.1: Primary Energy Consumption and CO_2 Emissions in the City of Dublin in 2006

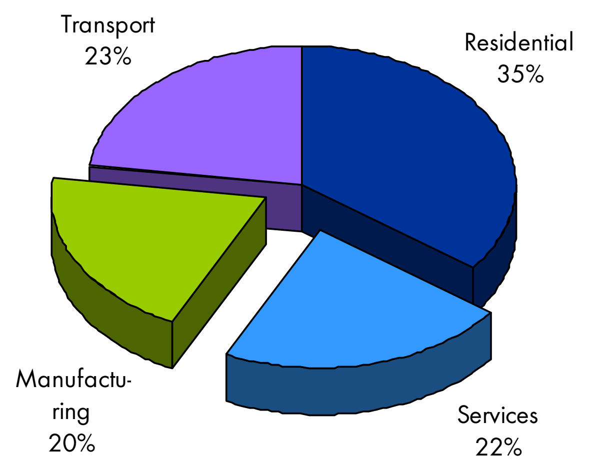

Figure 4.1: Primary Energy Consumption in the City of Dublin by Sectors in 2006

Economy and Future Development

Since 1990 Dublin City and Region has seen an incredible growth in its economy; by 2000 there had been a 98% increase in GDP [3]. This has increased by between 5% and 10% per annum since [4].

Consequently, there has been a boom in office buildings in the city centre; construction in the sector is up five fold compared with 2006. In the first three months of 2007 129,519m^2 of new office space was completed in the Dublin Region up from 23,898m^2 for the first quarter of 2006. Indeed, it was greater than the total office completions for all 2006 [5].

It seems that although the residential building sector has shown signs of cooling, there is an increasing demand for new office buildings; 44% of office space currently under construction is pre let. Office space is rented at an average of €372 per m^2 [6] making it competitive with other major European cities and the majority of financial and public administrative activities are carried out in the city. Of the 40,000+ businesses in the Dublin Region over 90% belong to the service sector [1].

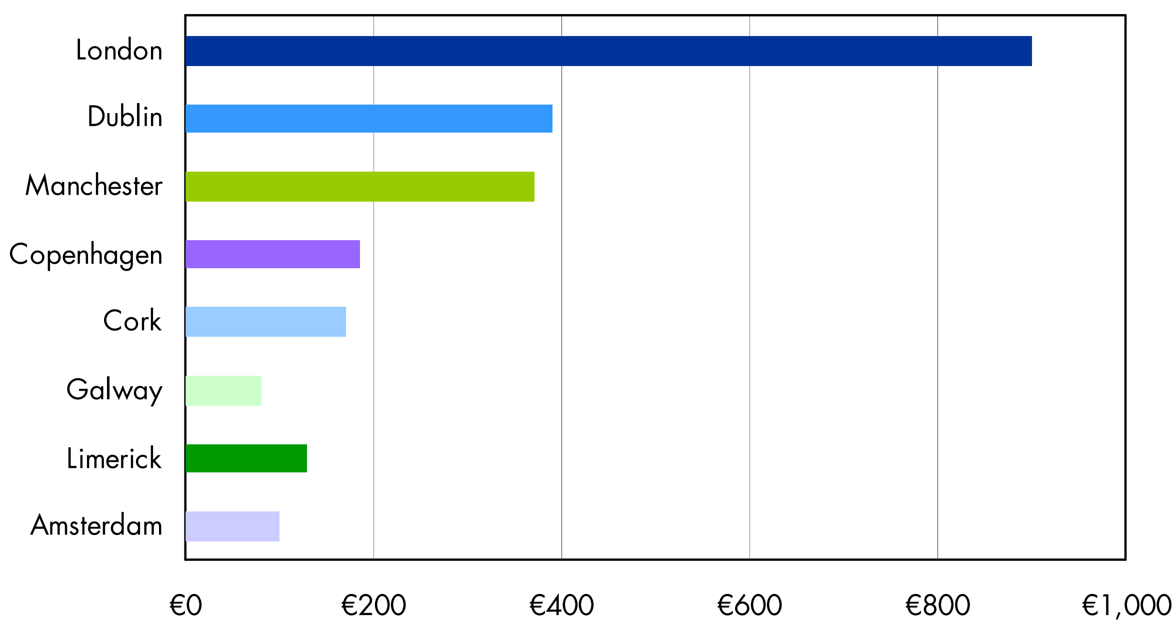

Figure 4.2: Commercial Retail Space Price Comparisons – Office Rent/m^2

Methodology

The methodology for the services and manufacturing sectors is based on two sources of data: (i) A special tabulation of the POWCAR data from the 2006 census to establish the number of persons at work in each activity [7] and (ii) SEI data on the primary energy consumption and CO_2 emissions per employee in the related activities [8] [9]. This is considered to be the best available data for making a first approximation for the services and manufacturing sectors.

The methodology for the sectors therefore utilises national data and applies it to the local level per employee. The sectors are accordingly divided into individual service and manufacturing activities such as retail, office, textiles etc; each activity having a different energy demand per employee.

National data pertaining to energy use in each activity is calculated per head of employee working in that activity and then applied to the same activity employee numbers for Dublin City. This allows an individual breakdown of CO_2 and fuel use per activity (see Table 4.2 for services fuel use).

Energy in the sectors is examined under three headings; electricity, natural gas and oil and are calculated in their primary form, that is, the losses during generation and delivery are accounted for and factored in to the final figure, thus giving a more accurate picture of the 'actual' energy required to meet the demand of the sectors.

Activity	Dublin Employees	Electricity (MWh)		Oil (MWh)		Gas (MWh)		Total (MWh)
		per Employee	Total	per Employee	Total	per Employee	Total	
Motor Trade	**3,024**	14.8	44,735	16.3	49,209	1.1	3,314	**97,258**
Wholesale Trade	**7,994**	13.4	106,917	2.0	16,335	2.2	17,859	**141,111**
Retail Sale of Food	**5,573**	26.7	148,877	2.1	11,893	1.1	5,946	**166,716**
Other Retail and Repair	**12,972**	18.1	235,140	1.1	14,460	0.8	10,845	**260,445**
Hotels	**5,224**	19.8	103,368	5.8	30,415	10.7	56,150	**189,933**
Restaurants,Bars,Catering	**9,709**	31.2	302,930	4.6	44,769	5.2	50,818	**398,517**
Post and Tele	**16,824**	7.9	133,310	0.2	3,879	0.7	11,638	**148,828**
R&D and Office	**62,987**	11.6	732,607	1.4	88,475	1.5	95,937	**917,018**
IT	**8,254**	24.4	201,470	0.4	3,157	0.8	6,314	**210,941**
Recreation and Sports	**6,970**	18.6	129,612	6.2	43,056	3.5	24,372	**197,040**
Other Services	**18,839**	20.0	376,821	5.2	98,031	11.8	221,956	**696,808**
Public Services								
Office Based	**24,854**	11.6	289,079	1.4	34,911	1.5	37,856	**361,846**
Education	**19,800**	11.6	230,295	1.4	27,812	1.5	30,158	**288,265**
Health								
Acute/Maternity Hospital workers	**17,365**	8.2	142,393	7.9	137,184	7.9	137,184	**416,760**
Other Health Workers	**24,025**	11.6	279,437	1.4	33,747	1.5	36,593	**349,776**
Total								**4,841,262**

Table 4.2: Sample of the Calculation Matrix for Fuel Use in the Services Sector

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Definition of Sectors

If defined economically, the services sector consists of business establishments that are not engaged in transportation, manufacturing or other types of industrial activity (agriculture, mining or construction), and includes all service based public activities.

Conversely the manufacturing (industrial) activities can be described as those not engaged in the services sector.

For the purpose of this report the services and manufacturing sectors have been broken into categories as defined in the POWCAR (census) data.

Services activities

- Motor Trade
- Wholesale Trade
- Retail Sale of Food
- Other Retail and Repair
- Hotels
- Restaurants/Bars/Catering
- Post and Telecommunications
- Research and Development and Office (R&D)
- IT
- Recreation and Sports
- Other Services
- Public (Office and Education)
- Health (Hospital and Office based)

Manufacturing activities

- Food, Beverage and Tobacco
- Textiles and Textile Products
- Wood and Wood Products
- Pulp, Paper, Publishing and Printing
- Chemicals and Man Made Fibres
- Rubber and Plastic Products
- Other Non Metallic Mineral Products
- Basic Metal and Fabricated Metal Products
- Electrical and Optical Equipment
- Other Manufacturing

There is very little agricultural, forestry, fishery and construction activity within Dublin City and as such have not been included. This leaves a total of 260,118 employees that have been included.

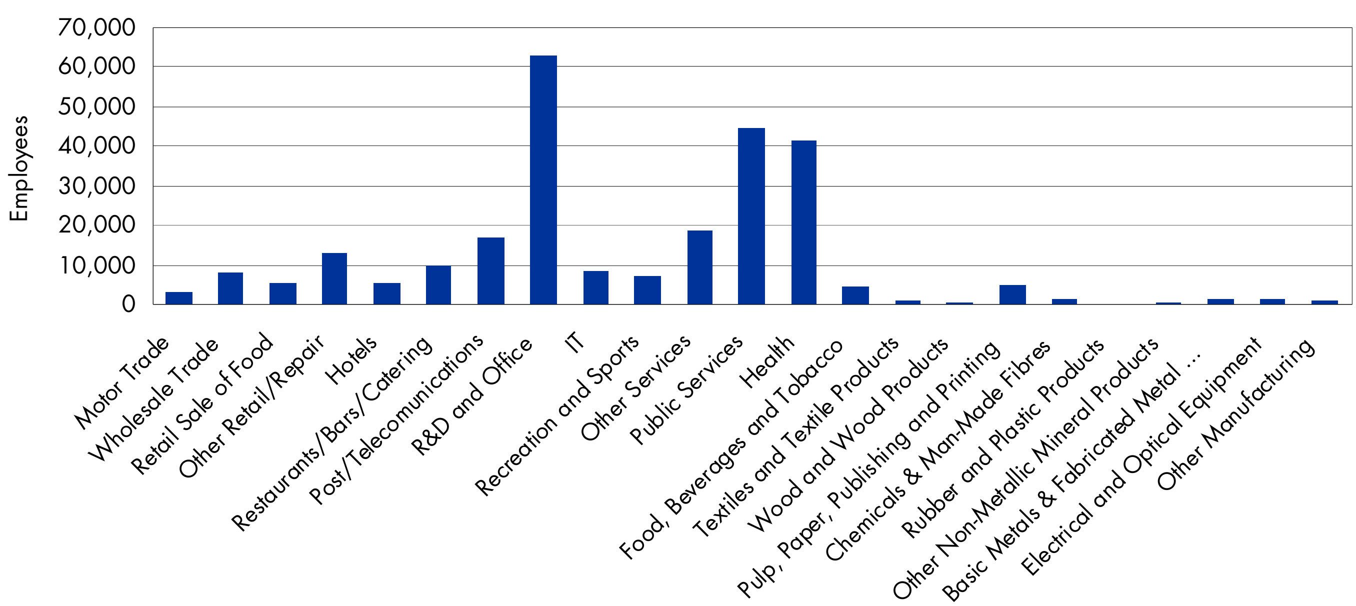


Figure 4.3: Employment Numbers in each Activity for Dublin City

Analysis of the Manufacturing Sector

The centre of any major city has a low intensity of manufacturing industries due to logistics and price of land and Dublin is no exception. Manufacturing (as defined in this report) accounts for only 6% of total employment in the city but consumes 4.4 TWh of energy per year which is 20% of the total energy demand for the city. This emphasizes the energy intensive nature of the sector.

There is a large consumption of electricity which is to be expected in such an energy intense activity and due to the fuel mix production of electricity in Ireland has meant that the manufacturing sector is a big emitter of CO_2 relative to its employment numbers at 990 ktonnes in 2006.

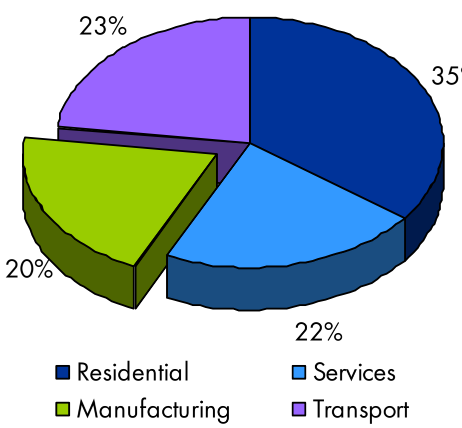


Figure 4.4: Manufacturing Percentage Share of Energy Use

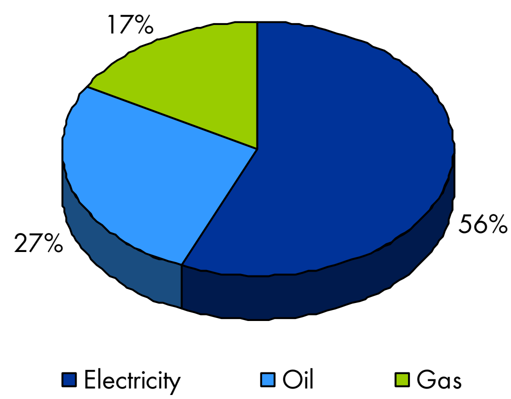


Figure 4.5: Manufacturing Fuel Mix Percentage Share

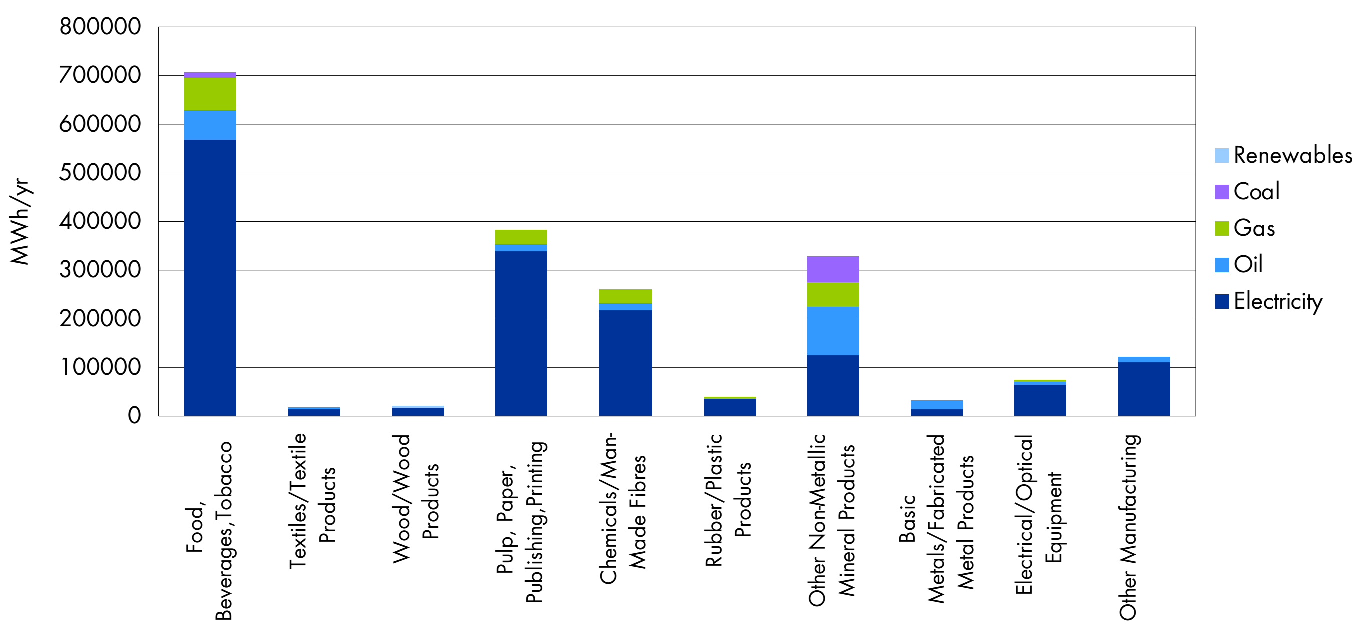


Figure 4.6: Fuel Mix per Activity

Future Trends in the Manufacturing Sector

Although there are no scenarios examined for the reduction of energy in the manufacturing sector future trends have been extrapolated using ERSI data [1]. These show that there is a gradual reduction in employment numbers in the sector as industry continues to migrate from the city centre and the national economy becomes less reliant on manufacturing and moves towards a service based economy. It does highlight the potential for savings in the remaining industries and its contribution to the city's total reductions.

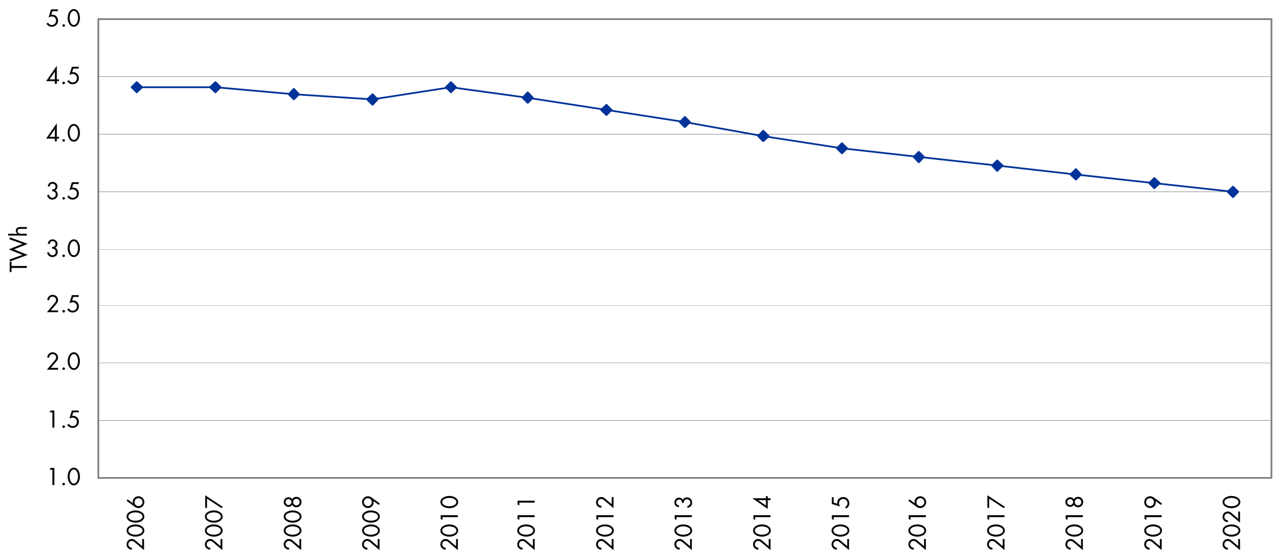


Figure 4.7: Predicted Future Trend of Energy Demand in the Manufacturing Sector

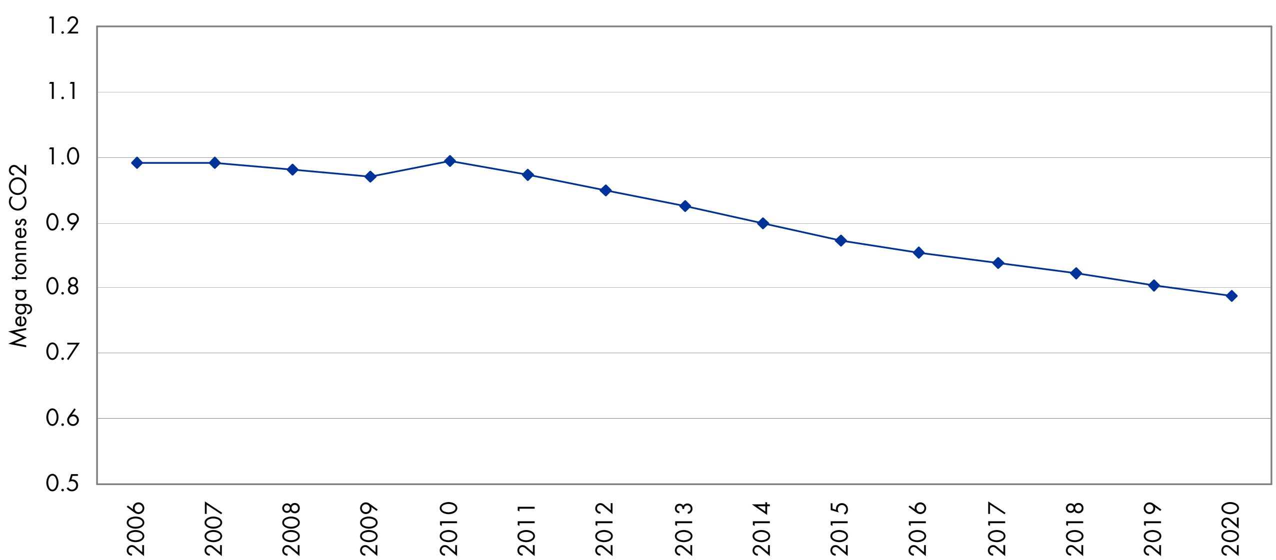


Figure 4.8: Predicted Future Trend of CO_2 Emissions in the Manufacturing Sector

Analysis of the Services Sector

The services sector consumes an almost equal share of the city's energy as transport and manufacturing. Although not as energy intensive as the manufacturing sector it does use a disproportionate amount of electricity compared to oil and gas which reflects its profile as a largely office based technological sector.

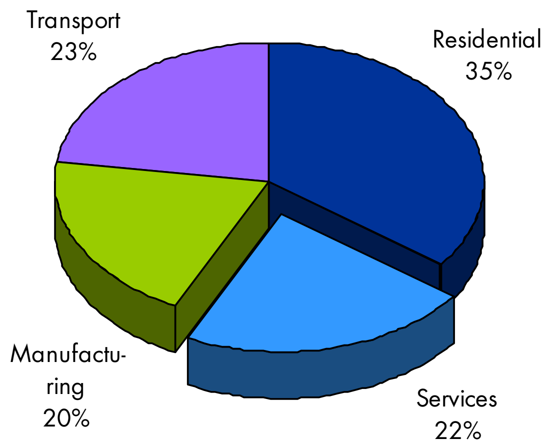


Figure 4.9: Services Percentage Share of Energy Use

The activities in this sector are varied in terms of their energy demand per employee and the fuel type that dominates. For example, office based activities have a high ratio of electricity demand compared with their oil and gas consumption. Hotels on the other hand demand large quantities of both electricity and oil. This gives each activity an individual energy and fuel demand and although the demand per employee in office based activities is smaller compared to, say, retail sale of food, the large numbers employed in offices means that the activities energy demand outstrips all others.

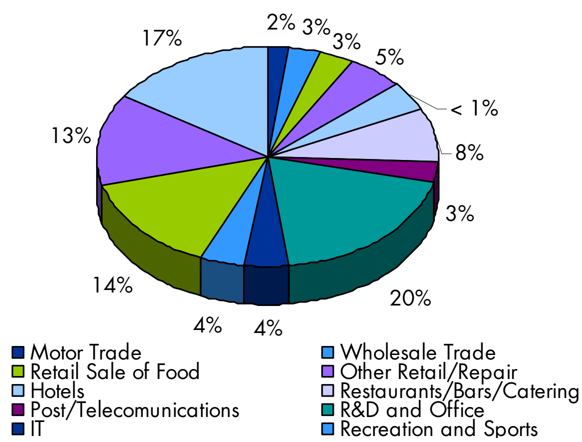


Figure 4.11: Employee Percentage in the Services Sector

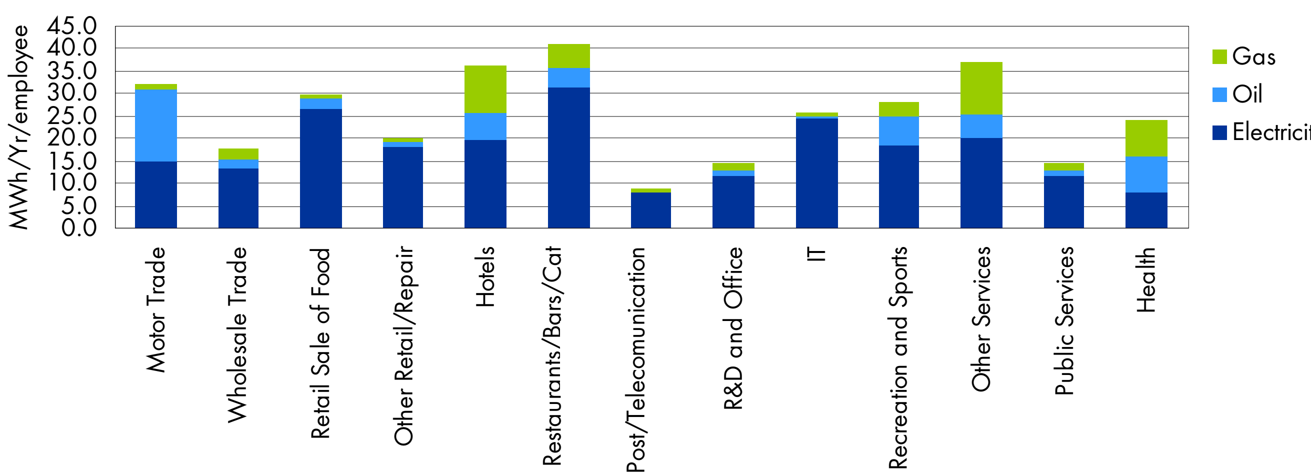


Figure 4.10: Energy Intensity per Employee per Year

Discussion

Because of the homogenous nature of some of the activities and difficulty in obtaining specific information for exact areas of fuel consumption it is more relevant to discuss the results under two headings of office based activities and other activities.

Office Based Activities

Included under this heading are Research and Development (R&D) and office, IT, public administration and office based health workers. These dominate employment in the services sector in Dublin City, accounting for 49% of the total employment. Within this activity there is a wide variation in fuel use and intensity. Research and Development (R&D) and office is by far the biggest single employer with 26% of the total employment and consumes over 917,000 MWh in 2006, but has a relatively low energy intensity per employee. Whereas IT has a very high intensity of electrical use at 24.4 MWh per employee but only accounts for 4% of total energy consumption.

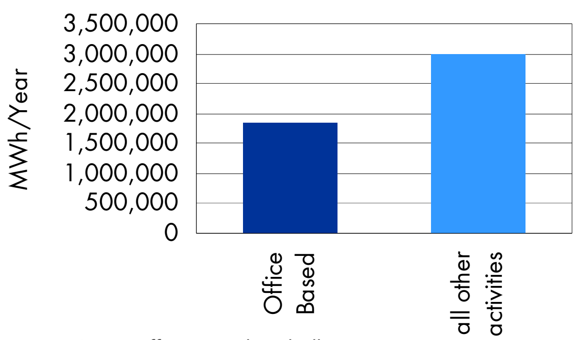


Figure 4.12: Office Based and all Activities Comparison

Other Activities

These are varied and in general do not have comparable characteristics as with the office based, so some individual discussion is needed.

The hospitality industry, which is accounted for under the headings of hotels and restaurants/bars/ catering, has one of the highest intensities of any of the activities across all fuel types. The constant demand and varied use of energy in the activity means it has a large consumption for a small employment share of 6%.

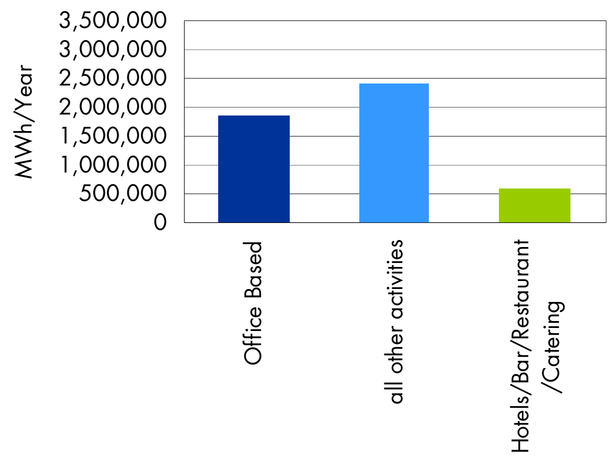


Figure 4.13: Office Based, Hospitality and all other Activities Comparison

The retail and wholesale activities account for 11% of total employment accounting for 11% of total energy consumed. It is intensive in its electricity use and as a result its CO_2 emissions.

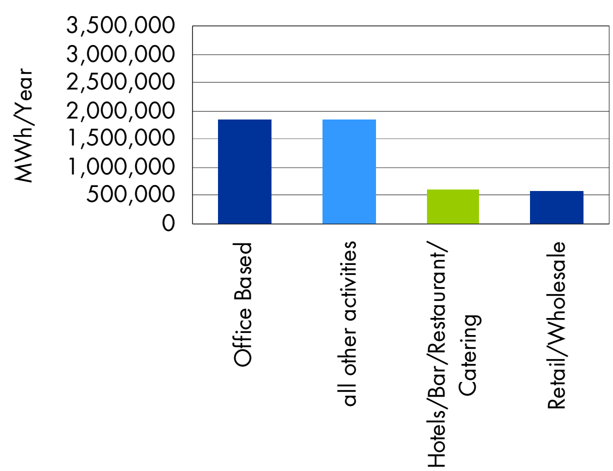


Figure 4.14: Office Based, Hospitality, Retail and all other Activities Comparison

Overview

Service activities (as defined in this report) have become a major growth area for the Dublin economy over the last decade. This has meant a dramatic rise in citizens employed and the amount of energy consumed. Commercial construction and letting has proved more resilient than the residential sector and growth will continue apace for the foreseeable future.

The widespread use of air conditioning, 24hr lighting and computer based activities in office activity as well as the prevalence of electrical storage heating has led to this large consumption of electricity and, as in the manufacturing sector, a large emission of CO_2 for the energy consumed (1,120 ktonnes in 2006).

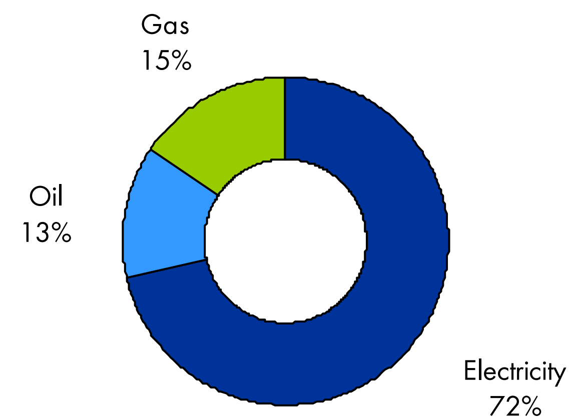


Figure 4.15: CO_2 Emission Percentages as Fuel Types

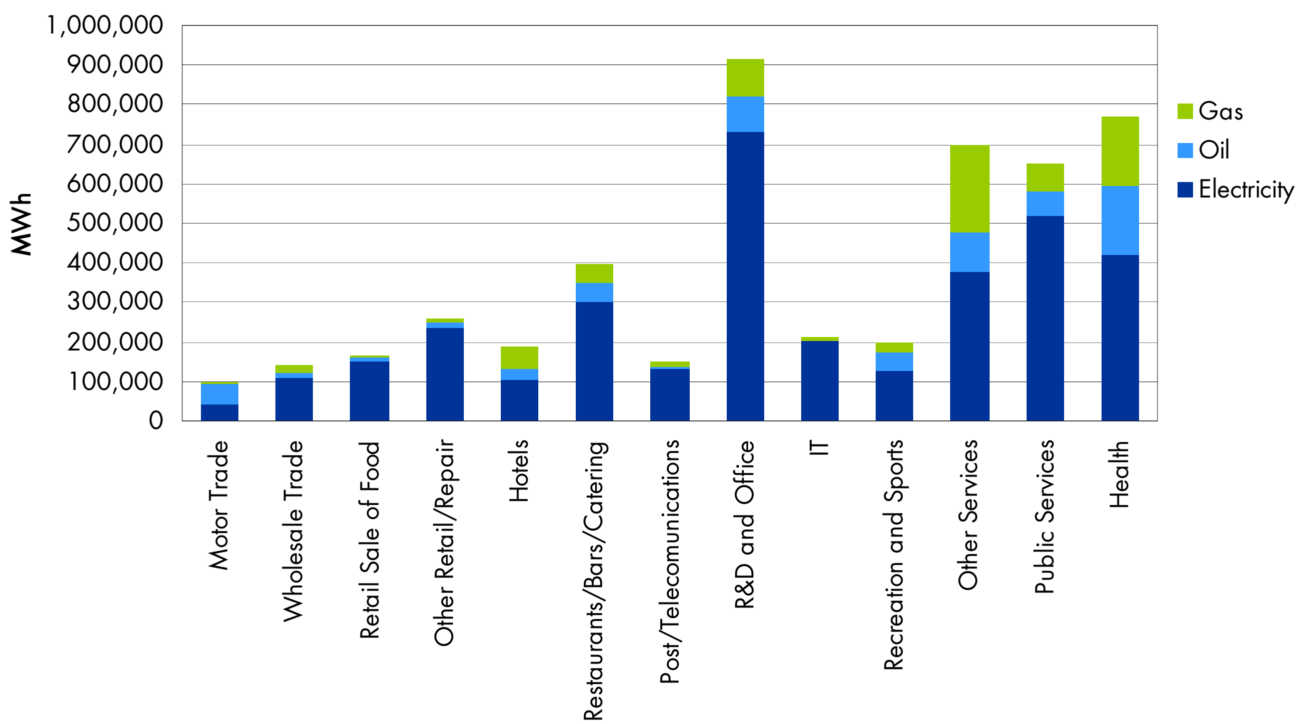


Figure 4.16: MWh Energy use and Fuel Share per Activity

Future Trends in the Services Sector

Using recent studies [1], future trends in the services sector may be extrapolated. These show that the city moves even further away from its traditional base of manufacturing industries towards knowledge based economy.

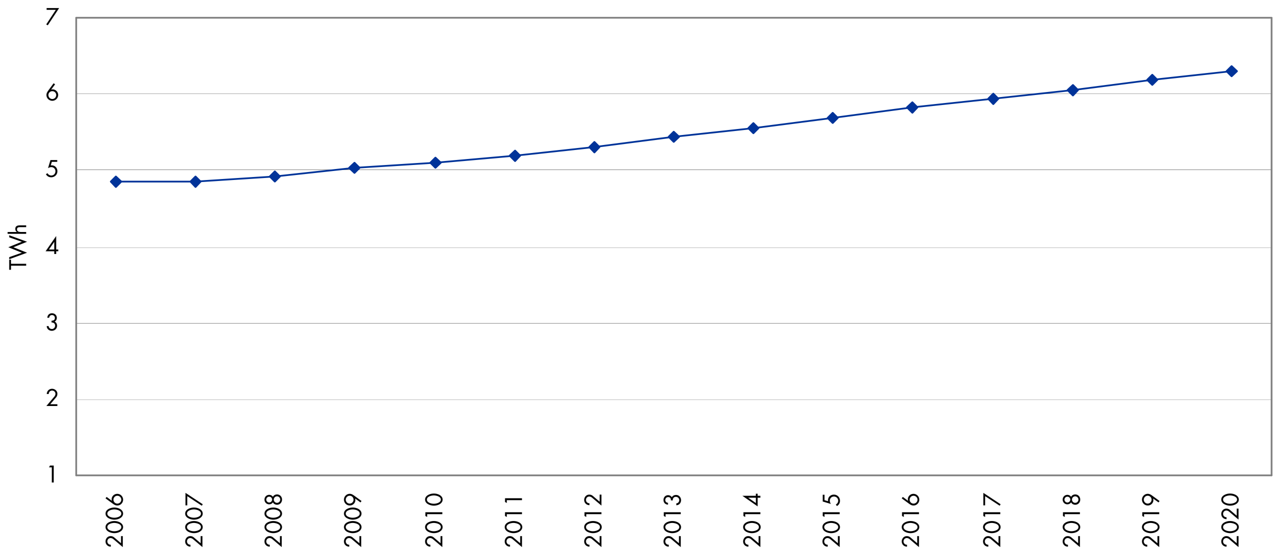


Figure 4.17: Predicted Future Trend of Energy Demand in the Services Sector

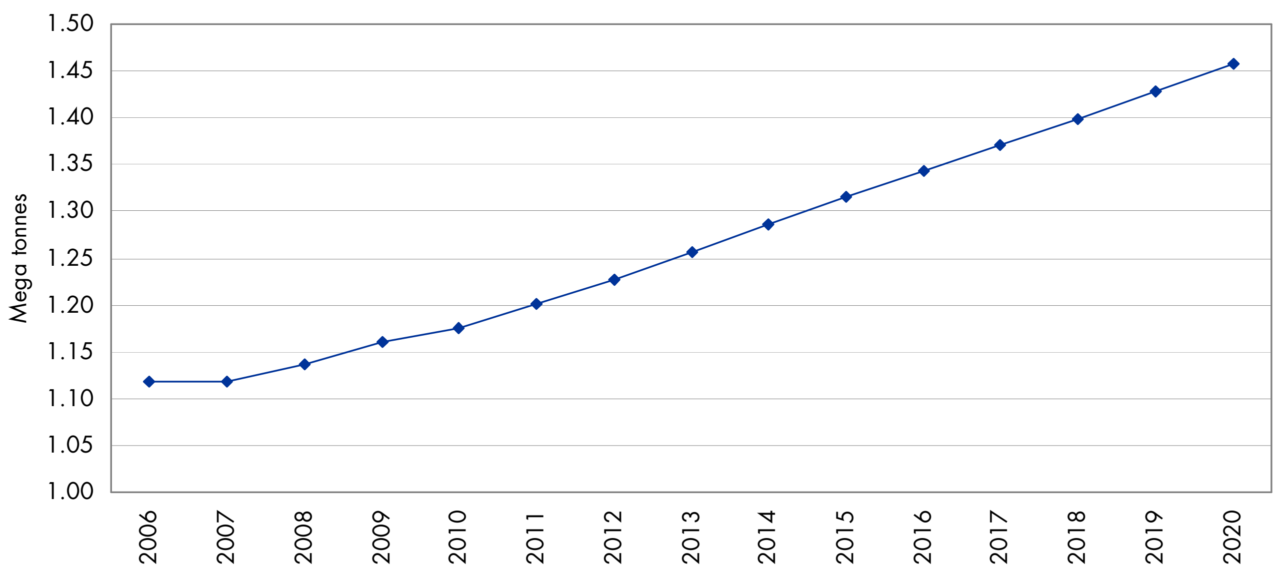


Figure 4.18: Predicted Future Trend of CO_2 Emissions in the Services Sector

codema Sustainable Dublin

Summary

Manufacturing

In 2006 the manufacturing sector consumed 4.4 TWh of energy and emitted 990 ktonnes of CO_2. The largest activity was Food/Beverages/Tobacco which accounted for 36% of the energy demand in the sector. The general trend between 2006 and 2020 is for a 19% fall in CO_2 and a 20% fall in energy consumption. This is due to a fall in the projected number of employees in the manufacturing sector generally as opposed to an increase in energy efficiency.

	2006	2020
TWh	4.4	3.5
CO_2 ktonnes	990	800

Table 4.3: TWh and CO_2 Comparison for the Manufacturing Sector 2006 and 2020

Services

In 2006 the services sector consumed 4.8 TWh of energy and emitted 1,120 ktonnes of CO_2. The largest activity was the R&D and Office which accounted for 19% of the total energy consumed. The general trend between 2006 and 2020 is for a rise of 30% in energy consumption and 30% in CO_2 emissions due to the increasing importance of the service industry to Dublin City's economy.

	2006	2020
TWh	4.8	6.3
CO_2 ktonnes	1,120	1,460

Table 4.4: TWh and CO_2 Comparison for the Service Sector 2006 and 2020

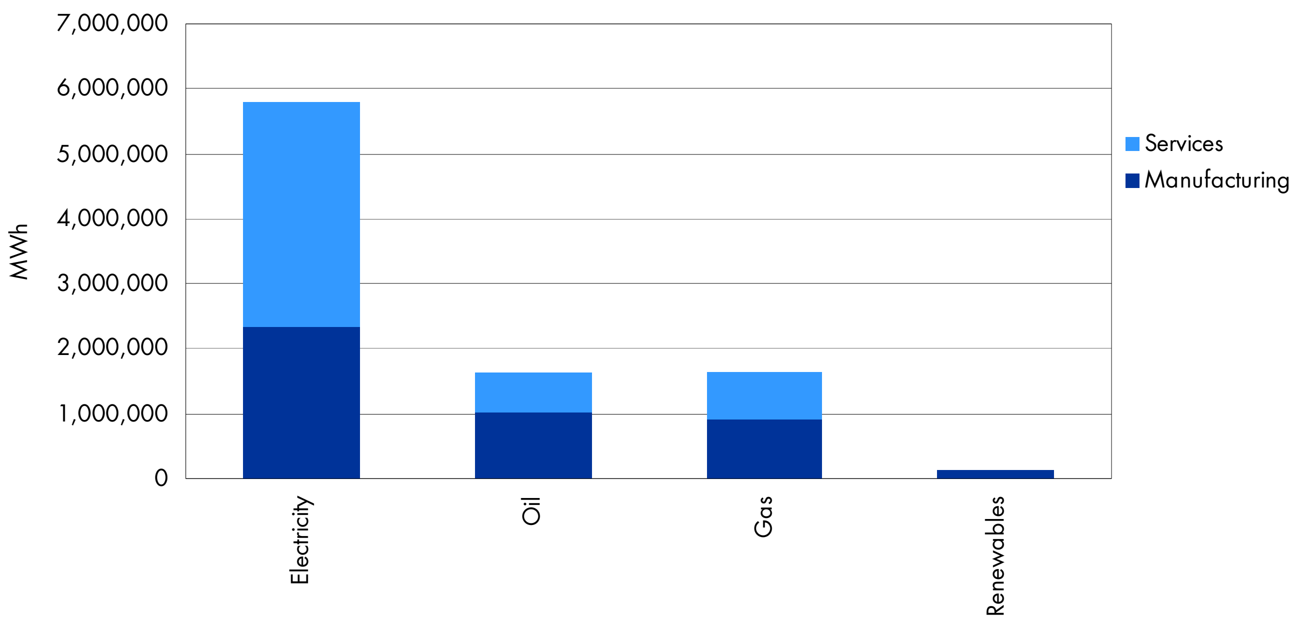


Figure 4.19: Energy Use and Fuel Type Comparison 2006

Possibilities for Sustainable Energy

Sustainable energy use for the commercial sector can be described as: Practices put in place, either through improved physical infrastructure, increased energy efficiency in electronic equipment and energy supply and behavioural change that reduces energy demand to a level that can be sustained indefinitely without detrimental effects to the City's economy or environment.

Technical Solutions

Technical solutions affect the physical envelope of a building, either during construction or in retrofitting. Measures include improvements to or replacements of heating systems, electronic equipment, lighting and systems used to manage a building's energy use. Over the life-cycle of the building the inclusion of these solutions offers a greater payback than a Business As Usual model (see below).

Options for Sustainable Technical Solutions

- Improved thermal efficiency of building Fabric in either new build or retro fit
- Improvements (as in Scenario 2) to heating ventilation and air conditioning (HVAC), either regular maintenance or replacement
- Low energy lighting (Scenario 1)
- Energy efficient office equipment
- BEMS (Building Energy Management Systems)
- CHP (Combined Heat and Power) onsite electricity generation
- District Heating
- Renewable Energy Systems (solar thermal, heat pumps, wind power, biomass)

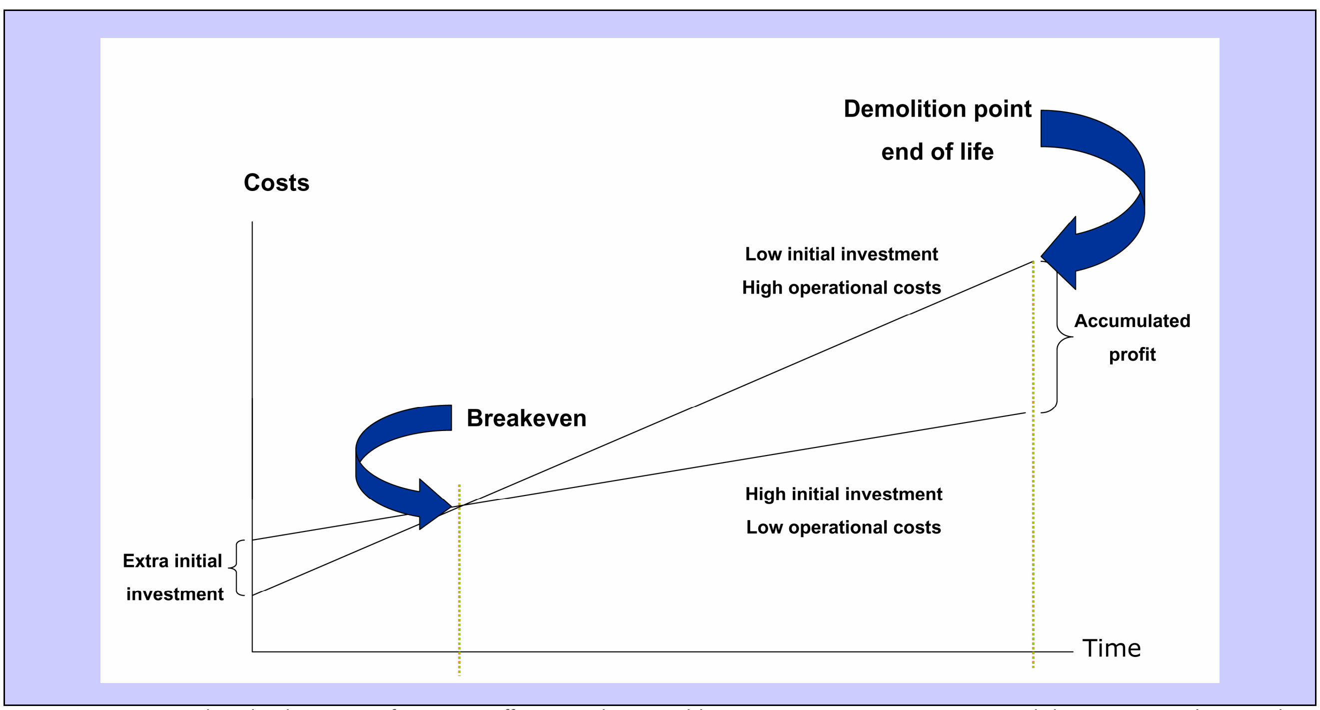


Figure 4.20: Cost and Payback Scenario for Energy Efficient and Renewable Energy Options (Source: IVL Swedish Environmental Research Institute)

Variation (No. 22) of the Dublin City Development Plan 2005 – 2011

Variation No. 22 of the Dublin City Development Plan adds an Energy policy in the Residential chapter 4 - Policy Res 20, and complementary site development standard, in Chapter 15 - para.15.9.0. The variation seeks to achieve improved energy efficiency in new buildings throughout the city.

The following are the additions to the plan:

Policy Residential 20:

'That *Dublin City Council will seek to promote more sustainable development through energy end use efficiency, increasing the use of renewable energy, and improved energy performance of all new building developments throughout the City.*

This policy objective will be achieved by:

- *Encouraging responsible environmental management in construction*
- *Promoting sustainable approaches to housing developments by spatial planning, layout, design and detailed specification*
- *Ensuring high standards of energy efficiency in all housing developments and encouraging developers, owners and tenants to improve the environmental performance of the building stock, including the deployment of renewable energy*
- *Through the phased introduction of a performance based Building Energy Rating (BER) target for all new building developments greater than 10 dwellings or greater than 1,000 sq.m. floor area for non residential and mixed developments.'*

Paragraph 15.9.20 Energy Efficiency

'In accordance with Policy Residential 20, the Building Energy Rating (BER- calculated using the Dwelling Energy Assessment Procedure, ref. www.sei.ie) target shall require a collective (per sq.m) average BER rating of at least B1 (on a scale of A to G), effective from 1st January 2008 for residential developments greater than 10 dwellings and effective from 1st July 2008 for non residential and mixed developments greater than 1,000 sq.m. floor area.

The BER target shall further require a collective (per sq.m.) average BER rating of at least A3, effective from 1st January 2009, for all new building developments greater than 10 dwellings or greater than 1,000 sq.m. floor area for non-residential and mixed developments.

Accordingly it will be a requirement that all planning applications submitted to the planning authority after 1st January 2008 include a statement from a competent and qualified person certifying that the proposed development conforms with the energy rating outlined above.'

Adopted by the Dublin City Council on 5th Nov. 2007 [14]

Non-Technical Solutions

Energy Awareness Campaign

Some of the greatest savings in the commercial sector can be achieved using an effective energy awareness campaign. The way in which a building and the equipment is used can have major implications towards its energy consumption. For example, equipment on 'stand-by' can consume nearly as much power as fully operational equipment over its life time. Other behavioural actions include internal temperature settings, switching off lighting when not in use and closing windows when the heating is in operation.

It is vital to implement a coherent and well designed awareness campaign, followed by indicators of success which can be communicated to the employees. An energy management plan should be formulated in order to ensure this awareness campaign is successful and any other implementations are carried out

Energy Management Plan

The aim of an energy management plan is to achieve organisational objectives at the minimum energy cost, either through achieving the best tariff paid for energy used and/or reducing the energy consumed by the aforementioned technical and behavioural methods.

The company's energy performance can be measured and monitored with the help of good energy management. Good energy management incorporates an energy policy and is designed according to the principle "plan-do-check-act" (see next page).

Following this principle, good energy management leads to a continuous improvement. It is based on the three pillars: management, people and technology. Energy-saving measures require investment, but the investment for higher energy efficiency is paid off within a short time-span due to lower operational cost.

'What's involved in Energy MAP?

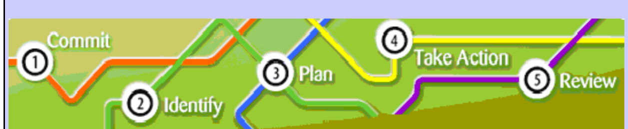
The effort required to manage energy effectively will vary depending on company size, energy costs and energy intensity. However energy costs can be controlled, and often reduced, by implementing measures that do not require significant investment. Although it is best practice, it is not absolutely necessary to complete all steps in the plan in sequence. Any of the 20 steps or 5 pillars can be completes on their own, or for more specific practical actions see the energy saving wizard (www.sei.ie).
Technical knowledge whilst an advantage is not required.

Who is it for?

Energy MAP was created for small and medium enterprises. By providing such a support tool it is hoped that SMEs will be in a position to implement best practice energy management strategies in their own sites. For very large energy users a variety of other programmes are available. See the business section of SEI's website for more information.

How do I begin? / Getting started

The best way to begin is by registering so that you can keep track of which steps you've read and completed. If you have already begun an energy management programme then go to the overview of Energy MAP to find out what stage you are at. Or, if you are new to energy management, you can just jump straight to the first pillar – Commit.'



[10]

Plan–Do-Check-Act

A method of planning, action and continuous action insures that any energy management plan will have the best chance of succeeding. The method is widely used in the ISO 14001 environmental standards as a way to ensure that proper actions are taken, the correct documentation is completed and records are kept.

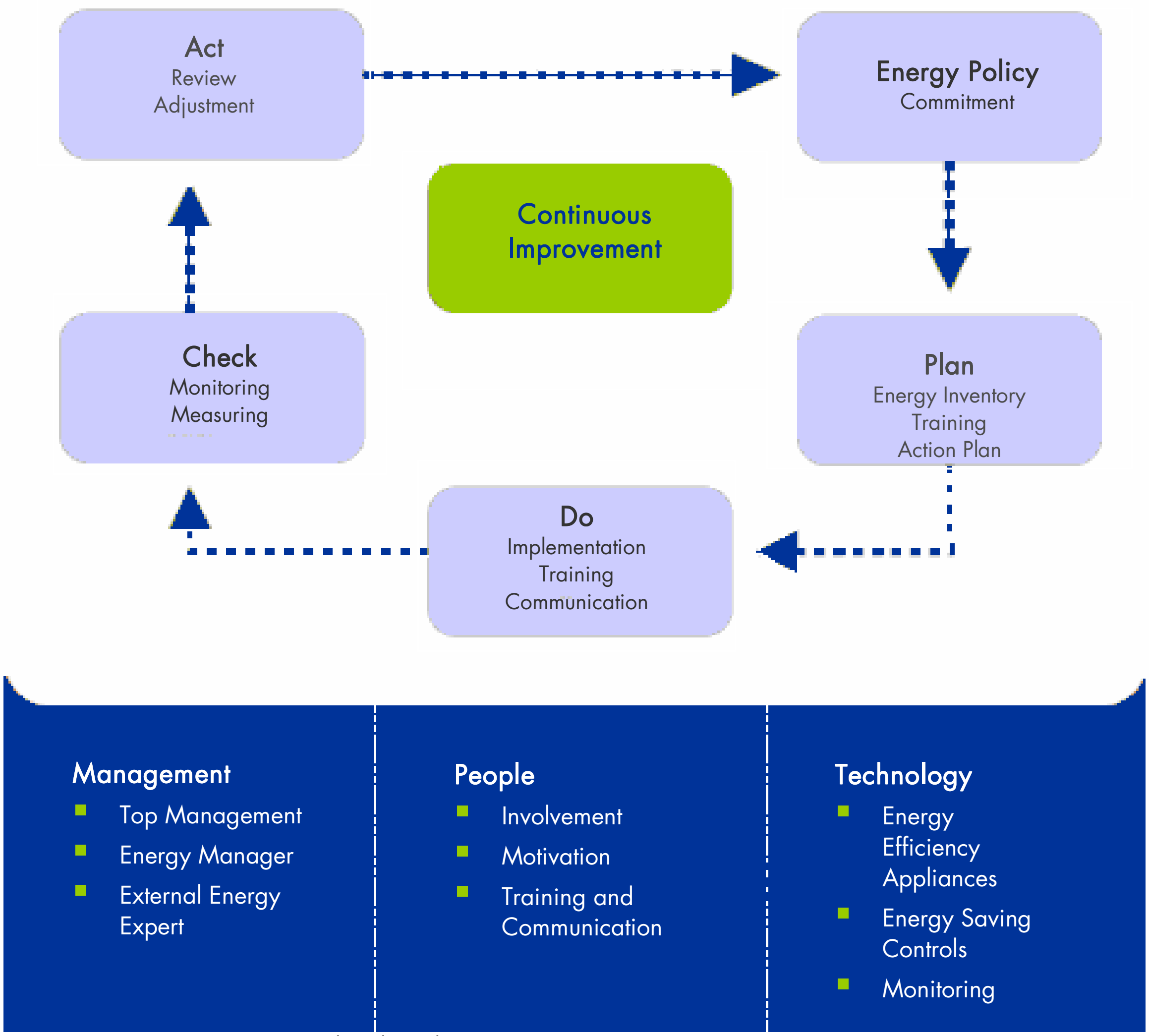


Figure 4.21: Energy Management Plan Flow Chart

Dublin City Council Leading by Examples

Hydro Power at Roundwood Reservoir

An innovative design of water turbine powers the water treatment works and exports the excess electricity into the national grid. This reduces Dublin City Council's own carbon footprint by 24 tonnes of CO_2 per year, saves €45,000 per year and contributes 0.2% renewable energy for the municipality's own energy use.

Renewable Energy

Vartry Waterworks contributes up to 85,000 m^3 of water daily to Dublin's water supply. A reservoir of11 million m^3 is retained by a 20 m high earthen dam, from which the filter beds are fed. An innovative 90 kW water turbine is been combined with a water flow restrictor in an integrated unit that controls the flow of water (by gravity) from the reservoir into the filter beds. At the same time, it generates enough electricity to meet the 50 kW energy needs of the Waterworks and exports the excess electricity into the grid.

Innovative Turbines

The innovative element in the design of the water turbine is integration of a wicket gate to control the flow of water within the turbine itself. To reduce the flow of water to the filter beds the wicket gate can be partially closed by an external control. The mechanism is designed to extract the maximum power from the water as it drops through a head of approximately 10 meters from the reservoir level. In the past, there was a simple flow valve, without energy recovery – so why not extract the free energy?

Examples of Alternative and Renewable Energy

Figure 4.22: CHP Finglas Swimming Pool, Dublin

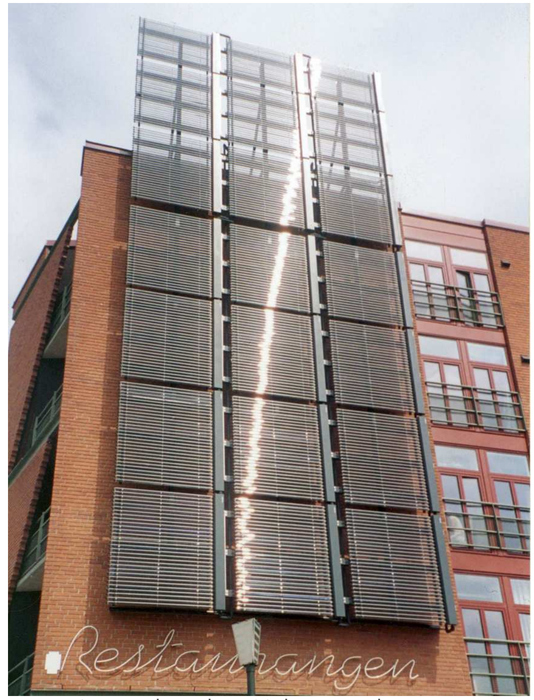


Figure 4.23: Solar Tubes, Malmö, Sweden

Figure 4.24: Wind Turbines, Fr Collins Park, North Fringe, Dublin (under construction May 2008)

Case Study

Medium Sized Office Based Enterprise

Codema carried out a case study with an SME employing 80 staff. The company has recently moved its office to a newly built commercial building in the Docklands. It is now a tenant in an open plan office of 630m² with a few cellular units.

The first audit on energy includes the two main areas for energy saving: heating and cooling and electricity. The following analysis of these two areas outlines the challenges and the potentials for energy savings. Worst case scenarios are drawn and saving potentials for energy, CO_2 emissions and costs are calculated using the data collected during the first site visit. Detailed usage analysis can show to what extent the real office situation matches the worst case scenario.

Heating and Cooling

The building fabric, choice and operation of the heating and cooling systems are the three components responsible for the energy demand. The building incorporates a glass facade. Glass facades usually lead to a higher heating and cooling demand compared with a masonry building. The heat energy demand is higher because glass has a higher U-value than a wall. Higher U-values mean that the heat transfer through the glass is higher and this lost heat has to be covered by more heat energy input.

In the summer months the cooling demand is higher in rooms oriented to the south-west, because the heat of the sun passes through the glass and would overheat the room if no cooling system were in place. This can be avoided by the installation of sun blinds; however, these may cause over-shadowing and result in the use of artificial lighting.

The building is equipped with an air-conditioning system delivering warm or cool air. The system is supposed to adjust regularly according to the temperature measured in the office. During the site visit the following observation was made: Although it was quite a cold day, the windows were open because the indoor temperature was above-average. It was obvious that the office was over-heated and that the air-conditioning system needs to be adjusted.

Electricity

Electricity is used for heating purposes as well as for lighting, office equipment and white goods.

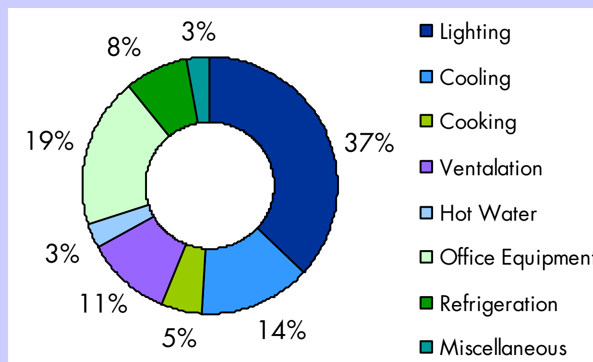


Figure 4.25: Electricity Use in a Typical Office

White goods:
Fridge, dishwasher and drink machines etc. are common in an office. Energy-efficient A-labelled white goods operational costs are lower. During their usage energy can be saved by optimising the operation temperature of the fridge and by reducing the frequency of using the dishwasher through space-saving arranging of the dishes.

Lighting:
There are more than 400 lamps and although they are all energy efficient types, the total power installed is 21 kW. During the site visit it was noticed that lights were on although there was sufficient natural light coming through the windows. Some windows were completely shadowed with blinds in order to avoid glare on the monitors.

Glare could also be avoided by a new arrangement of the monitors and by using semi-transparent blinds that would allow natural light to enter the room making artificial light unnecessary.

The worst case scenario assumes that all lights are on during office hours throughout the year, resulting in costs of nearly €9,100. But in fact, artificial lighting is only needed during winter months. By switching off the lights when not needed, the costs will be just 25%; saving €6,500 and 25 t of CO_2 emissions.

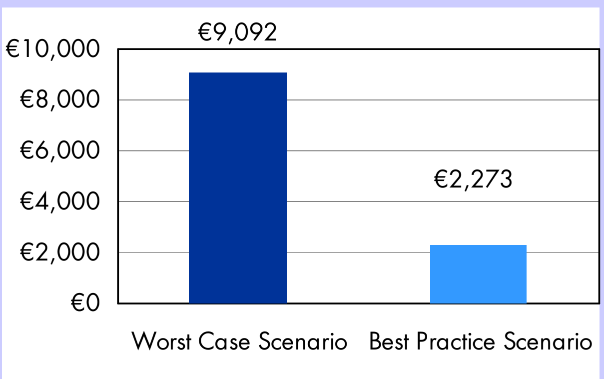


Figure 4.26: Savings for Best Practice in Lighting

Office equipment:
A few printers and photocopiers and 100 computer workstations are in place. In the worst case scenario it is assumed that 40 energy-efficient computers and CRT-monitors are left in the operation mode outside the office hours. Switching off these 40 PCs (plus CRT-monitors and disconnecting them from the power supply with the help of a multiple socket) outside of the office hours during one year results into cost savings of more than €3,300. This corresponds to a saving of more than 13,000 kWh energy and 8.4 t CO_2 emissions

If all recommendations were implemented an overall saving in costs, energy and CO_2 emissions of 20% could be expected.

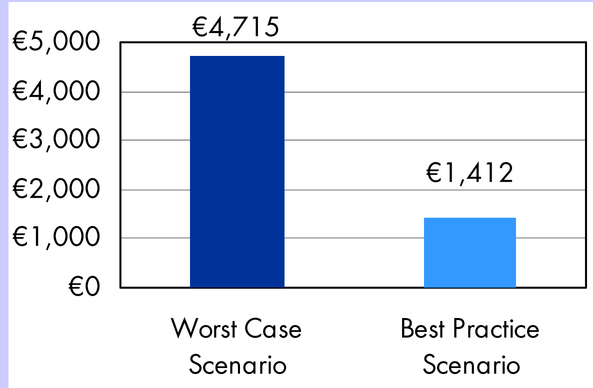


Figure 4.27: Savings for Best Practice in Office Equipment

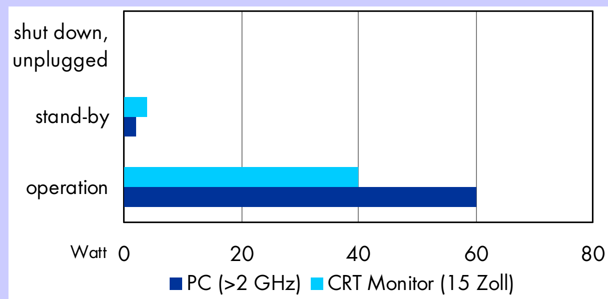


Figure 4.28: Typical Wattage for the Operation of a Computer Station

Scenarios for the Services Sector

Business As Usual

Business as usual describes the situation when present levels of energy use are sustained, coupled with predicted growth for the sector. The trend is estimated by applying predicted national growth in employment to the commercial sector as a year on year average from ERSI projections [1].

Scenario 1

Low Energy Lighting and Behavioural Changes
Lighting accounts for between 15% and 50% of total electrical consumption (depending on the activity and based on traditional lighting systems).

In this low cost scenario it was assumed that there could be a 10% saving in electricity demand through upgrading lighting systems to low energy fluorescents and spot bulbs. This is a modest assumption compared to larger savings that have been quoted (up to 40% savings on lighting) [11]. The new lighting should be installed when previous conventional bulbs have reached the end of their life-cycle.

In tandem with an upgrading of the lighting system is the opportunity for behavioural change and training within companies, behavioural change as discussed (see page 62) has shown a possible improvement of up to 20% on energy demand. To make this figure more conservative it was assumed that activities such as retail and hospitality would have less control over the energy use compared to office based activities. Therefore a saving of 5% was estimated for all non office based activities in electricity demand and a 20% saving in all office based activity electricity demand. A saving of 10% in oil and gas consumption was estimated as it was assumed that these fuels were mostly used for space heating.

The scenario was gradually introduced over the period of 2009 – 2014 and any electricity savings from a behavioural change took into account the changes to low energy lighting.

Scenario 2

The commercial sector is unique from the residential because year on year premises are becoming less energy efficient.

According to recent studies [12] modern commercial premises with air conditioning use 37.5% more energy than premises using a good practice model. It is estimated that 60% of both the retail and restaurant activities have either upgraded or have been purpose built with air conditioning and 40% of office activities using this form of ventilation.

This scenario is based on an upgrade to the heating, ventilation and air conditioning systems (HVAC) as well as improved thermal efficiency of the building fabric. The estimations and technical information are based on a UK model of office refurbishment [13] as no studies have been done in Ireland to date, but the climatic conditions and general fabrics are very similar. Office refurbishment to this level can be highly disruptive to day to day activities and as such it was estimated that only 50% of premises would consider this process and in an ideal situation would take at least 5-6 years to implement.

In addition all new build commercial buildings over 1000m^2 according to variation 22 of the Dublin City Development plan [14] will be required to meet a BER standard of B1 by July 2008 and A3 by 2009. The increase in this efficiency has not been incorporated into future trends of energy and CO_2 but should be noted that this may have a positive affect on these trends.

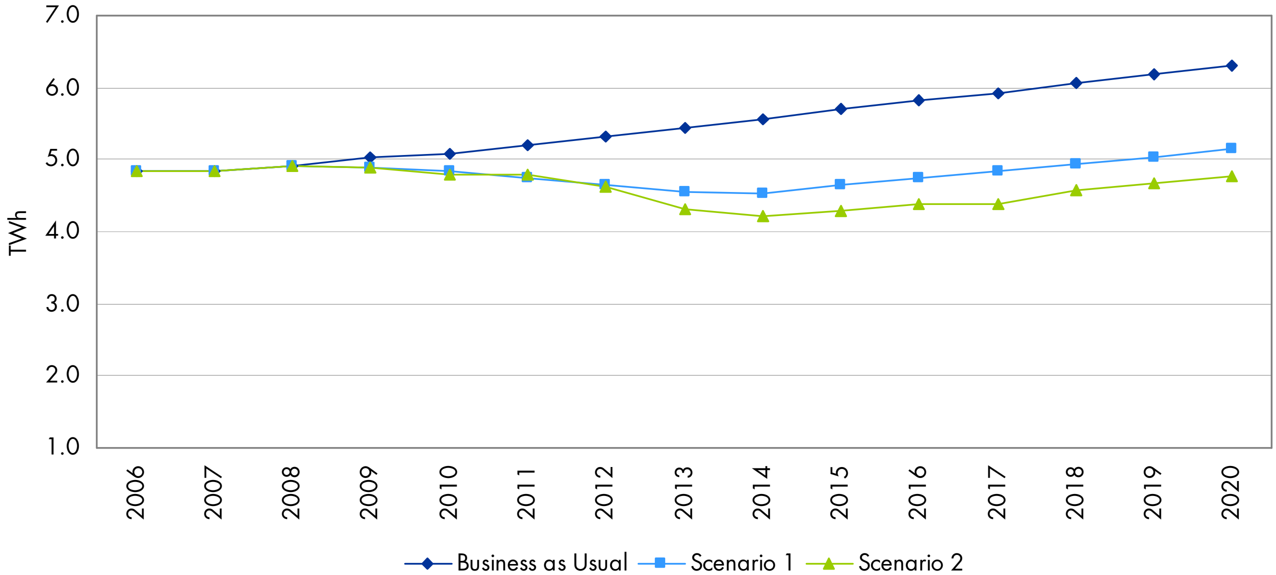


Figure 4.29: Projections for Energy Demand in Business as Usual and Scenarios 1 and 2, 2006-2020

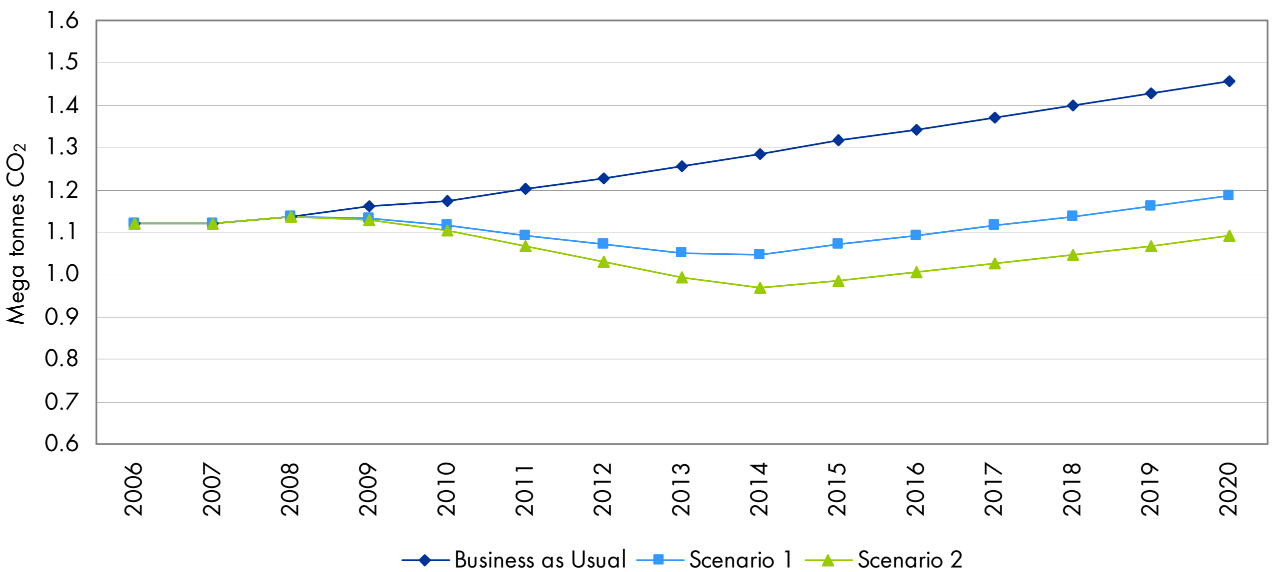


Figure 4.30: Projections for CO_2 Emissions in Business as Usual and Scenarios 1 and 2, 2006-2020

Analysis of Scenarios

Business As Usual

This refers to a continuation of the present situation up to 2020, as all calculations for the sector are made per head of employee future trends are dependent on growth in the sector. To this end an estimated employment growth trend [1] was applied to the sector and its future energy and CO_2 trends extrapolated. This produced an increase of 30% in both energy consumption and CO_2 emissions.

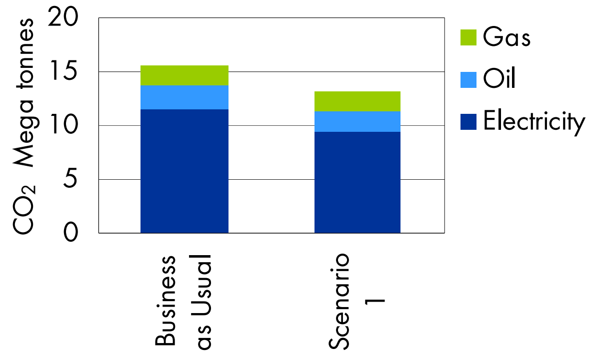


Figure 4.32: Emissions of CO_2 per Fuel Type, Business as Usual compared to Scenario 1, 2006 to 2020

Scenario 1

As discussed, introducing a program of replacing conventional lighting with low energy lighting (when conventional lighting needs replacing routinely) and implementing behavioural change within the office to change the way energy is consumed by the end users from 2009 to 2014. This is estimated to produce a cumulative saving of 15% or 10.2 TWh; the major savings are to be had in electricity use of upwards of 18% and an 8% saving in both oil and gas. Because of the higher savings in electricity the overall CO_2 savings are slightly larger then the energy savings at 15.3%.

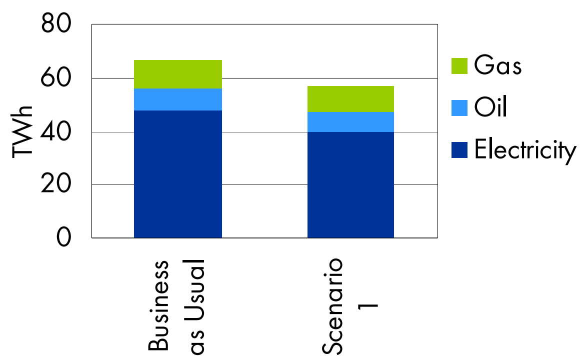


Figure 4.31: Energy Use in TWh per Fuel Type, Business as Usual compared to Scenario 1, 2006 to 2020

Scenario 2

By improving the thermal efficiency of the building fabric and improving the HVAC in 50% of office based businesses from 2009 to 2015 there is a 21% or 13.9 TWh saving in energy compared to the business as usual model and a 6% increase in savings compared to lighting and behaviour on its own. This translates as a 21% saving on business as usual CO_2 emissions.

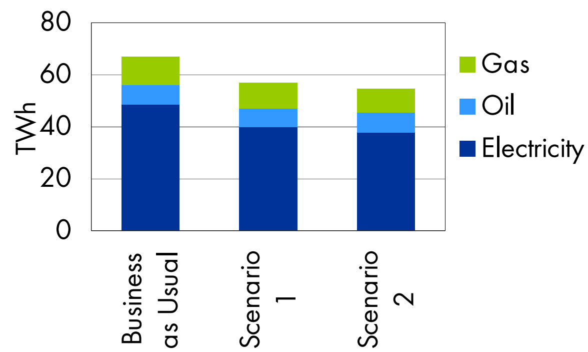


Figure 4.33: Energy Use in TWh per Fuel Type, Business as Usual compared to Scenario 1 and 2, 2006 to 2020

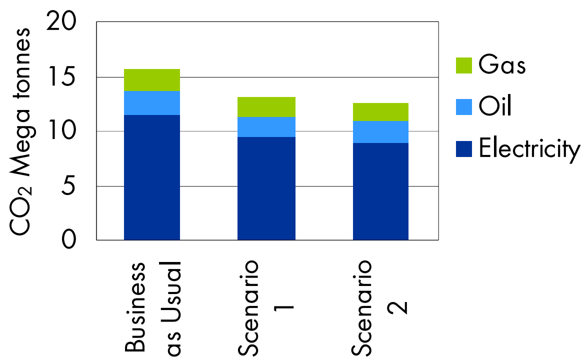


Figure 4.34: Emissions of CO_2 per Fuel Type, Business as Usual compared to Scenario 1 and 2, 2006 to 2020

Conclusions

Manufacturing

The manufacturing sector in Dublin City has been migrating from the city centre over many years and this trend continues to 2020. Although the sector only accounts for 6% of employment it consumes 20% of the total energy due to its energy intensive activities. The sector's CO_2 emissions and energy demand will decline toward 2020, but there is still wide scope for energy saving measures to be implemented to magnify this saving.

	2006	2020	Difference
TWh	4.4	3.5	- 20%
CO_2 ktonnes	990	800	- 20%

Table 4.5: Potential Savings Scenario 1 compared to Business as Usual

Services

The services sector continues to grow apace and the commercial building industry seems more buoyant then the residential sector at the moment, due to Dublin City's continuing attractiveness as a business location. In 2006 the services sector consumed 4.8 TWh of energy and emitted 1,120 ktonnes of CO_2, within the sector office based activities were dominant in both employment numbers and energy demand.

The trend for the services sector in a business as usual model was for a 30% increase in both energy consumed and CO_2 emissions. Under the two scenarios discussed there are potential savings of between 10.2 and 13.9 TWh and between 2,370 ktonnes and 3,263 ktonnes of CO_2.

	Energy Saving	CO_2 Saving
Business as Usual	+ 30%	+ 30%
Scenario 1	-15%	-15%
Scenario 2	-21%	-21%

Table 4.6: Potential Savings Scenario 1 and 2 compared to Business as Usual

Financial Analysis

Introduction

This section focuses on the possible financial costs and benefits of the proposed actions. They will together form the scenarios with low energy lighting and behaviour forming one scenario and this in addition to improvements in building fabric and HVAC forming the second. Below is a table showing the implementation periods of the actions along with the statutory action of improved regulations [14].

Details of Proposed Actions

Low Energy Lighting

This action when implemented over a six year period (and continuing for new employees until 2020), produces a cumulative saving of 7% compared to Business as Usual. Because all of the actions concentrate on electricity use within the activities upwards of 9% can be saved in electrical use and an overall CO_2 emissions savings of 7% can be achieved when compared to business as usual.

Cost is based on purchase of low energy florescent tube and spot lighting plus labour. Savings are based on the savings on electricity on a general purpose (SME) day tariff.

Possible Savings	Energy	4,424 GWh
	CO_2	1,053 ktonnes
Capital Cost	€15 million	
Cost Savings	€290million	
Business	€264 million	
Carbon Credits	€ 26 million	

Behavioural Actions

This action involves each employee attending an energy saving behavioural course over the 6 year implementation period. Savings vary depending on the activity, for example, up to 20% can be saved on electricity and 10% in both oil and gas in office activities. This may not be possible in retail or catering etc as there is a limit to saving options. Costs are based on each employee attending an energy map type course. This action takes into account the installation of low energy lighting.

Possible Savings	Energy	5,680 GWh
	CO_2	1,316 ktonnes
Capital Cost	€107 million	
Cost Savings	€369 million	
Business	€336 million	
Carbon Credits	€ 33 million	

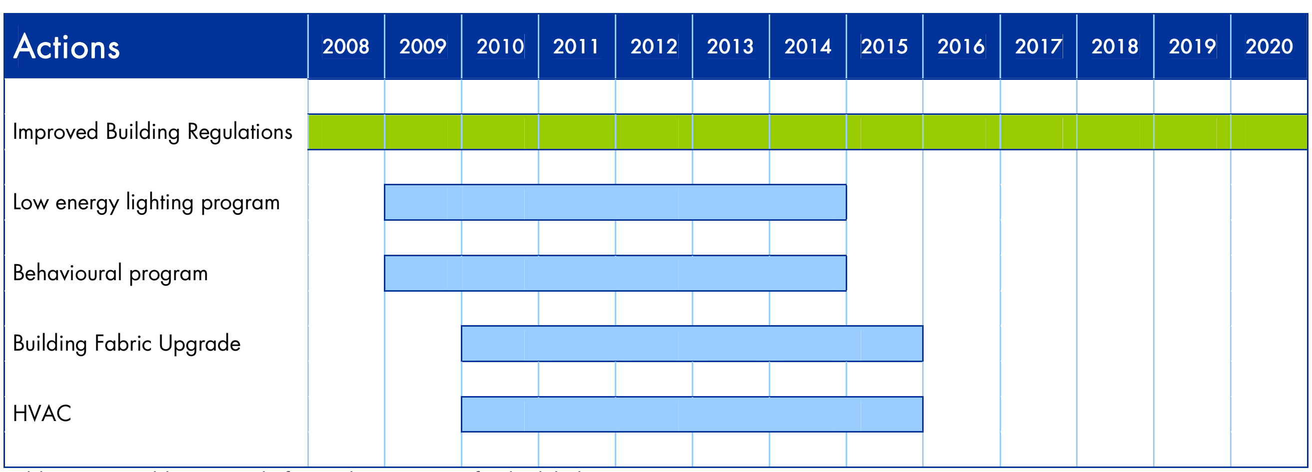


Table 4.7: Possible Timescale for Implementation of Scheduled Actions

Building Fabric and HVAC Improvements

This set of actions when implemented over a six year period (and continuing for new employees until 2020), produced a cumulative saving of 6%. They are based on the refurbishment of building fabric and improving HVAC in 50% of office based activities over 6 years. The energy and cost savings are based on a UK study of office refurbishment [13]; the measures include boiler upgrade, heating control upgrade and the improvement to building fabric.

Possible Savings	Energy	3,833 GWh
	CO_2	894 ktonnes
Capital Cost		€396 million
Cost Savings		€250million
Business		€228 million
Carbon Credits		€ 22 million

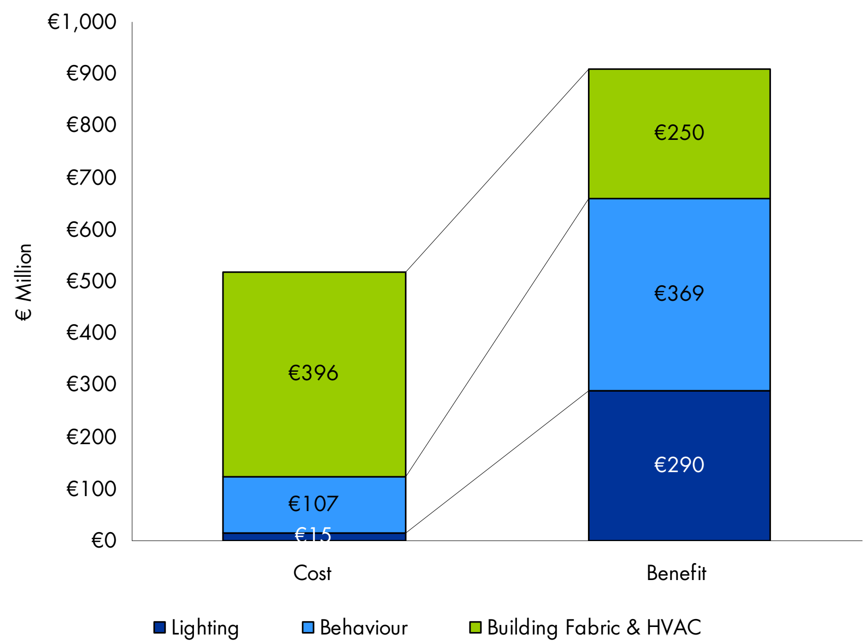


Figure 4.35: Cost-Benefit-Analysis for Proposed Actions

Actions	Primary Energy Savings	CO_2 Savings	Cost Savings	Costs of Action	Benefits to Cost Ratio
	TWh	ktonnes	million €	million €	
Lighting	4.4	1,053	€290	€15	19.3
Behaviour	5.7	1,316	€369	€107	3.5
Building Fabric and HVAC	3.8	894	€250	€396	0.63
Total	13.9	3,263	€909	€518	1.75

Table 4.8: Cost and Savings of Proposed Actions

Conclusions

- The Services sector shows signs of continual growth in both employment and construction of commercial property, the manufacturing sector is predicted to decline in Dublin City.
- The two sectors combined are the biggest consumer of energy in Dublin City.
- There are substantial energy savings possible through cost effective actions such as low energy lighting and behavioural change within the services sector.
- Fabric and HVAC improvements are more costly and disruptive, but through DCC initiatives (variation 22), future commercial buildings will be more energy efficient.

Services

	Description	Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Current Situation	Energy Consumption / CO_2 Emissions 2006	4.8	1,120
Business As Usual	Business as Usual – 2020	6.3	1,457
Scenario 1	Low energy lighting and behavioural actions	5.1	1,185
Scenario 2	Low energy lighting, behavioural actions and improvements to building fabric and HVAC	4.7	1,091

Table 4.9: Current Situation and Scenarios for the Primary Energy Consumption and CO_2 Emissions

Manufacturing

	Description	Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Current Situation	Energy Consumption / CO_2 Emissions 2006	4.4	990
Business As Usual	Business as Usual – 2020	3.5	788
Scenario 1 and 2	Not defined for manufacturing		

Table 4.10: Current Situation and Business As Usual for the Primary Energy Consumption and CO_2 Emissions

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Analysis of Transport Sector

Introduction

Transport in Dublin has experienced an immense and unforeseen growth in the last 15 years. Between 1990 and 2006 the number of road vehicles registered in the Dublin Region increased by 104%. The main factors contributing to this increase are economic growth, increase in population and labour force and growth in car ownership.

The impacts of this growth are a 167% increase of primary energy consumption and a 168% increase of CO_2 emissions originating from transport in the City of Dublin between 1990 and 2006 along with congestion, noise and air pollution, health problems and subsequent costs for the business community and public.

The current trends are:

- Number of private cars in total and per capita is increasing.
- Engine size of private cars is increasing.
- Share of trips to work by car is increasing.
- Share of trips to school made by car is increasing.
- Level of congestion is increasing.
- Average speeds on roads are decreasing.

In the City of Dublin transport accounts for 23% of the primary energy consumption and 25% of CO_2 emissions.

Sector	Primary Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Residential	7.8	1,570
Services	4.8	1,120
Manufacturing	4.4	990
Transport	5.0	1,240
Total	22.0	4,920

Table 5.1: Primary Energy Consumption and CO_2 Emissions in the City of Dublin in 2006

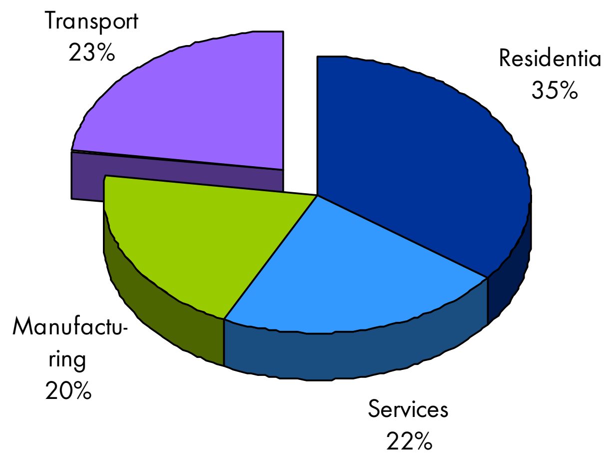

Figure 5.1: Primary Energy Consumption in the City of Dublin by Sectors in 2006

Methodology

The transportation system in the City of Dublin is strongly cross-linked with its surrounding counties and trips made in the City of Dublin originate not only within the city area but throughout Dublin City and County and in the Greater Dublin Area (GDA) at its outer limit. Therefore, traffic in the City of Dublin can not be considered in isolation.

Hence, the volume of road traffic and associated energy consumption and CO_2 emissions are calculated for Dublin City and County in order to master this complexity of transport. The figures are then broken down in proportion to the population living in the City of Dublin. A break down according to the number of people working in the City of Dublin was considered, as work places are the main driver for rush hour traffic congestion, but not applied as 70% of the trips have a journey purpose other than work [1].

The capital investment framework Transport 21 and transport in the Greater Dublin Area are considered within this report. However, they are not subject matter for the calculations of energy and CO_2 emissions as the focus lies with the City of Dublin and its sphere of influence and secondly, scenarios are drawn for a period up to 2020, therefore exceeding the time framework of Transport 21.

Sources of Information

A number of sources are drawn on for the calculations of energy consumption and CO_2 emissions:

Central Statistic Office (CSO):
- Road Freight Transport Survey 2006
- Census 1996, 2000 and 2006
- Census 2006 Place of Work - Census of Anonymised Records (POWCAR)

Department of the Environment (DEHLG):
- Conversion factors for energy and CO_2
- Irish Bulletin of Vehicle and Driver Statistics annually published, 1990- 2005

Department of Transport (DoT):
- Irish Bulletin of Vehicle and Driver Statistics 2006

Dublin Transportation Office (DTO):
- Greater Dublin Area Household Survey 2006
- Travel to Education Survey 2006

Dublin Bus, Railway Procurement Agency (RPA), Iarnród Éireann:
- Annual energy consumption of fleet

Sustainable Energy Ireland (SEI):
- Analysis of national car test data 2008
- Energy in Transport. 2007 Report
- Energy in Transport. Trends and Influencing Factors. 2006 Report
- Energy Statistics 1990-2005

Figure 5.2: Transport is dominated by Car Traffic

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Analysis

City of Dublin

The City of Dublin is responsible for 43% of the primary energy consumption and associated CO_2 emissions originating from transport in Dublin City and County; 5 TWh and 1,240 ktonnes CO_2 emissions. This break down is based on the ratio of population living in the City of Dublin.

Dublin City and County

The primary energy consumption of transport in Dublin City and County is 11.8 TWh which emits 2,900 ktonnes CO_2.

Transport is dominated by private car traffic (64%) and road freight (22%), together accounting for almost 90% of primary energy consumption and CO_2 emissions.

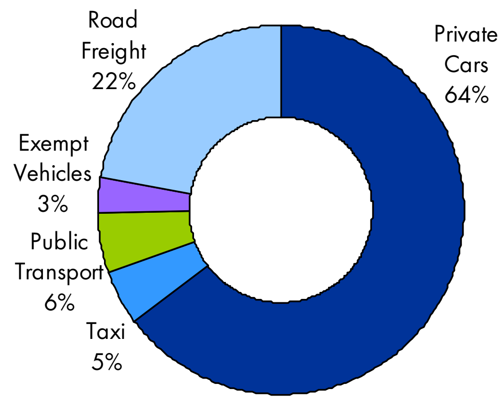


Figure 5.3: Primary Energy Consumption of Transport in Dublin City and County in 2006

Public transport and taxis have a 6% and 5% share respectively. Exempt vehicles account for 3% of the sectoral primary energy consumption. CO_2 emissions are distributed likewise.

Transport Mode	Fuel	Number of Vehicles	Passenger Journeys (m)	Primary Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Pedestrian Traffic	n/a	0	222	0	0
Bicycle Traffic	n/a	0	23	0	0
Private Cars	Petrol/Diesel	470,952	556	7.63	1,879
Taxis	Petrol/Diesel	11,567	27	0.55	136
Dublin Bus	Diesel	1,082	146	0.36	89
Other Buses	Diesel	203	27	0.07	17
LUAS	Electric	40	26	0.04	8
DART	Electric	154	20	0.09	21
Commuter	Diesel	132	13	0.09	23
Exempt Vehicles	Petrol/Diesel	7,572	n/a	0.34	83
Road Freight	Diesel	59,101	n/a	2.63	651
Total				11.8	2,907

Table 5.2: Key Figures for the Various Modes of Transport in Dublin City and County in 2006 [1]

[1] In comparison CO_2 emissions generated from air transport through Dublin airport are approx. 2,100 ktonnes.

Key Figures in 2006

Pedestrian and Bicycle Traffic

In 2006 pedestrian traffic amounted to 222m and bicycle traffic to 23m passenger journeys in Dublin City and County [2] while energy consumption and CO_2 emissions are zero.

Private Cars

The primary energy consumption of private cars is 7.63 TWh and associated CO_2 emissions are 1,879 ktonnes in Dublin City and County in 2006.

There are 470,952 private cars registered in Dublin City and County [3]. The average mileage is 13,113 km per petrol vehicles and 21,882 km per diesel vehicles according to SEI analysis of the national car test data [4] summing up to a total of almost 7,000 million vehicle-km in 2006. The specific fuel consumption of new cars in 2000 is computed for the average fuel consumption of the car fleet [5]. These figures are chosen because the number of cars sold in 2000 in Ireland was exceptionally high [6]. Next, a factor of 1.4 is introduced in order to account for higher fuel consumption due to city driving and congestion. Private cars are accounting for 556m passenger journeys [2].

Taxis

Taxis consume 0.55 TWh primary energy and causes 136 ktonnes CO_2 emissions. 11,567 taxis are registered, providing estimated 27m passenger journeys. The average mileage is 33,733 km per petrol vehicle and 51,944 km per diesel vehicle [4] amounting to 502 million vehicle-km in 2006. In order to calculate the fuel consumption the same approach as that for private cars is applied.

Bus

The primary energy consumption is 0.43 TWh and associated CO_2 emissions are 106 ktonnes. Bus services are mainly provided by Dublin Bus and to a smaller extent by other operators. Dublin Bus has a fleet of 1,082 vehicles delivering 146m passenger journeys while taking up 29 million litre of diesel fuel [7]. Other bus operators provide approx. 27m passenger journeys [2].

LUAS

The LUAS operated 40 vehicles and reported 26m passenger journeys in 2006 [8]. The electricity consumed amounts to almost 14 million kWh [9] corresponding to 0.04 TWh and associated CO_2 emissions of 8 ktonnes.

DART and Commuter

Dart and commuter trains are carrying 20m and 13m passengers respectively while using 34 million kWh electricity and 7 million litre diesel fuel [10]. The primary energy consumption of both is 0.18 TWh and associated CO_2 emissions are 43 ktonnes (rounded).

Exempt Vehicles

Exempt vehicles (including government owned, diplomatic, special (invalid), fire brigade vehicles, ambulances and rescue service vehicles) account for 0.34 TWh primary energy and 83 ktonnes CO_2 emissions. The average mileage is computed to be 40,225 km per vehicle [11] and there are 7,572 vehicles registered [3].

Road Freight

Road freight consumes 2.63 TWh while causing 651 ktonnes CO_2 emissions. This figure is obtained by breaking down the national final energy demand of road freight (1,186 ktoe) [12] according to the 17.4% share of tonne-km carried in Dublin City and County [13].

Energy Efficiency of Travel Modes

The analysis of passenger traffic in Dublin City and County shows that 55% of passenger journeys are undertaken by private car and taxi, using 93% of primary energy consumption. In contrast, 22% of passenger journeys are undertaken by public transport, which accounts for 7% of primary energy consumption. Bicycle traffic represents 2% of passenger journeys while pedestrian traffic amounts to 21%, neither of which consumes any primary energy.

Therefore, bicycle and pedestrian traffic are the most energy efficient and consequently most sustainable modes of transport, while journeys by private cars and taxis are the least energy efficient ones.

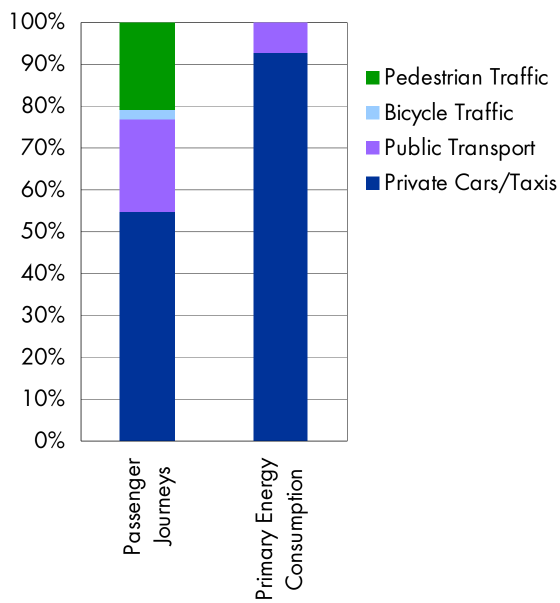
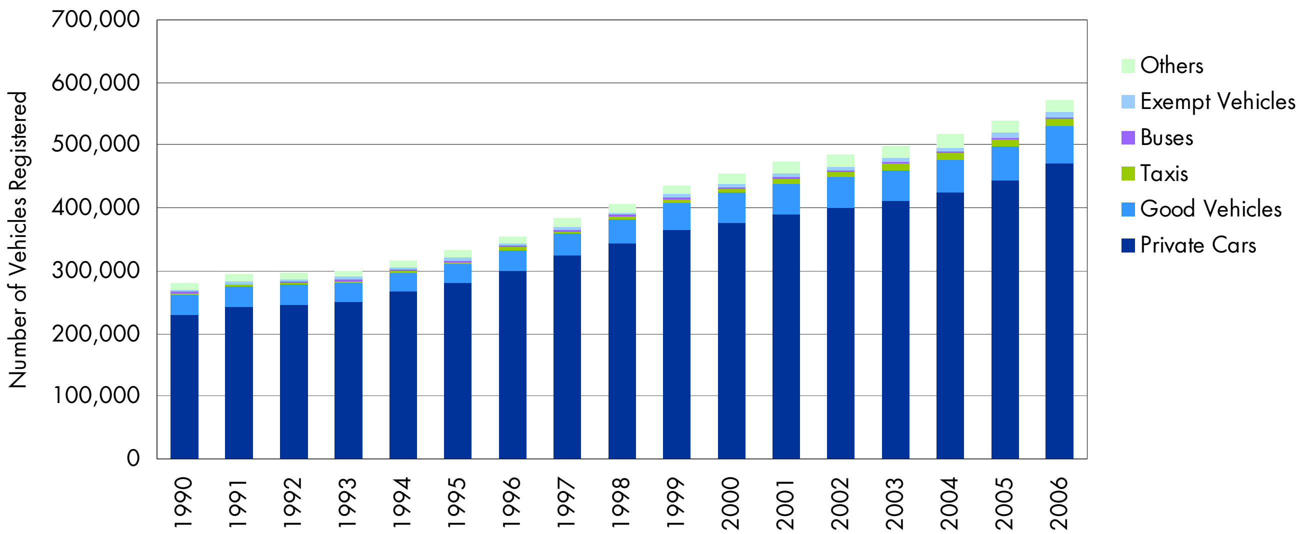
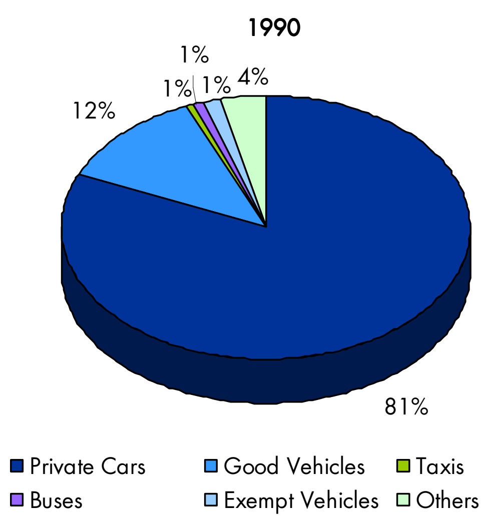


Figure 5.4: Modes of Passenger Traffic in Dublin City and County: Passenger Journeys, Primary Energy Consumption and CO_2 Emissions

Traffic Statistics in Dublin City and County

The total number of road vehicles registered in Dublin City and County has increased by 104% between 1990 and 2006 to reach 572,733 in 2006. The share of the different types of vehicles has not changed significantly. Private cars represent the great majority, with a share of over 80%. Detailed information is given on the following pages [3] [14].





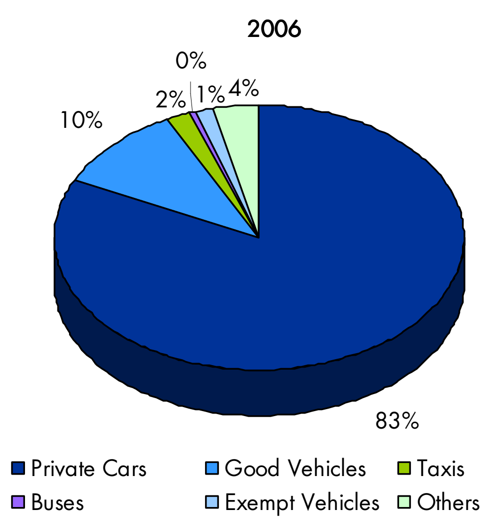
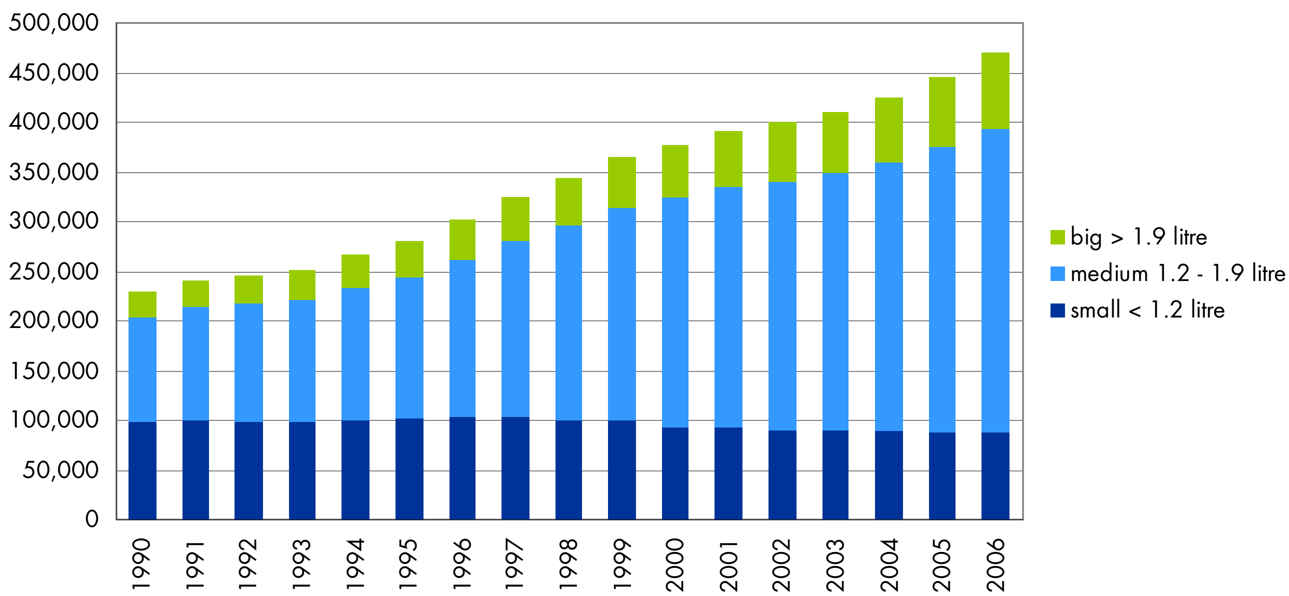
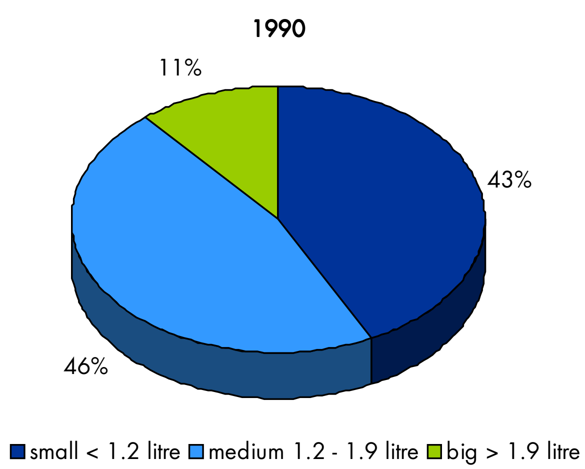


Figure 5.5: Road Vehicles Registered in Dublin City and County 1990 to 2006

Private Cars

In the Dublin Region the number of private cars registered increased by 105% between 1990 and 2006, accounting for 470,952 vehicles in 2006. While the number of cars with an engine size of 1.2 litres or less is steadily declining, the number of cars with an engine size of larger then 1.2 litres is continuously rising. In 1990 cars with an engine size of 1.2 litres or less had a share of 43%, but accounted for only 19% in 2006. In contrast, cars with an engine size of 1.2 to 1.9 litres represented 46% in 1990, but 64% in 2006. Cars with an engine size of more than 1.9 litres also increased, from 11% in 1990 to 17 % in 2006. 84% of private cars are running on petrol and 16% on diesel.





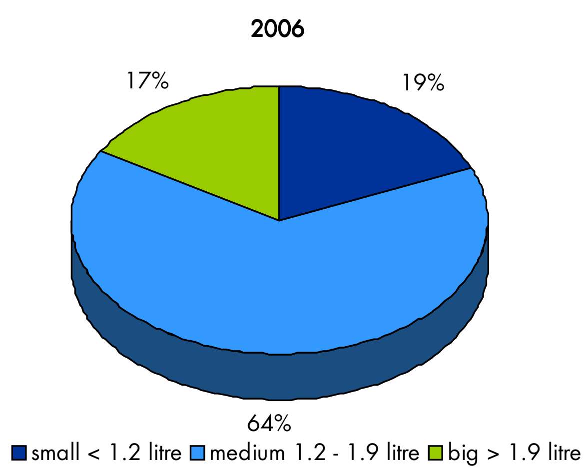


Figure 5.6: Private Cars Registered in Dublin City and County 1990 to 2006

Private Car Ownership

The number of cars per 1,000 of population increased by 77% from 224 in 1990 to 397 in 2006. It is still lower than the national average of 420 in 2006 or the EU 25 average of 476 in 2005 [15].

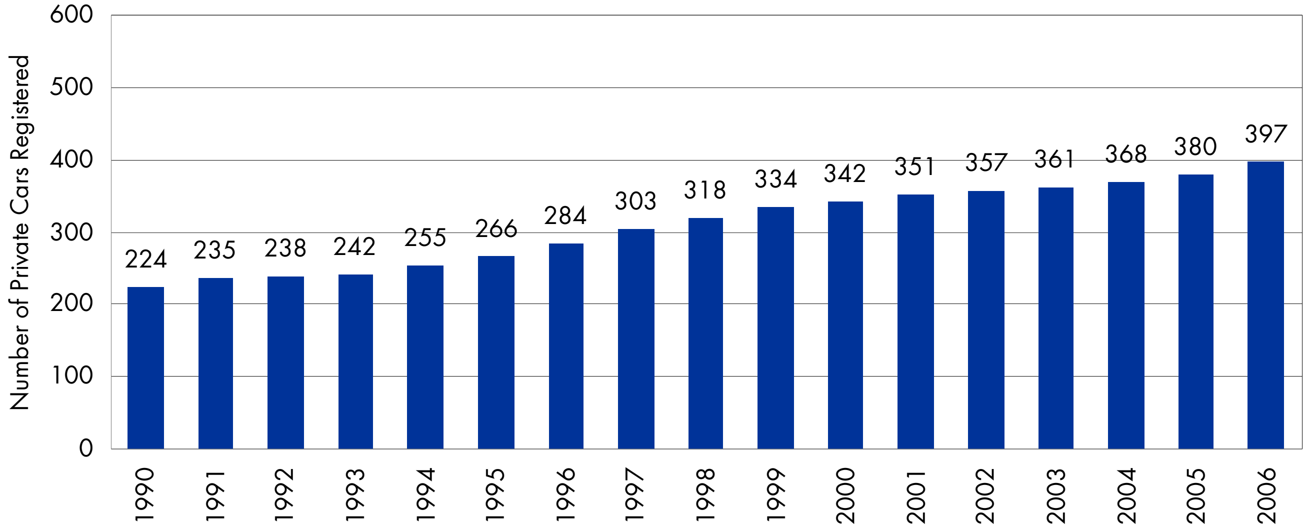


Figure 5.7: Private Cars per 1,000 of Population Registered in Dublin City and County 1990 to 2006

Taxis

In the Dublin Region the number of taxis (including taxis, hackneys and limousines) increased by 522% between 1990 and 2006 from 1,859 to 11,567. 47% of taxis run on petrol, 53% on diesel.

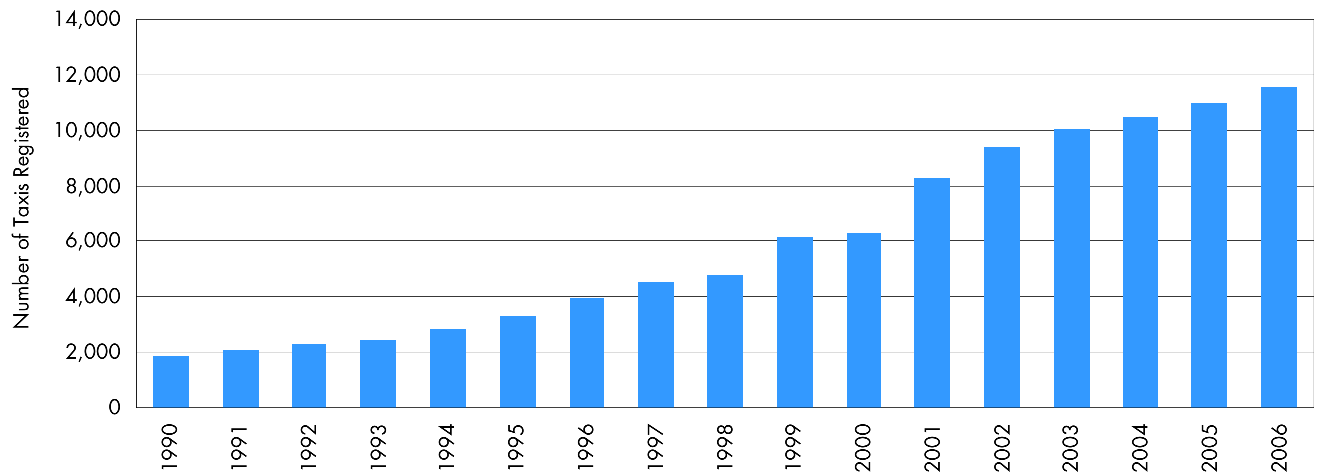


Figure 5.8: Taxis Registered in Dublin City and County 1990 to 2006

Buses

The number of buses in the Dublin Region increased by 53% from 1990 to 2006, accounting for 2,686 vehicles in 2006. 40% of the buses belong to Dublin Bus.

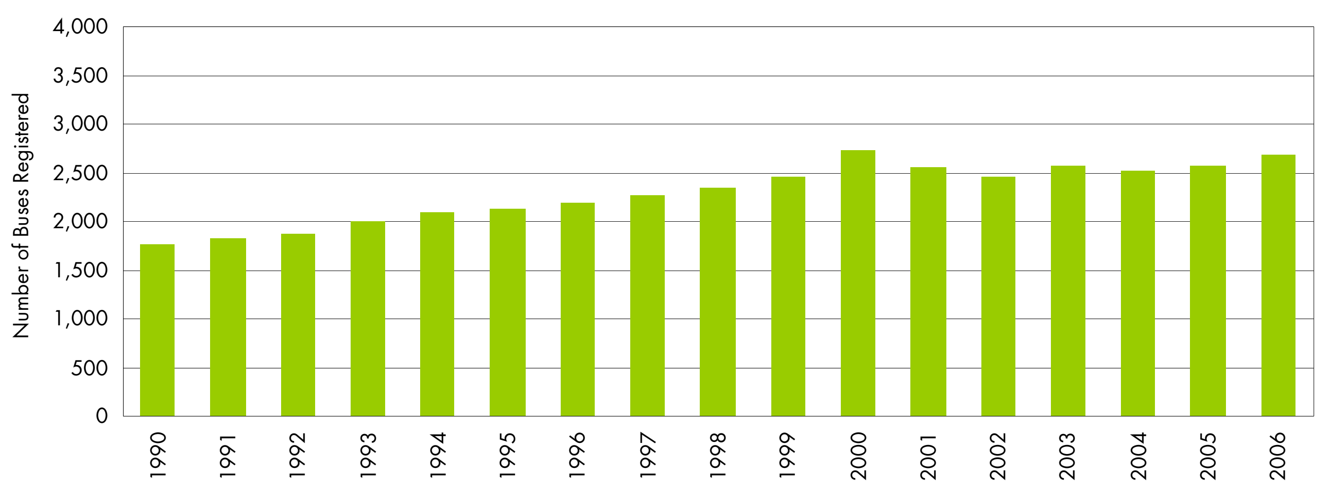


Figure 5.9: Buses Registered in Dublin City and County 1990 to 2006

Taxis versus Buses

The number of buses in Dublin City and County is 2.3 per 1,000 of population in 2006 compared with 1.7 in 1990. By contrast, the number of taxis is exceptionally high in Dublin City and County with 9.7 taxis per 1,000 of population in 2006. This remarkable increase is due to the deregulation of licenses in 2000 and due to the demand for travel by Dublin's citizens – a demand that is not met by the current public transport in place.

In total, there are more than 11,500 taxis registered in the Dublin City and County, serving a population of almost 1.2 million inhabitants. In comparison, there are 21,700 taxis available to the population of 7.5 million in London, corresponding to 2.9 taxis per 1,000 of population in London [16].

In the statistics taxis are termed as 'small public service vehicles' as opposed to 'large public service vehicles' such as buses. Comparing the share of small and large public service vehicles shows that the share of taxis was 51% in 1990 but increased to 81% in 2006.

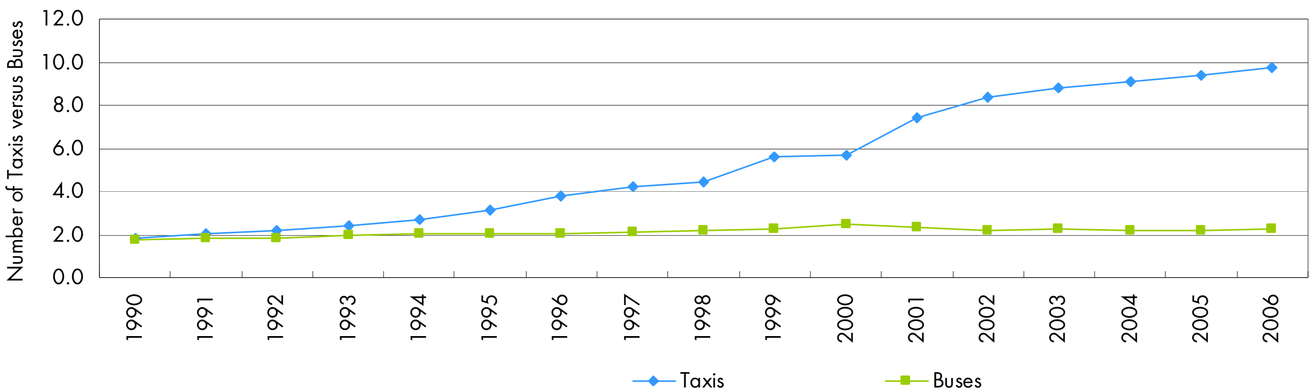


Figure 5.10: Taxis and Buses per 1,000 of Population Registered in Dublin City and County 1990 to 2006

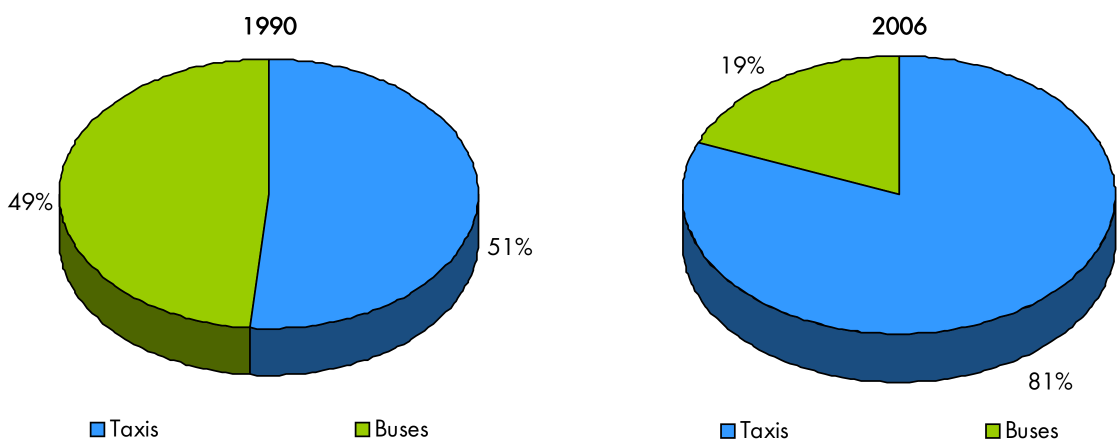


Figure 5.11: Share of Taxis and Buses Registered in Dublin City and County in 1990 and 2006

Exempt Vehicles

In Dublin City and County the number of exempt vehicles (including government owned, diplomatic, special (invalid), fire brigade vehicles, ambulances and rescue service vehicles) increased by 88% between 1990 and 2006 from 4,022 to 7,572. 53% of exempt vehicles run on petrol, 47% on diesel.

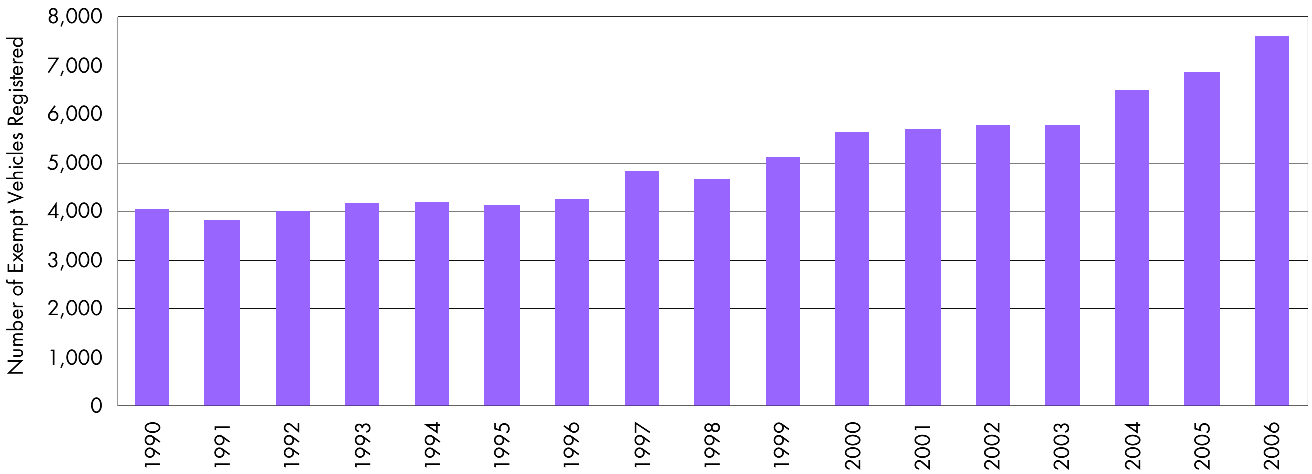


Figure 5.12: Exempt Vehicles Registered in Dublin City and County 1990 to 2006

Road Freight

The number of goods vehicles registered in the Dublin Region increased by 78% between 1990 and 2006 accounting for 59,100 vehicles in 2006. The share of good vehicles with an unladen weight of 2,032 kg or less decreased from 81% to 74% and the share of good vehicles with an unladen weight of 4,065 – 8,128 kg decreased from 8% to 5%.

Goods vehicles with an unladen weight of 2,033 – 4.064 kg experienced an increase; from 5% in 1990 to 13% in 2006 and goods vehicles with an unladen weight of 8,126 or more increased from 6% to 8%.

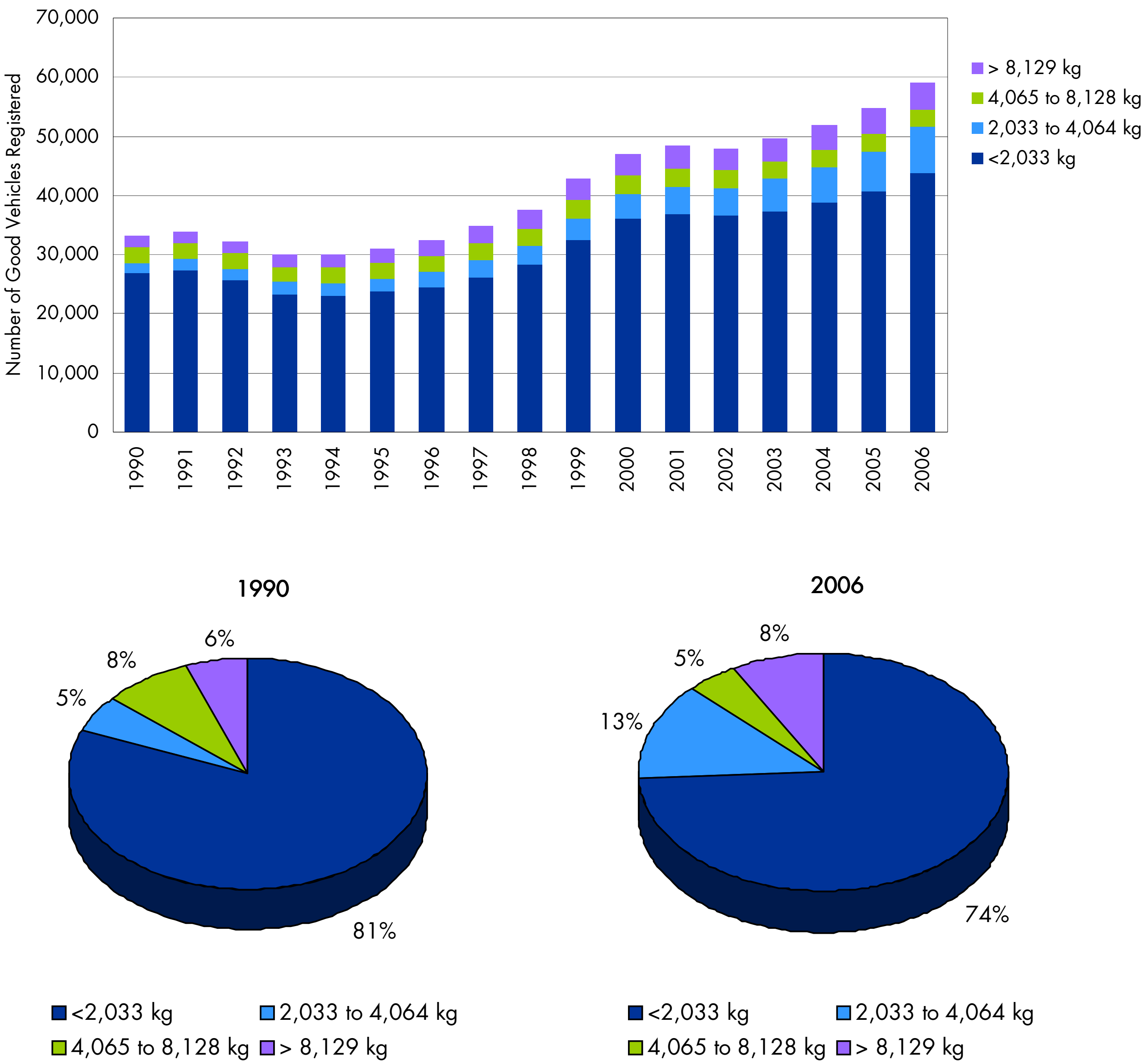


Figure 5.13: Goods Vehicles Registered in Dublin City and County 1990 to 2006

Port Traffic and Dublin Port Tunnel

As an island, Ireland is trading 99.5% of Irish foreign trade (by volume) through its seaports [17]. In 2006 39% of all goods received or forwarded through seaports nationwide were handled in Dublin Port corresponding to 21m tons [18].

Because the port is located at the edge of the city centre all traffic, arriving at the port or heading to the port had to travel through the city centre. Hence, the City of Dublin had to sustain about 9,000 heavy goods vehicle (HGV) journeys daily causing air and noise pollution, unpleasant and unsafe conditions for other road users and congestion. In order to take the majority of these HGVs off the streets of Dublin City, the Dublin Port Tunnel was built. In addition, the HGV Cordon Restrictions came into operation on the 19th February 2007 prohibiting 5+axle vehicles and over travelling within a cordon area from 07.00-19.00 Monday to Sunday and making it obligatory to use the Port Tunnel instead. Only vehicles with a valid permit issued by DCC are exempt [19]. The benefits for Dublin City and for the economy are evident (see Table 5.3) [20].

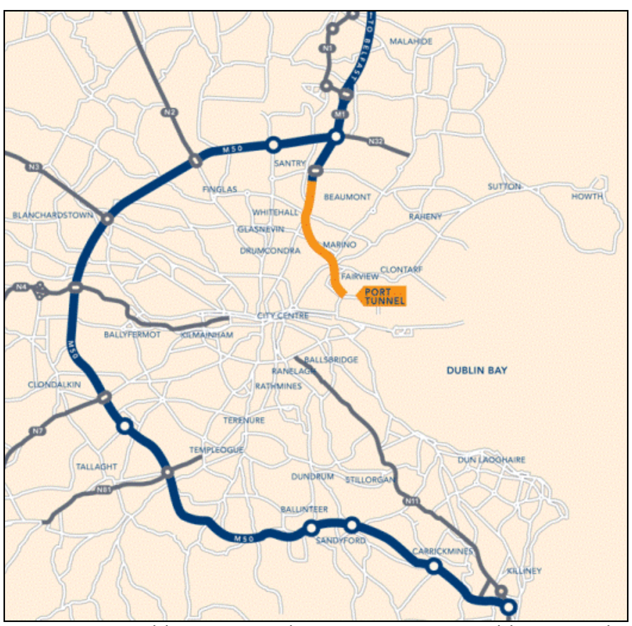


Figure 5.14: Dublin Port Tunnel (orange) connects Dublin Port with the Motorway M1 [21]

Benefits
Dublin City: • Significant reduction of HGVs in Dublin City • Aid improvement of public transport, pedestrian and cycle facilities • Reduced traffic congestion • Safer street • Reduction of noise pollution • Improved air quality and environment
Economy: • High quality traffic link from Dublin Port to M50 • Continued development of Dublin Port • Support for the growth of external trade • Shorter reliable delivery times for business and industry

Table 5.3: Benefits of the Dublin Port Tunnel for Dublin City and the Economy

Personal Travel Patterns

Travel Patterns in Dublin City and County

Travelling by car is the predominant mode; the car as a mode of transport is used most often by half (49%) of the inhabitants in Dublin City and County, either as driver or passenger. 20% travel most often by bus and 6% by other public transport modes (Train, DART, LUAS). In total, about three quarter of inhabitants use most often motorised modes of transport. 3% percent use most often the bicycle and 16% named walking as the mode of transport used most often [22].

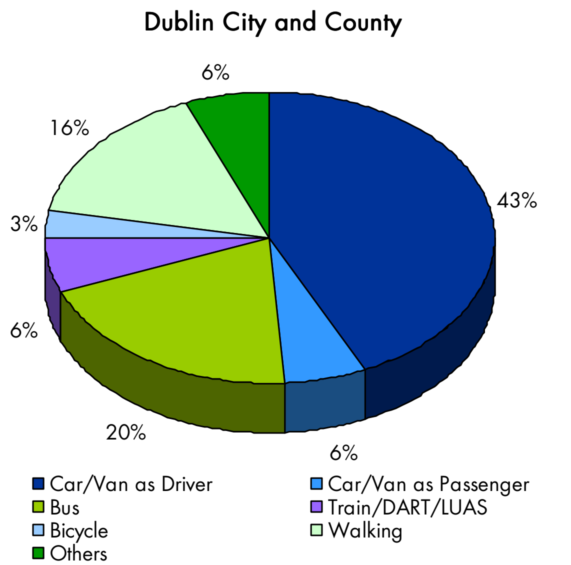


Figure 5.15: Share of Inhabitants Naming Modes of Transport as Used Most Often in Dublin City and County in 2006

Travel to School or College

The number of students in education in Dublin City and County decreased by 7% from 261,569 in 1996 to 242,154 in 2006, but the share of students travelling as car passenger increased over the same period by 32% from 49,798 to 65,636 holding a share of 27% in 2006 [23].

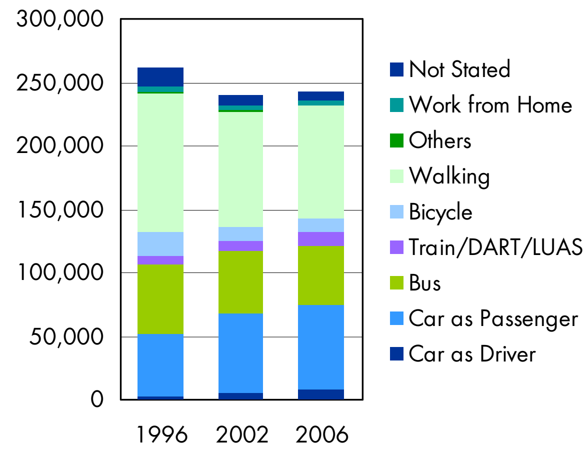


Figure 5.16: Travel to School or College in Dublin City and County 1996, 2002 and 2006

Travel to Work

The number of people in Dublin City and County at work increased by 37% from 408,752 in 1996 to 559,050 in 2006. The number of workers travelling by car as driver increased by 45% from 184,380 to 267,750 over that time period holding a share of 48% in 2006 [24].

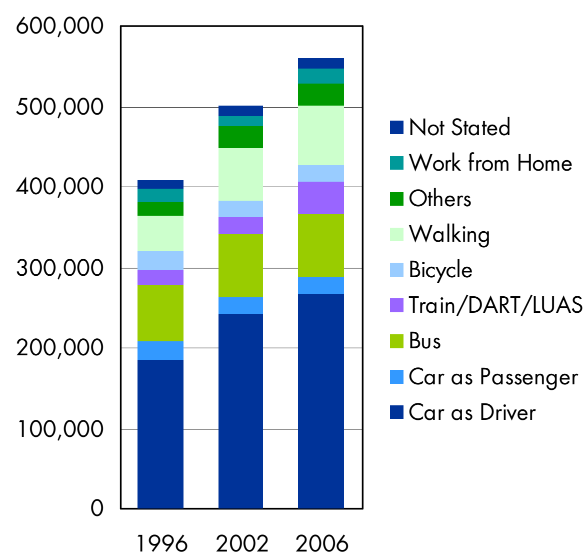


Figure 5.17: Travel to Work in Dublin City and County 1996, 2002 and 2006

In Dublin City and County 54% of workers are travelling between 2 and 14 km, 16% between 15 and 25 km; the weighted average is 11 km. The travel time is between 15 and 45 minutes for 51% of the labour force and 50% are leaving home between 7:00 and 8:30 [25].

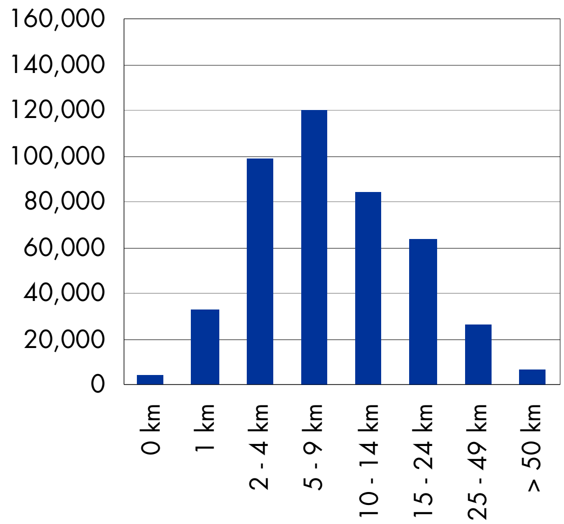


Figure 5.18: Travel Distance to Work in Dublin City and County in 2006

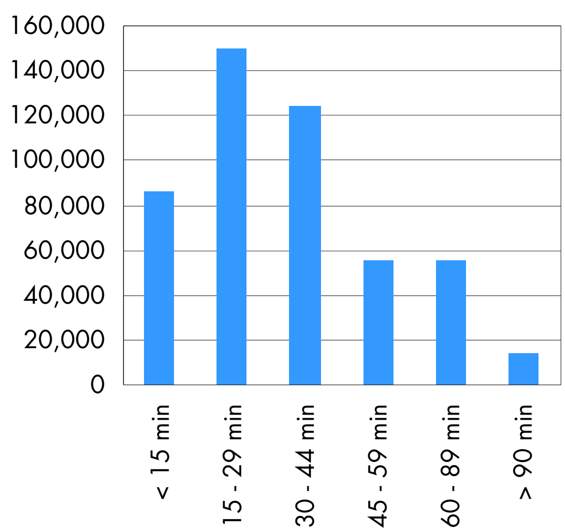


Figure 5.19: Travel Time to Work in Dublin City and County in 2006

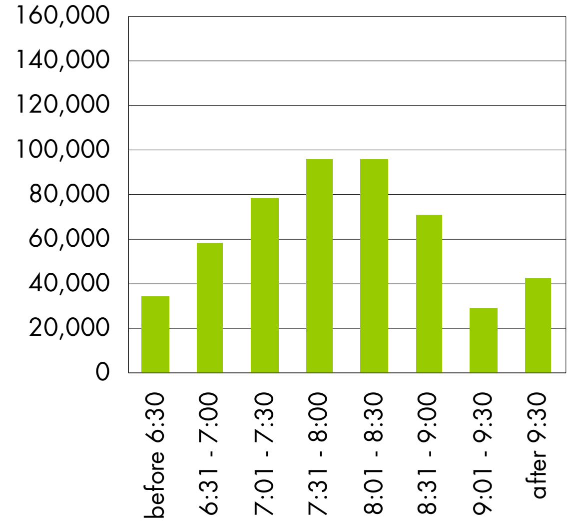


Figure 5.20: Time Leaving Home to Travel to Work in Dublin City and County in 2006

City of Dublin in Comparison

A comparison of the travel patterns in the City of Dublin with the other council areas and regions shows that car use is least in the City of Dublin (39%) and greatest in the Mid East Region (63%). In contrast walking has the greatest share in the City of Dublin (21%) and the lowest share in Dun Laoghaire Rathdown (10%). The bus also has a high percentage modal share in the City of Dublin (24%) with a low percentage modal share in the Mid-East Region (11%) [26] reflecting the difference in availability.

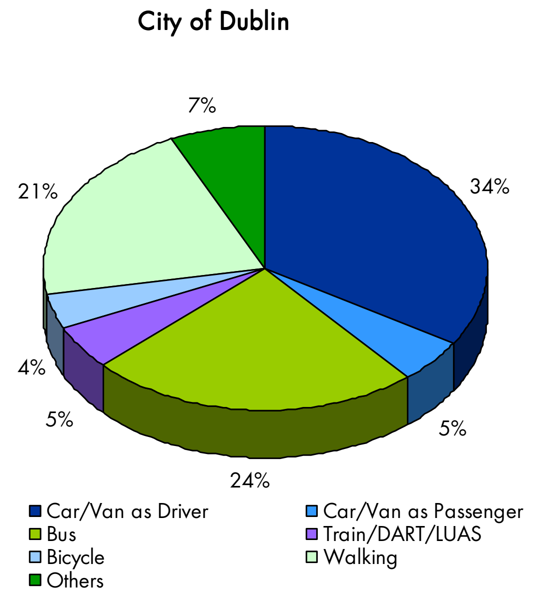


Figure 5.21: Modes of Travel Used Most Often in the City of Dublin in 2006

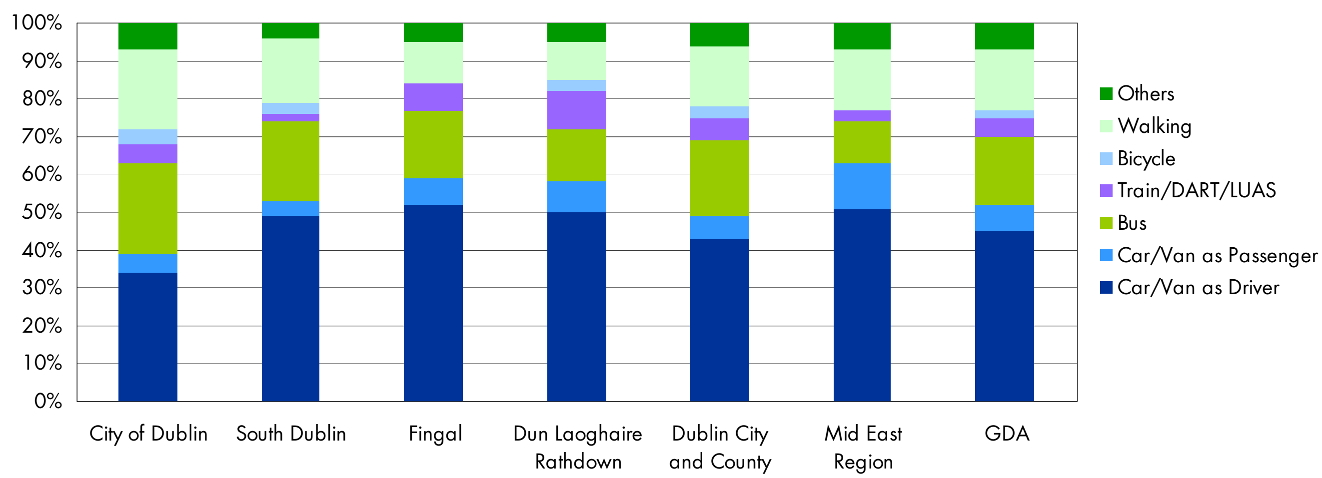


Figure 5.22: Modes of Travel Used Most Often in Dublin City and Counties and Regions in 2006

Travel Patterns in the GDA

More than 40% all person trips in the Greater Dublin Area have either workplaces (26%) or education (17%, including escort to education) as destination. Other journey purposes are shopping (22%), leisure (16%), visit (10%) and other (10%). 60% of the trips to work are undertaken by car, either as driver or as passenger, as well as 30% of those travelling to education. The share of car drivers and passengers is about 50% for other journey purposes such as shopping, leisure and visit [27].

In contrast to the more diverse trips for purposes such as shopping, leisure and visits, trips to workplaces and education are routine trips on a specific route and at a specific time, mainly during rush hours. Therefore they are also the main drivers of peak congestion. On the other hand these kinds of trips can be more easily targeted with measures to promote and achieve a mode shift.

The car share for both commuting to work and travelling to education has increased over the last 10 years due to the economic growth that has been taking place. This upward trend is not sustainable and results in congested roads, poor air quality, increasing emissions and health risks.

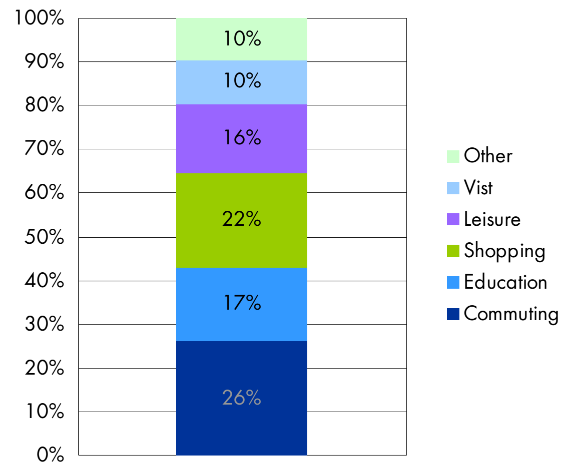


Figure 5.23: Journey Purpose (outward trips) in the GDA in 2006

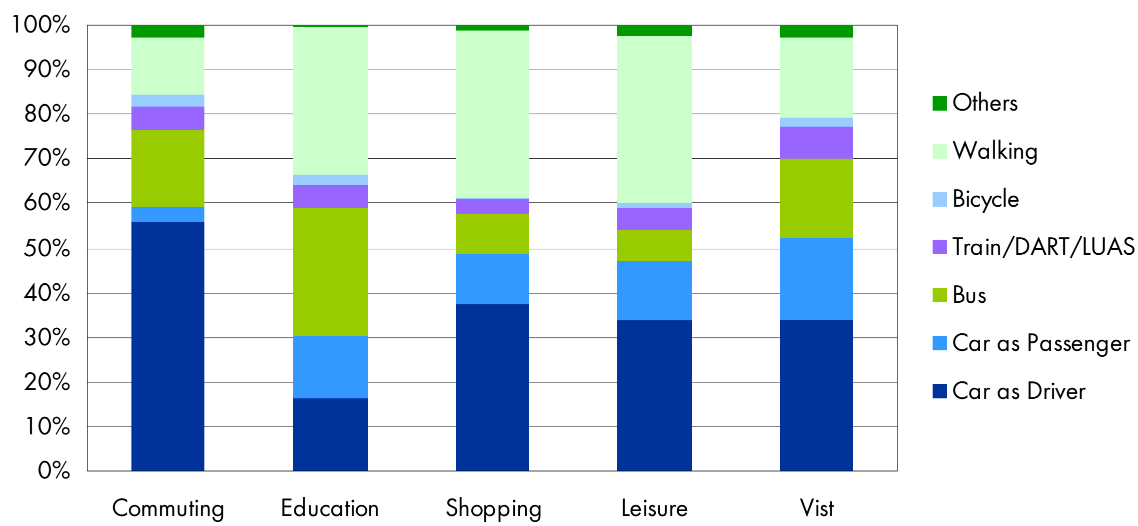


Figure 5.24: Travel Mode by Journey Purpose (outward trips) in the GDA in 2006

Possibilities for Sustainable Energy

Introduction

In Dublin motorised transport in terms of car use and road freight has experienced an immense and unforeseen growth in the last 10 years. A reversal of this trend needs to be achieved with significant investments into 'hard measures' such as pedestrian areas, bicycle lanes and public transportation and into 'soft measures' such as information and awareness campaigns as well as travel plans. Walking, cycling and public transport have to be prioritised whereas car use has to be discouraged.

Possibilities for more sustainable energy use in transport are outlined in four sections:

- Reducing individual motorised travel
- Optimising motorised travel
- Fiscal incentives
- Urban planning

Finally, examples for measures taken by Dublin City Council in order to reduce its own energy consumption are presented.

Reducing Individual Motorised Travel

Workplace Travel Plans

There are only a few workplace travel plans implemented in Dublin because this is a relatively new feature in Ireland. Public sector bodies should be the ones at the cutting-edge, starting the process by establishing successful workplace travel plans for their own staff. Private companies would soon become aware of the benefits of taking the responsibility for their commuting employees, such as retention of key staff. Workplace travel plans can induce a reduction of car trips to the workplace by 15% as international experience shows [28].

School Travel Plans

Most pupils live within walking and cycling distance of their school. Even so, the share of pupils travelling by car to school (including students travelling by car to university) has increased in the Dublin Region from 20% in 1996 to 30% in 2006.

School travel plans can support the reversal of this trend by addressing the travel behaviour of the pupils. Pilot projects have shown that, depending on the budget allocated, reductions in car use by up to 22% can be achieved. International experiences indicate a reduction of car use by 8-15% on average. The Irish Green Schools, a programme and award scheme that deals with various environmental issues has potential to build the link for the implementation of school travel plans. Schools should be targeted firstly because they function as multiplier and secondly, because the behaviour established in childhood is the key determination of adult behaviour. There is certainly a long term effect; the pupils taken by car to schools today are the car drivers of tomorrow [29].

Cycling Traffic

The share of people cycling to work or to education has declined in the last years and is now as little as 2% in the GDA and 4% in the City of Dublin [2626].

The reasons for not cycling are various as are the initiatives that would motivate people to cycle to work, as a survey on car commuters undertaken by the Dublin Transportation Office (DTO) shows [30]. This indicates that investments in soft measures as well as in hard measures are needed.

The local authorities in Dublin have agreed on the DTO Cycle Policy as a statement of intent. This policy specifies people travelling to work and education as target groups and refers to the objective of the DTO Strategy to decrease the share of short trips (up to 6km) undertaken by car to 30% by 2016. In fact, 21% of car commuters would consider cycling to work according to the aforementioned survey by the DTO.

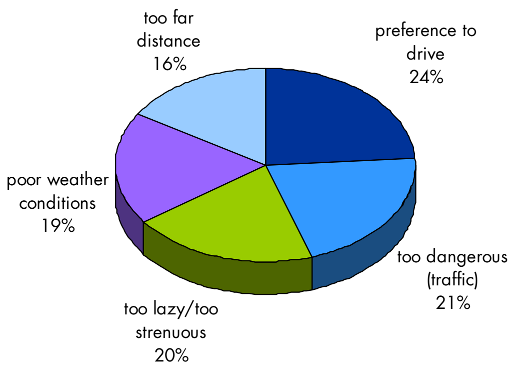


Figure 5.25: Reasons for Car Commuters not to Cycle to Work

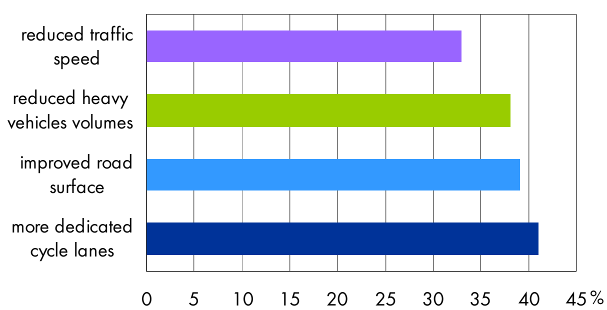


Figure 5.26: Initiatives Motivating Car Commuters to Cycle to Work

Figure 5.27: Greater Dublin Strategic Cycle Network in 2005 displaying Existing (green) and Proposed Cycle Paths (red) [31]

Dublin City Bike

The provision of a public self funding bicycle rental system on behalf of Dublin City Council is proposed. The suggested Dublin City Bike scheme would provide at least 500 bikes at 25 bike stations. The facility would be accessible to residents and visitors alike, 24 hours 7 days a week with no or a marginal fee paid by the users [32].

Such City Bike Schemes are successfully installed in many cities across Europe (Austria: Vienna; Denmark: Copenhagen; Finland: Helsinki, France: Lyon, Paris; Germany: Berlin, Cologne, Frankfurt, Munich; Norway: Oslo, Bergen, Trondheim; Spain: Barcelona, Seville; United Kingdom: London) [33][34][35]. These City Bike Schemes provide an alternative to car use and increase the mobility of people living and working in the area and visitors alike.

Pedestrian Traffic

In the city centre pedestrians are omnipresent, especially in the commercial streets. Pedestrian areas, boardwalks and campshires along the river Liffey provide what is needed to make walking attractive; a safe and pleasant environment that is also accessible for the disabled. In order to enhance and strengthen the centre of Dublin, city planners prepared a plan with walking routes within and between the shopping centres on the north and south side of the Liffey [36].

There is still a great need for making areas more pedestrian friendly. The first priority should be to (re)design ways to school in order to counteract the current trend of driving pupils to school (see school travel plans). Secondly, the ways to workplaces should be targeted (see workplace travel plan). Hard measures need to be accompanied by soft measures such as communication campaigns to inform the public about the benefits of walking in regard to health, environment and costs.

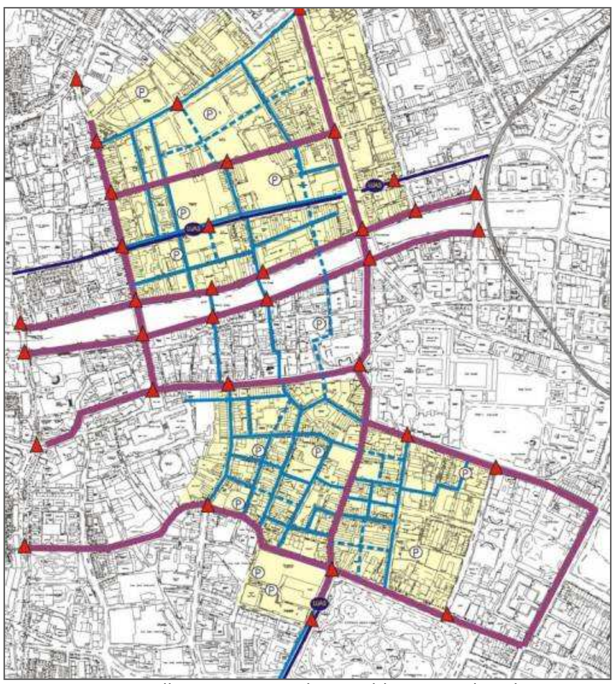


Figure 5.28: Walking Routes within and between the Shopping Centres on the North and South Side of the Liffey [36]

Safety

Increasing the safety for those who are walking and cycling is crucial. Nearly 60% of road users killed in Dublin City in 2006 were pedestrians and cyclists, and a third of the road users injured [37].

In Dublin City the modal split is 25% for pedestrians and cyclists. The comparison with road accident statistics shows that the share of pedestrians and cyclists killed is disproportionately high.

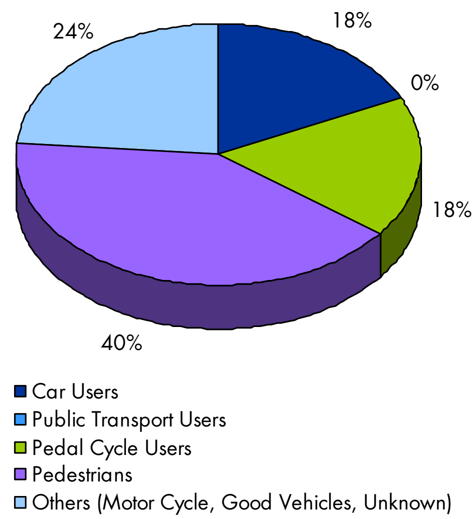


Figure 5.29: Road Users Killed in Dublin City in 2006

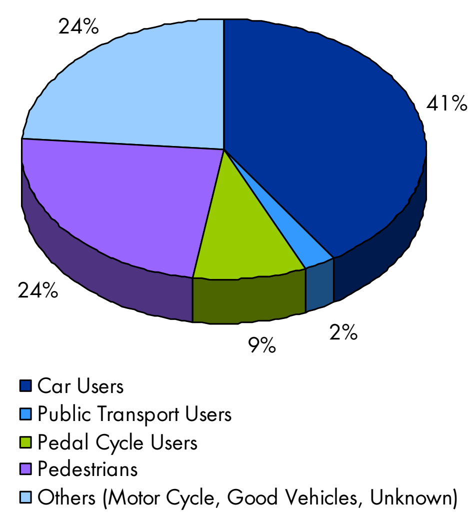


Figure 5.30: Road Users Injured in Dublin City in 2006

codema
Sustainable Dublin

A lack of safety is indeed the reason for car commuters not cycling to work [30] and for parents not allowing their children to cycle to school [38]. 5% of car commuters consider cycling to work but find it too dangerous because of traffic and 35% of the parents driving their child to primary school find cycling and walking too dangerous. This indicates that there is a clear potential for increasing the share of cyclists and pedestrians amongst employees and pupils if walking and cycling are safe(r).

Optimising Motorised Travel

Public Transport

A good public transportation system is essential for achieving a mode shift. The public transportation system needs significant investments in infrastructure [39] (bus lanes, vehicles, stops, shelters, integrated ticketing, frequency, reliability) and information (routes, real time information, maps) in order to provide an attractive alternative to car trips.

Existing Infrastructure

Buses:

In order to improve the service provided by public buses, Quality Bus Corridors (QBC) have been installed during the last 10 years. QBCs include a dedicated road space and traffic signal priority in order to reduce journey times and improve reliability. The existing QBC network connects suburban areas with the city centre via the canal cordon crossings. There are additional regular bus lines crossing the canal cordon. While the number of cars crossing the canal cordon on non QBC/bus routes has dropped by 1,200 vehicles during the morning peak between 1997 and 2007, the amount of cars on the QBC and bus routes has dropped by more than 9,000 vehicles [40] [41].

There is in general a huge potential for a more (energy) efficient operation of buses in Dublin through measures such as optimising routes and time schedules, avoiding empty and "out of service" drives, no engine idling and implementing eco-driving.

Rail:

The Dublin suburban rail network incorporates the DART (Dublin Area Rapid Transit) and commuter trains. The DART is an electrified service operating on about 35 km along the coast from the north via the city centre to the south. The commuter trains are running on four routes; partly sharing the rail tracks with the DART. In contrast to the DART, the commuter trains are running on diesel [42]. The electrification and provision of rolling stock on the Dublin suburban network is one of the projects under Transport 21. Electric trains need less energy and operate more efficiently than diesel trains and thus contribute towards a cleaner environment [43].

Luas

Since 2004 there are two tramways called "LUAS" in operation. The LUAS provides a frequent, reliable and comfortable service. It operates mostly on off-road rails, unaffected by road congestion. Surveys show that 20.7% of the LUAS passengers had switched from travelling by car (17.6%) or taxi (3.1%) [44].

In 2005, the LUAS recorded a successful year with 26m passenger journeys and a profit of €228,000 making state subvention redundant [45].

The research on buses and LUAS shows that as soon as there is a reliable public transportation option in place, up to 20% of people that are currently travelling by car will change their travel behaviour in favour of public transport.

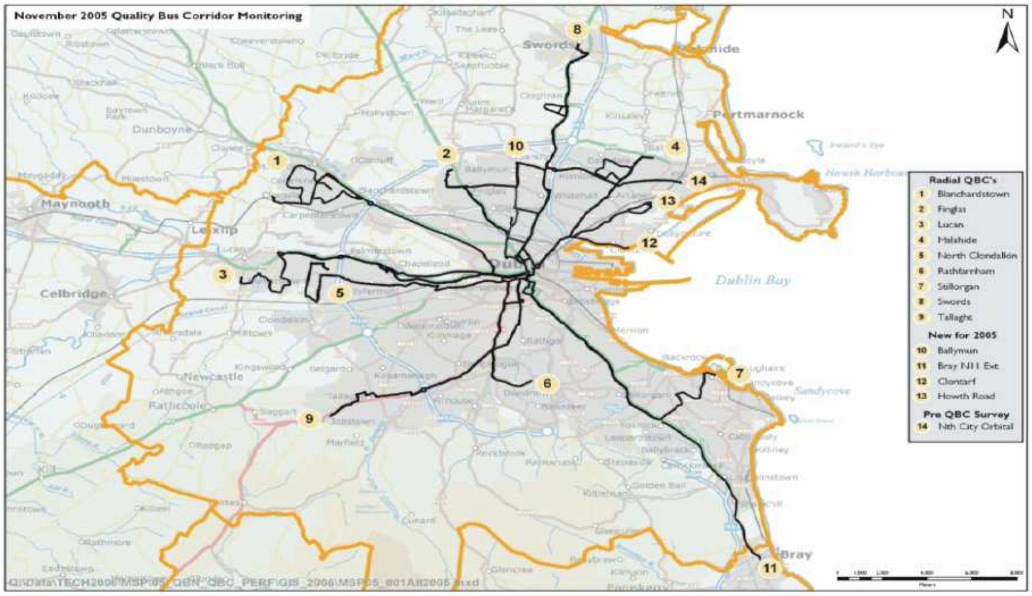


Figure 5.31: Quality Bus Corridors Monitored by the DTO (2005) [46]

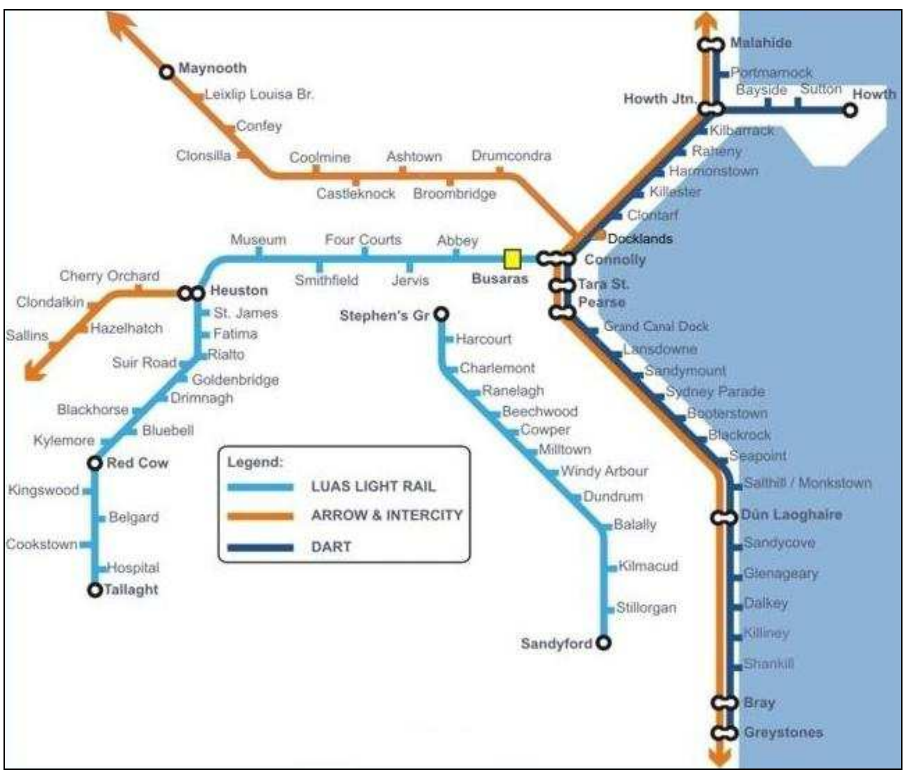


Figure 5.32: Existing Dublin Rail Network including LUAS, Commuter (Arrow) and Dart [47]

Transport 21

Necessary improvements of the existing infrastructure are being delivered by 'Transport 21', the capital investment framework through which the transport system in Ireland will be developed, over the period 2006 to 2015. Transport 21 allocates €14bn to the Greater Dublin Area in order to develop both individual traffic and public transport [43].

It is anticipated that there will be a 28% increase in total motorised trips in the GDA during the morning peak hour, from 428,000 trips in 2005 to 550,000 in 2015. Through Transport 21, the public transport modal split during the morning peak period is expected to increase from 28% to 44% [48]. The annual public passenger journeys are expected to be 375 million in 2015; an 88% increase compared with 200 million passenger journeys in 2005 [49]. This accession is going to be accommodated by bus (25 million), LUAS and Metro (75 million) and DART/Commuter (75 million) [50].

Transport Mode	Major Projects
Private Car Commercial	• M50 Dublin outer ring road upgrade
Buses	• Developing the bus service • Traffic management
Heavy Rail	• City centre re-signalling • New rail station in Docklands • Interconnector (Northern Line to Heuston Station) • Electrification and provision of Rolling stock on the Dublin Suburban Network • Re-opening of the Navan Line • Kildare Rail quadrupling of track
Metro	• Metro North • Metro West
LUAS	• Expanding and extending the existing LUAS network

Table 5.4: Major Projects of Transport 21 in the GDA

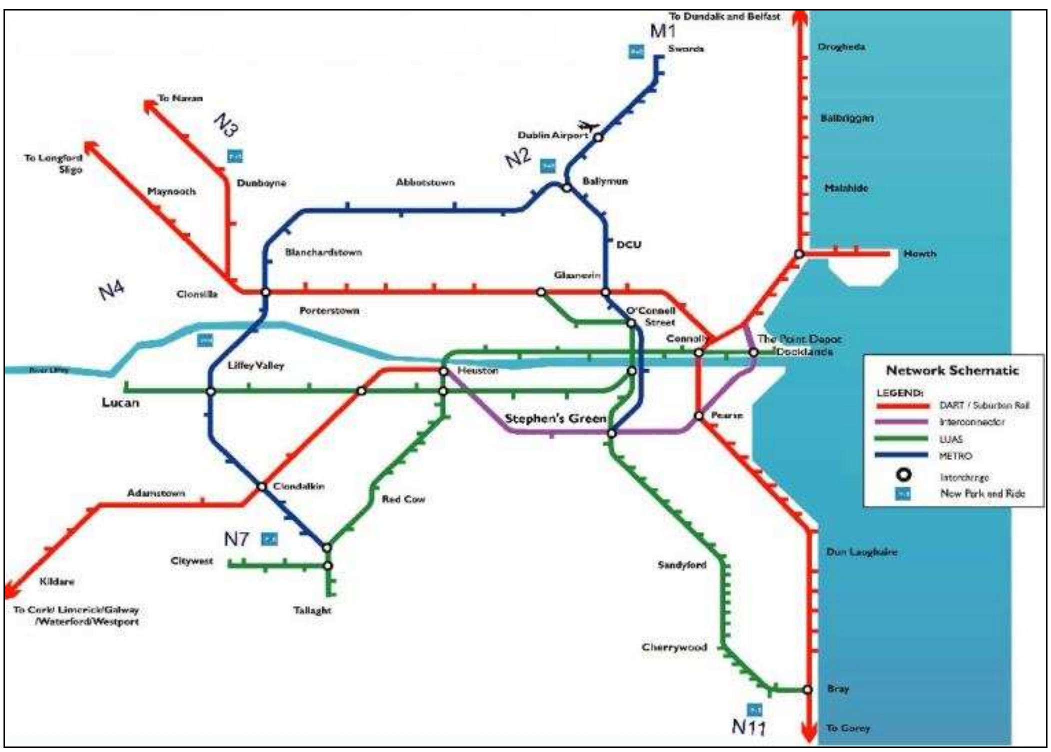


Figure 5.33: Greater Dublin Area Rail Network as provided by Transport 21 [51]

Real-Time Information

Real-time information for public transport provides timely and accurate data such as route number, final destination, waiting time, service disruptions, etc. Commuters can make decisions about modes of travel and travel routes based on the provided information. All over Europe, cities are implementing real-time information systems and analysis show that these measures result in an increase of up to 6% of patronage.

In Dublin real-time information is available for the LUAS, DART and some commuter trains, but not for buses. The introduction of such as system will also lead to an increase of up to 6% of patronage.

"Phoebus" in Brussels

Due to the provision of real-time information the use of public transport on the lines equipped increased by 6%. The Phoebus system resulted in 90% user satisfaction and it is regarded as being very user-friendly. The pay-back period is 4 years [52].

"Countdown" in London

In London a demonstration route was equipped with real-time information and the key findings from the passenger survey are that in general the service is perceived as more reliable and waiting at night is perceived as safer.

89% find waiting itself is more acceptable.
83% experience that time seemed to pass more quickly.
68% state that general feelings improved towards bus travel.
65% perceive a shorter waiting time.
A minimum of 1.5% new revenue was generated. [53].

The introduction of the countdown system for the bus fleet by 2008 is now part of the Transport for London 5 year investment programme [54].

"Timechecker" in Liverpool

In Liverpool the installation of real-time information at more than 150 stops in the city and nearby towns has led to a 5% increase in patronage on these routes.

89% want to see an expansion in the provision of real-time information at all bus stops.
87% have a feeling of reassurance.
85% believe that waiting is more acceptable.
68% use the provided information consistently.
57% perceive decreased waiting times at bus stops [55].

Road Freight

In fact, 31% of the national commercial transport in terms of both tonne-km and tonnes carried takes place in the Greater Dublin Area [56]. 22% of these transport activities are related to transporting goods to or from the local ports [57]. In the short-term carriers can contribute to a reduction of commercial transport by implementing a goods transport management system that avoids empty drives and operates most efficiently. In the long-term the road freight has to be moved on to rail. Significant investments into the local and national rail network would be necessary to realise this shift.

Eco-Driving

Smart, smooth and safe driving techniques are termed as 'eco-driving' and lead on average to fuel savings of 5-10%. Cost savings and fewer accidents as well as reductions in emissions and noise levels are other benefits [58].

Drivers are in general not aware of the benefits of eco-driving. On the contrary engine idling is a common habit among drivers of private cars, but also among professional drivers such as bus and truck drivers. An awareness and education campaign for the public as well as measures such as eco-driving courses for professional drivers would help to address this wasteful behaviour and to realise the potential for fuel savings of 5-10%. Dublin City Council could also realise these savings by educating its drivers.

Electric Vehicles

There are three types of electric vehicle; battery electric vehicles, hybrid electric vehicles and plug-in hybrid electric vehicles. Battery electric vehicles (BEVs) are powered by electricity, which is derived from batteries in the vehicle, and employ electric motors and motor controllers instead of internal combustion engines. Hybrid electric vehicles (HEVs), in turn, are powered by a combination of electricity and conventional fuels (petrol, diesel) bonding internal combustion engines with electric engines. Plug-in hybrid electric vehicles (PHEVs) are hybrid vehicles with batteries using petrol or diesel engines and stored electricity for electric motors alternatively. All types are more energy efficient than conventional ones and therefore imply reductions of primary energy consumption, fuel costs and emissions; whereas the cuts on CO_2 emissions of BEVs exclusively depend on the carbon intensity of the electricity used for the battery charging. This means that BEVs can be operated at zero emissions provided that the electricity is sourced from renewable energy [59].

Fiscal Incentives

Transport is the most highly state-subsidised sector, yet it creates enormous external costs by damaging the environment and human health. Current practice is indeed encouraging non-sustainable modes of transport. Only if the polluter-pays-principle is introduced can the transport problem be brought under control.

Removal of Non-Sustainable Incentives

There are incentives in place that are in fact encouraging car use such as free workplace parking and travel allowances in favour of car usage. In order to achieve a mode shift these incentives have to be removed and replaced by incentives that favour sustainable modes of transport.

Congestion Charging

Congestion charging is one of the incentives that would provide what is needed to achieve a mode shift; a strong fiscal discouragement for non-sustainable single occupancy car use in line with the polluter-pays-principle.

A study by Booz, Allen and Hamilton submitted to the DTO in 2004 clearly emphasizes the implementation of congestion charges, preferable in combination with a workplace parking levy. With such a combination and with additional travel demand measures, the reduction in vehicle-km is predicted to be up to 5% and the reduction in vehicle hours up to 12% in 2008 during the morning peak compared with the Business As Usual Scenario [60]. The proposed charging area is within the outer orbital routes (North Circular Road and South Circular Road/Grand Canal).

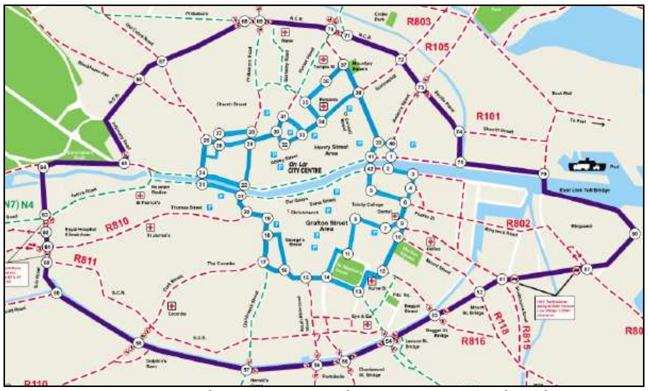


Figure 5.34: Proposed Congestion Charging Area within the Outer Orbital Route (violet line) [61]

European cities such as London and Stockholm have congestion charge schemes in place and attest to their effectiveness. Congestion charging will be accepted given public transport alternatives are in place and if congestion is reduced [62].

London Congestion Charging

In London congestion charging was introduced in February 2003. Vehicles are now charged €12 (£8) when entering the charging zone between 7am to 6pm Monday to Friday. The money raised is allocated to the further development of public transport [63]. The result is a 14.6% reduction in traffic in terms of vehicle-km within the charging zone and a 3.9% reduction in the doughnut surrounding the charging zone [64].

Initially, the congestion charge was criticised and opposed but has since been accepted and was even requested by residents of other areas in London [65]. Regarding the impact on the business sector, surveys show that "*Even if the congestion charge has had an impact on the economy, whether good or bad, it hasn't been an overwhelming one.*" Nearly three-quarters of companies in London think that the congestion charging scheme is successful and that it is good for the image of the capital [66].


Figure 5.35: London Congestion Charging Area [67]

Stockholm Congestion Charging

In Stockholm a congestion charging scheme was tested from January 2006 to August 2006. Vehicles were charged €1-2 (max. €6.5 per day) when entering the charging zone between 6:30am and 18:30 pm Monday to Friday [68].

Before, during and after the trial period detailed analyses were carried out for car traffic, public traffic, cycling and walking, parking, travel patterns, traffic safety, air quality, emissions, noise, urban environment, economy (micro- and macro level), society.

Some of the key findings are that there was a 20-25% reduction in traffic, 30-50% reduction in congestion time and 8-14% reduction in emissions within the charging zone during the trial period [69]. The analyses also showed that more than 50% of inhabitants in Stockholm would vote for congestion charging [70]. Because of the success of the congestion charging trial the Swedish government decided to introduce a permanent scheme in August 2007 [71].

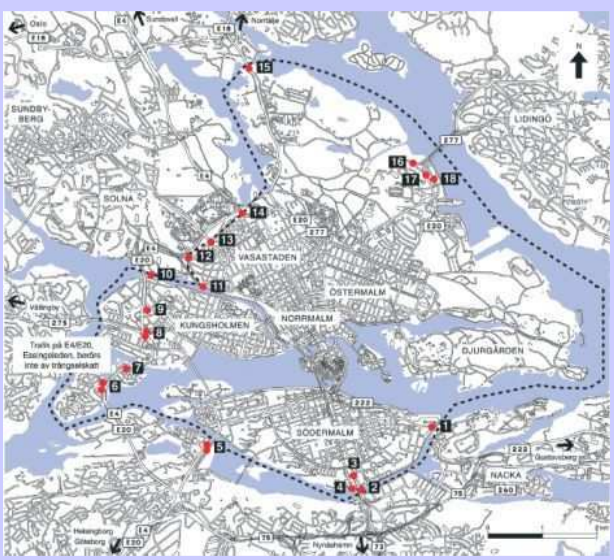


Figure 5.36: Stockholm Congestion Charging Area [72]

Urban Planning

The potential for more sustainable transport realised through foresighted planning is major. Because today's planning plays the most important role for current and future development, the opportunity for rethinking current practice has to be taken. Indeed, urban planning policies have to ensure that sustainable modes of transport are not only kept in mind but prioritised and realised.

Dublin City provides guidelines and policies for planning and development in the 'Dublin City Development Plan 2005-2011'. The chapter on transportation contains a number of policies promoting sustainable transport.

Transportation Contents

- Integrated Land Use/Transportation
- Promoting Modal Change
- Quality Bus Network/Priority
- Rail and Interchange
- Cycling and Pedestrian Use
- Mobility Management Plans and Transport Impact Assessment
- Pro-active Parking Policy
- Provision of Additional Road Capacity (also for public Transport and Pedestrians)
- Traffic Management
- Additional Provision for the Mobility Impaired and Disabled

Table 5.5: Contents of the Transportation Chapter in the Dublin City Development Plan 2005-2011 [73]

A further development of the policies and strengthening of the guidelines would ensure that sustainable transport issues are not dealt with at the last stage but at the very first stage of planning.

Planning (urban development, public transport, etc.) often occurs without the participation of the stakeholders that are affected by the planning and even with the best intentions the needs of the users are often not met. Participation offers a great possibility to bridge the gap between desktop planning and actual requirements. Furthermore, the extent of participation is not only an indicator for lively democracy but a substantial element of sustainable development.

Dublin City Council

Signal Conversion Project

Traffic signals are an integral part of any city street network and provide a safe means of regulating and controlling the flow of vehicles, cyclists, trams and pedestrians. Between the years 2001 and 2003, Dublin City Council's Road and Traffic department installed several test sets of LED signals. In 2004, in consultation with ESB Customer Supply and Sustainable Energy Ireland it was decided to replace approximately 400 signal heads at numerous junctions as part of a set of urban rejuvenation projects underway throughout the city centre.

Workplace Travel Plan

Codema is working on the implementation of a workplace travel plan for the Dublin City Council offices with the mobility management company VIPRE Ltd. Workplace travel plans will have benefits for both employees and employers and will in a wider context contribute to sustainable city development.

Policies

Dublin City Council has also developed a Green Procurement Guide [74] that could and should include specification regarding energy.

Further improvement opportunities would be green standards for contractors, energy efficient traffic signals, eco-driving courses for staff and drivers, etc.

Dublin City Council Leading by Example

Signal Conversion Project

Traditional Halogen Bulb System:
Dublin City Council Road and Traffic department is responsible for the safe operation and maintenance of 680 sets of traffic signal installations throughout the city. Traditionally, the Council has been using halogen bulbs, which consume 55 Watts of electricity per bulb.

The LED Signal Technology:
The new traffic signal bulbs use Light Emitting Diodes (LED), rather than incandescent halogen bulbs. The LEDs are small individual electronic lights, which are energy efficient and have a very long life. The signals can comprise of either a multiple array of LEDs over the viewing area of the signal head or a cluster of high intensity LEDs with an optical diffusion system.

Energy Savings:
The energy saving for the LED signal is significant. The LED signal bulb uses approximately 15 watts of power, compared to the average 55 watts of power used by the halogen or incandescent bulb representing a saving of 40 watts per bulb. Each signal head operates 24 hours per day every day of the year. With always one of the bulbs illuminated the wattage saving thus results in annual savings of 350 kWh per signal head. For 400 signals this represents an annual saving of 140 MWh and a saving of 1,400MWh over the ten-year life of the LEDs.

CO_2 Savings:
The above energy saving represents an annual saving of 91 Tonnes CO_2 and a saving of 910 tonnes over the ten-year life of the LEDs.

Cost Savings:
The energy cost saving for each signal head amounts to 38.50 per head (this is at Average Unit Price of 11 cents per kWh). There would also be a reduced relamping and maintenance cost of €42 per signal head giving a total annual cost saving for the €400 signal heads of €32,200. Over the lifetime of the LEDs a total saving of €322,000 is expected.

Dublin Leading by Example

Travel Plans for Dublin City Council

A Travel Plan is a Transportation Demand Management tool which reduces car trips, improves access, provides and promotes sustainable travel alternatives, and makes more efficient use of existing transport resources and infrastructure. This is usually delivered through a strategic combination of "push and pull" measures, i.e. policies and incentives.

How Travel Plans Work:

Travel Plans work by focusing on the user at the centre of trip generation and by inducing travel behaviour change within the existing transport context. The aim is to enable users to make considered choices in advance of choosing 'mode to travel' by removing the barriers to using sustainable modes and by filling any transport 'gaps' as applicable. Travel plans will often redress an existing imbalance where the barriers (physical, informational, perceptual) to using sustainable transport are greater than those to using cars.

Travel Plans – Progressive Approach:

Travel Plans are increasingly receiving international recognition as a more effective and sustainable approach to transportation planning. As workplaces constitute the main drivers of "rush hour" traffic congestion, Workplace Travel Plans can contribute to congestion-reduction and sustainable city development. Travel plans are low-cost transport interventions that have proven effectiveness, at local and wider-area levels.

Benefits:

Travel plans are low-cost win-win interventions that benefit end-users, employers and civic authorities. They help reduce CO_2 emissions from fleet, business travel or commuting, reducing traffic and noise emissions in the community. A more sustainable workplace is created through improved corporate social responsibility and improved recruitment and retention by caring for staff travel, a healthy workforce and reduced absenteeism through active commuting

Process for Implementation:

1. Meetings with decision makers and stakeholders
2. Site audit
3. Staff survey: travel habits and attitude
   Mapping and analysis
   Survey report
4. Reviewing policies of organisation
5. Collecting local transport context data
6. Writing workplace travel plan and
   Recommendations
7. Implementing Workplace Travel Plan [75]

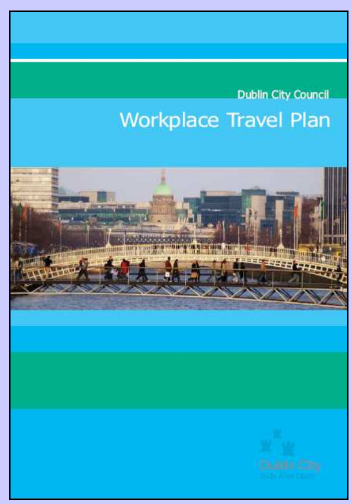


Figure 5.37: DCC Workplace Travel Plan Brochure [76]

Possibilities for Renewable Energy

Biofuels

The realistic potential for biofuels produced in Ireland is estimated to be 500-600m litres per year. There are different types of biofuels such as pure plant oil, biodiesel and bioethanol. These biofuels can be used for operating cars, buses, goods vehicles and trains. Some applications are already internationally approved, while others need further research [77].

Transport in Ireland is 99.9% dependent on oil products. There are a number of national schemes targeted at increasing the share of renewable energy.

The 'Biofuels Mineral Oil Tax Relief Scheme' envisions that 163 million litres biofuels (biodiesel, bioethanol, pure plant oil) will be produced by 2010, representing 2.2% of the fuel used for road transport [78]. The 'Vehicle Registration Tax Relief Scheme' allows a 50% tax relief for flexible fuel vehicles that can accept gasoline as well as a blend of gasoline and a minimum of 85% bioethanol [79].

The initiative "Biofuels for Transport" is part of Transport 21 and it aimed to have 50 vehicles running on pure plant oil by the end of 2007 in Ireland [80]. Furthermore, the 'Energy Crops Scheme' provides aid to farmers that are growing energy crops for producing biofuels [81]. Despite these schemes the share of biofuels is not going to increase significantly on a national level over the next years. Dublin could lead the way by launching a local initiative.

Biodiesel for Dublin City Council's Fleet

Dublin City is currently setting up a collection system for cooking oil from restaurants and pubs within the local authority area. Biodiesel could be produced from these recovered cooking oils and could be used for Dublin City Council's own fleet. Cooking oil blocks drains and interferes with the biological process at the sewage treatment plant and its removal is cost-intensive. But if collected and used for the production of biodiesel, cooking oil presents a valuable renewable resource. Furthermore, the fuel consumption for Dublin City Council's fleet increased by 8.6% per year since 2002 [82] and this growth could preferably be met with biofuels. The usage of homemade biodiesel would not only reduce the carbon footprint of Dublin City Council, but contribute to security of supply too.

Biofuels for Buses

Public buses running on biofuels not only pollute less but they function as a communication tool if the appearance and labels of the bus advertise its usage of biofuels. Theoretically, the public buses running on diesel could be phased out in favour of buses running on biofuels. But in Dublin the public buses are not in ownership of Dublin City Council and thus there is little exertion of influence.

Biofuels for other Road Users

Car drivers and hauliers represent the majority of road users. Incentives are necessary in order to motivate these road users to switch to biofuels. Currently there are two fiscal incentives, the Biofuels Mineral Oil Tax Relief Scheme and the Vehicle Registration Tax Relief Scheme in place that stimulate the market for biofuels and vehicles that can be fuelled with bioethanol.

Transport in 2020

In Ireland the primary energy consumption of the transport sector increased by 167% and CO_2 emissions related to transport increased by 168% between 1990 and 2006 [83].

Two exemplary scenarios are presented in order to show what efforts are necessary for reversing this trend and for achieving energy and CO_2 emission reductions.

Business As Usual

A 2% annual growth is applied for the period 2006 to 2020 according to a forecast made by SEI [84]. The projection of this trend shows that both primary energy consumption and CO_2 emissions increase by an additional 32% between 2006 and 2020 resulting in a primary energy consumption of 6.6 TWh and 1,640 ktonnes CO_2 emissions respectively.

Scenario 1

Actions 1-3 which are measures to reduce individual motorised travel are implemented. The increase in primary energy consumption and associated CO_2 emissions will be mitigated from 32% to 23% between 2006 and 2020 amounting to 6.2 TWh and 1,530 ktonnes respectively in 2020.

Scenario 2

Additional to the actions of scenario 1, actions 4 and 5 to optimise motorised travel are implemented. The increase in primary energy consumption and associated CO_2 emissions will be mitigated from 32% to 18% between 2006 and 2020 amounting to 5.9 TWh and 1,460 respectively in 2020.

Calculations are made considering the timeline of implementation according to Table 5.6.

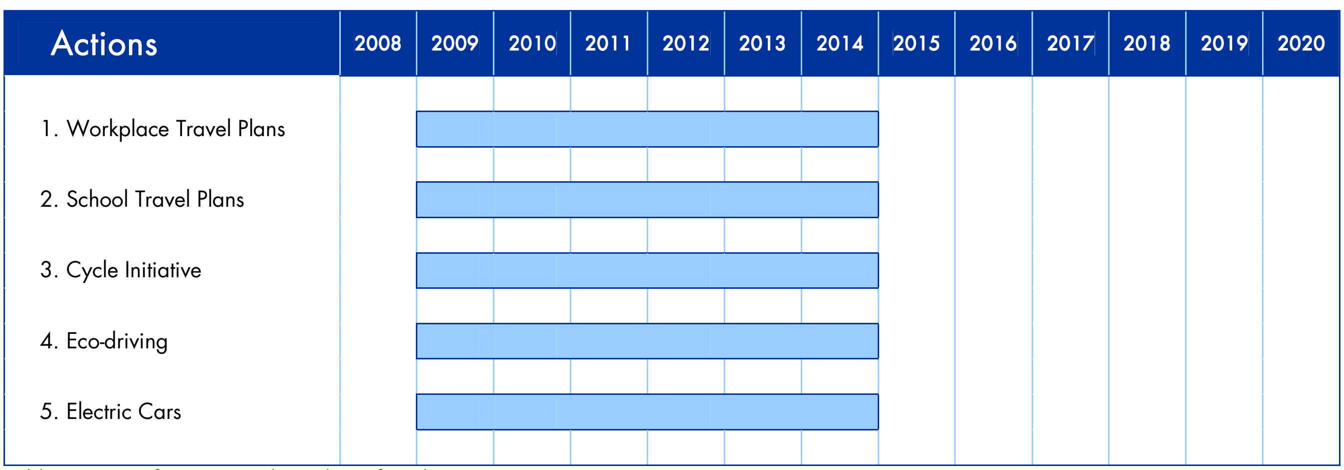


Table 5.6: List of Actions and Timeline of Implementation

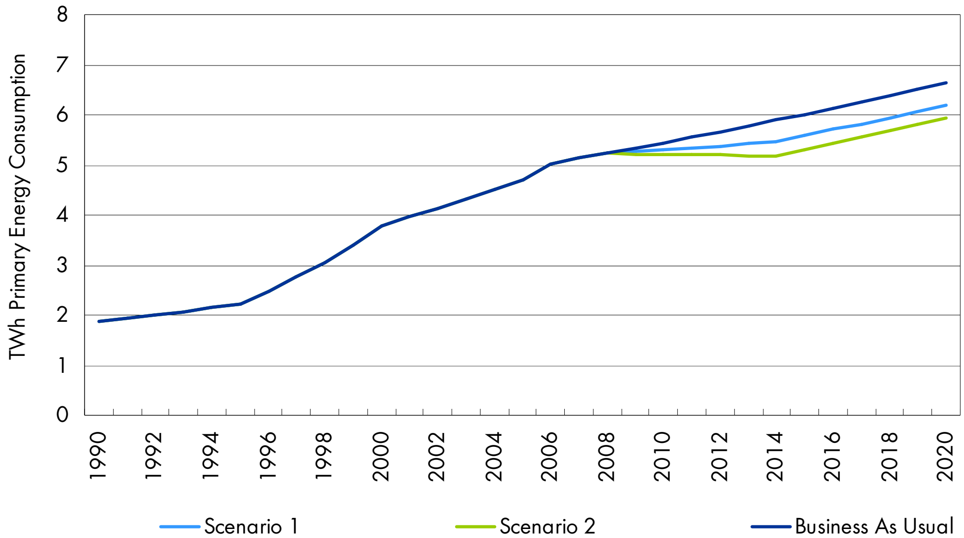


Figure 5.38: Primary Energy Consumption of Transport in Dublin City 1990 – 2020, Business As Usual, Scenario 1 and Scenario 2

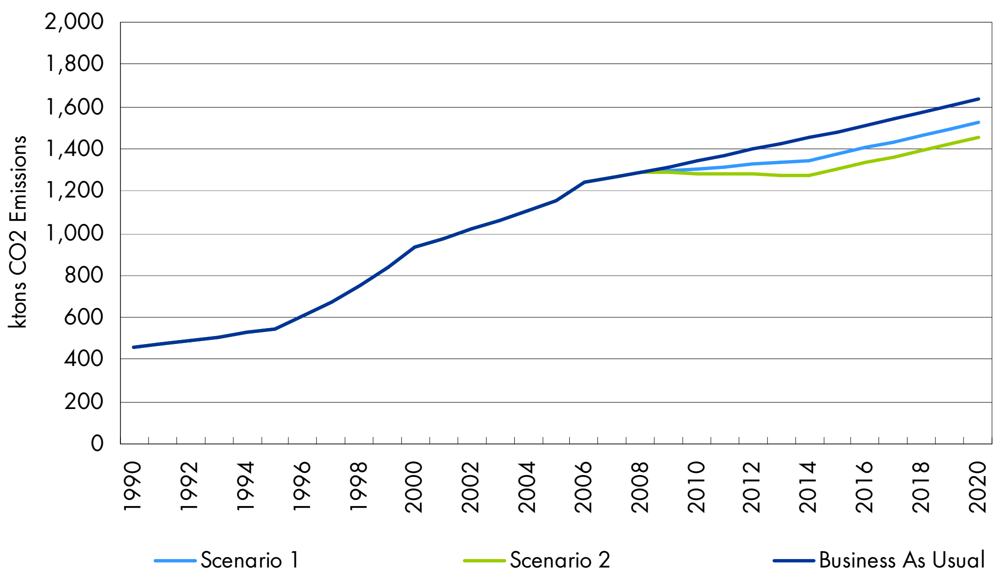


Figure 5.39: CO_2 Emissions of Transport in Dublin City 1990 – 2020, Business As Usual, Scenario 1 and Scenario 2

Financial Analysis

Introduction

Possible energy and CO_2 savings as well as the capital costs and costs savings are indicated for five possible actions. Costs and benefits are calculated for each of the actions for the period 2008 to 2020 based on the timeline for implementation as presented in Table 5.6.

The calculations are based on the 2006 figures for population, travel modes, work force, number of pupils, number of vehicles and CO_2 emission for electricity.

Cost savings due to fuel savings are based on the price for fuel in January 2008 [85].Cost savings due to CO_2 savings - referred to as Carbon Credits - are calculated with €25/ton CO_2 saved. Apparent inconsistency between the total cost savings and their subtotals are due to rounding to the nearest decimal point.

Details of Proposed Actions

1. Workplace Travel Plans

This action aims at reducing the modal split of workers travelling by car from 48% (Census 2006) to 39% by introducing workplace travel plans. The number of employees in the City of Dublin is calculated to be 270,775 [86]. In order to achieve this goal, half of the 19% of the workforce who use cars switch to public transport, and half to cycling. The costs for the implementation of workplace travel plans are calculated to be €60 per employee [87]. In order to calculate the cost savings for individuals the savings on fuel costs are offset against the costs for an annual bus ticket with the tax saver scheme being applied [88]. The travel distance to work originally done by car and replaced by public transport is calculated to be 10 km and 5.2 km for those switching to cycling [89].

Possible Savings:	Energy	0.90 TWh
	CO_2	221 ktonnes
Capital Cost:	€ 16.2 million	
Cost savings:	€ 24.1 million	
Individuals	€ 18.6 million	
Carbon Credits	€ 5.5 million	

2. School Travel Plans

School travel plans aim at reducing the share of pupils in the first and second level being driven by car to school from 34% to 23%. The number of pupils in the City of Dublin is calculated to be 79,585 [90]. In order to achieve this goal a third of the pupils currently being driven by car will walk or cycle instead. The travel distance to school, originally made by car as passenger, is calculated to be 3.6 km [91].

Possible Savings:	Energy	0.12 TWh
	CO_2	29 ktonnes
Capital Cost:	€ 2.6 million	
Cost savings:	€ 12.4 million	
Individuals	€ 11.7 million	
Carbon Credits	€ 0.7 million	

3. Cycling Initiative

The cycling initiative aims at replacing 10% of the car mileage with bicycle mileage. It includes investment into infrastructure in all 4 local authorities in the amount of € 88 million. This sum would allow the construction of 1,000 km of one-way cycle lane [92] or could be ideally invested in one-way cycle lanes and other cycle infrastructure. Furthermore, costs for the purchase of bicycles for half of the population are considered. The arising costs and cost savings for the City of Dublin are calculated according to the share of the population.

Possible Savings:	Energy	3.09 TWh
	CO_2	761 ktonnes
Capital Cost:	€ 88.1 million	
Cost savings:	€ 329.8 million	
Individuals	€ 310.8 million	
Carbon Credits	€ 19.0 million	

4. Eco-Driving

Through eco-driving - meaning smart, smooth and safe driving - fuel savings as much as 10% can be realised, particularly if professional drivers (of buses, trucks and taxis) received training in eco-driving. Training costs are estimated to be € 1,420 for each driver. It is assumed that there is one driver per vehicle registered in Dublin City and County, except for Dublin Bus company, where the number of the actual bus drivers is considered [93]. The arising costs and cost savings for the City of Dublin are calculated according to the share of the population.

Possible Savings:	Energy	1.46 TWh
	CO_2	362 ktonnes
Capital Cost:	€ 44.4 million	
Cost savings:	€ 150.3 million	
Individuals	€ 141.2 million	
Carbon Credits	€ 9.0 million	

5. Electric Cars

10% of the private petrol cars registered in Dublin City and County are replaced with electric cars. Apart from the additional costs for electric cars in comparison with a conventional car [94] the costs for charging points are calculated [95]. The arising costs and cost savings for the City of Dublin are calculated according to the share of the population.

Possible Savings:	Energy	1.16 TWh
	CO_2	315 ktonnes
Capital Cost:	€ 223.0 million	
Cost savings:	€ 180.5 million	
Individuals	€ 172.7 million	
Carbon Credits	€ 7.9 million	

Action	Primary Energy Savings	CO_2 Savings	Cost Savings	Costs of Action	Benefits to Cost Ratio
	TWh	ktonnes	million €	million €	
1. Workplace Travel Plan	0.90	221	€24.1	€16.2	1.5
2. School Travel Plan	0.12	29	€12.4	€2.6	4.7
3. Cycle Initiative	3.09	761	€329.8	€88.1	3.7
4. Eco-driving	1.46	362	€150.3	€44.4	3.4
5. Electric Cars	1.16	315	€180.5	€223.0	0.8
Total	6.73	1,687	€697.2	€374.4	1.9

Table 5.7: Costs and Savings of each Proposed Action Calculated over the Period 2008 to 2020

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Capital Costs versus Benefits

The capital costs versus benefits of the actions are presented in the following chart and are calculated for the period 2008 to 2020, implying the timeline of implementation (Table 5.6).

The benefit to cost ratio of actions 1-4; Workplace Travel Plans, School Travel Plans, Cycle Initiative and Eco-Driving is 1.5 to 4.7, action 5 - Electric Cars - has a benefit to cost ratio of 0.8.

It is worth considering that the cost savings are based on fuel prices in 2008 and could therefore rise significantly.

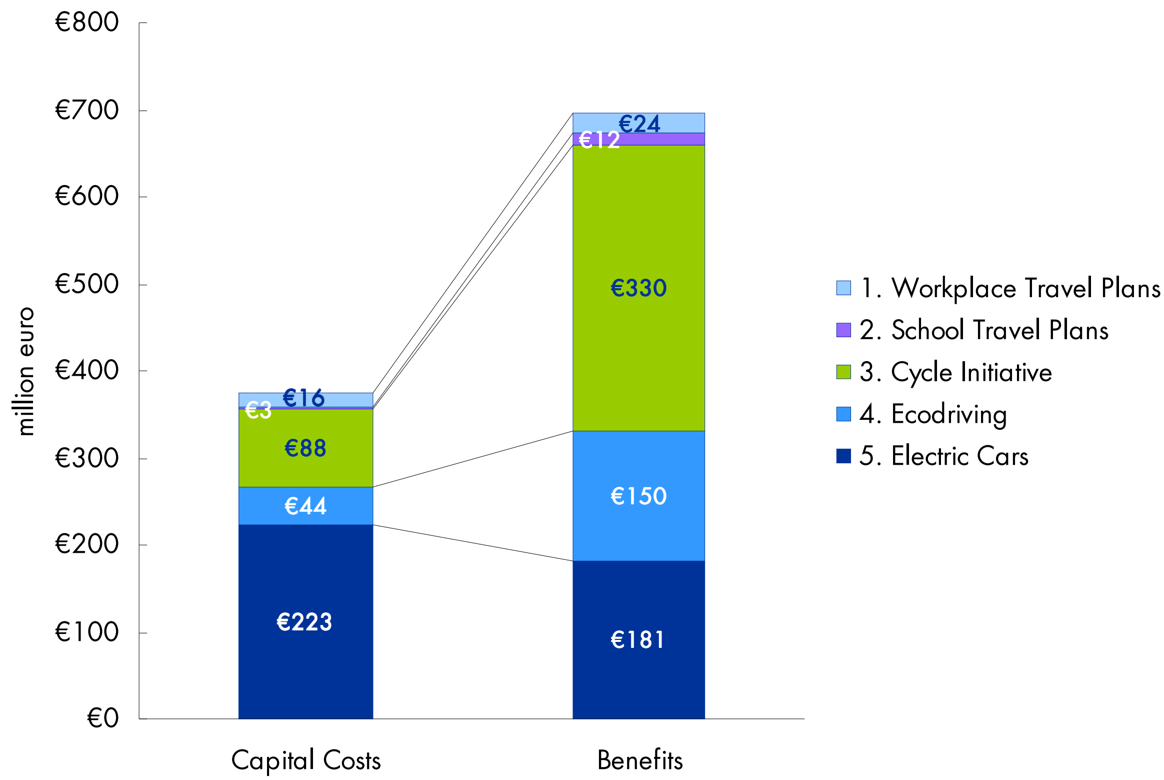

Figure 5.40: Cost-Benefit-Analysis of Actions

Conclusions

- In 2006 the primary energy consumption for traffic in the City of Dublin was 5 TWh and associated CO_2 emissions were 1,240 ktonnes.
- Transport accounts for 23% of the primary energy consumption and 25% of CO_2 emissions of Dublin City.
- Primary energy consumption originating from transport has increased by 167% and associated CO_2 emissions by 168% between 1990 and 2006.
- Transport has experienced an immense growth in the last 15 years; the number of road vehicles registered in Dublin City and County increased by 104% between 1990 and 2006.
- In Dublin City and County half of all trips (49%) are undertaken by car either as driver or passenger.
- The number of people in Dublin City and County at work increased by 37% between 1996 and 2006 amounting to 559,050 in 2006. The number of workers travelling by car as driver increased by 45% holding a share of 48% in 2006.
- If a moderate growth (2% per annum) is applied for the period 2006 to 2020, then the primary energy consumption will account for 6.6 TWh and the CO_2 emissions 1,640 ktonnes in 2020, a 32% increase compared with 2006.
- Possibilities for sustainable energy are many and comprise reducing and optimising motorised travel, fiscal incentives and urban planning. Biofuels are a possibility for more renewable energy.
- Energy savings and CO_2 emission reductions can be realised with a set of five far-reaching measures and can mitigate the increase forecasted for 2020 from 32% to 18%.

Scenario	Description	Primary Energy Consumption (TWh)	CO_2 Emissions (ktonnes)
Current Situation	Energy consumption /CO_2 emissions 2006	5.0	1,240
Business As Usual	2% Annual Growth between 2006 and 2020	6.6	1,640
Scenario 1	Actions 1-3 to reduce individual motorised travel	6.2	1,580
Scenario 2	Actions 1-3 to reduce individual motorised trips and Actions 4-5 to optimise motorised travel	5.9	1,460

Table 5.8: Current Situation and Scenarios for the Primary Energy Consumption and CO_2 Emissions.

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Conclusion

Conclusions

This concluding chapter is presented as work-in-progress. It offers a summary the options, costs and benefits for energy in the context of a sustainable Dublin and informs the debate among policymakers, stakeholders and citizens on Dublin's future energy planning.

Summary of Options

Regulatory Instruments

i. ***Dublin City Development Plan 2005-2011:*** A high 'A' standard of BER (Building Energy Rating) is specified for all new residential and commercial buildings larger than 1,000 m^2 from January 2009 in a variation to the City Development Plan that was adopted by Council on 5th November 2007. The variation adds an energy policy and complementary site development standard that seeks to achieve improved energy efficiency and renewable energy in new buildings throughout the city and that will have a major benefit to the built environment over the long life-cycle of the building stock

ii. ***Dublin City Development Plan Review:*** The working group on sustainable environment and infrastructure has prepared an issues paper outlining a sustainable Dublin framework and approach for the upcoming City Development Plan Review

iii. ***Dublin City Council Water Bye-laws 2003:*** These water bye-laws provide for the management of water services and the conservation of drinking water through requirements for efficient fixtures and fittings. This also helps reduce the energy consumed in production and pumping of potable water, in waste water pumping and treatment and in heating domestic water

Fiscal Incentives

iv. ***Congestion charges:*** The costs, benefits and effects of congestion charging may be assessed, especially in terms of greenhouse gas emissions, possibly introduced before the completion of Transport 21

v. ***Free parking for electric vehicles:*** New generation electric hybrid vehicles are cleaner and more energy efficient than conventional petrol/diesel units. On the issue of Dublin City Council providing free parking for electric vehicles, there is a need to clarify existing legislation on assigning individual parking bays for charging electrical vehicles and to examine the costs and benefits of introducing special charging facilities for electric vehicles

vi. ***National and EU incentives:*** There is a variety of grants available under national and European programmes that support specific local sustainable energy projects helping to deliver Irish and EU policy objectives for energy and climate change. For example national programmes managed by Sustainable Energy Ireland (SEI) and EU programmes managed by the Executive Agency for Competitiveness and Innovation (EACI)

Behavioural Measures

vii. Localized advice and information for households

viii. Bottom-up programme for services sector – especially SMEs

ix. Workplace travel plans and school travel plans

x. Eco-driving promotion for professional drivers

Technical Measures

xi. Low energy lighting for both the residential and business sectors

xii. Insulation of pre-1990 social and private housing, with the objective of improving the BER from a D/E rating to a B/C rating in the existing housing stock

xiii. Heating systems upgrades in existing housing with new technology boilers and other highly efficient heating systems

xiv. Upgrades in commercial buildings in both the building fabric and also the HVAC systems, including combined heat and (CHP) power and/or district heating connections

xv. A new Dublin district heating and cooling network linking up new and existing group heating schemes and CHP units

xvi. Renewable energy sources including solar, waste-to-energy, deep geothermal heat, urban wind power and ocean energy

xvii. Cycle initiative, including more and better quality dedicated cycle lanes and soft measures to encourage a modal shift in favour of cycling

Scenarios

The practical options that are available to Dublin from now to 2020 are assessed, under 3 headings:

Business As Usual (BAU)

BAU sees the trajectory of CO_2 emissions continue along the rising trend line from 1990 to 2006 [1]. This scenario amounts to a minimal compliance with legal requirements, with no long-term vision.

Scenario 1

Scenario 1 comprises 'the low hanging fruit' measures, that are generally very cost-effective (but not at zero cost, as is sometimes assumed) and that can be applied immediately.

Scenario 2

Scenario 2 includes all the measures listed under Scenario 1, plus major additional measures using existing technologies that are either not common in Ireland at present or are not cost-effective.

Sector	Scenario 1: Actions
Residential Sector	• Improve user behaviour • Low energy light bulbs • Attic insulation in existing homes • All new houses to be 'A' energy rated on BER scale
Services Sector	• 'Good housekeeping' (e.g. switching off equipment not in use) • Low energy lighting systems and controls
Transport Sector	• Workplace travel plans for commuters • School travel plans • Cycle initiative
Sector	**Scenario 2: Additional Actions**
Residential Sector	• Complete major refurbishment of existing houses, including wall insulation, energy efficient windows, high efficiency boilers and renewable energy for heat and hot water • High penetration of District Heating and renewable energy
Services Sector	• Upgrade of heating, ventilation and air conditioning • Insulation of the fabric of existing commercial buildings • All new commercial buildings over 1,000 m^2 to be 'A' energy rated
Transport Sector	• Eco-driving training for professional drivers of buses, trucks and taxis • Electric cars (including plug-in hybrids) at 10% market penetration

Table 6.1: Summary of Energy Actions for Scenarios 1 and 2

Energy Models

Detailed energy models have been created in this report specifically for each of the four sectors: residential, services, manufacturing and transport.

The models are based on the most robust and up-to-date data available from Census 2006, National Car Testing, DTO, SEI, EPA, ERSI, DOEHLG and other sources. Matrices for energy consumption (in units of kWh) are computed and presented according to both sector and fuel type. It is then a simple matter to calculate the CO_2 emissions, and other quantities, using standard conversion factors.

These models are valuable for evaluating the impacts of the various options for energy saving, both as individual options and, by simple addition, the impacts of several measures taken together. For example, CO_2 emissions for the current (2006) year and projections to 2020 are shown in figures 6.1, 6.2 and 6.3 for the three scenarios: BAU, scenario 1 and scenario 2, respectively.

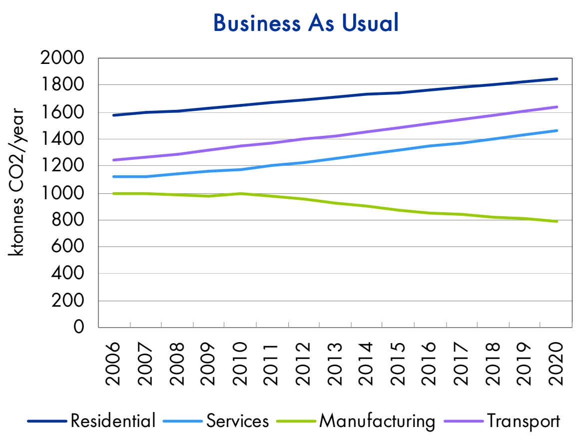

Figure 6.1: CO_2 Emissions Projection to 2020 - Business As Usual

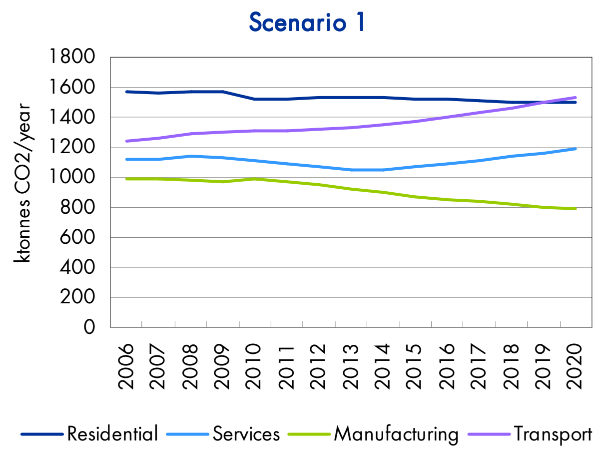

Figure 6.2: CO_2 Emissions Projection to 2020 under Scenario 1

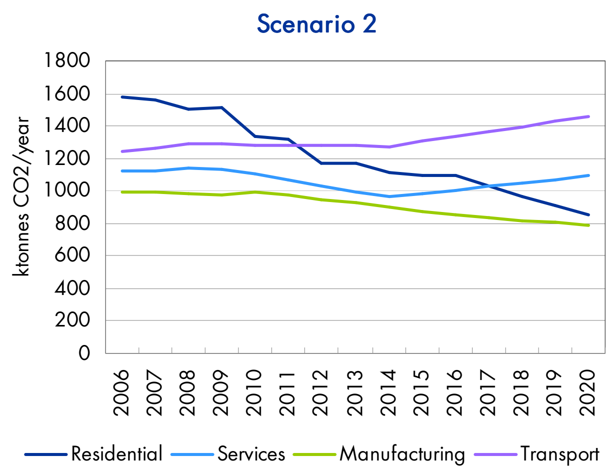

Figure 6.3: CO_2 Emissions Projection to 2020 under Scenario 2

Economic Model

An economic model has also been created to estimate the costs and benefits of the various measures and groups of measures.

The model is based on:

(a) The estimated cost of the works at 2008 prices, including VAT but not including interest on borrowings

(b) The energy saved in kWh, which is derived from the energy models

(c) Electricity, gas and fuel tariffs from the most recently published tariff, including VAT

The costs and benefits are shown in figure 6.4 for scenario 1 and in figure 6.5 for scenario 2, with regard to the residential, services and transport sectors.

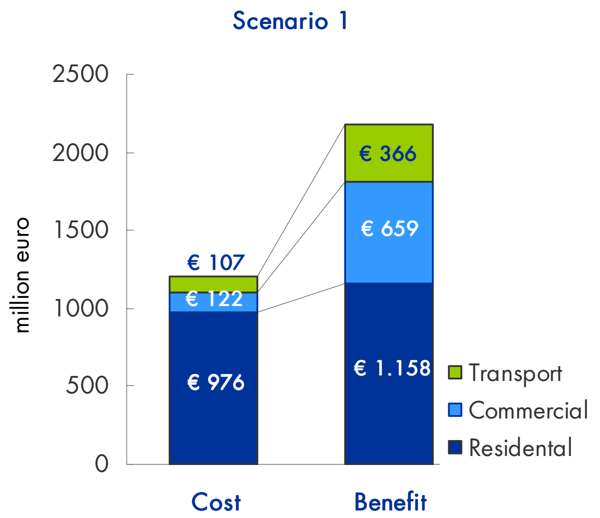

Figure 6.4: Cost-Benefit-Analysis of Scenario 1, by Sector

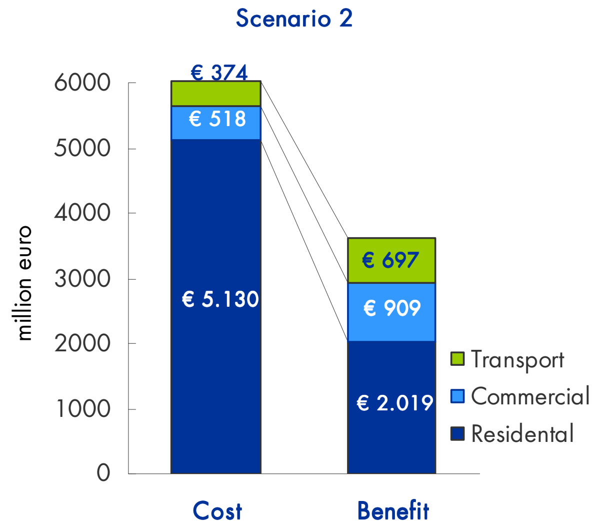

Figure 6.5: Cost-Benefit-Analysis of Scenario 2, by Sector

Clearly, any future increases in the cost of electricity, gas and motor fuels will increase the benefits proportionally. Already, the Energy Regulator has published a proposal for an average 17.5% increase in electricity for households and SMEs, from August 2008. Bord Gais has published a corresponding increase of 25.26% for natural gas, from October 2008. This means that measures which are not currently cost-effective, or marginally so, will become more cost-effective in the future.

Strategic Options

Business as Usual

Minimum compliance with regulations, no long-term vision

Scenario 1

Stabilization of emissions at 2006 level through relatively easy 'low hanging fruit' measures

Scenario 2

Reversing the upward trend in emissions, through major changes in practices. Also, through innovative technologies that already exist but are either new to Ireland or are not yet cost-effective here.

Reframing the Question

The issue of emissions *targets* is a difficult question, because in practice the impacts cannot easily be controlled. Instead, the strategic options can be re-cast in terms of *timelines*, which are easier to influence. There can be long-term (e.g. 50 year) measures and more immediate ones (on timescales of 7 to 16 years).

Examples of short-term measures include behavioural changes, retrofitting of existing buildings and more efficient electrical lighting and appliance. Long-term measures include carbon neutral buildings and transport, extensive renewable energy sources, electric hybrid vehicles and sustainable land-use.

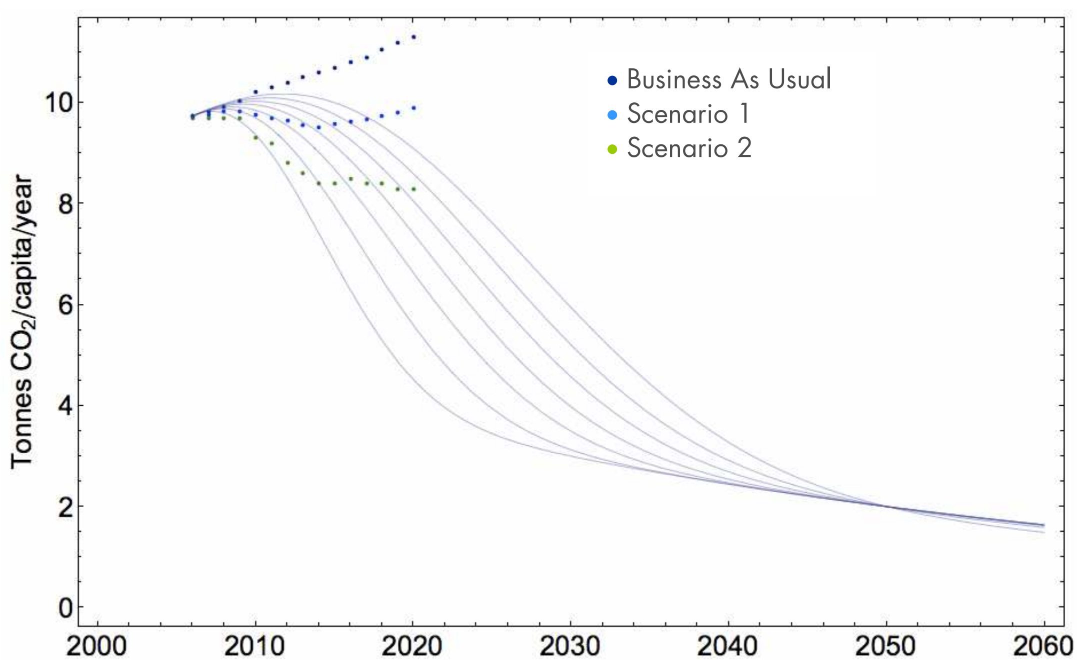

Figure 6.6: Two-component Mathematical Model of Emissions Trajectories Constrained to (a) Existing 2006 Baseline, (b) Existing 2006 Trend Line, (c) 2050 Target of 2 tonnes CO_2/capita/year

Bundling of Measures

Environmental Bundle

Of the many ways that the various measures can be combined together into 'bundles', one example is an 'Environmental Bundle'. This was selected on the simple basis of choosing the two measures from each sector that are most effective in reducing CO_2 emissions. This bundle of six measures will deliver 40% of the total potential CO_2 emissions saving, i.e. 40% of the benefit from just six of the measures. This bundle is cost-effective, in that the savings to 2020 will exceed the capital costs.

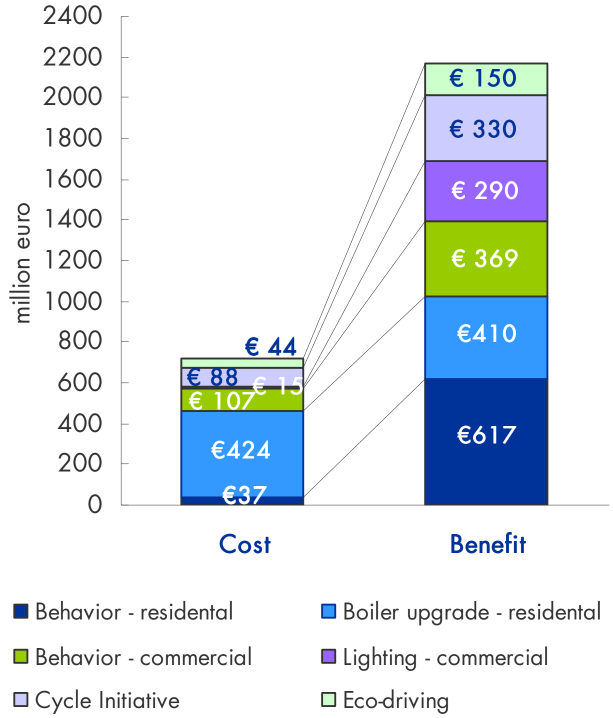

Figure 6.7: Cost-Benefit Analysis of the 'Environmental Bundle'

Social Bundle

From the social perspective, the most important measures are those that improve the energy performance of Dublin's existing housing stock. Particularly important are the houses which were constructed prior to 1991, the year that building regulations were first introduced, where the risk of Fuel Poverty is highest among the more vulnerable citizens. Energy efficiency refurbishment can reduce the heating costs in winter and make the homes more healthy and comfortable to live in. This bundle as a whole is not cost-effective at today's fuel prices. It could benefit from some form of financial subsidy or tax incentive.

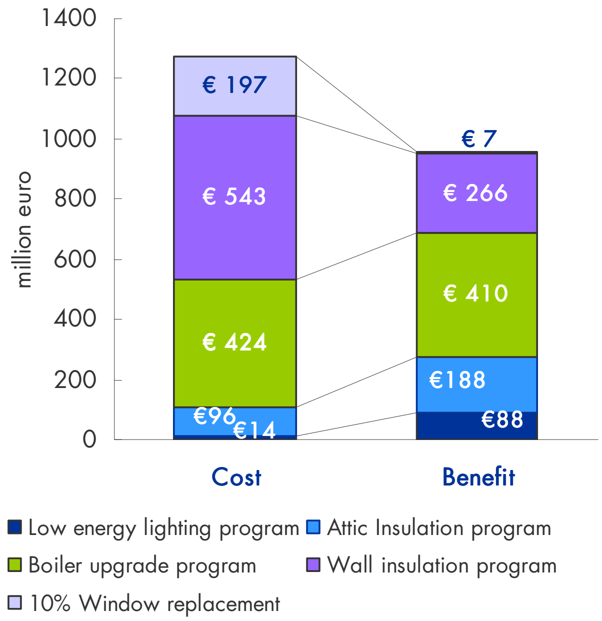

Figure 6.8: Cost-Benefit Analysis of the 'Social Bundle'

Key Questions

1. Strategic Options

The first key question relates to the strategic options for Dublin in addressing the problems of sustainable energy and climate change.

The context of this question lies within an overarching framework for a sustainable Dublin, committed to taking a sustainable approach to achieving its vision of a vibrant, healthy, clean, safe, green and inclusive city.

Rather than focussing solely on the distance from (emissions) targets, whose impacts cannot easily be controlled, the targets can be re-cast in terms of a time-frame that can be more easily influenced. An appropriate combination of long-term and short-term measures can reduce emissions by 2050 by almost 80%, as compared with 2006. This is close to the goal of the Intergovernmental Panel on Climate Change (IPCC) for the developed nations.

The strategic options for Dublin are broadly parallel to the political options for the Irish Government, as detailed in the IIEA report *'The Climate Change Challenge: Strategic Issues, Options and Implications for Ireland'* [2]. The solutions are correspondingly interlocked, with local sustainable energy projects supported by, and adding value to, national programmes, all combining to help deliver Irish and EU energy policy objectives.

2. Bundling of Measures

The second key question relates to the delivery of sustainable energy measures. This cannot be left to market forces alone, although there will be savings on fuel bills, an improvement in the quality of life and benefits for the environment.

This report identifies two potential bundles of measures that can be implemented immediately:

- The 'Environmental Bundle', in which six measures across the sectors will deliver 40% of the total potential CO_2 reductions
- The 'Social Bundle' focuses on improving the energy performance of existing housing and reducing the risk of fuel poverty

In a broader context, the city regions of the world are responsible for the major portion of greenhouse gases emitted; they are also very important in this global economy we inhabit and they are therefore critical partners in the climate change debate.

The delivery of sustainable energy measures in bundles across several sectors naturally occurs at the local and regional levels of government. There will also be economies of scale to be taken advantage of in the case of Dublin City because of its large size, where new measures can be replicated many times over.

Next Steps

These two key questions defined in the conclusions to this consultation draft of the *'Action Plan on Energy for Dublin'* are directed towards the ongoing debate among policymakers, stakeholders and citizens on Dublin's future energy planning.

It can be concluded that much remains to be done. It is hoped that this report will help to inform and inspire the ongoing debate for a sustainable Dublin and that it will contribute to reducing the City's carbon footprint and improving the quality of life for the present and future generations.

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Appendix

List of Figures and Tables

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Residential Sector

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References

Introduction

[1] C40 Cities climate leadership group. (2008). [Internet]. Available from http://www.c40cities.org/[Accessed 8 August 2008]

[2] European Commission Executive Agency for Competitiveness and Innovation. Grant Agreement IEE/07/526/SI2.499392 – MINUS 3% *Shining Examples for the Implementation of the Energy End-use Efficiency and Energy Services Directive.*

[3] Department of Communications, Energy and Natural Resources. (2007). *Delivering a Sustainable Energy Future for Ireland.* Energy White Paper. DCENR. Dublin.

[4] Department of the Taoiseach. (2007). *Programme for Government 2007 - 2012.*Government Publications. Dublin.

[5] European Commission Intelligent Energy Executive Agency. Grant Agreement EIE/05/125/SI2.419789 – SECURE *Sustainable Energy Communities in Urban Areas in Europe* www.secureproject.org

Background

[1] World Commission on Environment and Development, (1987). *Our Common Future, Report of the World Commission on Environment and Development.* Published as Annex to General Assembly document A/42/427, *Development and International Co-operation: Environment* Oxford University Press, Oxford.

[2] Department of the Environment and Local Government. (2002). *National Spatial Strategy 2002 – 2020.* Government Publications. Dublin.

[3] LaSalle Investment Management. (2007). *European Regional Economic Growth Index (E-REGI) 2007.* [Internet] Jones Lang LaSalle IP, Inc London. Available from http:/www.lasalle.com/NR/rdonlyres/176C0343-9986-4F9B-912D-B069807E08CD/38209/EREGI2007_WEB.pdf [Accessed 9 July 2008]

[4] The World Economic Forum. (2007). *Global Competitiveness Report* 2007–. 2008 *The Global Competitiveness Index rankings, 10* [Internet]. Available from www.weforum.org/pdf/Global_Competitiveness_Reports/Reports/gcr_2007/gcr2007_rankings.pdf [Accessed 21 July 2008]

[5] Artus, P. and Kaabi, M.. (2005). The price of oil in 10 years' time: USD 380 a barrel. *Flash* vol 38, pp 1-8.: IXIS Corporate & Investment Bank. Paris.

[6]. Campbell, Colin J. (2008). *About Peak Oil: Understanding Peak Oil.* [Internet*]* ASPO. Available from: http://www.peakoil.net/ [Accessed 22 July 2008]

[7] McCarthy, S. (2008). *Peak Oil and the Northern Link Environmental Statement.* [Internet] ASPO Australia. Available from: http://www.aspo-australia.org.au/References/ASPO-Brisbane/Northern-Link-EIS-28Jan-2008-v2.doc [Accessed 22 July 2008]

[8] United Nations Development Programme. (2008). *Fighting Climate Change: Human solidarity in a divided world* in Human Development Report 2007/2008. *Palgrave* Macmillan. New York

[9] Sen, A. (1998). *Origins of the Human Development Approach – Human Development Reports (UNDP).* [Internet]. Available from: http://hdr.undp.org/en/humandev/origins/ [Accessed 9 July 2008]

[10] Sen, A. (2008). *Climate policy as human development. Special contribution to United Nations Development Programme, 2008* in Human Development Report 2007/2008 *Fighting Climate Change: Human solidarity in a divided world.p*28-29. Palgrave Macmillan. New York

[11] National Competitiveness Council. (2008). *Discussion Paper on Wellbeing and Competitiveness.* Forfas. Dublin.

[12] Fitzgerald *et al.* (2008). *Medium-Term Review 2008-2015.*: The Economic and Social Research Institute. Dublin

[13] Stern, N. (2008). *Key Elements of a Global Deal on Climate Change.* LSE. London.

[14] Pachauri, R. (2007). *Presentation at Carbon Day at the Institute of European Affairs, Dublin, 1st June 2007.* [Internet]. Available from http://www.iiea.com/newsxtest.php?news_id=115 [Accessed 17 July 2008]

[15] Germanwatch. (2007). *The Climate Change Performance Index.*[Internet] Available from http://www.germanwatch.org/ [Accessed 11 July 2008]

[16] Brennan, P., and Curtin, J. (eds). (2008). *The Climate Change Challenge: Strategic Issues, Options and Implications for Ireland*: IIEA. Dublin.

[17] Institute for International and European Affairs. (2008). *Energy and Climate Change Policy Brief.* IIEA. Dublin

[18] Community Climate Change Consortium for Ireland (C4I). (2008). *Ireland in a Warmer World; Scientific Predictions of the Irish Climate in the 21st Century.*[Internet] *Available from* www.c4i.ie/docs/IrelandinaWarmerWorld.pdf [Accessed 9 July 2008]

[19] Fealy, R. and Sweeney, J. (2007). Statistical downscaling of precipitation for a selection of sites in Ireland employing a generalised linear modeling approach. *International Journal of Climatology*, vol 27, pp 2083-2094.

[20] Murray, T. *et al.* (2008).The Heat is on. *Physics World,* vol 21 (5), pp 24-29.

[21] Fealy, R. (2003).The impacts of Climate Change on Sea Level and the Irish Coast. In Sweeney, J. et al *Climate Change Scenarios and impacts for Ireland*. EPA, pp 189-220.

Residential Sector

[1] CSO. (2007). *Private households in each Province, County and City, classified by type of accommodation*, vol 6 , table 2. [Internet], http://beyond2020.cso.ie/Census/TableViewer/tableView.aspx?ReportId=7282 [Accessed on 17 August 2007].
[2] Howley et al. (2006*). Energy in Ireland 1990-2005- Trends, issues forecasts and indicators*. SEI Publications. Cork.
[3] Department of the Environment, Heritage and Local Government, Housing Statistics (2006). Excel Worksheet [Internet], available from http://www.environ.ie/en/Publications/StatisticsandRegularPublications/HousingStatistics/. [Accessed on 5 July 2007].
[4] Watson, D and Williams, J. (2003). *Irish National Survey of Housing Quality* .ESRI. Dublin.
[5] Hayden, Joe. (2004). *Assessment Of The Accuracy Of The Heat Energy Rating*. MSc Thesis. DIT. Dublin.
[6] Cox, Fiona. (2007). *An Investigation of Energy User Awareness and Behavior in the Residential Sector*. MSc Thesis. DIT. Dublin.
[7] DCC. (2005). *Dublin City Development Plan 2005-2011*. DCC. Dublin
[8] Fitzgerald, J et al. (2005). *Medium Term Review 2005-2012*. ERSI Publications. Dublin
[9] SEI. (2007). *DEAP methodology software*. [Internet]., available from http://www.sei.ie/index.asp?locID=1011&docID=-1. [Accessed on 7 May 2007].
[10] Dublin City Council. (2007). *Variation 22 to the Dublin City Development plan*. [Internet].http://www.dublincity.ie/Planning/DublinCityDevelopmentPlan/VariationstotheDevelopmentPlan/Documents/AdoptedVariationNo22Spec.pdf. [Accessed on 5th November 2007].
[11] Howley, M, et al. (2007). *Energy statistics 1990-2006*. SEI. Cork
[12] SEI (2008). *General information on the Building Energy Rating* available from http://www.sei.ie/index.asp?locID=1177&docID=-1 [Accessed on 2nd February, 2008].
[13] RPS Ireland (2007). *District Heating for Dublin, Feasibility Study*. RPS. Dublin.

Commercial Sector

[1] Fitzgerald, J et al. (2008). *Medium Term Review 2008-2015*. ERSI Publications. Dublin
[2] Molloy, P. (2008). Information from the revenue commissioners on employer statistics. Correspondence. 30/07/08
[3] Dublin City Development Board (2000) *Dublin- A City of possibilities 2002-2012. DCC. Dublin*
[4] Davy stockbrokers. (2007). *Economic Growth of Dublin*. [Internet], available from www.davy.ie. [accessed on 3 July 2008].
[5] McCartney, J (2007). *Lisney Estate agents research*.[Internet], available from www.lisney.com. [accessed on 8 April 2008].
[6] Forfas (2007). *Annual competitiveness report 2006 [Internet], available from*. www.forfas.ie [accessed on 3 July 2007].
[7] CSO (2008). POWCAR special tabulation for Dublin City 27/07/2008 conducted by the CSO
[8] O'Leary et al (2005). *Profiling Energy and CO2 Emissions in the Services Sector*. SEI Publications. Cork
[9] O'Leary et al (2007). *Energy in Industry*. SEI Publications. Cork
[10] SEI. (2008). Energy map programme. [Internet], available from http://www.sei.ie/energymap/ [accessed on 3 July 2008].
[11] nifes. (2004). *Building energy manager's resource guide*. SEI. Dublin.
[12] Mayor of London (2004) *Green light to clean power-The Mayor's Energy Strategy*. GLA. London
[13] Burton, S. (ed). (2001). *Energy efficient office refurbishment. Part II Chapter 3* Earthscan publications.London.
[14] Dublin City Council (2007). Variation 22 to the 2005-2012 Dublin City Development Plan. [Internet], available from http://www.dublincity.ie/Planning/DublinCityDevelopmentPlan/VariationstotheDevelopmentPlan/Documents/AdoptedVariationNo22Spec.pdf.[Accessed 28/08/08]

Transport Sector

[1] Millward Brown IMS & Faber Maunsell/Aecom (2006): Report DTO. *Greater Dublin Area Household Survey 2006. March – July 2006*. p. 30. Dublin.
[2] McCabe Frank. (2008). Email-Communication with F. McCabe employee at DTO on July 9th, 2008.
[3] DoT (2007). *Irish Bulletin of Vehicle and Driver Statistics. 2006*. p. 7-20. DoT. Dublin,.
[4] SEI Energy Policy Statistical Support Unit (2008): SEI analysis of NCT data. SEI. Cork.
[5] Howley, M et al. (2008): *Energy in Transport. 2007 Report*, p. 30. SEI. Cork..
[6] O' Leary, F et al. (2007): *Energy in Transport. Trends and Influencing Factors*. 2006 Report p .32.SEI. Cork.

[7] McGovern Anne (2007). Email communication with A. McGovern employee at Dublin Bus on July 6th 2007.
[8] LUAS. (2007). FQA [Internet], available from www.luas.ie [accessed on July 8th, 2007].
[9] Lillis, A. (2007). E-mail communication with A. Lillis employee at RPA on August 7th, 2007.
[10] Sheridan, C (2007). Email communication with C. Sheridan employee at Irishrail on August 20th, 2007.
[11] SEI. (2007). *Hybrid Electric and Battery Electric Vehicles. Technology, Costs and Benefits* p.87. SEI. Cork.
[12] Howley, M. (2007). *Energy in Transport 2007 Report* p.49. SEI. Cork..
[13] CSO (2007). *CSO Road Freight Transport Survey 2006* p.8. CSO. Dublin. .
[14] DEHLG (1996-2005). *Irish Bulletin of Vehicle and Driver Statistics.* Annually published.DEHLG. Dublin.
[15] Howley, M.(2008). *Energy in Transport. 2007 Report.* p. 24. SEI. Cork. .
[16] Public Carriage Office. (2007). *Transport for London Factsheet.* PCO. London.
[17] Dublin Port Company (2007). *Facts and Figures.* [Internet], available from http://www.dublinport.ie/about-dublin-port/facts-and-figures/ [accessed on August 28th, 2007].
[18] CSO. (2007). Tonnage of Goods handled classified by Port and Region of Trade, Table 8 in *Statistics of Port Traffic 2006.* CSO. Dublin.
[19] DCC. (2007). *Transport. Dublin Port Tunnel.* [Internet], available from http://www.dublin.ie/transport/dublin-port-tunnel.htm [accessed on August 28th, 2007].
[20] DCC (2004). *Living in the City. Dublin Port Tunnel.* [Internet], Available from http://www.dublincity.ie/living_in_the_city/your_area/north_central/projects/dublin_port_tunnel.asp [accessed on August 28th, 2007].
[21] Dublin Port Tunnel, NRA. (2007). *National Road Network Map.* [Internet], Available at http://www.dublinporttunnel.ie /route_and_location_maps/national_road_network_map/ [accessed on August 28th, 2007].
[22] DTO, Millward Brown IMS & Faber Maunsell/Aecom (2007): *Greater Dublin Area Household Survey 2006.* March-July 2006. p.4. Dublin.
[23] CSO. (2007). Travel to Work, School and College. Table 7A, 8A, 9A in *Census 2006.* vol 12 pp.25, 28, 31. CSO. Dublin.
[24] CSO. (2007). Travel to Work, School and College. Table 6A in *Census 2006.* vol 12 p. 22. CSO. Dublin.
[25] CSO. (2007). Travel to Work, School and College. Table 10A, 14A, 18A in *Census 2006* vol 12 pp.34, 46, 58. CSO. Dublin.
[26] Millward Brown IMS & Faber Maunsell/Aecom (2006). *Greater Dublin Area Household Survey 2006.* p.3-5. Dublin.
[27] Millward Brown IMS & Faber Maunsell/Aecom (2006). *Greater Dublin Area Household Survey 2006.* p.42. Dublin.
[28] Booz et al. (2004). *Greater Dublin Travel Demand Management Study. Final Report* p.64 .DTO. Dublin.
[29] DTO. (2005). *Safer Routes to School. Next Steps.* pp.8, 13, 22. DTO. Dublin.
[30] DTO. (2006). *DTO Cycling Policy* p. 5. Adopted by the DTO Steering Committee.DTO. Dublin.
[31] DTO. (2005). *Metropolitan Area Cycle Network.* DTO. Dublin. .
[32] DCC. (2006). *City Bike – Appendix 1.* [Internet], available from http://www.dublincity.ie/Images/Appendices%201-5%20reduced_tcm35-48977.pdf [accessed on August, 18th 2007].
[33] Budgettravel. (2007). *Rent a Bike in Europe for Nearly Nothing.* [Internet], available from http://www.budgettravel.com [accessed on August, 14th 2007].
[34] Springwise. (2007). *City Bikes Scheme. Transport.* [Internet], Available from http://www.springwise.com/transportation/ [accessed on August 14th, 2007].
[35] ASTUTE (2007). City Bike Schemes seen during travel to project meeting in September, 2007.
[36] Gleeson, D. (2007). *Sustainable City Development in Dublin.* Powerpoint Presentation. Dublin, October, 19th 2006.
[37] Road Safety Authority. (2007).Road Users Killed and Injured in the Main Centres of Population, table 48 in *Road Collision Facts 2006*, p. 42. RSA. Ballina.
[38] DTO. (2005). *Safer Routes to School. Next Steps.* p.4. DTO. Dublin.
[39] DTO. (2001). *A Platform for Change. Strategy 2000-2016.pp.5-7*, pp.77-78. DTO. Dublin.
[40] Flaherty, G. (2007). *Report on Dublin City Council`s Canal Cordon Traffic Counts 2006.* pp. 5-6. DCC. Dublin.
[41] Flaherty, G. (2008). *Report on Dublin City Council`s Canal Cordon Traffic Counts 2007.* p. 6. DCC. Dublin.
[42] Iarnród Éireann. (2007). *Your Journey* [Internet], available from http://www.iarnrodeireann.ie/ [accessed on August 15th 2007].
[43] DoT. (2007). *Connecting Communities Promoting Prosperity.* DoT. Dublin.
[44] Indecon. (2005). *Economic and Social Infrastructure Operational Programme (ESIOP), Update Evaluation 2005* p.66. Dublin.
[45] Railway Procurement Agency. (2005). Operating and Financial Review in *Annual Report 2005* p.9. RPA. Dublin.
[46] DTO. (2005). *QBC Monitoring Report.* p. 19. DTO. Dublin.
[47] DTO. (2007). *Dublin Rail Network* [Internet]. Available from http://www.dto.ie/web2006/station_maps.html [accessed on August 15th, 2007].
[48] Hogan, V. (2008). E-mail communication with V. Hogan, employee at DoT, Transport 21 Division on August 21st 2008.
[49] Moyles, B. (2007). E-mail communication with B. Moyles, employee at DoT, Transport 21 Division on August 13th 2007.
[50] Treacy, M. (2007). Personal communication with M. Treacy, employee at DoT Transport 21 Division, on August 29th 2007
[51] DoT, Transport 21Division (2007): *Greater Dublin Area Rail Network* [Internet]. Available from http://www.transport21.ie [accessed on October 12th, 2007].
[52] Infopolis 2. (2007). *Passenger Information System Inventory: At-Stop Display. PHOEBUS* [Internet]. Available from http://www.ul.ie/%7Einfopolis/existing/annex_f/f3.htm [accessed on August 28th, 2007].

[53] Infopolis 2. (2007). *Passenger Information System Inventory: At-Stop Display. COUNTDOWN* [Internet]. Available from http://www.ul.ie/%7Einfopolis/existing/annex_f/f12.htm [accessed on August 28th, 2007].
[54] Mayor of London.(2005). The TfL business plan 2005/6-2009/10 in *Transport for London 5 Year Investment Programme*. p. 9. GLA. London.
[55] Infopolis 2. (2007). *Passenger Information System Inventory: At-Stop Display. TIMECHECKER*. Available from http://www.ul.ie/%7Einfopolis/existing/annex_f/f33.htm [accessed on August 28th, 2007].
[56] CSO. (2006). *Road Freight Transport Survey 2005*. p. 8. CSO. Dublin.
[57] CSO. (2007). *Statistics of Port Traffic 2006*. p. 9. CSO. Dublin.
[58] Ecodriven, SenterNovem (2006): *What is ecodriving?* [Internet]. Available from http://www.ecodrive.org/ [accessed on July 30, 2007].
[59] SEI. (2007). *Hybrid Electric and Battery Electric Vehicles. Technology, Costs and Benefits*. pp.7, 18, 27. SEI. Cork..
[60] Booz et al. (2004). *Greater Dublin Travel Demand Management Study. Final Report* p.141. DTO. Dublin.
[61] Booz et al. (2004). *Greater Dublin Travel Demand Management Study. Final Report* p.84. DTO. Dublin.
[62] Booz et al. (2004). *Greater Dublin Travel Demand Management Study. Final Report* p.42. DTO. Dublin.
[63] Transport for London. (2007). *Congestion charging where and when does it operate?* [Internet], from available from http://www.cclondon.com [accessed on August, 15th, 2007].
[64] London Councils. (2004). *An independent assessment of the central London congestion charging scheme*. Available from http://www.londoncouncils.gov.uk [accessed on August 15th, 2007].
[65] Litman, T. (2006). *London Congestion Pricing Implications for Other Cities*. VTP. Victoria.
[66] Clark, A. (2004*). London companies learn to love congestion charge*. [Internet] Available from http://politics.guardian.co.uk [accessed on August 15th, 2007].
[67] Transport for London. (2007). *Congestion charging where and when does it operate? Display Map of Zone*. [Internet], available from at http://www.cclondon.com [accessed on August, 15th, 2007].
[68] Vägverket. (2005). *Försök med trängselskatt i Stockholm* 3 januari - 31 juli 2006. Stockholm.
[69] Stockholmsförsöket. (2006): Stockholmsförsöket – hur gick det? Analysgruppens sammanfattning. Powerpoint Presentation [Internet], available from http://www.stockholmsforsoket.se/templates/page.aspx?id=8432 [accessed on August 15th, 2007]
[70] City of Stockhom. (2006). *Fakta och resultat från Stockholmsförsöket Andra versionen – augusti 2006*. Stockholm.
[71] Svetax Invest AB. (2007). *Detta om trängselskatt i Stockholm och vem som ska betala och hur det ska gå till*. [Internet], available from http://www.svetax.se [accessed on August 15th, 2007].
[72] Vägverket. (2005). *Försök med trängselskatt i Stockholm 3 januari - 31 juli 2006*. p 1. Stockholm.
[73] DCC. (2005). *Dublin City Development Plan 2005-2011*. Written Statement. DCC. Dublin..
[74] DCC. (2007). Green Procurement in *First Post* vol 10 Issue 16.
[75] McGrath, U. (2007). ASTUTE – Dublin – Workplace Travel Plans. Powerpoint Presentation to the Unions on July 13rd, 2007.
[76] DCC. (2008). *Workplace Travel Plan Brochure*. DCC. Dublin.
[77] SEI. (2004). *Liquid Biofuels Strategy Study for Ireland*. pp.6,20. SEI. Cork..
[78] O' Leary, F. et al. (2006). *Energy in Transport. Trends and Influencing Factors. 2006*. p.15. SEI. Cork. .
[79] Revenue commissioners. (2007). *Vehicle Registration Tax*. [Internet]. Available from http://www.revenue.ie [accessed on July 30, 2007].
[80] German-Irish Chamber of Industry and Commerce. (2007). Biofuels for Transport [Internet], available from http://www.biofuelsfortransport.ie/ [accessed on July 30, 2007].
[81] Department of Finance. (2006). *Budget 2007*. [Internet], available from http://www.budget.gov.ie/ [accessed on July 30, 2007].
[82] Codema. (2007). *Analysis of DCC Energy Consumption 200*. CODEMA. Dublin.
[83] Howley. M. (2007). *Energy in Ireland 1990-2006. 2007 Report*. p.10 Table 3, p. 36 Table 19. SEI. Cork.
[84] Howley, M. (2007). *Energy in Ireland 1990-2006. 2007 Report*. p.26. SEI. Cork.
[85] AA Ireland Ltd. (2008). *Latest Petrol Prices. Surveyed in January 2008 (avg. retail price per litre)*. [Internet], available from http://www.aaroadwatch.ie/petrolprices/default.asp [accessed on July 15, 2008].
[86] CSO. (2008). POWCAR special tabulation for Dublin City 27/07/2008 conducted by the CSO.
[87] UK Department of Transport. (2005). The influence of soft factor interventions on travel demand Smarter choices in *Changing the Way We Travel* p.29. UK Department of Transport. London.
[88] Córas Iompair Éireann Group. (2008). *Tax Saver Commutertickets*. [Internet], available from http://www.dublinbus.ie/fares_and_tickets
/taxsaver_commuter_tickets.asp [accessed on July 21, 2008].
[89] CSO. (2008). Census of Population of Ireland 2006 Place of Work Census of Anonymised Records (POWCAR) referred to by DTO, Frank McCabe, E-mail communication on July 9th, 2008.
[90] Department of Education and Science. (2008). *Education Statistics Database. National school pupils and classes by county in 2006/2007 and Number Of Second Level Pupils Classified By County/Local Authority Area in 2006/2007* [Internet], available from http://www.education.ie/home/home.jsp?maincat=17216&pcategory=17216&ecategory=17241&language=EN [accessed on July 8, 2008].
[91] DTO. (2007). Travel to Education Survey. referred to by Frank McCabe in email-communication on July 9th, 2008.

[92] Glotter, K. (2008). Email-Communication with K. Glotter employee at Administration Department 18 of the City of Vienna on July 30th, 2008.
[93] The Sunday Business Post online. (2008). *Breaking point for Dublin Bus* [Internet], available from http://archives.tcm.ie/businesspost/2007/11/18/story28333.asp [accessed on July 23, 2008].
[94] SEI. (2007). *Hybrid Electric and Battery Electric Vehicles. Technology, Costs and Benefits*. p.87. SEI. Cork.
[95] Doonan, N. (2008). Email communication with N. Doonan employee at Carra Ireland Ltd. on February 11th and August 5th 2008.

Conclusions

[1] Environmental Protection Agency (2008). *Ireland's National Greenhouse Gas Emissions Projections to 2020.* p.2. EPA.Wexford.
[2] Brennan, P., and Curtin, J. (eds). (2008). *The Climate Change Challenge: Strategic Issues, Options and Implications for Ireland*: IIEA. Dublin.

Glossary of Terms

ASPO
Association for the study of Peak Oil and Gas

BAU
Business As Usual, a term often used for scenarios.

BEMS
Building Energy Management System

BER
Building Energy Rating

CDER
Carbon Dioxide Emissions Rating

CHP, Combined Heat and Power
Combined Heat and Power. The waste heat from electricity generation is put to another useful purpose.

Climate Change
The global climate system is subject to natural variation, but also attributable to human activity arising from the release of greenhouse gases into the atmosphere.

CO_2
Carbon dioxide is a chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. Carbon dioxide is the main greenhouse gas arising from human activities and also naturally occurring.

CSO
Central Statistics Office

DART
Dublin Area Rapid Transit

DCC
Dublin City Council

DEAP
Dwelling Energy Assessment Procedure

DEHLG
Department of the Environment, Heritage and Local Government

DG TREN
Directorate-General for Energy and Transport of the European Commission

DTO
Dublin Transportation Office

Dublin Region
The Dublin Region includes the four local authority areas of Dublin City, Fingal, South Dublin and Dun Laoghaire Rathdown

EC
European Commission

Energy End-Use
Energy that is consumed by the end user, usually as set out on the utility bill.

EPBD
Energy Performance of Buildings Directive

GCI
Global Competitiveness Index

GDA
Greater Dublin Area (Dublin Region and Counties Meath, Kildare and Wicklow)

Greenhouse Gas
A gas in the atmosphere that freely allows radiation form the sun through to the earth's surface, but traps the heat radiated back from the earth's surface. The heating effect is analogous to the manner in which the glass of a greenhouse traps the sun's radiation to warm up the air inside the greenhouse. Most greenhouse gases occur naturally and are a necessary part of the global climate system, but their concentrations can be increased by human action, causing climate change.

GSHP
Ground Source Heat Pump. A heat pump is a machine or device that moves heat from one location (the 'source') to another location (the 'sink'), using work. The energy efficiency decreases with increasing temperature difference. Thus a ground source heat pump, which has a very small temperature differential, is relatively efficient.

HDI
Human Development Index

HGV
Heavy Goods Vehicles

IPCC
Intergovernmental Panel on Climate Change

Joule
Joule is an international unit of energy. One joule is the work done, or energy expended, by a force of one Newton moving an object one metre along the direction of the force

Kilowatt Hour (kWh):
The conventional unit of energy for that electricity is measured and charged commercially.

LUAS
Dublin Light Rail System

Modal Share/Modal Split
Modal share, or Modal split, is a traffic / transport term which describes the percentage of travelers using a particular type of transportation.

Modal Shift
Move from the use of one mode of transport to another, e.g. traveling by public transport instead of driving by car.

MPCDER
Maximum permitted carbon dioxide emissions rating

NOx
Generic term for mono-nitrogen oxides (NO and NO_2)

NQHS
National Quarterly Housing Survey

NRA
National Road Authority

PM2.5
Particles of less than 2.5 micrometres in aerodynamic diameter

PM10
Particles of 10 micrometres or less in aerodynamic diameter

Primary Energy
Energy, that exists in a naturally occurring form such as coal, oil or gas, before being converted into an end-use form.

Primary Energy Consumption
Primary energy consumption refers to the direct use at the source, or supply to users without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process.

QBC
Quality Bus Corridor

RPA
Railway Procurement Agency

SEI
Sustainable Energy Ireland

SME
Small and Medium-sized Enterprise

Tonne of Oil Equivalent (toe)
A standardized unit of energy defined on the basis of a tonne of oil having a net calorific value of 41,686 kJ/kg.

VOC
Volatile Organic Compounds

WHO
World Health Organisation

codema
Sustainable Dublin

Energy Conversion Factors

To:	toe	MWh	GJ
From:	Multiply by		
toe	1	11.63	41.868
MWh	0.086	1	3.6
GJ	0.02388	0.2778	1

Decimal Prefixes

deca (da)	10^{1}
hector (h)	10^{2}
kilo (k)	10^{3}
mega (M)	10^{6}
giga (G)	10^{9}
tera (T)	10^{12}
peta (P)	10^{15}

Action Plan Steering Committee

Matt Twomey	Assistant City Manager, Environment and Engineering Department and Fire Brigade
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List of Organisations Consulted

Codema would like to thank the following organisations for their input into the consultation process:

- Dublin City Council:

  City Manager Dept.

  Finance Dept.

  Planning and Economic Development Dept.

  Roads and Traffic Dept.

  Engineering Dept.

  Housing and Residential Services Dept.

  Architects Division
- Department of Communications, Marine and Natural Resources:

  Energy Efficiency Division
- Department of the Environment, Heritage and Local Government:

  Housing and Building Standards Inspectorate

  Air Quality and Climate
- Department of Transport
- Office of the Director of Community and Enterprise
- City Centre Business Association
- Academy of Engineers
- Cultivate
- RPS Group Plc.
- COWI
- Bord Gáis Networks
- Dalkia
- Gate Power
- J. J. Rhatigan
- McArdle McSweeney
- Varming
- MLP Facility Managers
- Sustainable Energy Ireland (SEI)
- Dublin Transportation Office
- RPA Railway Procurement Agency
- Dublin City Development Board
- Chamber of Commerce
- Dublin Docklands
- Institute of Public Health
- Dublin Institute of Technology
- Energy Action
- FEASTA
- Eoin Kenny Associates
- Real Eyes
- Second Hand
- Second Nature
- IVL Sweden
- Energyagency Skåne, Sweden
- City of Malmö, Sweden
- City of Tallinn, Estonia
- Cenergia, Denmark
- Pedersen Cenergia, Denmark
- Hillerod Municipality
- Comhairle na n'Óg
- Ballymun Regional Youth Resource
- Shelbourne Park Residents Assoc Ltd
- Terenure Residents' Association
- Railways Union Sports Club
- Ard na Greine Resident's Association
- Labour T.D. for Dublin North East and Spokesperson on Communications, Marine and Natural Resources
- Sunflower Recycling
- Vincent Quinn – personal capacity
- Corinna Diestelkamp and Dr. Joachim Diestelkamp – personal capacity
- Mags Buckley – personal capacity

Acknowledgments

The Action Plan on Energy for Dublin is being developed by Codema in association with Dublin City Council. It is supported by the EU SECURE project (*Sustainable Energy Communities in Urban Areas in Europe*). The project draws on recent experience from some of the most successful city development projects in Europe.

The work is being carried out in close collaboration with our project partners cities: Malmö (Sweden), Hillerød (Denmark) and Tallinn (Estonia), and other project partners; IVL (Swedish Environmental Research Institute), Respect Europe (Sustainable Business), Cenergia as well as Hillerød El, Vand og Värme.

The SECURE project is co-founded by the Intelligent Energy Europe programme of the European Commission, contract number EIE/05/125/SI2.419789.

Finally, we would like to thank all the organisations consulted for the time they have taken to contribute to this work and also the many individuals for their valuable help.

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Mr Declan Mc Cormac holds a Master of Science (MSc) in Sustainable Development and is the sustainability analyst for CODEMA. He is qualified as a BER assessor in the DEAP methodology. For this report he studied the Commercial and Manufacturing sectors, using on-site case studies of small and medium sized enterprises to inform his results.