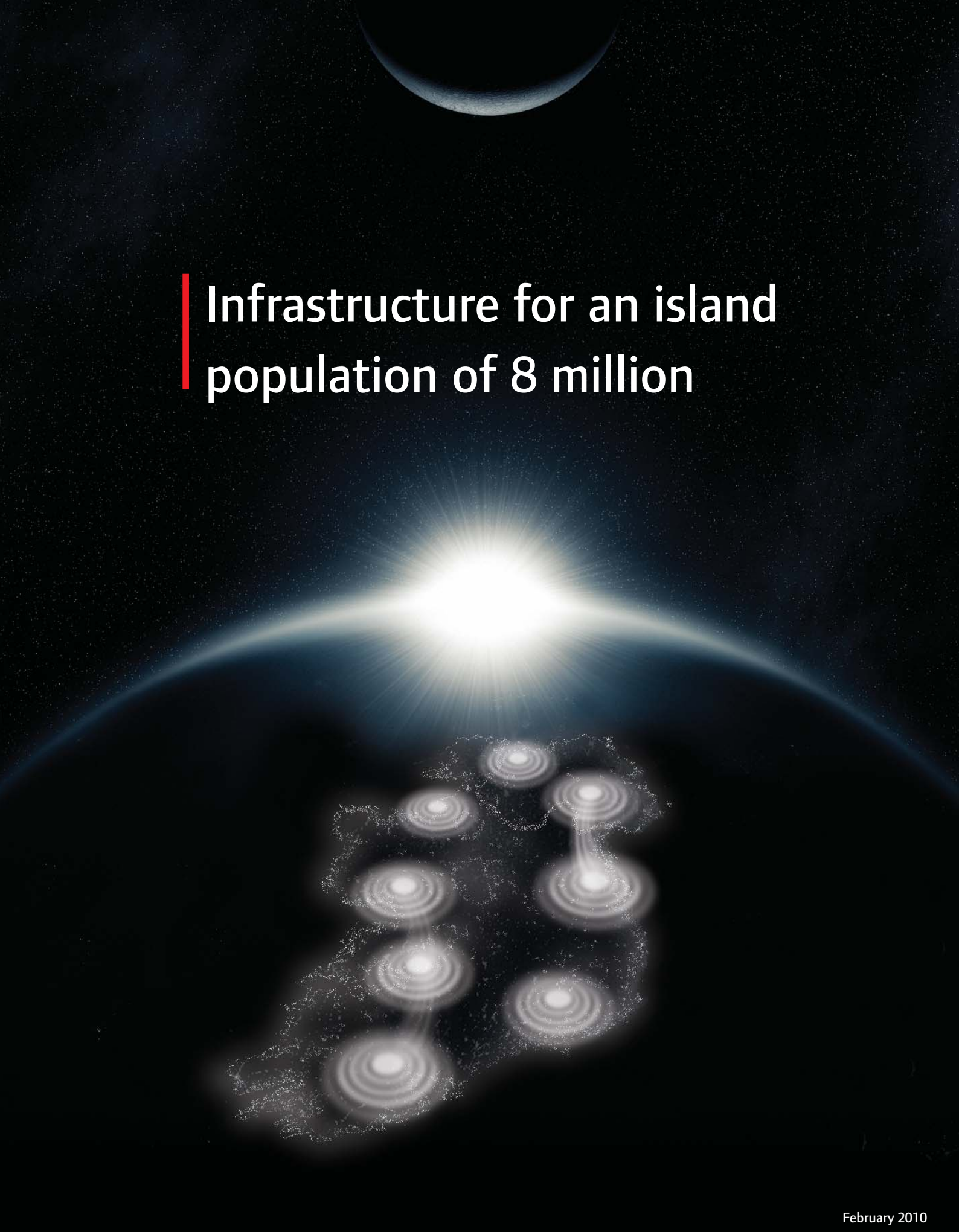
Infrastructure for an island population of 8 million



February 2010

InterTradeIreland

Engineers Ireland

The Irish Academy of Engineering

*This report has been prepared jointly by the Irish Academy of Engineering and Engineers Ireland, both of which are all-island engineering organisations. The report was commissioned by Inter*Trade*Ireland.*

The Irish Academy of Engineering

The Irish Academy of Engineering is an all-Ireland body, concerned with long-term issues where the engineering profession can make a unique contribution to economic, social and technological development.

Its members are Irish engineers of distinction, drawn from a wide range of disciplines and membership currently stands at approximately 120.

Drawing on the experiences and knowledge of its distinguished members, The Academy works to facilitate communication and dialogue on engineering-related matters. It publishes reports and analyses, some jointly with other learned and professional bodies.

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Engineers Ireland

Engineers Ireland was founded in 1835, has over 24,000 members and is the largest professional body operating on the island. It is concerned with promoting the development of the engineering profession and an environment which will stimulate world-class development on the island. Engineers Ireland is the operating name of the Institute of Engineers of Ireland.

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Acknowledgement

*The Irish Academy of Engineering and Engineers Ireland wish to thank Inter*Trade*Ireland for their kind support for this Report.*

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The members of the Taskforce participated in extensive discussions in the course of a series of meetings and submitted comments on a series of drafts of the report. Its content conveys the general tone and direction of the discussions, but its recommendations do not necessarily reflect a common position reached by all members of the Taskforce, nor do they necessarily represent the views of the organisations to which the members belong.

This report has been prepared by a Taskforce organised by the Irish Academy of Engineering and Engineers Ireland representing the engineering profession on the island of Ireland. It has been commissioned by Inter*Trade*Ireland.

The purpose of the report is to identify and make recommendations on the long-term infrastructure which will be required in order to achieve world-class competitiveness for the island. Adopting a long-term perspective ensures that economic choices are made and avoids the risk of revisiting incremental decisions based on short-term pressures.

The world economy is going through a period of unprecedented change and adaptation. The rapid growth in the economic power of China and India, the threats posed by climate change and to energy supplies, the global banking crisis and the enlargement of the European Union all present new challenges.

Estimates of the population of the island which were prepared by the Official Statistics Agencies, North and South, before the onset of the current recession, indicated that, based on certain assumptions (used by the CSO), the population of the island could reach eight million around 2030. The projections were based on the M2F1 traditional variant which combines continued (albeit declining) international migration with constant fertility. This increase in population will be accompanied by a major demographic change with the proportion of the population over 65 growing from 11% in 2007 to approximately 22% in 2030.

The recession seems likely to postpone the achievement of the eight million estimate by a number of years. It is still important, nonetheless, to identify and put in place in an integrated manner the infrastructure required for an economy with an increased population of eight million given the long-term nature of this activity.

In economic terms, the gross national income per capita of the island economy ranks in the top 13 in the world. An economic growth rate from 2012 in excess of 3% per annum will be necessary to sustain the population increase assumed as the basis for this report.

The pressures of the global economy emphasise the importance of achieving substantial improvement in the infrastructure of the island which will support an enhancement in economic competitiveness and quality of life for this population.

Context

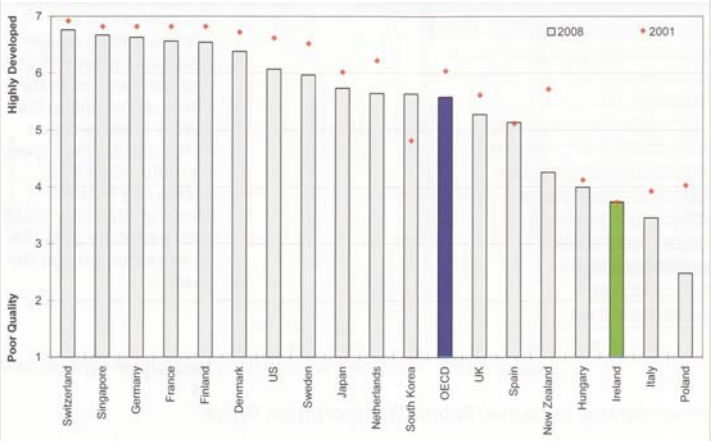
The combined economies on the island of Ireland comprise a very small percentage of world economic output. They compete in an international market place which has become ever more globalised. The living standards of people on the island are among the highest in the world. This has been achieved by investment in education and health, and having favourable conditions for industrial location.

However, there are very significant changes occurring in the world economy including increased competition from the so called BRIC countries (Brazil, Russia, India and China), the pressures of climate change and limits on the supply of oil. It is of fundamental importance that industry on the island has the opportunity to operate efficiently, innovatively and flexibly in this framework of changing international conditions, and can continue to achieve world-class competitiveness.

It is our considered view that for the island to take its place amongst the most advanced competitive economies in the world, the following is required:

- a focus on eight City Regions accounting for 90% of the population which will deliver economies of scale and efficiencies necessary for international competitiveness;
- increased urbanisation and density of the city populations, which will allow the delivery of the first-class infrastructure;
- a Dublin–Belfast Corridor with a population of four million and appropriate infrastructure investment which can compete with other major European urban zones; this would be complemented by a South Western corridor linking Cork, Limerick and Galway and comprising a further two million people;
- high quality connectivity both within and between the eight City Regions;
- development of Dublin Airport, complemented by Belfast International, as an international hub to improve worldwide connectivity for business on the island; and,
- use of innovative financing to fund infrastructure development.

Figure 11.2 Perception of Overall Infrastructure Quality (Scale 1 – 7) 2008



Source: WEF Global Competitiveness Report 2008/09 in Forfás National Competitiveness Council Report 2009

A key element in the future growth of Ireland's economy and in attracting investment to Ireland is the quality of its infrastructure. A number of competitiveness surveys point to the significant infrastructure gap on the island of Ireland. Although Ireland's relative investment in infrastructure compares well with other countries, it is still perceived by the business community to be inferior to that of competing countries as it is coming from a lower base (**Figure 11.2**).

The *Allianz European Jobs and Growth Indicator 2009,* published under the auspices of the Lisbon Council, gives further cause for concern. Referring to overall competitiveness it said: "*By contrast, Ireland fell the farthest – and the hardest. It leaves the ranking of top European performers, falling nine places in the European Growth and Jobs Monitor to No. 13, just ahead of Italy, the perennial laggard*". It further made the point that "*extra public funds channelled into infrastructure and energy efficiency are investments in the future in that they increase Europe's longer-term economic growth potential and, in so doing, contribute to sustainable prosperity*".

To achieve infrastructural quality comparable with the best in the developed OECD countries, it is of critical importance that the island continues to invest, on average, over 5% of its combined GDP annually over the next 20 years either directly by means of Government funding and/or through mechanisms such as public private partnerships and/or, where appropriate, by direct private investment.

This report identifies the long-term infrastructure which will be required on the island of Ireland to ensure sustained competitiveness. It starts with an examination of population concentration issues such as urbanisation and densification. The percentage of population living in towns and cities in the developed world is now over 75% and is continuing to

increase. The population catchments on the island are examined. Almost 90% of the population is located within a 65km catchment of eight main cities (**Figure 2.4, page 16**). The population density of the cities is also considered. Higher population density has many advantages. It offers the opportunity to become more urbanised with resultant improvements in services such as transport, energy, education and research and development. Travel to work times can be reduced; productivity improved; energy consumption diminished; international linkages improved; and innovative capacity enhanced.

Using the most recent official projections for Ireland (up to 2026) and Northern Ireland (up to 2033)[1] the report estimates that the population of the island will be just over eight million by 2030.[2] An increase in the island population of one-third offers the opportunity to look anew at the possibility of providing infrastructure in a more cost efficient manner. This needs to be done in order to make good our infrastructure deficit which places the island at a competitive disadvantage (**Figure 11.2**).

The report finds that priority should be given to the provision of infrastructure in the eight City Regions which account for 90% of the island's population and which have the potential to be internationally competitive. The eight City Regions are Dublin, Belfast, Cork, Limerick, Galway, Waterford, Derry/Londonderry and Sligo. The City Regions are based on areas with a 65km radius centred on each city.

Transport issues are critical to any infrastructural development. The need for the planning and development of road and rail transport as a single transport system on the island is identified. Issues such as the time taken in getting to work, and internal and international connectivity for airports and ports serving the City Regions, are also considered. Particular attention is given to improving connectivity between Dublin and Belfast, the two main cities on the island, in order to improve the opportunities for economies of scale and specialisation in a way which is not currently feasible.

Energy policy will be influenced by three factors – competitiveness, sustainability (including climate change) and security of supply, and these are borne in mind when making policy recommendations. In particular, the potential contribution of renewable energy generation, carbon capture and storage, gas storage, electric vehicles, and district heating in cities is examined. It is clear that wind energy, which will provide approximately 30% of electricity generation, should be developed by first exploiting sites adjacent to the high tension electricity grid and taking into account the storage possibilities offered by the charging of electric car batteries. Smart metering should be installed which will allow variable pricing and control switches to large energy consuming devices so that they consume power when it is cheaper to produce. This will reduce the need for costly standby generation.

"A key element in the future growth of Ireland's economy and in attracting investment to Ireland is the quality of its infrastructure."

In addition, in order to ensure enhanced energy security, gas storage should be considered in tandem with increased substitute oil distillate storage at power stations.

The Study considers options for the use of residual waste matter, after reuse, minimisation and recycling options have been exhausted as an energy resource. Increased city density creates the opportunity to retrofit district heating schemes. Cities with high population density make possible the linking of waste to energy projects with district heating.

The island has a distinct advantage in the supply of water, which is a key resource. However, the most abundant supplies will be in the western half of the island, whereas the majority of consumers will be in the east. This requires investigation of a distribution system to convey supplies to the main centres of population. The quality of drinking

1 *Central Statistics Office, Regional Population Statistics, 2011-2026 (December 2008); Northern Ireland Statistics and Research Agency, 2008-based Population Projections (October 2009).*

2 *The projections give the island a total population of almost 7.7 million by 2026-30. The eight million total comes from an assumption that Ireland's 1.5% per annum increase up to 2026 would continue at least up to 2030. That would mean a further population increase of 341,000 – leaving a total of 6.03 million in Ireland and 1.99 million in Northern Ireland, or 8.02 million in total.*

water tends to be much higher in urban areas than in rural areas.

Climate change matters must also be addressed. Greater city density will make public transport more feasible, with consequential lower carbon emissions. Most cities are built on river estuaries and so rising sea levels need to be considered in determining flood protection measures. In addition, increased world population and climate change are likely to lead to food shortages by 2030. The island's "climate advantage" will allow it to increase its production of meat, cereals and dairy products.

Advanced broadband penetration will be a critical element in supporting the industries of the future. Ireland is currently ranked in a low position in the percentage of households and enterprises with access to broadband. Broadband speeds which match the performance of the most advanced global economies will be required in all of the eight city catchments using fibre to the home technology. This will have a special relevance to the provision of tele-medical health services in the home. The development of the island economy is dependent on increasing the productive capacity of manufacturing industry (including food processing) and internationally traded services. The main growth sectors are likely to be in pharmaceutical and medical devices, information and communications technology, energy, green enterprise, food and forestry, connected health and business and financial services. Foreign direct investment tends to locate in the larger cities. The fastest growing sector is internationally traded business services which accounts for the majority of projects in Dublin, Belfast and Cork.

Investment in research and development will remain a fast growing sector for an advanced economy and bears a strong correlation with the supply of PhD graduates. Over 85% of new foreign investment in research projects is located in the five largest cities on the island. The development of strategic industrial clusters and innovation centres and an integrated approach combining research, development and education will increase the likelihood of synergy between these sectors.

The integration of all of the above elements of infrastructure will be crucial in improving efficiency, effectiveness and competitiveness at minimum cost. Higher density cities can make a very substantial contribution to improving competitiveness on the island. The greatest opportunity lies in developing much greater synergy along the Dublin–Belfast Corridor, which is the most highly populated conurbation on the island. Strictly enforced planning guidelines can play a major role in improving the quality of life and increasing the population density of cities.

Key Recommendations

City Regions

1. Concentrate on improving the competitiveness of the eight City Regions.
2. Plan for greater urbanisation and an increase in the population density in cities by one-third by 2030.
3. Develop the Dublin–Belfast Corridor with appropriate infrastructure investment between both cities and the important nodal points along the Corridor.
4. Promote a South Western Corridor linking Cork, Limerick and Galway.

Transport

1. Improve transport connections, including a high speed, high frequency intercity rail system, between the cities of Dublin and Belfast.
2. Develop a second transport corridor along the South Western Corridor between Cork, Limerick and Galway.
3. Improve the motorway network to meet the projected increased traffic flows between the eight principal cities and links to ports and airports.
4. Determine the complementary role of road and rail when planning to improve traffic flows between the main centres.
5. Make capacity available in Dublin Port by relocating the Oil Zone to a new dedicated port with pipelines to supply aviation fuel directly to Dublin Airport.
6. Develop Dublin Airport, complemented by Belfast International, as a major international hub to improve worldwide connectivity for business on the island.

Energy

1. Prioritise investment in research and development of offshore wind, marine renewables and smart grid technologies.
2. Determine the optimum share that gas, coal and nuclear should contribute to the non-renewable segment of electricity generation.

3. Prioritise the location of new wind farms adjacent to the high tension electricity grid.
4. Increase energy security by providing long-term strategic storage capacity equivalent to 20% of annual natural gas usage on the island in line with international norms.
5. Make district heating a requirement in all new high-density residential and commercial developments.

Environment

1. Base development plans for all City Regions on clear sustainable principles.
2. Establish appropriately sized waste to energy (WTE) plants and strategically locate them to cater for residual waste from the City Regions.
3. Manage demand for water with an emphasis on conservation, loss reduction, metering and an economic charge for water.
4. Develop a shared water mains network which will allow for bulk transfer of water between sources of supply and population centres.
5. Undertake a programme of sewer renewal in urban areas. Have separate storm and foul water sewers where practicable.

Climate Change

1. Increase the energy efficiency of residential and commercial buildings.
2. Develop new non-greenhouse gas (GHG) emitting baseload electricity generation, coal or gas with carbon capture and storage technology and imported nuclear power.
3. Plan for the protection of cities in coastal areas and river basins against flood damage and rising sea levels.
4. Establish a register of critical infrastructure vulnerable to climate change. Carry out a flood risk assessment for each critical infrastructure asset identifying its frequency of exposure to a hazard, its resilience to exposure and the consequences of its failure.
5. Focus climate research on identifying key parameters critical for infrastructure design.

Information & Communications Technology (ICT)

1. Develop a high speed and large capacity information highway which will match the performance of that in the most advanced global economies. Prioritise the high density population corridor linking Dublin and Belfast and also the South Western Corridor.
2. Harness the potential of advanced IT and communications technologies to improve efficiencies and enable a sustainable competitive economy.
3. Establish a direct connection to Europe, in addition to routes through Great Britain, using advanced communication technology, thus enabling Ireland to be a virtual extension of the main internet exchanges in mainland Europe.

Enterprise

1. Encourage the development of specialised industrial clusters and innovation hubs in each city.
2. Maximise the enterprise opportunities arising from the island's climate advantage.
3. Support research and development (R&D) and innovation in higher education institutions. Support industrial investment in R&D.

Engineering for Health

1. Build an advanced IT infrastructure within the healthcare system linked to the broadband network, which will enable the use of sophisticated personal-use diagnostic devices and allow for early detection of life-threatening events.

Infrastructure Integration

1. Adopt an integrated approach to all infrastructure planning to ensure improved efficiency, effectiveness and competitiveness at minimum cost.

Economic Assessment

1. Finance the development of infrastructure using a combination of innovative financing sources including the Exchequer, public private partnerships, a possible island of Ireland infrastructure bank, capital markets and the European Investment Bank.
2. Develop a framework which will allow the private sector

Chapter 1
INTRODUCTION

to increase its share of investment in provision of infrastructure.

Preface

The purpose of this report is to make recommendations on critical elements of infrastructure required on the island of Ireland in order to cater for an increased population of eight million, and to support a world class competitive economy. By considering the combined needs on an all-island basis it is clear that there will be economies of scale which will benefit the population.

An advanced competitive economy requires first-class infrastructure, which will deliver efficient and integrated transport systems, high quality technical connectivity, including broadband, cost effective energy, sustainable environmental solutions and an attractive quality of life for its people.

It is our considered view that for the island to takes its place amongst the most advanced competitive economies in the world, the following is required:

- a focus on eight City Regions accounting for 90% of the population which will deliver economies of scale and efficiencies necessary for international competitiveness;
- increased urbanisation and density of the city populations, which will allow the delivery of the first-class infrastructure;
- a Dublin–Belfast Corridor with a population of four million and appropriate infrastructure investment which can compete with other major European urban zones;
- high quality connectivity both within and between the eight City Regions;
- development of Dublin Airport, complemented by Belfast International, as an international hub to improve worldwide connectivity for business on the island; and,
- use of innovative financing to fund infrastructure development.

The Context

Using the most recent official projections for Ireland (up to 2026) and Northern Ireland (up to 2033)[3] the report estimates that the population of the island will be just over eight million by 2030.[4] In the South the population increase will be based upon continuing (albeit declining) international migration and constant fertility. Of relevance to this report, it is likely to be accompanied by traditional internal migration patterns and movement of younger people to the urban areas. This will result in a rise from 4.23 million (2006) to 5.69 million (2026).[5] In the North natural growth (fertility) and improvements in mortality are the main factors behind the 0.7% per annum increase.

To achieve infrastructural quality comparable with the best in the developed OECD countries and to support the above population it is of critical importance that medium to long-term infrastructural planning takes place. There is clear evidence that there is at present an infrastructural deficit on the island. This deficit must be eliminated and we must then keep pace with developments in the more advanced

3 *Central Statistics Office, Regional Population Statistics, 2011-2026 (December 2008); Northern Ireland Statistics and Research Agency, 2008-based Population Projections (October 2009).*

4 *The projections give the island a total population of almost 7.7 million by 2026-30. The eight million total comes from an assumption that Ireland's 1.5% per annum increase up to 2026 would continue at least up to 2030. That would mean a further population increase of 341,000 – leaving a total of 6.03 million in Ireland and 1.99 million in Northern Ireland, or 8.02 million in total.*

5 *It should be noted that these projections were released in October 2008 before the current economic downturn and more recent signs of emigration. What effect this will have on the overall growth rate is open to question.*

competing economies which will continue to drive forward and improve their infrastructure.

Some guiding principles were adopted in preparing our report. We recognised that there are severe limitations on the financial resources likely to be available. It has been demonstrated internationally that cities are the key drivers of economic and social development. They are the engines of development within wider City Regions. We have focused on City Regions comprising a circle of 65km radius from the city centre and have identified eight City Regions, which together account for almost 90% of the population of the island and where we believe best value can be obtained from limited resources. The influence of a city does of course extend further, particularly along the transport corridors which link it to other cities.

Irish cities are small by international standards. We have therefore also considered the opportunities for the development of one or two conurbations which could have the economies of scale to compete with some of the larger urban zones in Europe. The Dublin–Belfast Corridor is the primary conurbation, and a second possibility exists on the South West Corridor linking Cork, Limerick and Galway.

The globalisation of world trade and travel is a further consideration. It is critical that there is a very high level of connectivity within the island and between the island and international centres of trade. This will involve the development of a major international airport hub on the island.

The cost of providing the necessary infrastructure will be substantial. It will be necessary to harness all the available public and private resources in a manner which will provide the highest return in employment and exchequer revenue to the people of the island. Focus should be on providing essential infrastructure for the high growth City Regions which have the greatest attraction for inward investment and which will provide the highest return, and lead to higher employment and living standards. The alternative of spreading limited resources too thinly will yield less positive results.

"An advanced competitive economy requires first-class infrastructure, which will deliver efficient and integrated transport systems, high quality technical connectivity, including broadband, cost effective energy, sustainable environmental solutions and an attractive quality of life for its people."

Chapter 2
CITY REGIONS

Key Recommendations

1. Concentrate on improving the competitiveness of the eight City Regions.
2. Plan for greater urbanisation and an increase in the population density in cities by one-third by 2030.
3. Develop the Dublin–Belfast Corridor with appropriate infrastructure investment between both cities and the important nodal points along the Corridor.
4. Promote a South Western Corridor linking Cork, Limerick and Galway.

2.1 Introduction

Infrastructure is a uniquely human requirement. From transport systems to water treatment, from specialist facilities to modern energy and communications networks, infrastructure helps to enhance the quality of human life by supporting economic productivity, improving health and wellbeing, protecting our environment and providing opportunities and venues for social engagement and enjoyment. In this sense, infrastructure requirements are driven by people and communities whose needs support the economic case for investment.

In assessing optimal future infrastructure requirements, therefore, it is important first to understand the potential future size of the population and its settlement patterns across the island. This report takes as its formative assumption a population of eight million on the island of Ireland. The purpose of this chapter is to assess the likely settlement pattern of this population and the growing importance of cities and their hinterland (together referred to as the 'City Region' in this report) to future sustainable growth and prosperity.

2.2 Urbanisation and Increasing Urban Density – International Trends

Across the developed world, more and more people are moving to cities. The urbanisation trend and the increasing density in cities are driven by a desire for higher living standards, proximity to employment opportunities, access to a wide range of services, better infrastructure and social and cultural needs. At the same time, successful cities are becoming more densely populated, rather than responding to growth with excessive physical sprawl. Today, 79% of the population of the US and 74% of the population of the EU live in urban areas. By contrast, on the island of Ireland, currently less than 66% of people live in urban areas (defined in this report as settlements with populations greater than 1,500 people) but the trend towards increased urbanisation is evident here also. By 2030, it is likely that levels of urbanisation in Ireland will be comparable to the current average in the EU and that the development of our cities and connections to their natural hinterlands will be an important feature of this development.

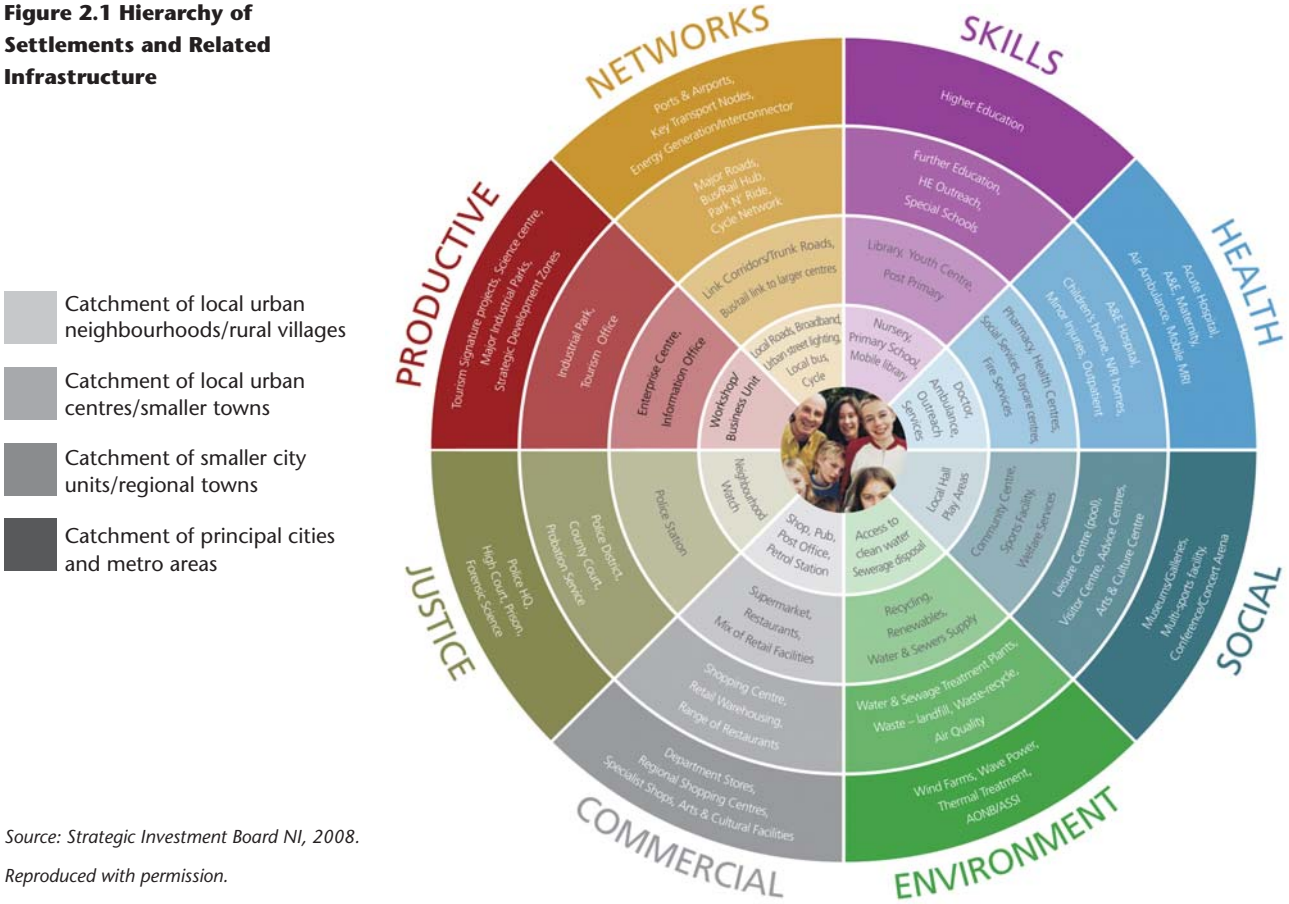
2.3 Role of Cities in Driving International Competitiveness

Cities are increasingly seen as the drivers of national competitiveness and of economic and social development. Across the world cities are focusing on improving their positions in a global league table. They play an increasingly crucial role in the development of national competitiveness in modern knowledge-based economies.

As cities on this island contend for high value-added mobile business and talent, then the infrastructure needs to be on par with, if not better than, competitors, all other things being equal. Given that there are not infinite resources, investment in our cities' economic and social infrastructure must be prioritised to maximise returns for the region as a whole.

6 *National Competitiveness Council/Forfás, Our Cities: Drivers of National Competitiveness, April 2009.*

Figure 2.1 Hierarchy of Settlements and Related Infrastructure



Source: Strategic Investment Board NI, 2008.

Reproduced with permission.

The National Spatial Strategy (NSS) in Ireland (ROI) and the Regional Development Strategy (RDS) in Northern Ireland (NI) set out the spatial plans for the respective jurisdictions over the next 20 years. They identify the key growth centres and articulate the significance of cities in raising living standards and securing the future prosperity of the regions. The recent National Competitiveness Council/Forfás report[6] identifies the key elements of successful cities as enterprise, connectivity, sustainability, and attractiveness and inclusiveness – achieving all these has significant implications for infrastructure investment.

2.4 Infrastructure Planning – City Regions

Infrastructure planning in City Regions and the provision of efficient, cost-effective services require a clear understanding of what is operationally and financially sustainable in settlements of differing size. **Figure 2.1** captures the strong relationship between settlement size and the levels of service that can be supported, i.e., the level of services likely to be appropriate for cities, towns and villages. It also shows the critical interdependence between urban centres and rural hinterlands and the importance of the physical linkages between these places.

This approach also recognises that:

- settlements often provide either a greater or lesser range of services than the core population may dictate. It is not appropriate therefore to consider 'urban' population alone in classifying service settlements – the population of rural hinterlands can also support services in urban centres;
- service centres tend to be hierarchical, with a large number of centres providing a smaller range of services, and a smaller number of centres providing a wider range. Each class of settlement provides services lower down in the hierarchy; and,
- accessibility to some services is more sensitive than to others. For example, access to emergency health provision is critical and a more geographically remote town may require a more enhanced range of health services than a town of similar size that is in close proximity to a larger urban settlement.

City level functions are represented on the outer tier of the wheel. These functions need a critical mass of population to be functionally and operationally sustainable – and thus draw on and serve the entire City Region population. At the other end of the scale, quality local neighbourhoods – whether in rural villages or in city neighbourhoods – are important to sustain a high quality environment with access to local services, whilst comprising an essential component of the coherent City Region.

In planning successful City Regions, therefore, it will be important to nurture the linkages between urban and rural areas – between the local and the region-wide – recognising the inter-dependencies of both. Rural areas and rural dwellers form a vital part of successful City Regions.

2.5 Advantages of High Density

Urban density is an important aspect of a competitive economy. The Annual Competitiveness Report 2008 for Ireland recommends that "*sustainable patterns of urban development should be promoted, particularly, higher residential densities in locations which are, or will be, served by public transport*".

A more concentrated population increases the range of economic, social, and cultural services available and creates economies of scale, which reduces the cost of provision. Advantages include:

- cost savings in land, infrastructure and energy;
- reduced economic cost of time spent travelling;
- reduced cost of doing business in the public and private sectors;
- increase in the operational financial sustainability of specialist services like tertiary hospital services, retail offerings and visitor attractions;
- concentration of knowledge and innovative activity in the core of the city, thus supporting specialisation in skills and markets;
- provision of public spaces and amenities within walking distance;
- potential for reduced air emissions by increased use of public transport and district heating;
- sustainable living environment and promotion of social connectedness; and,
- encouragement of greater physical activity with consequent health benefits.

Table 2.1 Population Density Comparison with Other European Cities (per sq km)

Barcelona	16,000
Lyons	9,500
Copenhagen	6,000
Dublin City	4,400
Belfast City	3,400

2.6 Density of Cities on the Island of Ireland

The cities on the island of Ireland suffer from the disadvantage of low density. Even the two largest cities, Dublin and Belfast, have a population density much lower than exemplar cities on mainland Europe such as Copenhagen, Lyons and Barcelona (**Table 2.1**). Comparisons with other European cities show Dublin, the largest city on the island, only ranking as the 34th largest urban zone in the European Union. This lack of density increases the relative cost in the provision of energy, transport and social services and results in proportionally higher greenhouse gas emissions than would otherwise occur.

There are now 20 cities in the world which have a population in excess of 10 million. Cities on the island cannot aspire to provision of the level of service of the megacities such as London or New York. However, by increasing their density they can create the economies of scale which will enable better services to be provided at lower cost, and become more effective engines for economic growth. The principal conurbations need to be globalised cities which are ICT hubs and have very good connectivity.

A study by Newman and Kenworthy referred to in a recent EU transport policy document shows the relationship between urban density and traffic-related energy consumption. It demonstrates that energy consumption per capita is about one-third lower in a high density city like Vienna compared to a relatively low density city like Stockholm (**Figure 2.2**).

High density cities have a lower travel time to work, lower carbon emissions per capita and enable provision of public and private services at lower cost, including district heating schemes, quality water services, education and health services. In addition, industries have a greater opportunity to source essential supplies and services locally with a

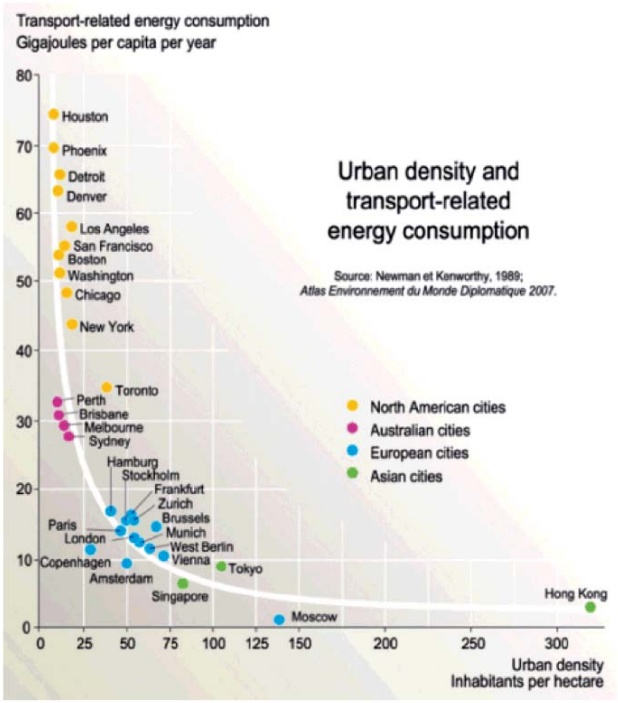
Table 2.2 Irish Cities – Present and Projected Population Densities (per sq km)

	2006	2030
Dublin	4,400	6,000
Belfast	3,400	4,500
Cork	3,200	4,300
Limerick	2,500	3,300
Derry/Londonderry	2,000	2,700
Sligo	1,600	2,100
Galway	1,400	1,900
Waterford	1,100	1,500

consequent favourable impact on their costs and competitiveness. **Table 2.2** shows the ranking of cities on the island in relation to the population density. In each case the city area is that defined by the municipal authority.

The projected population density on the island in 2030 is one third higher than that in 2006. This will require that cities plan for increasing density in line with the overall population increase to counter the trend of recent decades in having greater expansion of the suburbs and commuter towns with a consequent diminution of the availability of services to the population in the suburbs and a reduction in quality of life for inhabitants.

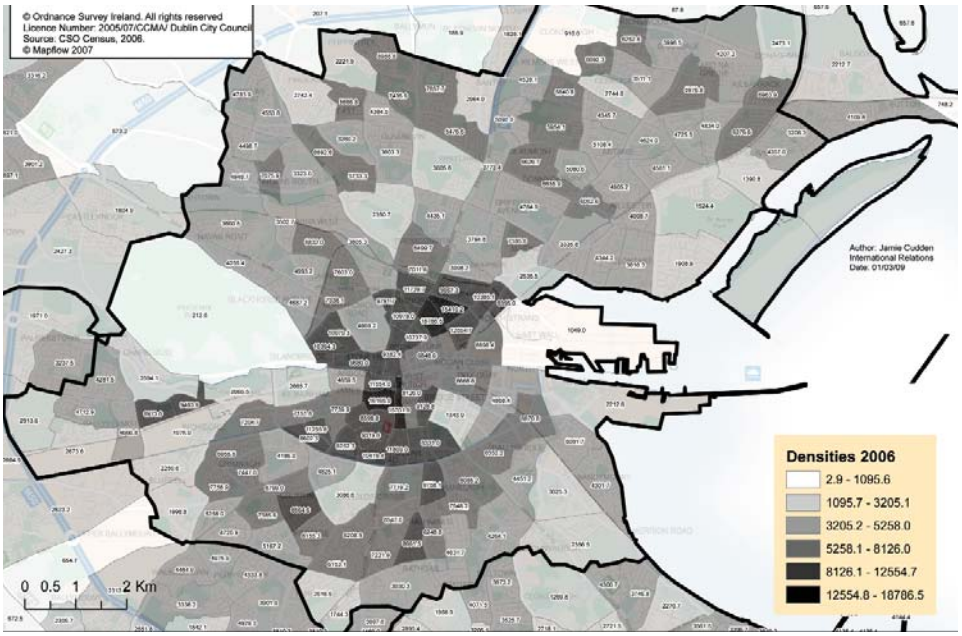
Figure 2.2 Urban Density and Transport-Related Energy Consumption



Source: Newman and Kenworthy, 1989

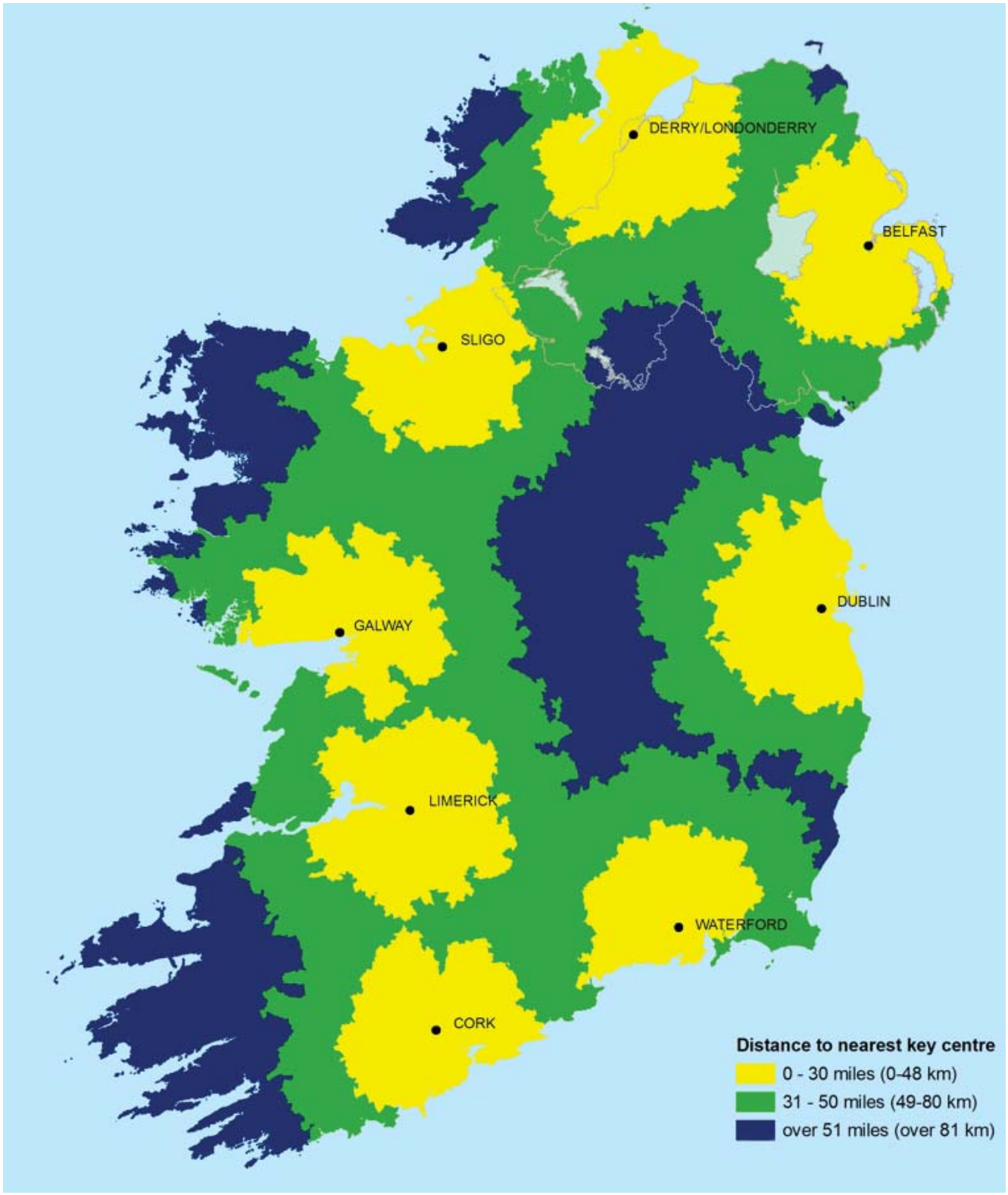
The feasibility of achieving higher densities is demonstrated by the example of Dublin population densities in 2006 (**Figure 2.3**). This shows areas of the city ranging in density from less than 1,000 persons per square km to over 12,500.

Figure 2.3 Population Densities – Dublin City Council 2006



Source: Dublin City Council

Figure 2.4 Distance by Road to the Largest Settlement in Each of Eight City Regions



Source: Strategic Investment Board NI

2.7 Urbanisation in City Regions

The distribution of population on the island is likely to become more concentrated along key transport corridors and in the catchment areas around the main cities shown in (**Figure 2.4**). Each of these cities has a substantial population catchment based on its location and the area of the island it serves. These centres will continue to grow and increase in density over the years ahead, and each city region will become more urbanised, as shown in **Table 2.3**. When the distribution of an increased population of eight million is estimated on a pro rata basis, taking into account the relative increases in the eight cities and their catchments over the past decade, the results reveal that the eight City Regions will accommodate over 90% of the population in 2030 (living in urban and rural settlements) (**Table 2.4)** with a wide variation in the degree of urbanisation in the catchment areas of the principal cities. The eight City Regions are Dublin, Belfast, Cork, Limerick, Galway, Waterford, Derry/Londonderry and Sligo and they are based on areas with a 65km radius centred on each city. Priority should be given to the provision of infrastructure in these City Regions. In addition to the eight cities above, the Midlands Gateway and the Newry–Dundalk 'Twin City' also play important regional roles and will continue to do so going forward. Newry–Dundalk is an important node on the Dublin–Belfast economic corridor, strategically placed and well connected to both cities.

Figure 2.5 GVA Regional Convergence (Growth versus Wealth)

Source: Forfás National Competitiveness Council Annual Report 2009

2.8 Income Per Capita in Cities

The income per capita in cities on the island is typically higher than the average for the whole economy. **Figure 2.5** shows that when 13 population centres on the island are compared, the Gross Value Added (GVA) per inhabitant (the equivalent of GDP per person) is by far the greatest in the main high density population centres of Dublin and inner Belfast, followed by the South West (Cork).

There is a distinct hierarchy amongst the cities of the island. Dublin and Belfast are the only cities of potential international scale. Whilst they are the largest conurbations on the island, both cities are small by international standards, but combined together they have a scale which could match some of the larger urban zones in Europe.

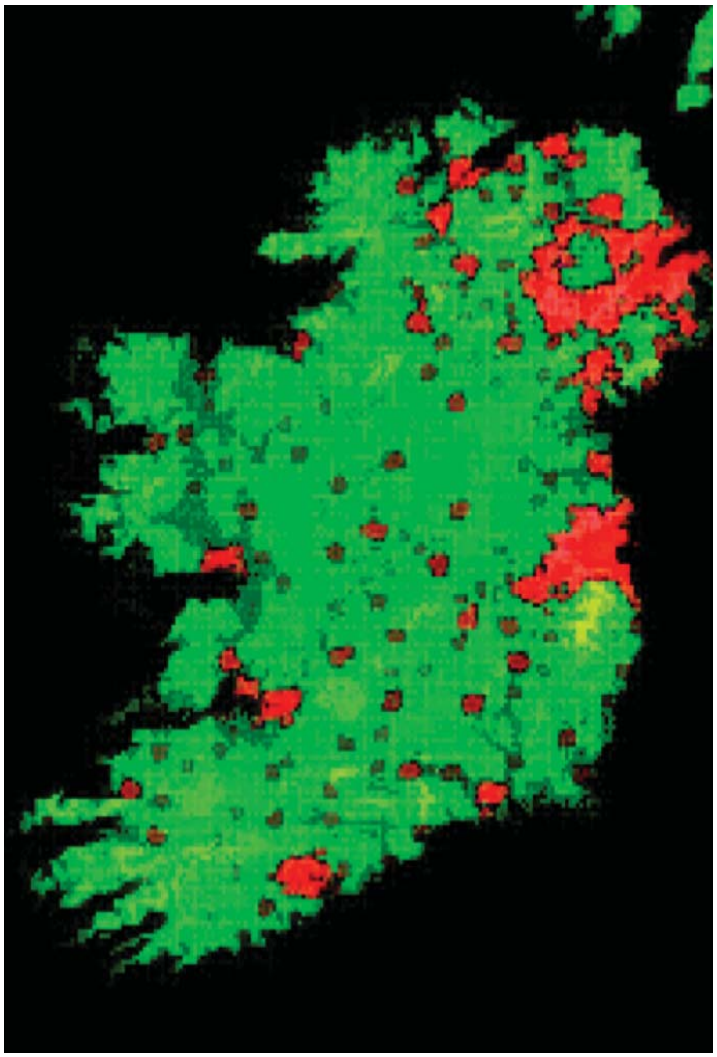
Table 2.3 Current and Projected Urbanisation Rates for Each City Region (%)

	2006	2030
Dublin	82	96
Belfast	68	79
Derry/Londonderry	49	57
Cork	37	43
Limerick	27	32
Waterford	27	32
Galway	22	26
Sligo	18	21
Island	**63**	**73**

Table 2.4 Distribution of a Population of Eight Million (Catchments with a 65km Radius)

Dublin	2.4m
Belfast	1.5m
Cork	0.82m
Limerick	0.72m
Waterford	0.64m
Galway	0.58m
Derry/Londonderry	0.45m
Sligo	0.35m

Figure 2.6 Ireland – Satellite Image of Night-Time Electric Light Emissions in 2000 (European Space Agency)



A recent Forfás report states the need to support all cities in Ireland, but it recognises the distinct role of Dublin as the key driver of national competitiveness.[7] A report on the future of Belfast recommends that *"government should start with the big places"* and that *"the Assembly should support Belfast more as the largest city. It should focus upon competitiveness as well as social cohesion"*.[8]

Improving the connectivity between Belfast and Dublin offers the opportunity to develop a corridor of very high added value per person which can drive the more rapid economic development of the whole island.

2.9 The Dublin–Belfast Corridor

Half the population of the island will be located in the Dublin–Belfast Corridor including the Newry–Dundalk gateway, with a population density five times greater than the rest of the island. **Figure 2.6** shows this eastern concentration in the form of night-time electric light emissions as captured by a satellite image.

The population of the Corridor is comparable to that of larger urban zones such as Hamburg and Milan which rank in the top ten urban zones in Europe. The challenge is to create on the island a conurbation which can match in competitiveness these highly developed centres, and overcome the distance between the cities to the greatest extent possible. Economies of scale can enable the Corridor to become a more powerful magnet, comparable to European Urban Zones having a population of four million or more, for foreign direct investment, particularly in advanced manufacturing and high added-value business services such as software, international shared services centres and financial and professional services.

An effective corridor will have strong interconnectivity through fast and frequent transport services including top quality air connectivity and access to ports. It will foster linkages between businesses and have world-class broadband communications and close liaison between universities and industry, as well as well developed education, health, and cultural services. It will also generate higher incomes per capita. Development of such a corridor will allow effective competition with other European urban zones and add substantially to jobs and living standards on the whole island.

Some international examples of economic corridors include:

- Frankfurt–Cologne;
- Washington–Baltimore;
- Glasgow–Edinburgh; and,
- Vancouver–Seattle.

There is a unique opportunity to implement a vision of a conurbation corridor which will have much greater economies of scale than can be achieved by each city operating separately.

7 *Forfás/National Competitiveness Council, Our Cities, Drivers of National Competitiveness, 2009.*

8 *Where is Belfast Going? Professor Michael Parkinson, Liverpool John Moores University, July 2007.*

2.10 The South Western Corridor

About one-quarter of the population of the island will be located along a south western arc comprising Cork, Limerick and Galway. The density of population along the arc is about half that of the Dublin–Belfast Corridor, but considerably greater than in the rest of the island. Here too, economies of scale can be developed by a similar enhancement of interconnectivity between the three cities including high-speed transport services, broadband and access to ports and airports.

The South Western Corridor has a leadership role on the island in many sectors including the pharmaceutical and biomedical sectors, agriculture and forestry and deepwater ports. It has well developed fourth level education and research and development resources, and has the second highest income per capita on the island after the Dublin–Belfast Corridor. The development of strong two-way linkages between the two corridors will be of benefit to both.

2.11 Summary

The emergence of increased urbanisation and greater population density in the cities will be key features of the island economy in 2030. These characteristics will be essential prerequisites to the development of a more competitive island economy. Global international competition for investment will be between cities which can provide the range of facilities and the quality of life required by modern industry.

The recommendations in the remaining chapters of the report suggest an integrated set of infrastructure policies which will support the improved competitiveness and dynamism of the island economy within the global economy.

"Half the population of the island will be located in the Dublin–Belfast Corridor including the Newry–Dundalk gateway, with a population density five times greater than the rest of the island."

Chapter 3
TRANSPORT

Key Recommendations

1. Improve transport connections, including a high speed, high frequency intercity rail system, between the cities of Dublin and Belfast.
2. Develop a second transport corridor along the South Western Corridor between Cork, Limerick and Galway.
3. Improve the motorway network to meet the projected increased traffic flows between the eight principal cities and links to ports and airports.
4. Determine the complementary role of road and rail when planning to improve traffic flows between the main centres.
5. Make capacity available in Dublin Port by relocating the Oil Zone to a new dedicated port with pipelines to supply aviation fuel directly to Dublin Airport
6. Develop Dublin Airport, complemented by Belfast International, as a major international hub to improve worldwide connectivity for business on the island.

3.1 Introduction

The quality of transport infrastructure determines the ease with which people can interact within City Regions and between cities, and is a key consideration in determining the competitiveness aspect of any location. Travel to work times affect quality of life and have a significant impact on where people choose to live. High density cities make feasible the provision of public transport systems which use less energy and emit less greenhouse gases (GHGs).

High quality rail and road connections reduce travel times and stimulate business and social interaction. They contribute to the achievement of economies of scale where the strengths of cities can be combined and greater synergy can be achieved than would be possible by cities operating separately. They also enable a greater number of people to access specialist services. Short journey times are particularly important in the highly populated corridors such as those between Dublin and Belfast, which will account for half the population of the island, and the South Western Corridor from Cork to Galway, which will account for a further quarter.

3.2 Roads

3.2.1 Introduction

It is envisaged that roads will remain the primary transport infrastructure up to 2030. The road network must therefore be developed to ensure freely flowing traffic to meet appropriate international standards for the level of service to users.

Estimates of traffic volumes in 2030 take into account historical experience of the annual growth of traffic volumes, population growth and expected trends in car ownership per capita.

Motorway or dual carriageway links will be required between the cities. Forecast traffic volumes will be used to determine the road classifications including the number of lanes, and whether motorway status will be required to provide a defined level of service to users.

3.2.2 Traffic Volumes

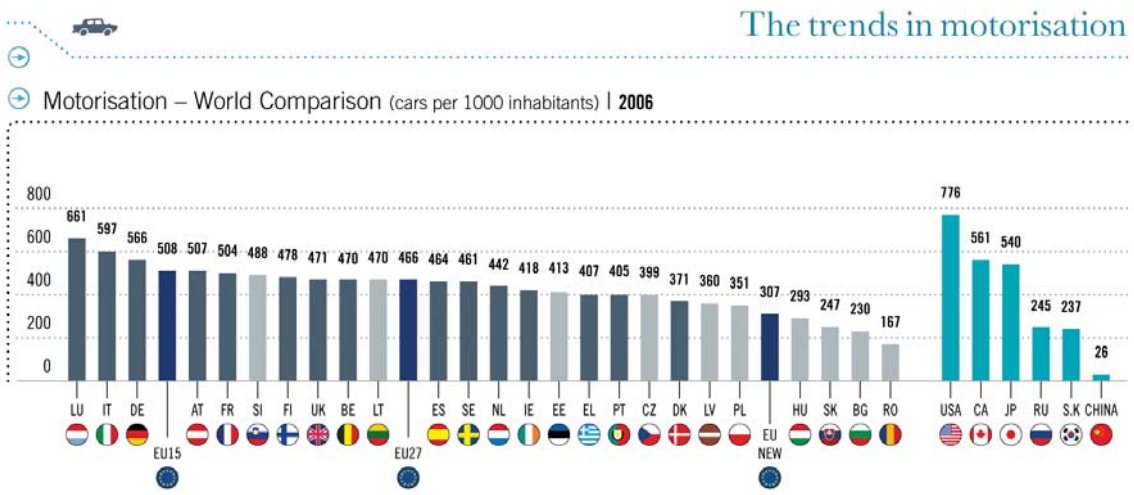
Car ownership in the Ireland and Northern Ireland is about 20% and 12%, respectively, below the average for Western Europe and Great Britain. **Figure 3.1** shows car density in Europe in 2006.

3.2.3 Car Density in 2006

It is assumed that the annual rate of increase in road traffic over the period to 2030 will be 3% in Ireland and 1.5% in Northern Ireland (in line with projections of the TEMPRO traffic prediction model used in NI) when growth resumes at a rate to achieve a population of eight million on the island after the current recession.

The traffic in 2006/2007 on the main inter-urban routes

Figure 3.1 Motorisation – World Comparison



Source: Eurostat

arranged according to the lowest and highest recorded annual rate outside the city hinterland is shown in **Table 3.1**.

Traffic densities of up to 98,600 were recorded on intercity routes in the Dublin hinterland and 54,100 in the Belfast hinterland. It should be noted that there are a limited number of traffic counters on the intercity routes. More detailed analysis is necessary to determine definitive priorities.

This would indicate that the required standard of road in 2030 on some sections of the above intercity roads will be as shown in **Table 3.2**.

3.2.4 Dublin–Belfast Corridor

The Dublin–Belfast Corridor linking the two main cities is likely to have the highest volume of inter-urban traffic and to require an expanded motorway which will ensure that users can travel at an average speed of up to 110km per

Table 3.1 Traffic Density on Main Inter-urban Routes – Vehicles per Day

	Lowest	Highest
Dublin–Belfast	19,000	51,820
Dublin–Cork	14,900	56,000
Belfast–Derry/Londonderry	13,600	25,500
Cork–Limerick	13,100	27,000
Dublin–Limerick	12,000	32,000
Dublin–Galway	11,700	18,000
Limerick–Galway	10,500	26,500
Galway–Sligo	14,500	24,100
Dublin–Derry/Londonderry	10,100	12,900
Dublin–Waterford	6,900	17,800
Sligo–Derry/Londonderry	7,000	10,200

Table 3.2 Motorway Standard

4-Lane Motorway	Dublin–Belfast[9]
	Dublin–Cork
	Dublin–Limerick
3-Lane Motorway	Dublin–Galway
	Dublin–Waterford
	Cork –Limerick
	Limerick–Galway
	Galway–Sligo
2-Lane Motorway	Dublin–Derry/Londonderry
	Sligo–Derry/Londonderry
	Belfast–Derry/Londonderry

9 *Assuming rail networks remain unchanged.*

Table 3.3 Traffic Volumes

	2007	2030
Hillsborough	39,500	52,500
Loughbrickland	19,060	25,000
Newry Bypass	26,190	35,000
Drumleck	28,790	54,000
Dunleer Bypass	31,310	58,000
Balbriggan	51,820	96,000

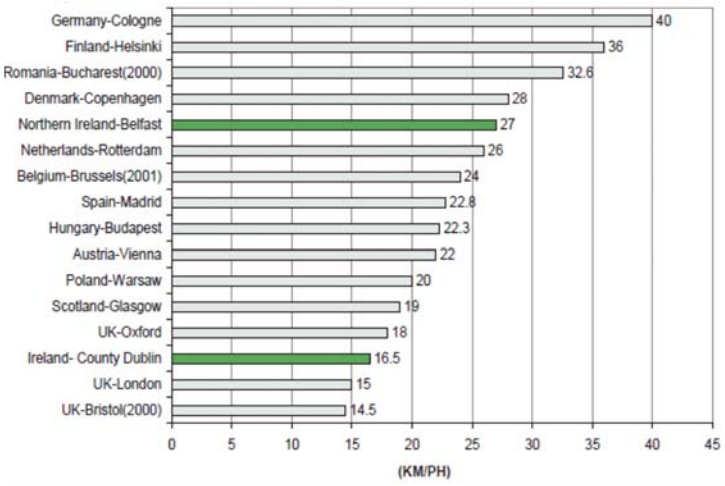
hour. The quality of the road corridor will be a key factor in increasing trading and business interaction between the two cities and will enable maximum advantage to be taken of the potential for specialisation of services based on their respective strengths. Improving transport connections between the two cities will contribute to the creation of an island conglomeration which can compete more effectively with similar international agglomerations such as the Glasgow–Edinburgh nexus.

The Dublin–Belfast Corridor has the busiest inter-city road on the island followed by the Dublin-Portlaoise road which serves both Cork and Limerick. **Table 3.3** shows average annual traffic density on the Dublin–Belfast Corridor at a number of traffic counters in 2007 and indicative volumes for 2030. It should be noted that the indicative figures for 2030 are likely to be delayed by the period required for recovery from the current recession. They also assume that rail transport will maintain the same percentage of total land traffic as at present.

The figures indicate that a four-lane motorway will be necessary for about two thirds of the distance,[10] and that rail traffic will maintain the same proportion of land traffic as at present. Should there be a significant increase in rail traffic it may be possible to reduce the need for a fourth motorway lane until a future date. On the other hand, if the speed and frequency of the rail service is not improved the requirement to build a fourth lane will occur earlier.

Figure 3.2 Average Peak Hour Speeds in Major Cities (km per hour) 2002

Source: Urban Transport Benchmarking Initiative, Dublin Transportation Office.



3.2.5 Urban Traffic

Improving the motorway network to meet the projected increased traffic flows between the eight principal cities and linking to ports and airports is a priority for 2030.

Ring roads or C-ring bypasses should, in principle, be constructed around each city at the intervals necessary to ensure free flow (in line with accepted international norms) of a sustainable level of traffic in urban areas (**Figure 3.2**). A number of high volume radial spokes should exist from the centre of each node connecting with inter-urban roads leading from the city. User charges should be implemented to manage congestion. The construction of additional dwellings and commercial buildings should be concentrated contiguous to the radial road spokes (and rail corridors) and ring or C roads to ensure that regular high frequency public transport can be provided thus reducing traffic congestion and GHG emissions. A clearly defined minimum level of service to public transport users should be provided with priority given to cyclists and pedestrians. Green spaces should be developed in the areas between the spokes and ring roads.

3.3 Rail

3.3.1 Introduction

Rail travel is particularly well suited to the mass movement of people and to high volume commuter traffic. Heavy rail can transport up to 50,000 passengers per hour, light rail up to 8,000, and buses up to 5,000 passengers per direction per hour. It also has a much lower level of carbon emissions per passenger than motor cars.

10 Based on the recommended flow ranges TA46/97 for various carriageway standards in N. Ireland.

3.3.2 Linking City Regions

Each of the eight cities is connected by rail to at least one other city. The Dublin–Belfast route has the greatest number of passenger journeys. Rail traffic on this route has increased by 70% over the past decade, albeit from a low base (**Table 3.4**).

In the period 1997-2007 intercity rail journeys increased by approximately 6% per annum. Road traffic increased more rapidly (by 7% per annum) on the Dublin–Belfast Corridor. A Limerick-Galway rail service will be reintroduced in the near future.

It is assumed that intercity rail traffic will continue to increase by an average of 6% per annum in the period to 2030. However, rail traffic on the Dublin–Belfast line has the potential to grow more rapidly, as has occurred over the last decade.

Table 3.4 Inter-urban Journeys 1999-2007
Annual Journeys (000s)

	1999	2007	Ratio
Dublin - Belfast [11]	5628	9736	1.7
Dublin - Cork	3572	5007	1.4
Dublin - Galway	1003	1583	1.6
Dublin - Waterford	899	1374	1.5
Dublin - Sligo	517	1239	2.4
Belfast – Derry/Londonderry	612 (1997)	1117	1.8
Dublin - Limerick	705	738	1.0
Total	**12,936**	**20,794**	**1.6**

3.3.3 Dublin–Belfast Rail Link

The Dublin–Belfast Rail Link is the main public transport link between the two largest cities on the island. It is of crucial importance in building competitiveness and in the creation of close communications between the people living in and between the two cities and the businesses on the corridor.

Improved transport communications should make it possible for people to commute between the cities and to benefit from the economies of scale which this will create. Businesses, whether main suppliers or subcontractors, will work more closely together; social contact will increase; access will be opened up to a wider range of services including education, health and air services. A high speed and high frequency intercity rail system linked to efficient urban rail and bus systems at the termini and along the route will be a critical building block in the creation of a European scale conurbation on the island.

It is expected that following the completion of the motorway between Dublin and Belfast road traffic between the two cities has the potential to increase significantly between now and 2030. A high frequency commuter train service between the two cities, similar to that between Glasgow and Edinburgh, would be expected to carry a significant percentage of the estimated road traffic or considerably more passengers than at present, provided the elapsed rail journey time is reduced to approximately one hour and 15 minutes. There will be a trade off between adding an additional lane to the motorway between the two cities, to ensure free flowing road travel, and improving the railroad and rolling stock and reducing carbon emissions.

Total passenger journeys are likely to increase by 7% per annum in line with historical experience leading to a quadrupling of passenger numbers by 2030, provided the competitiveness of rail does not deteriorate. An improvement in relative competitiveness by increasing speed and frequency can be expected to lead to a more rapid rate of annual growth.

Annual passenger journeys, which totalled 10.8m on the Dublin-Belfast line in 2008, can be divided into four distinct segments, as shown on **Table 3.5**.

It is therefore recommended that upgrading of the Dublin–Belfast line should be undertaken in the order of passenger usage per segment as this is likely to result in the greatest cost benefit. It is noteworthy that traffic on the Dublin–Belfast line currently accounts for almost half the total number of journeys on inter-urban routes on the island. Current peak time frequency from Drogheda to Dublin is 30

Table 3.5 Breakdown of
Dublin–Belfast passenger journeys

Dublin - Drogheda	7.6m
Portadown - Belfast	4m
Dundalk - Drogheda	1.2m
Dundalk - Portadown	0.9m

11 This includes passengers travelling between at least two of the six stations on the line.

Table 3.6 Urban Radial Spokes Passenger Numbers

Dublin	**1999**	**2007**
Kildare (Arrow)	618	2183
Maynooth		4670
Drogheda		6746
Wicklow		285
Howth - Greystones (Dart)	19,962	20,244
Belfast	**1997**	**2007**
Bangor	1583	2064
Portadown	1512	3008
Larne	1535	1905
Portrush	280	467
Cork		
Cobh	489	690
Midleton (commenced July 2009)		

Table 3.7 Potential Comprehensive Commuter Radial Rail Spoke Network

Dublin:	Malahide, Maynooth, Kildare, Navan, Drogheda, Bray, Dublin Airport
Belfast:	Bangor, Portadown, Larne, Portrush, Belfast International Airport
Cork:	Cobh, Midleton, Mallow
Limerick:	Tipperary; Ennis
Galway:	Athenry, Tuam, Gort
Waterford:	Ballyhale, New Ross
Sligo:	Collooney

Note: The Dublin suburban train service (DART) will increase frequency to 20 trains per hour each way in 2012 from 12 trains per hour today. The cost of this upgrade will be €220m.

minutes; and 20 minutes from Portadown to Belfast. A continued 7% per annum increase on the Dublin-Belfast line could lead to 39 million travelling non-stop between at least two of the six stations of Dublin, Drogheda, Dundalk, Newry, Portadown and Belfast, and would justify a frequency of a train every 15 minutes.

The estimated cost of a new track alignment, to facilitate 140mph trains to reduce the journey time (Dublin-Belfast) to 75 minutes, is approximately €2.5bn. This gross cost would be offset to some extent by the cost of renewing the existing track. The following are exemplar rail journey times between linked cities:

Glasgow to Edinburgh: Combined population: 2.8m; 51 miles apart; frequency: every 15 minutes; five stops; travel time: 50 minutes.

Frankfurt to Cologne: Combined population: 6m; 110 miles apart; four stops; travel time: one hour and 14 minutes.

The Dublin-Belfast rail should be the spine of the transport corridor between the two cities and should be directly linked to an integrated high frequency urban transport system comprising heavy rail, light rail, and bus rapid transit to deliver passengers seamlessly and speedily to their city destination and to airports and ports for international connections.

Rail passenger patronage between all the main cities has the potential to grow significantly by 2030 provided that an average rail speed comparable to average motor car speeds is achieved. There is also considerable scope to develop rail links along the South Western Corridor connecting Cork, Limerick and Galway where road traffic is projected to increase sharply.

Intercity services should be linked with commuter rail, light rail and bus in a single overall timetable design with ease of transfer between modes.

3.3.4 Commuter Travel

Each city will be served by at least one commuter radial rail spoke, and this will increase to as many as five high capacity spokes in the Dublin and Belfast regions (**Tables 3.6 and 3.7**). At present some of these routes account for almost 20,000 passengers per day but this patronage will treble on the most popular routes by 2030.

Table 3.8 Travel in City Regions

	Bus or Train	Car
Dublin	31%	69%
Cork	8%	92%
Limerick	5%	95%
Galway	6%	94%
Waterford	4%	96%
Sligo	2%	98%

Table 3.9 Targets for Travel by Public Transport

Dublin/Belfast	70%
Cork	25%
Limerick/Galway/Waterford/Derry	20%
Sligo	10%

Table 3.10 Public Transport Capacity Bands

Bus	3,500 to 5,000 per hour
Light rail	6,400 to 8,000 per hour
Heavy rail	Up to 50,000 per hour

Source: Dublin Transportation Office

An assessment of the potential for rail passenger traffic in 2030 should include the relative elapsed time to make the journey from city centre to city centre by car and by train. Experience on the island shows that more people will travel by rail when rail speeds are faster than those by car. The proportion travelling by rail was greater on the Dublin-Cork, and Dublin-Galway routes where rail speeds were significantly faster than average road speeds over the last decade. The opposite was the case for the Dublin-Belfast route where rail journey times were somewhat slower than could be achieved by car. It is important, therefore, that all plans to improve traffic flows between the main centres determine the complementary role of road and rail and how investment in the different forms of infrastructure can best contribute to efficiencies and support each other.

3.4 Public Transport

Urbanisation and higher densities will facilitate more use of public transport as will the introduction of carbon taxes and congestion charges. The proportion of people using public transport to go to work is likely to double by 2030. The average time taken to commute to work should not exceed 30 minutes as is currently the case in exemplar cities such as Berlin, Lyons, and Barcelona.

The choice of heavy rail, light rail, bus rapid transport or buses will be determined by potential traffic volumes. At present all of these options are adopted but the move towards greatest mass movements of people will stimulate moves towards higher capacity transport modes to ensure free flow of traffic, energy efficiency and lower carbon emissions. In this context, it should be a requirement that the quality of service demanded from service providers, both state owned and private, should be given equal priority with the quality of the public transport infrastructure.

3.4.1 Travel within City Regions

Travel to work by public transport is more energy efficient and generates less GHG emissions. A target for Dublin city in 2016 (*DTO Strategy A*) is to achieve 63% of person trips by public transport. In this context a target of 70% by 2030 seems reasonable (*Ref: DTO – Platform for Change*). The provision of park and ride facilities adjacent to suburban rail stations will be critical in achieving this goal.

The greater the city density the greater is the tendency to travel to work by public transport. **Table 3.8** shows the modal split of those travelling to work by bus or train, and car in the City Regions in 2006. On the highest performing quality bus corridors in Dublin city 57% of peak hour passengers travelled by bus in November 2007.

It is recommended that targets for travel by public transport (rail or bus) in 2030 should be as shown in **Table 3.9**.

An integrated public transport system should be developed for each city taking account of the capacity bands associated with each mode (**Table 3.10)**.

Where feasible a "fish bone" traffic design approach should be adopted to feed in traffic to the highest capacity transport mode available.

3.4.2 Level of Service

A public transport stop/route should be located within 800 metres of a house in a city area with frequency of at least 10 minutes at peak hours and 20 minutes at non-peak hours (*Ref: "Smarter Travel – A Sustainable Transport Future"*).

Average peak hour travel speeds in major cities in 2002 (**Figure 3.2**) ranged from 15km/hour in London to 40km/hour in Cologne. Belfast was in the upper range at 27km/hour while Dublin was in the lower range at 16.5km/hour. A target of at least 35km/hour is recommended by 2030.

"The quality of transport infrastructure is a key consideration in determining the competitiveness aspect of any location."

3.5 Ports

3.5.1 Overview

Marine transport accounts for about 98% of the island's trade by volume. The phenomenal growth in Ireland's external trade over the past decade was largely driven by the move to globalisation of world trade generally and the establishment of major international manufacturing operations on the island. **Figure 3.3** shows the evolution of trade from Ireland and Northern Ireland over the last decade. The great majority of goods traded to and from the island go through the eastern ports. Seven ports account for 86% of total port traffic. These are Dublin (28%); Belfast (17%); Shannon (14%); Cork (13%); Larne (7%); Rosslare (4%) and Waterford 3%. Movement of unitised goods by land from the western cities is the preferred option due to advantages of speed of delivery and the wide choice of east coast exit ports. More than half of the island's trade with mainland Europe is transported via Great Britain, from which there is a wide choice of ports available serving the ports on the European mainland. This proportion is likely to increase as more Irish-based manufacturers focus on the global market. Dublin, Belfast, Rosslare, and Cork are the primary ports for direct Continental traffic.

Figure 3.3 Total Port Traffic – Island of Ireland, 1998-2007 (000 tonnes)

Source: Indecon – Analysis of CSO and UK Department of Transport Port Statistics.

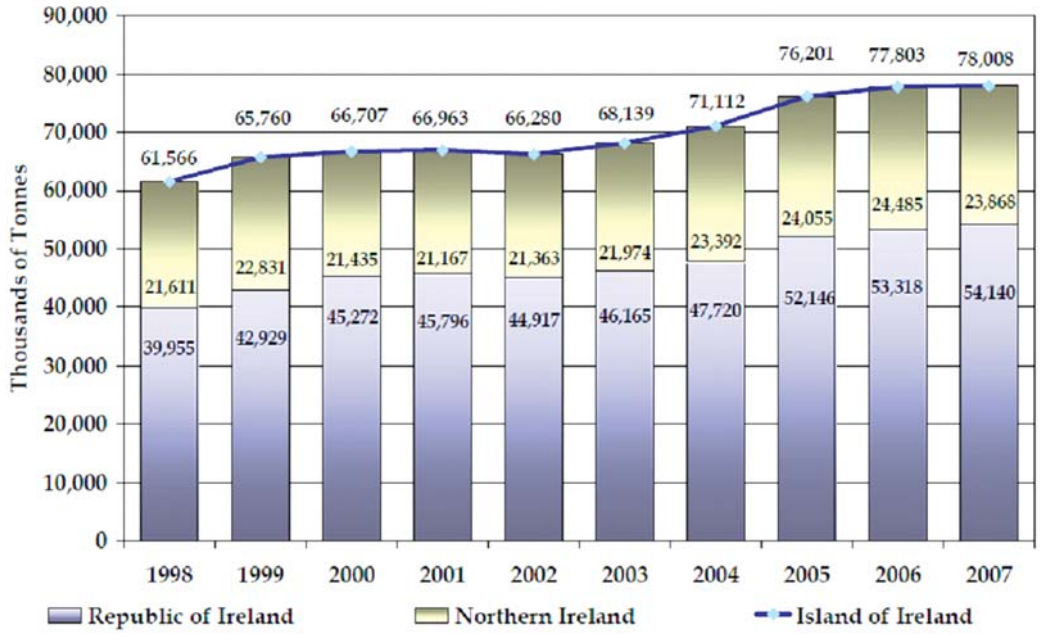


Table 3.11 Port Capacity

	LoLo	RoRo	Total
Total RoI	71ha	39.1ha	110.1ha
Total NI	17ha	33.5ha	50.5ha
Total island	88ha	72.6ha	160.6ha

3.5.2 Review of Trade through Main Commercial Ports

Trade is divided into five categories as follows:

- Ro/Ro: Unitised trade
- Lo/Lo: Containers or trailers
- Liquid bulk: Oil, chemicals, etc.
- Solid bulk: Coal, ore, etc.
- Break bulk: Timber, steel, cars/vehicles

Among the commercial ports on the island only three (Belfast, Cork and Dublin) are multi-modal, i.e., catering for all five categories listed above. Most of the remaining commercial ports are single mode, i.e., either roll on, roll off (Ro/Ro) or lift on lift off (Lo/Lo), or specialise in one or more of the bulk modes.

3.5.3 Unitised Traffic

76% of unitised (non-bulk) traffic is transported to or via Great Britain. RoRo is the dominant mode and is increasing market share. The remaining 24% of traffic sent directly to mainland Europe is currently dominated by LoLo but the market share of direct RoRo traffic to the Continent is increasing. RoRo is the preferred mode of transport for unitised goods, accounting for almost 74% of this traffic. The share of RoRo has been increasing over the last decade and this trend is likely to continue. Four ports, Dublin (40%), Larne (25%), Belfast (17%), and Rosslare (9%), account for over 90% of RoRo traffic. These ports are attractive as they offer the greatest choice of services to ports in Britain, and from there to the European mainland.

LoLo traffic is concentrated in Dublin (42%); Belfast (16%); Cork (11%); and, Waterford (11%), which together account for about 80% of LoLo traffic.

3.5.4 Increased Volumes

It is estimated that the volume of goods traffic through Dublin and Belfast ports will double by 2030. These ports are situated at either end of a conglomeration of population with a hinterland which will account for half of the population of the island.

Table 3.11 reflects the estimates of current port capacity on the island. (*Ref: Dublin Port National Development Plan Study, Indecon - July 2009*).

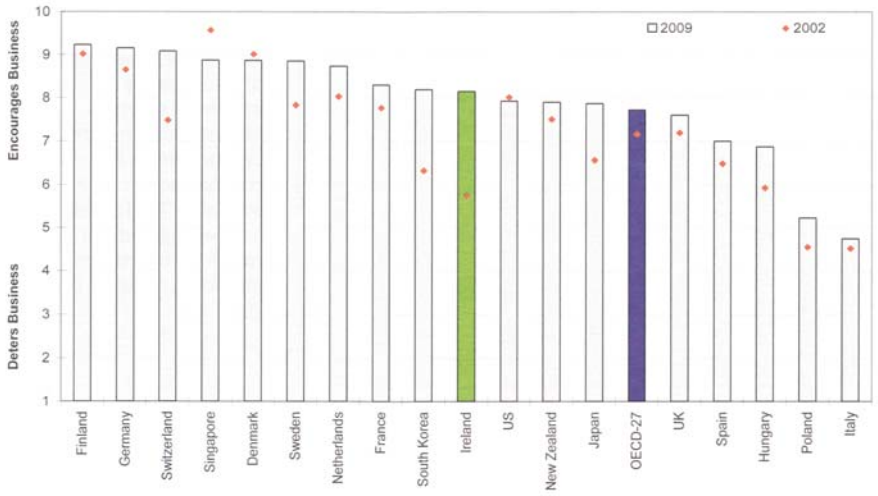
3.5.5 Development Plans

The commercial ports are essential links in the import/export chain that services the economy of the island of Ireland. It is estimated that demand will exceed existing capacity by 2025. It is therefore of critical importance that planning difficulties do not curtail the ability of ports to respond to the growth needs of the island's development.

Most of the larger commercial ports have development plans under consideration to cater for anticipated trade growth over the medium term. There is potential to improve capacity utilisation of ports on the island and this should be pursued as a priority. Unitised shipping trade is highly sensitive to port charges and the efficiency of service offered, i.e., port access, speed of ship turnaround and adequate storage areas will influence the share of trade accounted for by each port.

In addition, capacity should be made available in Dublin Port by relocating the Oil Zone to a new dedicated port with pipelines to supply aviation fuel directly to Dublin Airport. This would release approximately 20ha of existing land for alternative port use.

Figure 3.4 Perceptions of Quality of Air Transportation (Scale 1-10) 2009



This chart measures executives' perceptions of the quality of Ireland's air transportation infrastructure. Ireland's score has improved significantly in recent years. A second terminal at Dublin airport, due to open in 2009, should further improve Ireland's score.

Source: IMD World Competitiveness Yearbook, 2009 in Forfás National Competitiveness Council Annual Report 2009

3.5.6 Rail Freight

Rail freight traffic to ports is in decline, and accounts for a very small proportion of total port traffic on the island. This is unlikely to change unless EU policy favouring rail is introduced.

3.5.7 Road Access

High quality motorways and dual carriageways linking the key cities to the main ports will provide choice to businesses in accessing the ports which provide the most competitive service to meet their needs. Improvements in the eastern motorway from Dublin to Larne will improve access to Belfast and Larne ports for unitised traffic, while the completion of the Eastern Bypass in Dublin linking the South East to Dublin Port will increase the attractiveness of Dublin Port for traffic from the South. Similarly, a high quality motorway from Shannon/Foynes to the Limerick–Galway dual carriageway will increase the attractiveness of the port for the importation of bulk goods in particular.

3.6 Airports

3.6.1 Overview

International connectivity is of crucial importance in ensuring the competitiveness of businesses on the island. There was a significant improvement in the perception of the quality of Ireland's air transportation infrastructure between 2002 and 2007. It is now ranked above the average of OECD countries (**Figure 3.4**) and should improve further with the opening of the second terminal at Dublin Airport in 2010. Further improvements will enhance the potential of Irish airports to attract air traffic from other countries and to expand the range of services provided to Irish business.

Approximately 37 million air passengers used airports on the island in 2008. Dublin, with 23m passengers, is the largest airport, the 12th largest in Europe and 49th largest in the world.

Five airports account for 97% of air traffic on the island (**Table 3.12**). These airports provide a total of 320 scheduled services to external destinations (off the island). An efficient road and rail network between the key nodes and the main airports will play a major role in offering competitive choice and maximum international connectivity to airport passengers.

3.6.2 Internal Links

Internal air links exist between the long distance routes such as Belfast to Cork, Derry/Londonderry to Dublin, Galway to Dublin, Cork to Dublin, and Shannon to Dublin.

3.6.3 Market Share

The market share of the main airports has changed over the last decade with Dublin Airport accounting for 62% of traffic (**Table 3.12**). Air traffic through Dublin Airport has quadrupled over the last 20 years. Traffic through Belfast International has more than doubled.

As an international hub Dublin has scheduled services to 187 external airports, mainly to European destinations but also to North America, the Middle East and North Africa. This is followed by Belfast International, Cork, Shannon, and Belfast City.

3.6.4 Increase in Traffic

Air traffic to and from the island is expected to double to about 75m by about 2030. Of this total Dublin Airport is expected to have a throughput of about 50m passengers; Belfast International 9m; Belfast City 4m; Shannon 7m and Cork 6m. A second terminal building at Dublin Airport due to be completed in 2010 will increase capacity to 35 million passengers. Construction of a third terminal is at the planning stage.

The highest published target for Belfast International envisages 12m passengers in 2030, and there is a possibility of a rail link to the airport constructed along the mothballed Lisburn-Antrim railway line as set out in the Belfast Airport master plan.

The number of destinations served by scheduled services is likely to increase substantially from the current 320. These destinations will reflect the growing diversification of Irish Trade in response to the increasing role of the BRIC countries (Brazil, Russia, India and China) and the oil-producing countries in world economic consumption. For example, 7% of Irish exports are already sold to Asia and this percentage is likely to increase sharply in the period to 2030 creating a demand for direct air connections from the island to China Japan, and India in particular. It is also possible that the island may have an expanded role as an intermediate fuelling destination for intercontinental flights to Asia and the Middle East. It is important, therefore, that Dublin Airport, complemented by Belfast International, is developed as a major international hub to improve worldwide connectivity for business.

Table 3.12 Passenger Traffic – 2008

Airport	Passenger No	Air Traffic Market Share
Dublin	22m	62%
Belfast International	5m	14%
Shannon	3m	9%
Cork	3m	9%
Belfast City	2.5m	5%

3.6.5 Access to Dublin and Belfast Airports

Access to Dublin and Belfast hub airports will be by road, rail and air. Motorway links between the key cities and these primary airports will be of high importance. None of the other six cities will be located more than 150 minutes from a high frequency international airport serving an increasing number of foreign destinations. In addition, rail links to Dublin (including a Metro link) and Belfast International Airports, which together will account for up to 80% of air travel to and from the island, will ensure the efficient mass movement of passengers between urban destinations and reduced GHG emissions.

Opportunities for collaboration in developing high speed surface transport links between the two main airports should be explored.

Chapter 4
ENERGY

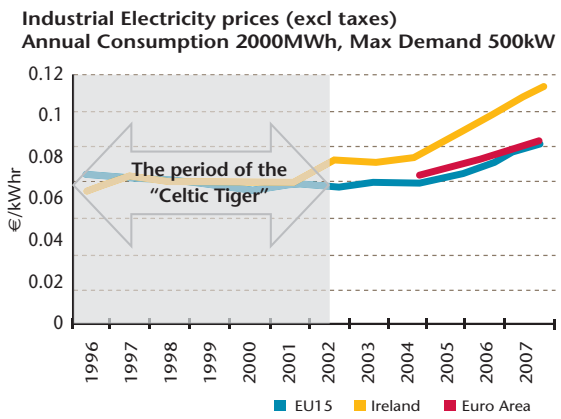
Key Recommendations

1. Prioritise investment in research and development of offshore wind, marine renewables and smart grid technologies.
2. Determine the optimum share that gas, coal and nuclear should contribute to the non-renewable segment of electricity generation.
3. Prioritise the location of new wind farms adjacent to the high tension electricity grid.
4. Increase energy security by providing long-term strategic storage capacity equivalent to 20% of annual natural gas usage on the island in line with international norms.
5. Make district heating a requirement in all new high-density residential and commercial developments.

4.1 Introduction

Climate change and energy security are likely to be two of the biggest challenges of the 21st century. Since the end of the Second World War the world has seen the greatest expansion of economic development and increase in living standards. Much of this development was driven by the availability of abundant cheap energy, most of it carbon based. The international consensus now is that to mitigate the effects of climate change we must move away from carbon based energy emitting greenhouse gases (GHGs) into the atmosphere. This presents us with a serious challenge to devise energy policies which allow the island to meet its commitments to reduce GHGs while producing competitively priced energy which is vital for our future economic success.

Figure 4.1 Industrial Price Competitiveness (Source: Eurostat)



4.2 Electricity

4.2.1 Industrial Competitiveness

Ireland today produces some of the most expensive electricity in Europe. Industrial prices are currently 28% above the EU average (excluding taxes). The success of the so called Celtic Tiger period was based on our ability to attract foreign direct investment in high technology industries which produced high value exports. This success was critically dependent on competitive input costs, including electricity.[12]

Figure 4.1 shows the decade long divergence between Irish and European average industrial electricity prices. A similar situation exists for domestic electricity – a decade ago Ireland had some of the lowest prices in the EU, now it is at the highest end of the comparison scale. Electricity prices in Ireland and Northern Ireland have converged over the past decade.

The future prosperity of the island of Ireland will depend on our success in the international traded sector. This in turn is dependent on competitive input costs, one of the most important of which is electricity. Future policies for the electricity sector must include a price impact analysis.

4.2.2 New Technologies

By 2030 new technologies and systems should materialise

12 *Irish Academy of Engineering – Irish Energy Policy: Update on Electricity Price Competitiveness, December 2009*

in a fully economic and environmentally sustainable manner. These include new renewable technologies such as wave and tidal power, offshore wind, advanced nuclear generation, clean fossil fuel technologies, smart grids, highly efficient appliances and new modes of transport.

It is essential that the investment in research and development of offshore wind, marine renewables and smart grid technologies is prioritised in order to take full advantage of these advances in a way which will enhance Irish economic development. To ensure this we need to:

- put in place mechanisms to ensure that we keep fully abreast of these technological developments;
- ensure proper flexibility by not excluding any technologies from proper consideration at this stage (nuclear energy for example); and,
- as an alternative, include purchase of emission quotas as a least cost option.

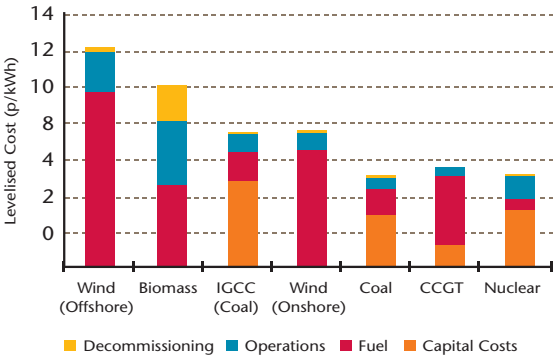
4.2.3 Primary Fuel Mix

In the long-term Ireland must allow for a significant change in its primary fuels as technology develops further and our competitors steadily make the best and most economic choices. **Figure 4.2** shows the relative cost of different types of generation.

The island of Ireland is already one of the highest users of natural gas for electricity generation in the EU. The current strategy is to diversify into wind generation. This strategy must be evaluated from a long-term competitiveness point of view. Techno-economic studies are required to identify the appropriate level of wind generation for the island. Given the intermittent nature of wind power it is likely to require storage facilities such as pumped storage or compressed air storage to match supply with demand. Denmark, which has ambitious targets for wind power, is considering diverting surplus wind power to its district heating systems.

By 2030 renewable generation (mainly wind) will provide approximately 30% of electricity generation. The key policy decision will be to decide on the mix of the remaining 70% of generation and to determine the optimum share that gas, coal and nuclear should contribute to the non-renewable segment of electricity generation. In the absence of policy direction it is likely that gas fired generation will fill the void by default as it is the easiest to permit and build. This would expose the island to a major energy security risk,

Figure 4.2 Relative Cost of Power Generation (Based on CO_2 Costs of €20 per Tonne)

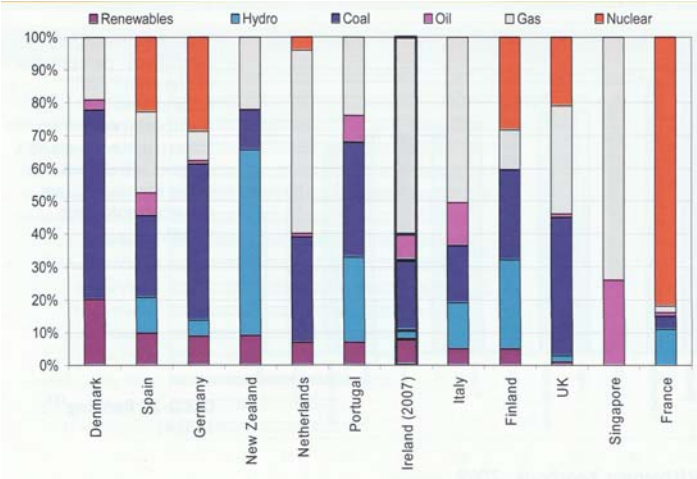


Source: Powering the Nation, 2009 Update, PB Power

as by 2030, with the North Sea fields depleted, gas will come mainly from politically unstable regions with a probability of supply interruption and price volatility. It would be prudent to plan for similar contributions each from gas, coal and nuclear for the 70% non-renewable segment. These targets should be flexible to take into account developments in technology and fuel supply.

Most other EU countries have significant hydroelectric or nuclear components in their generation mix (**Figure 4.3**). Ireland does not have additional hydroelectric resources to exploit and must open itself up to the possibility of nuclear generation in the longer term to ensure competitiveness.

Figure 4.3 Fuel Mix for Electricity Generation

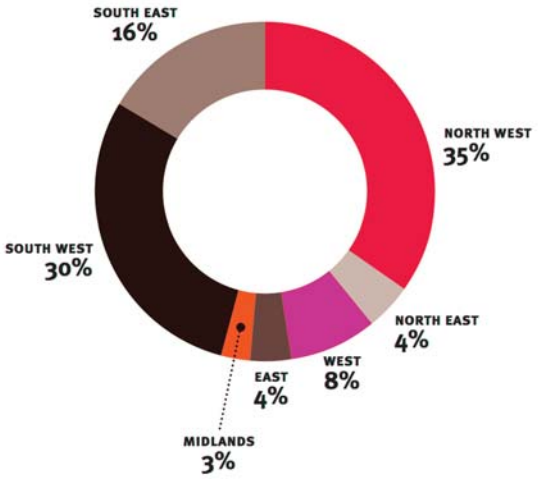


Source: Forfás National Competitiveness Council Annual Report 2009

Figure 4.4 Sites with Potential for CO_2 Storage

Source: SINTEF Energy Research, Norway

Figure 4.5 Regional Distribution of Renewable Capacity



Source: Eirgrid – Grid 25

This includes importation via the East-West interconnector of nuclear power from a contracted vendor in the UK or the construction of a plant on the island. In the longer term importation of nuclear power via an interconnector to France may be viable.

The existing 900MW coal-fired power station at Moneypoint should be replaced with a new coal fired plant using carbon capture and storage (CCS). However, before this decision can be taken, CCS technology must be shown to be technically and economically viable – demonstration plants are expected to be in production by 2012. There are long term reserves of coal available from many parts of the world. Using coal as a major component of the island's base load generation will enhance energy security and national competitiveness. **Figure 4.4** shows sites with potential for CO_2 storage.

4.2.4 Network Investment

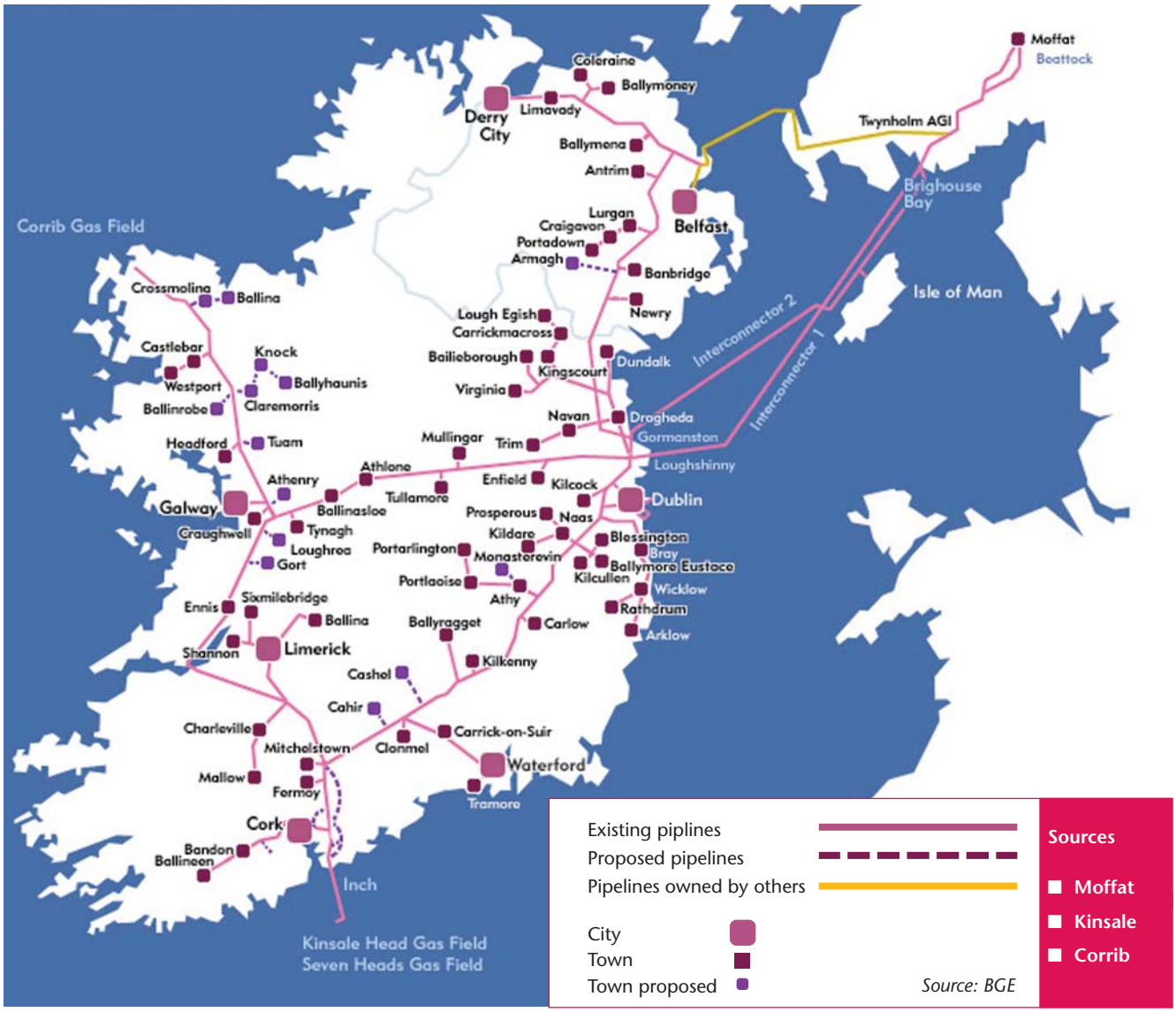
To attract the high-tech industry which will be the basis for the new economy, all the City Regions will require high-quality, high-voltage bulk power supply at 220kV and above. This will require a doubling in the capacity of the bulk transmission circuits over the next 20 years. A significant part of this investment is required to facilitate wind generation connecting to the system. Many of the locations suitable for renewable generation are in areas where there has been little or no generation to date (**Figure 4.5**). The aggregate of renewable generation capacity in some areas is equivalent to large conventional generation stations. It will not be possible to meet the island's targets for renewable energy without the construction of these new transmission lines.

The location of new wind farms adjacent to the high tension electricity grid should be prioritised. Consideration should be given to leasing lands in public ownership, adjacent to the existing transmission network, to wind power developers in order to maximise the use of existing assets. In the past, co-ordinated planning of generation and transmission led to considerable economies in the development of the overall power system. While this is no longer possible under a market-based system, it is possible to incentivise the location of generation at optimum transmission locations by imposing transmission development costs, including the cost of deep reinforcement, on new generators. Changes to the planning system will also be required to enable cost-effective construction of transmission lines, reducing the current planning and construction period of approximately seven years.

4.2.5 Smart Grid Technology

Most forms of renewable energy are intermittent in nature depending on wind, wave or tides to generate power and making it difficult to match generation with peak demand.

Figure 4.6 Gas Network



Smart metering should be installed which will allow variable pricing and control switches to large energy-consuming devices such as water heaters so that they consume power when it is cheaper to produce. This will reduce the need for costly standby generation.

4.2.6 Electric Transport

It is estimated that by 2030 around 30% of vehicles will be powered by batteries charged from the electricity grid in an effort to reduce CO_2 emissions. The success of this policy will depend on changing from generating plants using fossil fuel to non CO_2-emitting generation such as wind power, nuclear, and gas and coal fired plants using carbon sequestration.

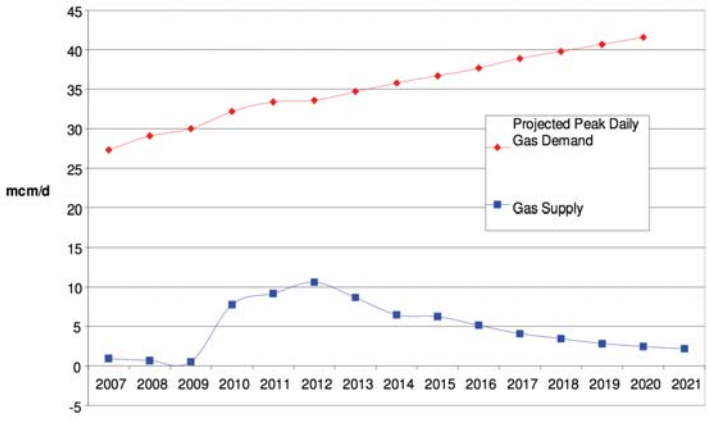
4.3 Gas

4.3.1 Introduction

Natural gas accounts for 27% of total primary energy demand in Ireland with oil accounting for 56%, coal for 9%, renewables for 3%, peat for 4% and electricity imports for 1%. Over 65% of Ireland's electricity is generated from natural gas and over 700,000 homes across the island use natural gas for heating and cooking. €3 billion has been invested to date in developing a modern efficient gas pipeline infrastructure. Annual gas demand is approximately seven billion cubic metres for the island, or equivalent to about 45 million barrels of oil.

Figure 4.7 Annual Daily Demand/Indigenous Supply Balance

Ref: Study on Common Approach to Natural Gas Storage and LNG on an All-Island Basis



(Commissioned by the Department of Communications, Energy and Natural Resources and the Department of Enterprise, Trade and Investment, NI)

The reality of climate change means that there is an imperative to move to a low carbon society in Ireland – the above statistics show the magnitude of the task facing the island. It is likely that it will take a considerable period to make this transition with natural gas, with its lower CO_2 emissions, displacing oil and providing a bridge to the low-carbon future.

4.3.2 Gas Network

The gas network currently services seven of the eight City Regions with the exception of Sligo (**Figure 4.6**). The network to Mayo came about as a result of the Corrib gas find. The network should be extended to Sligo City Region. Further extensions could be developed to cater for the following:

- a new gas find which might require a landfall remote from the existing grid, e.g., Donegal, Waterford or Kerry;
- a storage facility, either underground or (liquified natural gas (LNG), remote from the existing grid;
- construction of a gas-fired power plant remote from the existing grid; and,
- upgrading of the North–South pipeline to provide security flows.

Local gas networks should be developed to service each of the City Regions.

4.3.3 Security of Gas Supplies

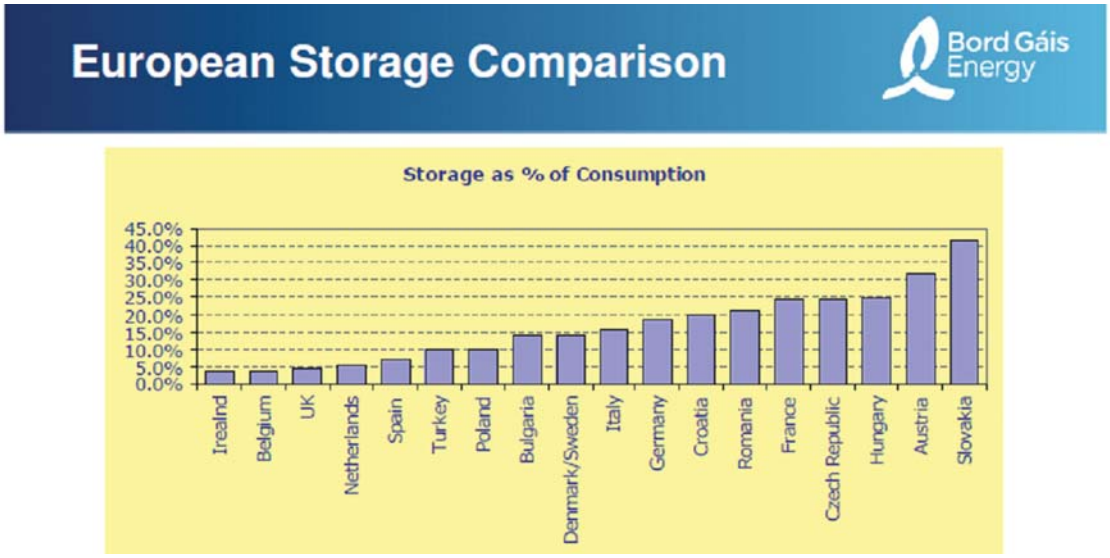
Ireland currently imports over 90% of its natural gas requirements through Great Britain (GB). The Corrib field will initially supply approximately 50% of the island's needs when it comes on stream. Within 3 or 4 years this will decline to less than 20% and if there are no further finds, the island will once more be hugely dependent on imports via the UK (**Figure 4.7**).

Table 4.1 Source: Study on Common Approach to Natural Gas Storage and LNG on an All-Island Basis

Storage facility capacities			
Type	**Capacity**	**Million cu metres**	**Basis**
Salt cavern	25 million cu metres	25	Average of 58 operational and approved caverns in GB
Depleted field	55 billion cu ft	312	Ballycotton production – 20-25% based on southwest Kinsale
LNG storage tank	200,000 cu metres	120	Proposed Shannon LNG tanks
LNG peak shaving plant	12mcm	12	Four operational in GB, range 4-20 million cu metres
LNG re-gasification vessel	82mcm	82	138,000 cu metres of LNG per vessel
Pressurise transmission system to 85 bar (linepack)	3.5mcm	3.5	BGE estimate 3-4 million cu metres

(Commissioned by Department of Communications, Energy and Natural Resources and the Department of Enterprise, Trade and Investment, NI)

Figure 4.8 European Gas Storage Comparison



This will be at a time when the UK's own indigenous supplies will be in steep decline, with a requirement to import more than 80% by 2020. Around this time there will be a shift from the North Sea, the Netherlands and Norway to more distant and less stable areas such the former Soviet Union, the Middle East and North Africa. This may lead to price volatility and concerns about security of supply.

Given our continued reliance on gas for the foreseeable future, and the serious consequences of an interruption in supply, there is a need for a diversity of supply and gas storage.

4.3.4 Gas Storage

Ireland is uniquely vulnerable given its location on the far western edge of the European gas network, dependent in part on a single piece of infrastructure for importation of 90% of its needs and 65% dependent on gas for power generation. **Table 4.1** shows the options for long-term storage requirements

In order to increase energy security long-term, strategic storage capacity equivalent to 20% of annual natural gas usage on the island should be provided in salt caverns, depleted gas fields and LNG tanks – **Figure 4.8** shows European storage comparison.

Part of this long-term strategic storage could also be provided by obliging gas-fired power stations to hold increased supplies of oil distillate, which can be used as an alternative fuel.

4.3.5 Diversity of Supply – Liquified Natural Gas (LNG)

LNG is natural gas (predominantly methane, CH_4) that has been converted temporarily to liquid form for ease of storage or transport (**Figure 4.9**). LNG takes up about 1/600th of the volume of natural gas in the gaseous state.

An LNG terminal located on the island will ensure that we do not become energy dependent on any region or country and could add around 11mcm/d of import capacity. It would also alleviate concerns in the electricity market about over-reliance on gas delivered through a single pipeline in Scotland.

Figure 4.9 LNG Vessel

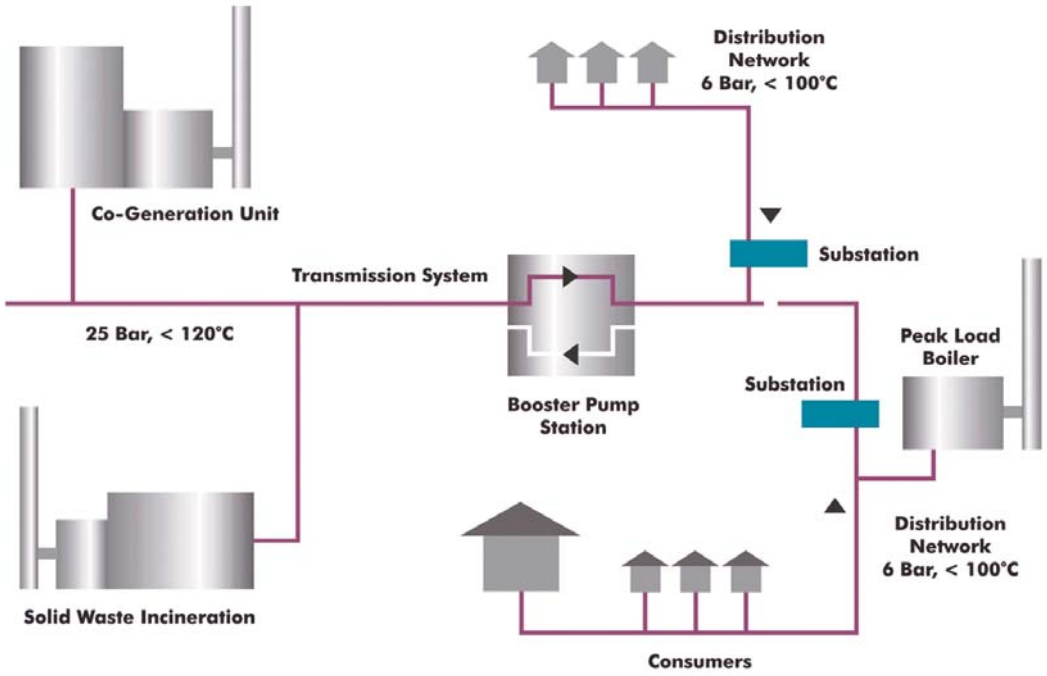
LNG supplies come primarily from diverse locations where large gas discoveries have been made remote from areas of high gas demand; these locations include Indonesia, Algeria, Qatar, Oman, Nigeria and Australia.

Should there be congestion in European ports a terminal in Ireland would have the potential to serve the UK, Dutch, Belgian and French Markets.

4.3.6 Impact of Wind Generation

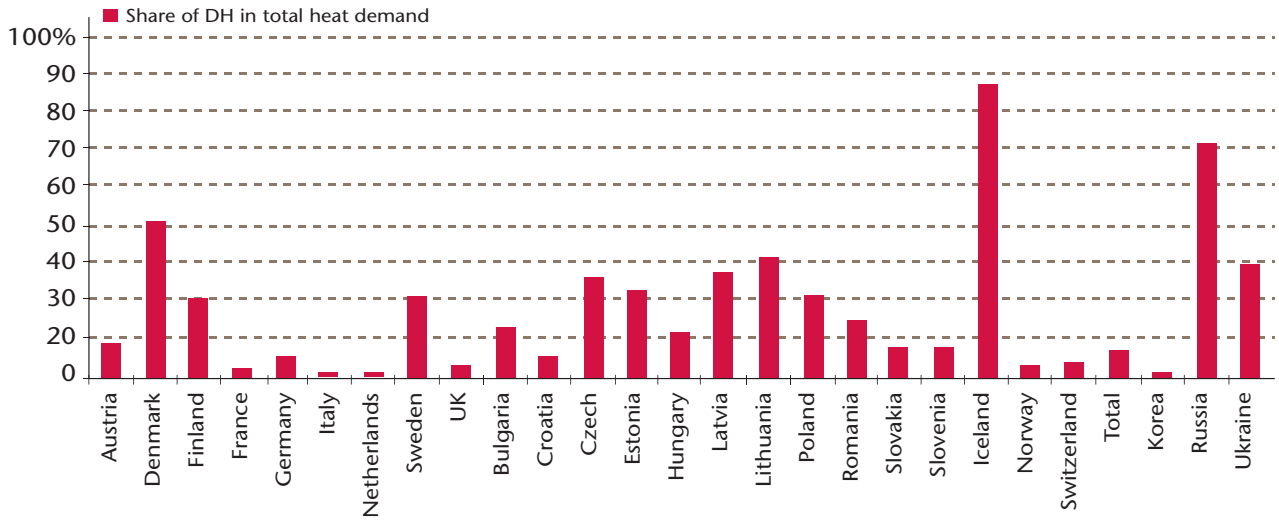
The large portfolio of wind generation anticipated by 2030 will introduce huge variability into the demand for gas. This will increase the purchase price and may lead to difficulties in sourcing gas. Managing the consequences of a large wind portfolio will require the development of on-island gas storage with an associated increase in cost for gas-fired generation.

Figure 4.10 Overview of a District Heating Network



Source: Dublin City Council – RPS/COWI

Figure 4.11 Share of District Heating in Total Heat Demand



Source: Euroheat & Power, 2007; (Ireland's share is negligible)

4.4 District Heating

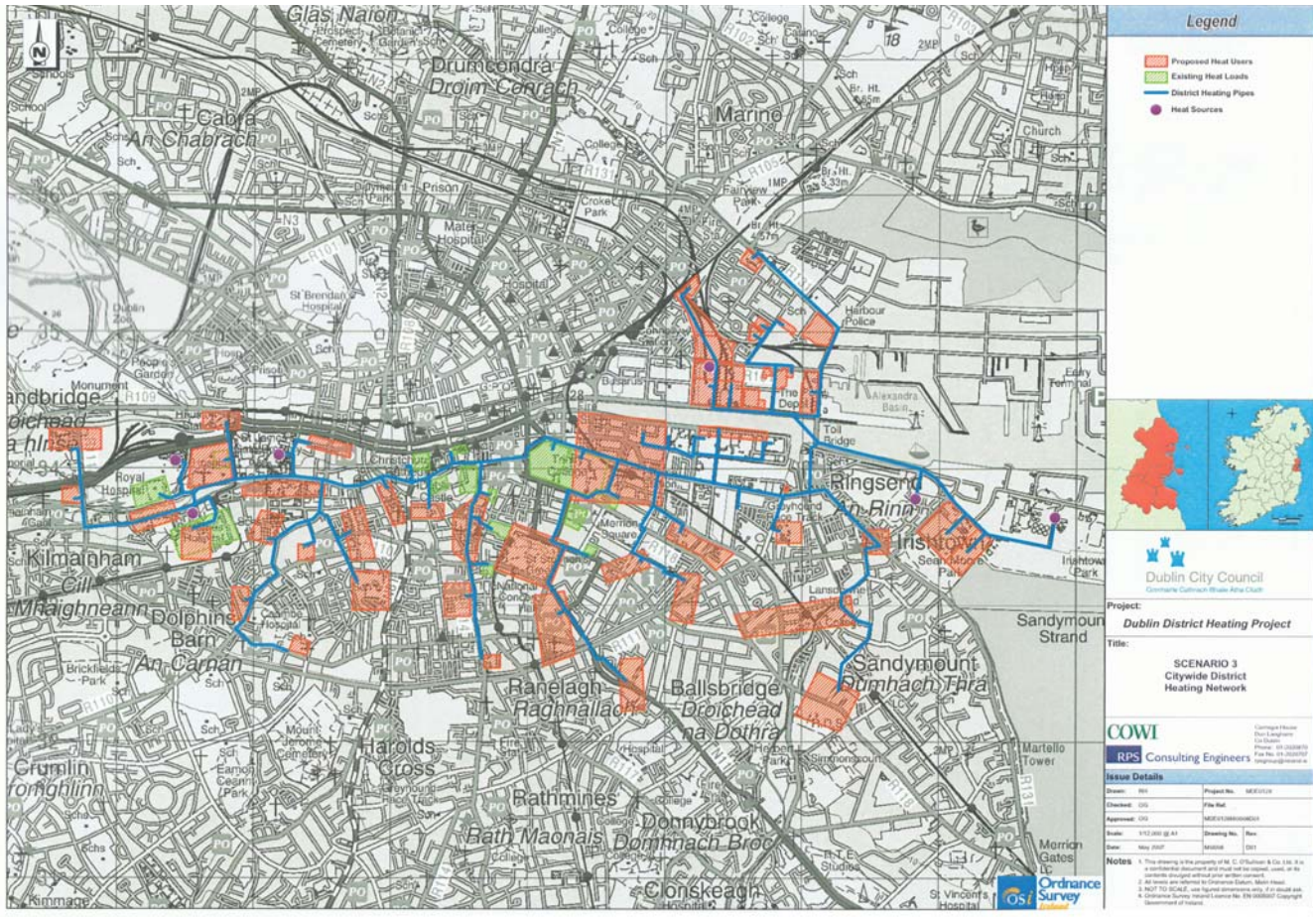
District heating (DH) systems are thermal energy networks that distribute hot water, chilled water or steam through insulated dual pipelines (supply and return) to serve commercial, residential and industrial energy needs for space heating and cooling, domestic hot water and industrial needs. DH systems allow heat, as distinct from fuel, to be bought and sold as a commodity. An overview of a DH system is shown in **Figure 4.10**.

In 27 European countries DH is distributed to 100 million people, this is 23% of the population of these countries (**Figure 4.11**). DH offers advantages in terms of higher efficiency, significantly reduced CO_2 emissions and reduced consumption of energy resources. It saves DH customers both the investment and space for their own boiler installation and the cost associated with its operation and maintenance.

DH should be a requirement in all new high-density residential and commercial developments. **Figure 4.12** shows a proposed DH system for Dublin's city centre.

Figure 4.12 Proposed District Heating Network for Dublin City

Source: Dublin City Council



Chapter 5
ENVIRONMENT

Key Recommendations

1. Base development plans for all City Regions on clear sustainable principles.
2. Establish appropriately sized waste to energy (WTE) plants and strategically locate them to cater for residual waste from the City Regions.
3. Manage demand for water with an emphasis on conservation, loss reduction, metering and an economic charge for water.
4. Develop a shared water mains network which will allow for bulk transfer of water between sources of supply and population centres.
5. Undertake a programme of sewer renewal in urban areas. Have separate storm and foul water sewers where practicable.

Cities compete to attract and retain mobile factors of production, namely labour and capital, according to the OECD. A key competitive factor in this regard is a high quality environment which is defined by clean water, fresh air, clean soil, and by the level of noise and the quality of light. A sustainable city will operate with minimal impact on the surrounding area and leave the smallest possible ecological footprint. Development plans for the City Regions should be based on clear sustainable principles.

"A sustainable city will operate with minimal impact on the surrounding area."

5.1 Waste

5.1.1 Introduction

Generation of waste should be decoupled from economic development. An integrated waste management approach should be applied to waste generated, with the objective of minimising disposal to landfill. This policy will be in accordance with EU directives which establish the following hierarchy in dealing with waste:

- prevention;
- reuse;
- minimisation;
- recycling;
- energy recovery; and,
- disposal.

Targets should be 60% of waste recycled, 25% used for energy recovery and the residual 15% disposed to landfill.

5.1.2 Public Education on Waste

Achievement of ambitious targets will be driven by delivering a message to schools, businesses and communities on the need for waste prevention and minimisation, with people taking responsibility for their own waste.

5.1.3 Waste Infrastructure

Each city catchment should establish accessible facilities to service its own needs. These should include:

- recycling centres including facilities for green composting;
- kerbside collection with separate bins for dry and wet recyclables and non-recyclable waste, funded by "householder pay by weight";
- bring banks for each 1,000 of population;
- managed landfill to cater for residual waste;a landfill tax should be used to minimise this form of disposal; and,
- WTE plants.

5.1.4 Waste to Energy

Appropriately sized WTE plants should be established and strategically located to cater for residual waste from the City Regions. Regional transfer of waste by rail should be permitted to give economies of scale where required. The WTE plants will have a high level of energy efficiency, feeding electricity to the national grid and producing heat for local district heating (DH). DH should be a requirement for all new build high density residential and commercial developments.

5.1.5 Waste as a Resource

Waste should be seen as a resource and its material and energy value maximised with the least environmental impact. National authorities should provide support for market development for recycled materials.

5.1.6 Cost Recovery

The "Polluter Pays Principle" should be implemented and user-related charges implemented to reduce waste and alter life style habits.

5.2 Water

5.2.1 Introduction

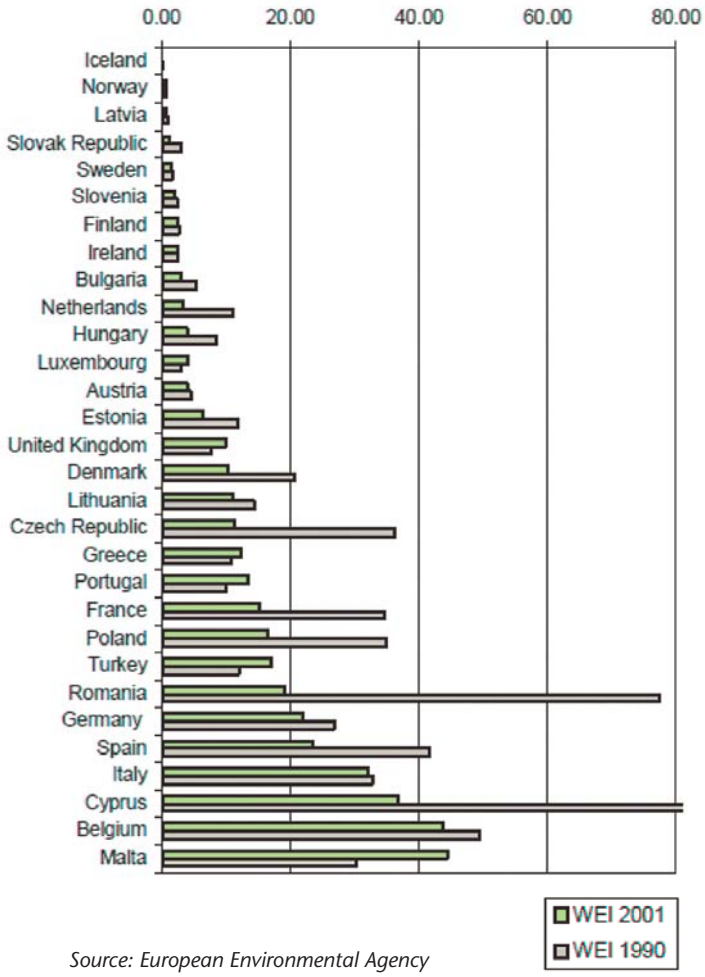
Water tends to be regarded as a free resource on the island of Ireland. This situation will, however, change as the impact of climate change is felt. The conservation, use, demand and treatment of water should, therefore, be given the most careful consideration in order to ensure a sustainable environment.

5.2.2 Water Supply Availability

Most of the eastern half of the island has 750 to 1,000mm of rainfall a year compared with 1,000 to 1,300mm in the west. When evaporation and plant transpiration losses are taken into account the annual effective rainfall is approximately 350 to 550mm in the east and 620 to 820mm in the west. Altered weather patterns this century due to climate change may result in 11% more rainfall in winter but 25-40% less rainfall in summer. In addition, more frequent extreme weather events are predicted, including severe droughts and flooding.

At present 70% of the population draws its water supply from surface water sources such as lakes, rivers and reservoirs.

Figure 5.1 Water Exploitation Index (%) across Europe



Source: European Environmental Agency

The remainder of the supply is from groundwater. This is much less than in other countries, e.g., North America (51%) and Europe (75%). The proportion of water supplied from groundwater will grow as demand increases. Less than 5% of effective rainfall becomes groundwater recharge because of impermeable heavy clay and bedrock with poor transmission capability. Continued research on groundwater recharge acceptance, storage, capacity and quality will be required to enable increased exploitation of this resource.

The Water Exploitation Index (WEI) (**Figure 5.1)** is a good example of the type of information needed to give an overview of the scale and location of the problems facing us. The Index shows available water resources in a country or region compared to the amount of water used. An index of over 20% usually indicates water scarcity. The Index shows the positive position of Ireland's water resources relative to other European countries.

5.2.3 Demand

An increased population of eight million will be distributed approximately 5.5 million in the east of the island and 2.5 million in the west. The resulting increase in demand for water should be managed in a sustainable manner with an emphasis on conservation, demand management, loss reduction from networks, use minimisation, metering and an economic charge for water.

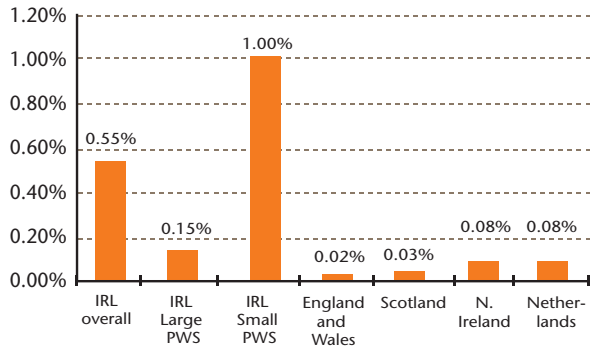
As outlined further in Section 6, drought as a result of climate change will cause a decline in food output from traditional European areas of production. This in turn will lead on the island to an increase in growth of "water thirsty" crops such as wheat (the production of 1kg of wheat requires 1,300 litres of water) in the south eastern part of the country, which may require irrigation.

Water treatment projects in Ireland are constructed where feasible on a public private partnership basis with the capital cost funded by the State but constructed and operated by private sector firms. Revenue is funded from charges for commercial customers and from public funds for domestic customers. In Northern Ireland major new water treatment projects are constructed on a private finance initiative basis with revenue from the state for domestic users and from charges from commercial customers. Domestic charges should be introduced and there should be greater reliance on private finance for construction.

5.2.4 Water Quality

The majority of public water supplies (PWS) in Ireland are small, serving less than 5,000 persons. A comparison of non-compliance with the *E. Coli* parametric value in public water supplies in Ireland with the UK and the Netherlands shows that further improvement is necessary, with the smaller PWS in particular having a much higher level of contamination (**Figure 5.2**).

Figure 5.2 Comparison of Non-Compliance with the *E. Coli* Parametric Value in Public Water Supplies in Ireland and Other EU Countries



Source: EPA – Quality of Drinking Water in Ireland 2007-2008

5.2.5 Critical Infrastructure

The increase in population, especially in the eastern part of the island with the lowest rainfall, will require a shared network which will allow for bulk transfer of water between sources of supply and population centres. This network should link the River Shannon and Lough Neagh with the Dubin–Belfast conurbation. This shared network will provide additional resilience to City Regions which will have two sources of supply to cater for interruption.

Climate change with an increase in the frequency and severity of flooding will present a serious threat to water treatment plants and the electricity substations providing them with power. These plants are often situated on river banks or flood plains and will require additional protection.

5.3 Wastewater

5.3.1 Overview

The provision of an adequate wastewater collection and treatment infrastructure is fundamental not only for the health of the population but also for maintaining the quality of our coastal waters and inland waterways. Rivers and lakes are the source of more than 70% of the island's potable water. The EPA report on *Urban Waste Water Discharges in Ireland 2006-2007* highlighted 13 seriously polluted rivers and seven beaches in Ireland where EU mandatory limits were not met due to the impact of wastewater discharges. The report also identified 112 locations in Ireland with inadequate or no wastewater infrastructure and effluent from 192 treatment plants which failed to meet EU standards due to either operational problems or excessive loading.

The improvement in the treatment of wastewater in the past decade has been driven by the EU Urban Wastewater Treatment Directive.

5.3.2 Expansion of Treatment Plants

Planning and implementation of the timely expansion of wastewater treatment infrastructure will be required in all

City Regions to cater for both population growth and industrial development. Many of the treatment plants built in the past decade have been designed so that modular expansion can be easily implemented in line with increased loading. In instances where the potential for such expansion is either not feasible or has been fully exhausted it will be necessary to construct new facilities to cater for requirements. The most notable example of this is the limited scope for further expansion of the treatment plant serving the Dublin urban area at Ringsend.

5.3.3 Sewer Renewal

Climate change will bring higher intensity rainfall and more frequent storm events. As existing urban drainage systems have not been designed to cater for such conditions, this will increase the occurrence of out of sewer flooding and polluting discharges from overloaded sewers.

Excessive flows of storm water reaching wastewater treatment facilities result in increased treatment cost and can cause the discharge of insufficiently treated effluent. The result of this can be the pollution of rivers and lakes which are used for the supply of water to urban areas. Where water treatment facilities drawing from these rivers and lakes are vulnerable to contaminants such as cryptosporidium the potential for interruptions to the normal water supply exist, an extreme example of which was experienced in Galway city during 2007.

A major programme of sewer rehabilitation and replacement should be undertaken in urban areas and, where practical, a key element of these works will be the separation of foul and storm sewers.

5.3.4 Sustainable Drainage Systems (SuDS)

SuDS are designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges. They try to replicate natural systems that use cost-effective solutions with low environmental impact to drain away dirty and surface water run-off through collection, storage and cleaning before allowing it to be released slowly back into the environment, such as into water courses.

This is to counter the effects of conventional drainage systems that often allow for flooding, pollution of the environment and contamination of groundwater sources

"Demand for water should be managed in a sustainable manner with an emphasis on conservation, loss reduction, metering and an economic charge for water."

used to provide drinking water. The paradigm of SuDS solutions should be that of a system that is easy to manage, requiring little or no energy input (except from environmental sources such as sunlight), resilient to use and environmentally, as well as aesthetically, attractive. Examples of this type of system are reed beds and other wetland habitats that collect, store and filter dirty water along with providing a habitat for wildlife. This type of sustainable drainage should be incorporated into all future development.

5.3.5 Funding Wastewater Infrastructure

As in the case of drinking water, waste water treatment plants in Ireland are constructed using public funds, but designed built and operated by private sector firms. Charges are levied only on commercial users with the remaining operating cost paid by the state. In Northern Ireland major new projects are funded on a private finance initiative basis while revenue is received only from commercial firms and the state. In future, charges are likely to be levied on domestic users and there is likely to be a greater reliance on private finance for construction.

Chapter 6
CLIMATE CHANGE

Key Recommendations

1. Increase the energy efficiency of residential and commercial buildings.
2. Develop new non-greenhouse gas (GHG) emitting baseload electricity generation, coal or gas with carbon capture and storage technology and imported nuclear power.
3. Plan for the protection of cities in coastal areas and river basins against flood damage and rising sea levels.
4. Establish a register of critical infrastructure vulnerable to climate change. Carry out a flood risk assessment for each critical infrastructure asset identifying its frequency of exposure to a hazard, its resilience to exposure and the consequences of its failure.
5. Focus climate research on identifying key parameters critical for infrastructure design.

6.1 Introduction

Climate change threatens the basic elements of life for people around the world – access to water, food production, health and use of land and the environment. Ireland, as a member of the European Union, is party to the EU's commitment under the Kyoto protocol, which has the aim of stabilising CO_2 in the atmosphere at a level 450 to 550ppm by the middle of the century.

Climate change will impact on the island in two ways:

- the requirement to reduce GHG emissions will demand a very different approach to energy production, transport, building design and agriculture; and,
- increased sea level, rainfall patterns and extreme weather events will necessitate major adaptations to the island's infrastructure.

6.2 GHG Abatement[13]

Policy targets for energy and climate change are driven by the EU commitment known as the 20-20-20 Initiative. This initiative aims to reduce GHG emissions by 20%, to increase the share of renewables in energy use by 20% and to improve energy efficiency by 20% – all to be achieved by 2020.

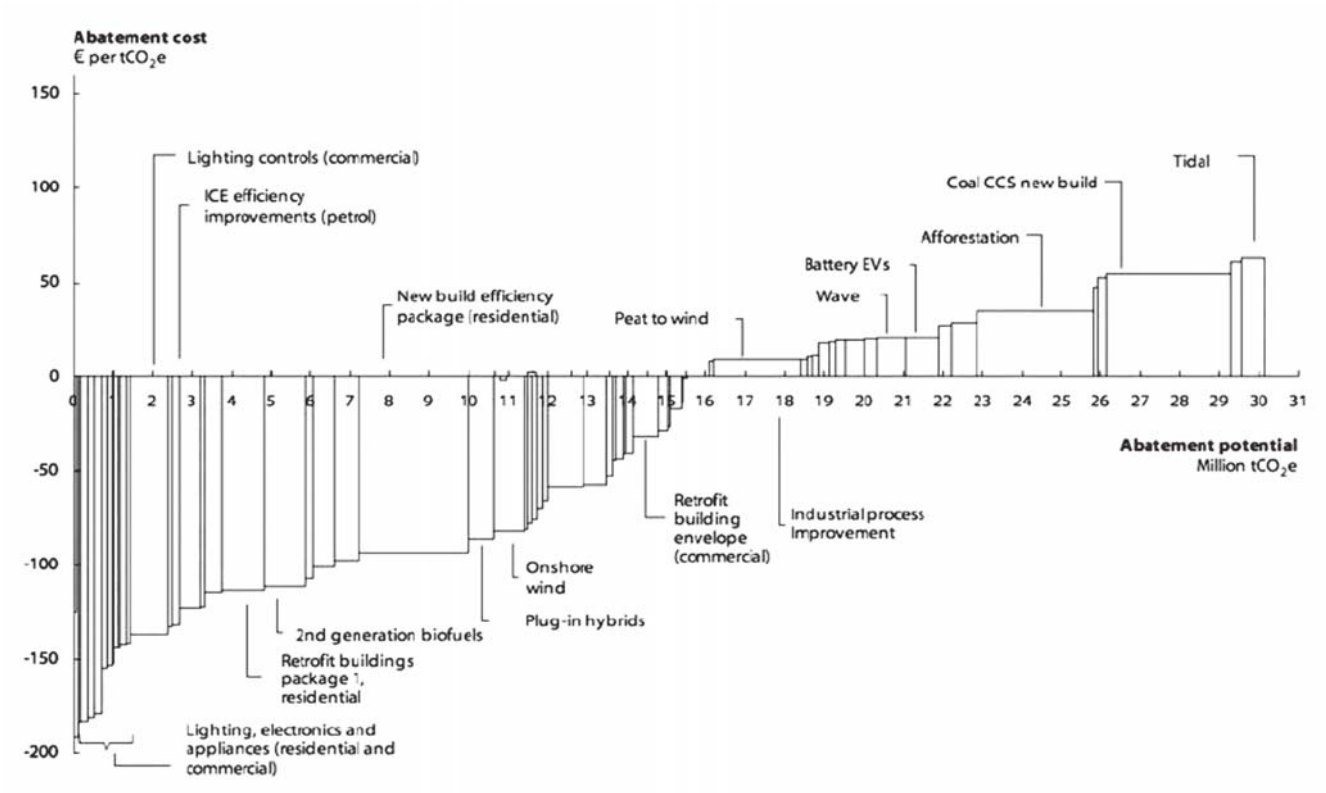
One of the significant features of the EU 2020 Climate Change package is the delivery of a new Renewable Energy Directive covering electricity, heat and transport. The new Directive on energy from renewable sources seeks to ensure that by 2020 renewable energy makes up at least 20% of the EU's total energy consumption. The Directive sets out a target of 16% renewable energy for Ireland for 2020.

The Ireland GHG Abatement Cost Curve (**Figure 6.1**) has been developed based on the proven methodology of McKinsey's global GHG abatement cost curve. The Ireland specifics were created through consultations with over 80 Irish stakeholders and experts from all sectors.

The GHG Abatement Cost Curve is an approach to assess technical abatement opportunities relative to a "business as usual" (BAU) emissions development scenario. It examines emission reduction potential and associated cost for each opportunity. Realising full potential identified by 2030 will reduce abatements relative to BAU by 42%. The top ten abatement levers deliver over 60% of the 2030 abatement potential. Power generation leads delivery of abatement in 2030 with 11.1MtCO_2e (40% of total) but all other sectors need to contribute to realise Ireland's full abatement potential. The abatement cost curve is based on oil at $120 per barrel and carbon at €80/t. The potential contribution of nuclear power to GHG abatement is not included.

13 *Refer also to Section 4 – Energy.*

Figure 6.1 Ireland's GHG Abatement Cost Curve



Source: SEI Report: Ireland's Low Carbon Opportunity – July 2009

6.2.1 Energy

The European Union Emission Trading System (EU ETS) has emerged as the primary instrument for reducing CO_2 emissions across power generation and heavy industry in Europe. By setting a price on carbon, it aims to generate incentives for companies both to reduce their operational emissions and to invest in lower carbon technology.

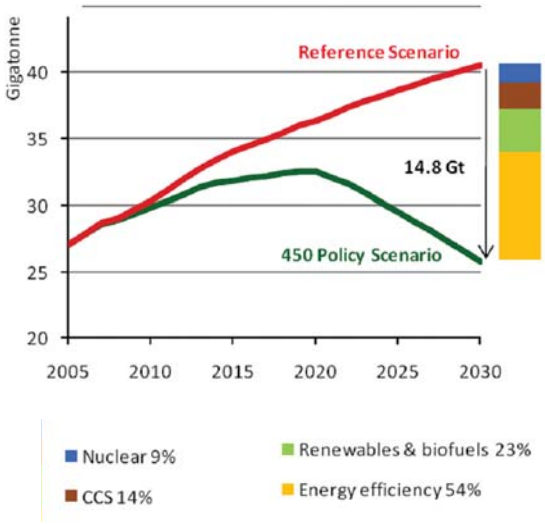
Figure 6.2 shows the potential contribution that different aspects of the energy sector can make to the EU target of reducing global CO_2 to 450ppm by mid century.

In considering the 2030 timeframe, it is proposed that emissions reduction in the energy sector will be achieved by:

- increasing the energy efficiency of residential and commercial buildings;
- 30% renewable power generation which will come mainly from onshore wind. New pumped storage located on the west coast where most of the wind farms will be situated, or other storage technologies such as compressed air, will assist with the intermittent nature of the output and grid stability problems associated with this scale of renewable generation;

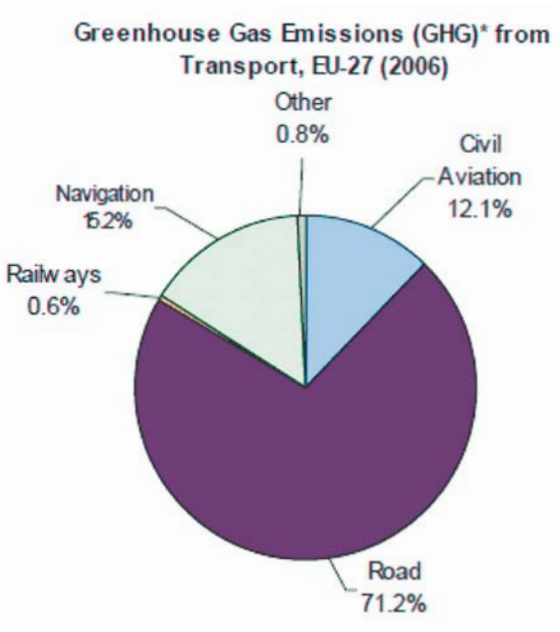
Figure 6.2 Reductions in Energy Related CO_2 Emissions in the 450 Policy Scenario

Reference Scenario refers to "Business as Usual"



Source: IEA 2008

Figure 6.3 GHG Emissions by Mode of Transport



Source: EEA

- new base load generation – nuclear (imported via an interconnector or from a plant on the island) and the replacement of the 900MW coal-fired plant at Moneypoint with a new coal plant with carbon capture and storage technology;[14]
- co-firing with approximately 30% biomass as a fuel substitute in the three peat fired power stations;
- development of offshore wind, wave and tidal energy. These technologies are still at an early stage of development and will require major R&D to achieve their commercial potential. It is likely to be post 2030 before they make any significant contribution to GHG abatement; and,
- district heating (DH), which should be a requirement for all new high-density commercial and residential construction with the heat supplied by waste to energy (WTE) plants or by local gas-fired or biomass combined heat and power plants (CHP).

6.2.2 Transport

Abatement measures should include:

- an increase in population density in the cities combined with the provision of comprehensive public transport, which will reduce commuting distances and the use of private cars. In the EU 71% of transport GHG emissions come from road transport (**Figure 6.3**);
- further fuel efficiency improvements in petrol and diesel engines; and,
- the introduction of electric vehicles charged off peak with electricity primarily from renewable generation sources and other non-CO_2 emitting sources such as coal and gas fired generation with carbon capture and storage and nuclear power.

6.2.3 Buildings

Increasing the energy efficiency of residential and commercial buildings will be the most cost-effective abatement measure with the added bonus of providing a stimulus to local economies.

Measures should include:

- raising insulation standards for new buildings;
- retrofitting insulation and draught proofing to residential and commercial buildings; and,
- more efficient lighting.

6.2.4 Agriculture

In the future more of the world's food will be produced in countries with access to water and production methods which minimise GHG emissions. Ireland exports enough food to feed five times its population. This food, which is primarily meat and dairy based, is produced with low GHG emissions because of the island's "climate advantage". Further reductions in emissions will be required and will be achieved by:

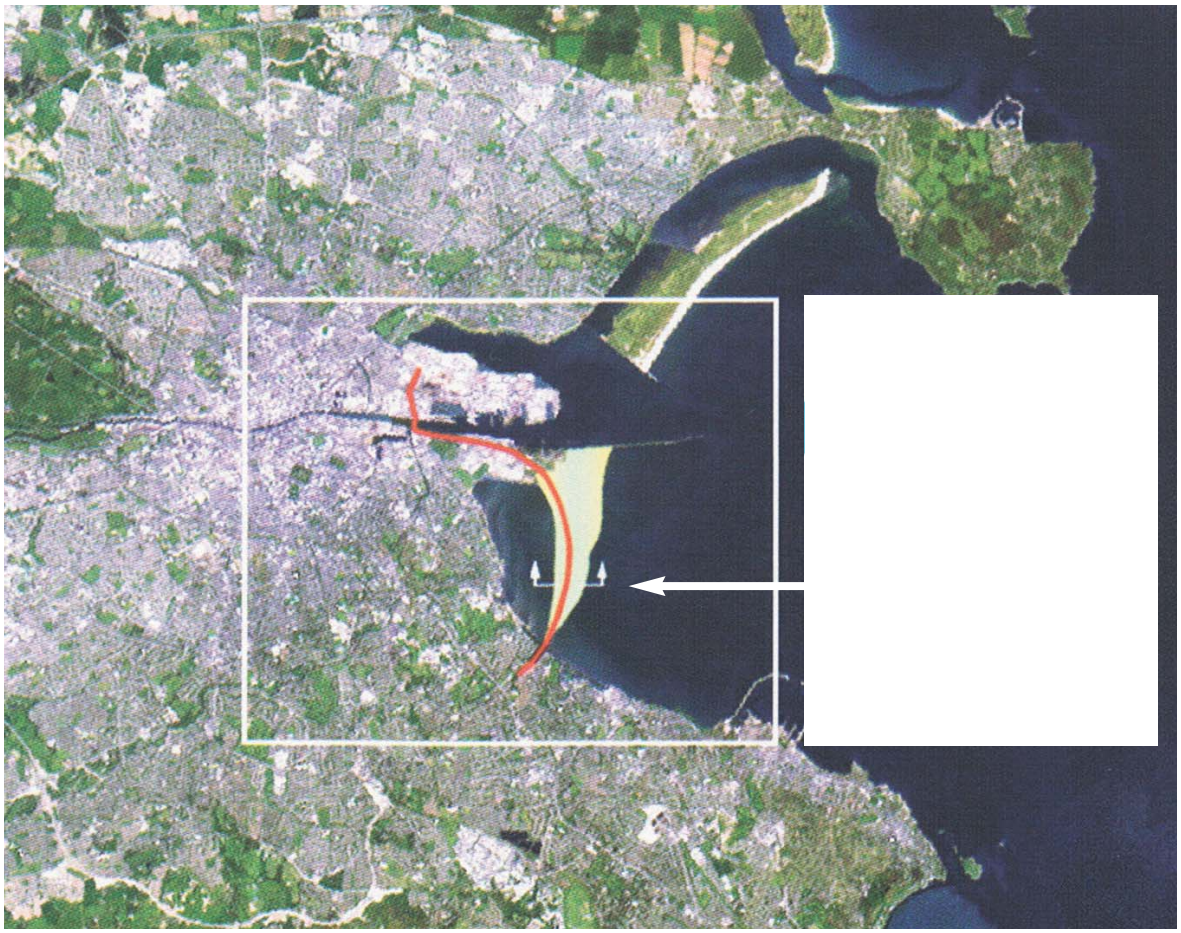
- livestock dietary management (extended grazing with a reduction in use of feed concentrates);
- grassland management; and,
- afforestation.

6.3 Infrastructure Adaptation

Even if GHGs were capped at 2000 levels, significant climate change will occur in the coming decades due to inertia in

14 *IAE report: Review of Energy Policy in the Context of the Changing Economy, June 2009*

Figure 6.4 Section of Tidal Barrier for Dublin Bay with Eastern Bypass



Source: Dublin City Council

the climate system. Therefore there is an urgent requirement to identify vulnerable critical infrastructure and prioritise adaptation measures.

To ensure that sufficient priority is given to infrastructure adaptation, responsibility as "Lead Agency" should be assigned to an existing government department in each jurisdiction north and south. The Lead Agencies should take an overall view of the impact of climate change on critical infrastructure, propose policy and recommend measures to their respective Governments. They should also co-ordinate implementation of required actions on an island basis.[15]

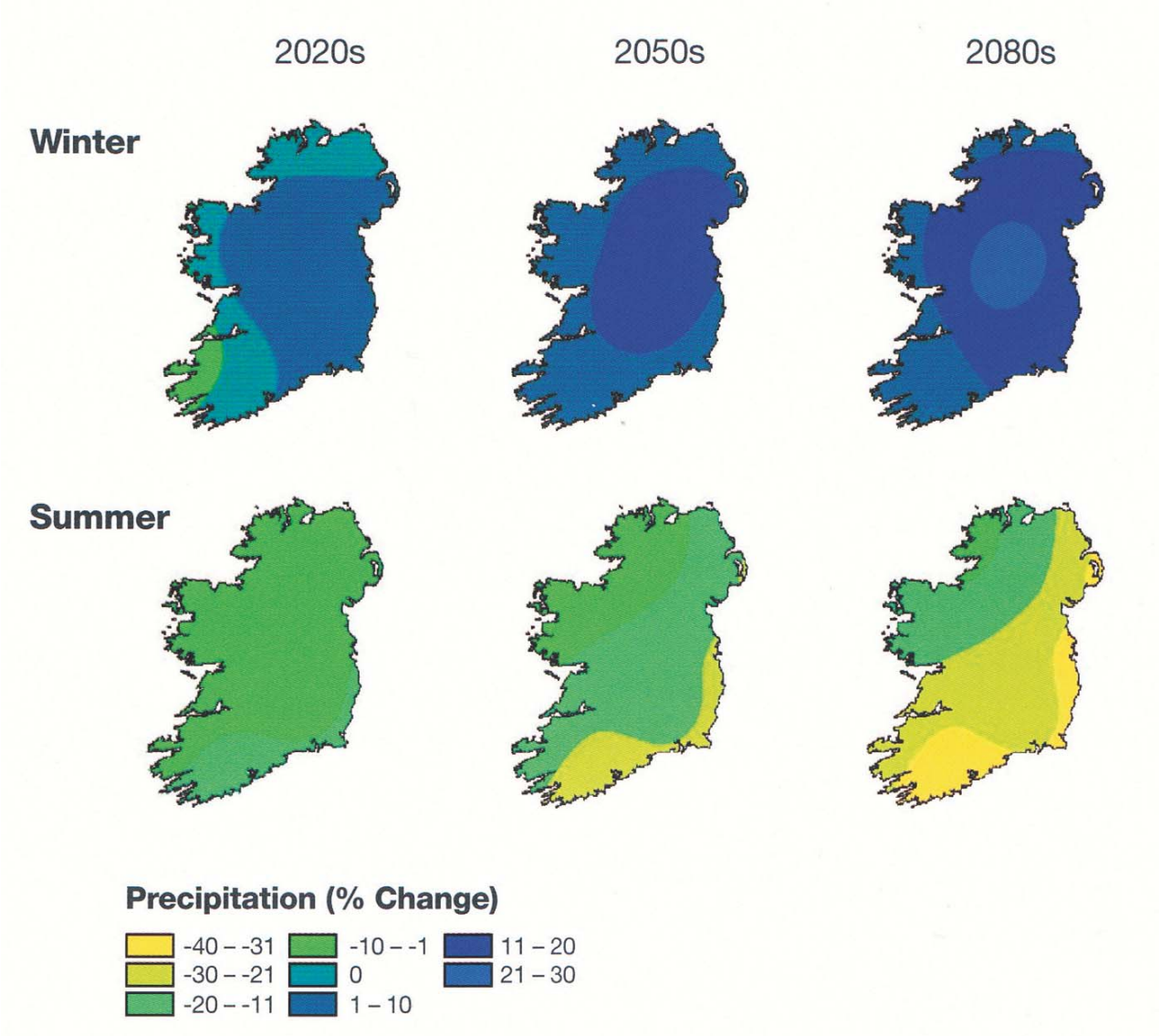
6.3.1 Sea Level and Storm Surges

A rise in sea level in the range 0.5-1m is predicted by the end of the century – it may be more based on ice melting patterns. Due to increases in tropical sea surface temperatures it is likely that tropical cyclones will become more intense. The remnants of these tropical storms can rejuvenate as they cross the Atlantic over the warmer surface temperatures of the Gulf Steam resulting in a significant increase in wave heights. For countries such as Ireland along the eastern Atlantic this will lead to increased vulnerability from flooding and storm damage. One-in-100-year coastal floods events are likely to become one-in-10-year events.

All of the island's principal cities are situated in coastal estuaries and will be vulnerable in varying degrees to storm surges. Protection will be required in the form of enhancement of existing coastal defences with substantial works required in Dublin, Belfast and Cork. In the case of Dublin, combining construction of a tidal barrier across Dublin Bay with the Eastern Bypass and a rail line could provide a cost effective solution (**Figure 6.4**).

15 IAE Report: Critical Infrastructure – Adaptation for Climate Change, November 2009

Figure 6.5 Changing Rainfall Pattern: Wetter Winters and Drier Summers



Source: ICARUS, NUI, Maynooth, 2007

6.3.2 Precipitation

Precipitation patterns and amounts will change, and we expect wetter winters and drier summers. In particular it is expected that the east of the island will experience much drier summers with consequent water shortages – **Figure 6.5**.

6.3.3 Protection of Critical Infrastructure

It is likely that river stream flow will increase by approximately 20% by mid century. Flood events are likely to become more frequent, with the current 50-year event likely to be associated with a circa 10-year return period. The implications therefore are that many existing river defences will have to be reinforced. Flooding from extreme precipitation will threaten the viability of entire settlements. Issues such as construction of flood defences or even site abandonment will be influenced by insurance weightings of homes and businesses.

Flood defences should be designed into all new infrastructure areas, avoiding flood plains. A robust and acceptable methodology should be developed on which to base the delineation of flood plains.

Road and rail transport routes will be particularly vulnerable, especially when following coastal and river valley routes. Cuttings and embankments will require alterations and improvements to cope with increased flooding.

The energy sector has critical infrastructure, including electricity sub stations, gas installations and oil terminals, located throughout the island, that is vulnerable to increased possibility of flooding or other damage caused by extreme weather events. Many of these plants have facilities such as cable tunnels and basements, which increase the risk of flooding. All owners of energy infrastructure should carry out a preliminary climate change risk assessment and prepare a climate change asset risk register. This should be carried out using climate change parameters decided by the Energy Regulator in both jurisdictions in consultation with the two climate change Lead Agencies and the owners of the energy infrastructure.

Water infrastructure which is dependent on electricity for pumping will need both flood protection and standby generation.

A register of critical infrastructure vulnerable to climate change should be established. A formal flood risk assessment should be carried out for each critical infrastructure asset identifying its frequency of exposure to a hazard, its resilience to exposure and the consequences of its failure.

6.3.4 Design Standards

The engineering profession and climate change researchers should co-operate in identifying which climate change parameters are critical to infrastructure design and what further climate change research is required to enable the engineering profession to amend current design standards. In the interim, it would be prudent that new construction should allow for a sea level rise of at least 0.5m.

"There is an urgent requirement to identify vulnerable critical infrastructure and prioritise adaptation measures."

Chapter 7
INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)

Key Recommendations

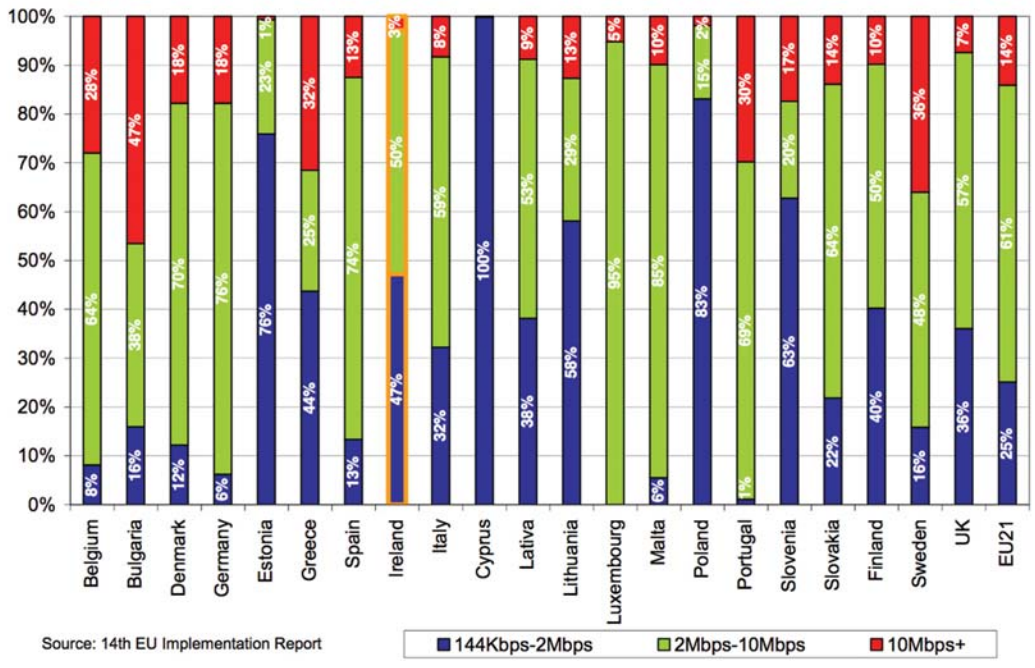
1. Develop a high speed and large capacity information highway which will match the performance of that in the most advanced global economies. Prioritise the high density population corridor linking Dublin and Belfast and also the South Western Corridor.
2. Harness the potential of advanced IT and communications technologies to improve efficiencies and enable a sustainable competitive economy.
3. Establish a direct connection to Europe, in addition to routes through Great Britain, using advanced communication technology, thus enabling Ireland to be a virtual extension of the main internet exchanges in mainland Europe.

7.1 Overview

To develop as a successful society, the island of Ireland must build a smart economy based on knowledge and sustainability. This will require the development of a high-speed and large capacity information highway which will match the performance of that of the most advanced global economies. Information and comunications technology (ICT) is a key element of knowledge societies and will also be a significant driver in delivering a low carbon economy. Digital technologies will provide the smart tools to drive the sustainable energy agenda in conservation, generation and transmission.

Knowledge societies and their economies have a range of characteristics. These include:

Figure 7.1 Fixed Broadband Lines by Speed, January 2009



Source: ComReg Key Data Q1 2009

- advanced high-speed broadband – domestic and enterprise;
- high level of electronic transactions in public, private and government services;
- high speed broadband and systematic usage in schools;
- high participation of students in advanced mathematics, science and engineering;
- world ranking universities with high level of international connectivity;
- technology-based industry producing innovative products and services for export;
- well-defined national ICT research programmes;
- high ranking in IT international surveys and global competitiveness;
- high number of full-time researchers in industry and at third level;
- strength in ICT, biotechnology and pharmaceuticals with high added-value indigenous manufacturing sectors; and,
- high level of international business connectivity with strong export revenues from products and internationally traded services.

7.2 Communications Networks

The smart economy will require the construction of a robust and reliable telecommunications network consisting of a low cost, high resilience, high bandwidth and low latency fibre backbone, throughout the island. Internet-based services will become the lifeblood of modern life.

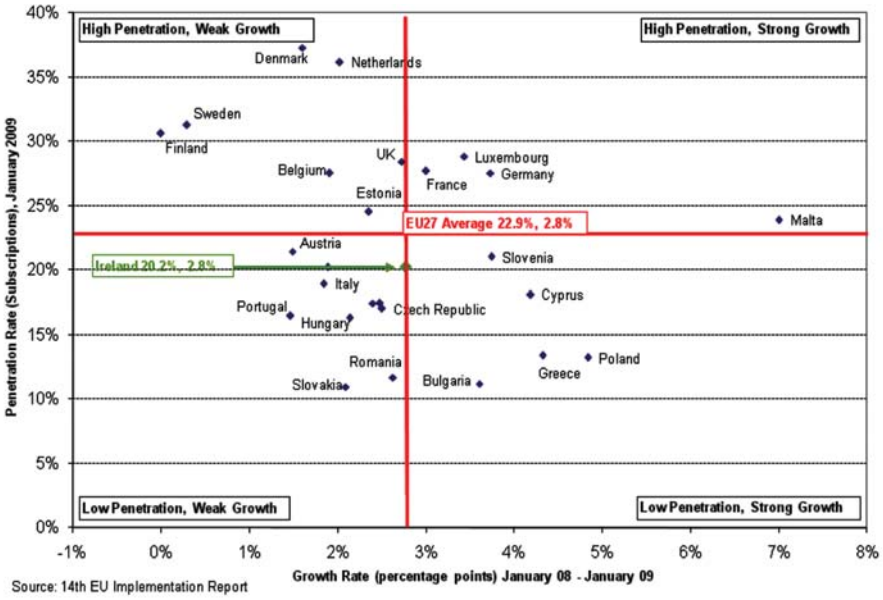
There is nothing that the World Wide Web does not touch today to the point that broadband services are now considered comparable to what landline voice services were over the last 40 years. The next 20 years will see the World Wide Web mature and become even more deeply embedded into everyday life. This means that today's technology will be replaced with even more exciting technologies tomorrow – most of which are being invented and developed today.

7.3 Broadband

Ireland ranks well below the EU average in the availability of high speed broadband services (**Figure 7.1)**. Only 3% of subscribers have download speeds in excess of 10Mbps. Ireland ranks 25th in the OECD in terms of its readiness to support next generation video and web services and is also below today's required standard.

In 2009, about 72% of broadband subscriptions were for a fixed landline platform, and the remaining 28% for mobile broadband. Mobile broadband applications almost doubled over the previous year, while fixed broadband increased by almost 14%.

Figure 7.2 EU Broadband Penetration and Growth, January 2009



Source: ComReg Key Data 2009

Ireland's fixed broadband penetration is below the EU average. Growth in penetration is at EU average (**Figure 7.2**).

7.4 Broadband Speed

Fibre to home technology will be essential for the speedy transfer of large volumes of information across wide bandwidth. There will be a demand for significantly increased bandwidth and download speed by businesses and individuals.

This will include large file sharing, visual networking and high definition video streaming. For example, in the health sector high bandwidth and very high transmission speeds will enable video images of medical procedures to be transmitted to central interpretive centres in real time, reducing the need for patients to travel long distances, and the cost of service provision.

Fibre to home networks will be able to carry more information much faster. Japan and South Korea are the leading countries in broadband implementation. Japan has implemented the provision of broadband speeds of up to 1024Mbps, which is 100 times faster than speeds available in Ireland or the UK, and requires fibre optic cables in new build and refit schemes. The island must achieve a performance which is equal to the best. As a first step it is recommended that the Communications Regulators on the island should examine the feasibility of requiring that all new residential buildings in excess of a minimum size should have fibre to home connections installed with an appropriate sharing of cost between the provider and user. This requirement should be imposed initially on the Dublin–Belfast Corridor and the South West Corridor linking Cork, Limerick and Galway.

7.5 Growth in Demand

The metro network connects all of the devices and people at the edge (the access network) to the internet brains providing the services. It is the metro network that pumps out packets going to and from the internet protocol (IP) service hosting centres to the devices and people requesting those services. IP traffic growth is doubling every two years, driven by internet services such as mobile data and internet, cloud computing and the programmable web, social networking and internet video services.

Fixed and mobile broadband access will increase over the coming years (50-100Mbps per subscriber is expected over the next five years). These broadband speeds will increase the risk of metro optical networks experiencing "packet brownouts" or, potentially, total network collapse. A new smart network using innovative optical technology and with a much lower carbon footprint will be required for metro networks.

"Ireland ranks well below the EU average in the availability of high speed broadband services."

7.6 International Connections

A direct connection to Europe should be established, in addition to routes through Great Britain, using advanced communications technology. This will enable Ireland to be a virtual extension of the main internet exchanges in mainland Europe and extend choice. Direct access to an international backbone will be needed in the South of Ireland similar to the Kelvin Project in Northern Ireland (this involves connecting a new submarine cable from Co. Derry to an existing transatlantic cable 22 miles offshore) with Government-supported interconnection to existing submarine cables.

7.7 Data Centres

Encouraging the location of data centres should be a key part of future ICT strategy. Data centres will attract further companies to the island and will drive the content industry and ancillary business. Data centres are major users of energy, especially for cooling. Success in this area will be dependent on the availability of competitively priced electricity produced with low GHG emissions.

Microsoft, the world's largest software producer, has opened its first "Mega Data Centre" in the Dublin area to offer cloud computer services which run customers' software in the data centre rather than on their own computers. This is a significant addition to the Dublin–Belfast Corridor.

The island has a climatic advantage for the location of large data centres due to the moderate temperatures prevailing which favours the use of natural cooling and reduces what would otherwise be very high energy costs.

Chapter 8
ENTERPRISE

Key Recommendations

1. Encourage the development of specialised industrial clusters and innovation hubs in each city.
2. Maximise the enterprise opportunities arising from the island's climate advantage.
3. Support research and development (R&D) and innovation in higher education institutions. Support industrial investment in R&D.

8.1 Industry Location

8.1.1 Overview

The development of the island economy is dependent on increasing the productive capacity of manufacturing industry and internationally traded services. The main growth sectors are likely to be pharmaceutical and medical devices, information and communications technology (ICT), energy, green enterprise, connected health, food and forestry and business and financial services.

The dominant factors influencing the location of industry are those impacting on international competitiveness. These include the taxation regime, the quality of education, ability to innovate, political stability, operating costs and productivity. The main elements of infrastructure such as transport, energy, broadband and specialised sectoral skills and R&D also play a very important role. As competition for international investment becomes more intense, it is essential that infrastructure planning supports enterprise needs.

Table 8.1 Structure of Manufacturing Employment on the Island

	1994	2004
Chemicals, pharmaceuticals	7%	9%
Computers, electrical	15%	20%
Food, drink and tobacco	21%	21%

Table 8.2 Distribution of FDI Jobs

Ireland	Dublin	34%
	Cork	19%
	Galway	9%
	Limerick	8%
	Waterford	8%
	Sligo	3%
N. Ireland	Belfast	74%
	Derry/Londonderry	24%

8.1.2 Industrial Clusters

There must be a continuing focus on the establishment of industrial clusters and innovation centres in City Regions. This will enable specialisation in research and development, education, knowledge and skills and provide economies of scale in the provision of support services. Centres for advanced research in universities and other higher education institutions should work in close partnership with industry.

Total manufacturing employment on the island was stable between 1994 and 2004. However, there was a significant change in the structure of employment (**Table 8.1**).

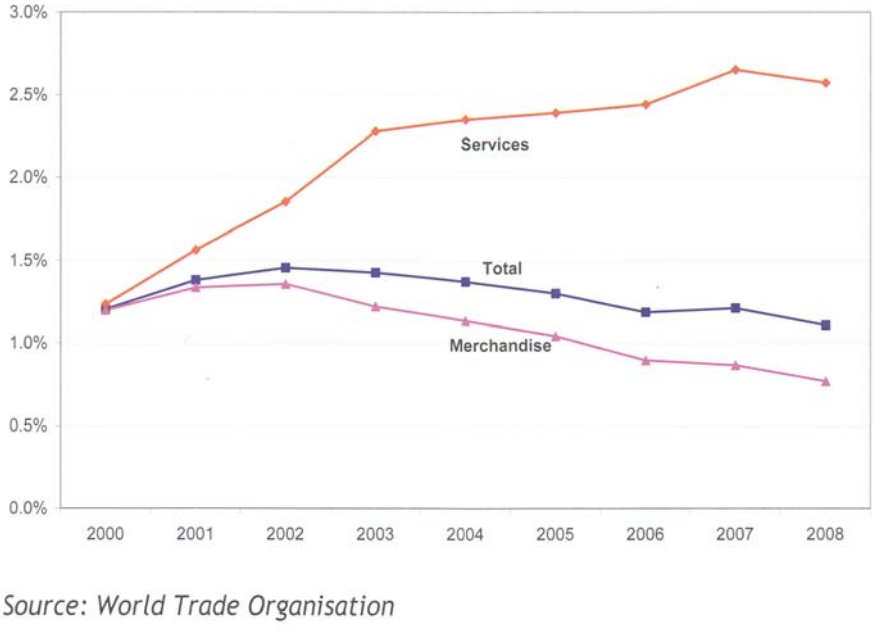
Business services has been the dominant foreign direct investment (FDI) sector in recent years accounting for almost half the total number of new jobs on the island (ROI 54%; NI 44%), followed by pharmaceutical and medical devices (primarily in the Republic) and electronics and engineering (ROI 12%; NI 9%). The emerging renewables and environmental services sector accounted for 3% of inward investment.

8.1.3 Industrial Location

The geographical distribution of new FDI jobs on the island over the last nine years is shown in **Table 8.2**.

Figure 8.1 emphasises the increasing role played by services in Irish exports where they now account for 45% of the total

Figure 8.1 Ireland's Share of World Trade: Overall, Merchandise and Services (2000-2009)



Source: Forfás National Competitiveness Council Annual Report 2009

and 2.5% of world service exports. These services exports include software and technical services and reflect the growing role of business services in FDI. Services are most likely to locate in the larger cities and now account for over 50% of new FDI projects in Dublin, Belfast and Cork. According to the Global Financial Centres Index Dublin is ranked as the sixth most competitive financial centre in Europe.

In the knowledge economy of 2030, business services projects servicing global markets will be established in the catchment of higher population cities which can provide access to a high quality labour force, fourth-level education and research institutes, competitive energy and top quality international transport connectivity. FDI manufacturing projects will be attracted to establish in industrial parks where planning and construction times can be minimised and common infrastructural services can be made available.

8.1.4 Specialisation

Sectoral specialisation by City Region is also evident (**Table 8.3**). Since 2000, 69% of new FDI employment in Dublin is in business services; 32% of new pharmaceutical manufacturing jobs are in the Cork region; 28% of new medical devices jobs are each in Galway and Limerick.

Table 8.3 Sectoral Concentration of New FDI Projects

Business Sector	City
Business services *(including software and financial)*:	Dublin 69%; Cork 58%; Belfast 54%
Pharmaceuticals/medical devices:	Cork 32%; Galway 28%; Limerick 28%
Electronics/engineering:	Belfast 31%; Galway 17%; Dublin 11%

An intensive development of the Dublin–Belfast Corridor is likely to deliver a concentration of high income business services FDI jobs along the corridor by 2030.

A recent Irish Government report states that the economy of the future "*will have at its core, an exemplary research, innovation, and commercialisation ecosystem. The objective will be to make Ireland an innovation and commercialisation hub in Europe – a country that combines the features of an*

attractive home for innovative R&D-intensive multinationals while also being a highly attractive incubation environment for the best entrepreneurs in Europe and beyond." [16]

8.1.5 Food and Forestry Sector

The food and forestry sector has a strong indigenous base and will become even more important in the future because of the island's "climate advantage". At an overall level the use of innovation in food production should be used to increase and further develop production of high value food products. Climate change is predicted to lead to world food shortages by 2030 at a time when the needs of the world population will require 50% more food production. Water scarcity will force more countries to import cereals, meat and food products.

North Western Europe, including the island of Ireland and other high latitude regions, will become main centres for global food production. World food reserves are currently at a 50-year low. Approximately 1,300 litres of water are required to produce 1kg of wheat. 1kg of wheat is easier to ship than 1,300 litres of water. By importing cereal, meat and other food products (so called imports of "virtual water"), countries can reduce their agricultural water use. In addition, some countries where water is scarce have already taken steps to buy large tracts of agricultural land in water-rich states to ensure food supplies and conserve water in their home countries.

There are positive implications for strong medium-term development of Irish food production, especially cattle, milk and grain crops. This food will be produced with further reductions in GHG emissions and using advanced technology. The primary centres for agricultural production are in the regions surrounding Cork, Limerick, Dublin and Waterford.

Similarly, the climatic advantages of the island for the development of forestry will result in bringing the development of this sector more into line with European norms. The island has one of the best climates for the growth of trees in Europe. Forestry is also a valuable carbon sink. However, at present the percentage of land afforested in Ireland is only 10% and in Northern Ireland is only 6%, compared to 33% in the EU. The level of afforestation in the EU increased by 35% over the decade to 2005, while the increase in Ireland was 27%. The target adopted by the Irish Government is to double the proportion of land under forestry by 2030. The primary locations for forestry on the island are the Limerick, Sligo, Waterford and Derry/Londonderry City Regions.

Finally, the island must also give priority to its marine resources. This will include supporting offshore aquaculture R&D which will enable the island to be a main producer of seafood in the future.

"In the knowledge economy of 2030, business services projects will be established in the catchment of higher population cities."

8.2 Education and R&D

8.2.1 Tertiary Education

The future of education on the island is critically dependent on assumptions made in relation to demographic structure. It is likely that the population growth will come primarily from natural growth together with inward migration. Given the current high level of participation in third-level education and the fact that many migrants will be educated to degree (or equivalent) level, this places the focus on the central importance of postgraduate and continuing education. There is also an ongoing need to continue training technicians to sustain continuing economic development.

The 2004 OECD Examiner's Report on Ireland stated that "*the growth in tertiary education in Ireland has been extraordinary with the age participation rate rising from 11% in 1965 to an estimated 57% in 2003 and in numbers from about 21,000 in 1965 to over 137,000 by 2003*" (Department of Education and Science, Ireland). Ireland was one of the first European countries to grasp the economic importance of education and economists suggest that this up-skilling of the labour force accounts for almost 1% per annum of

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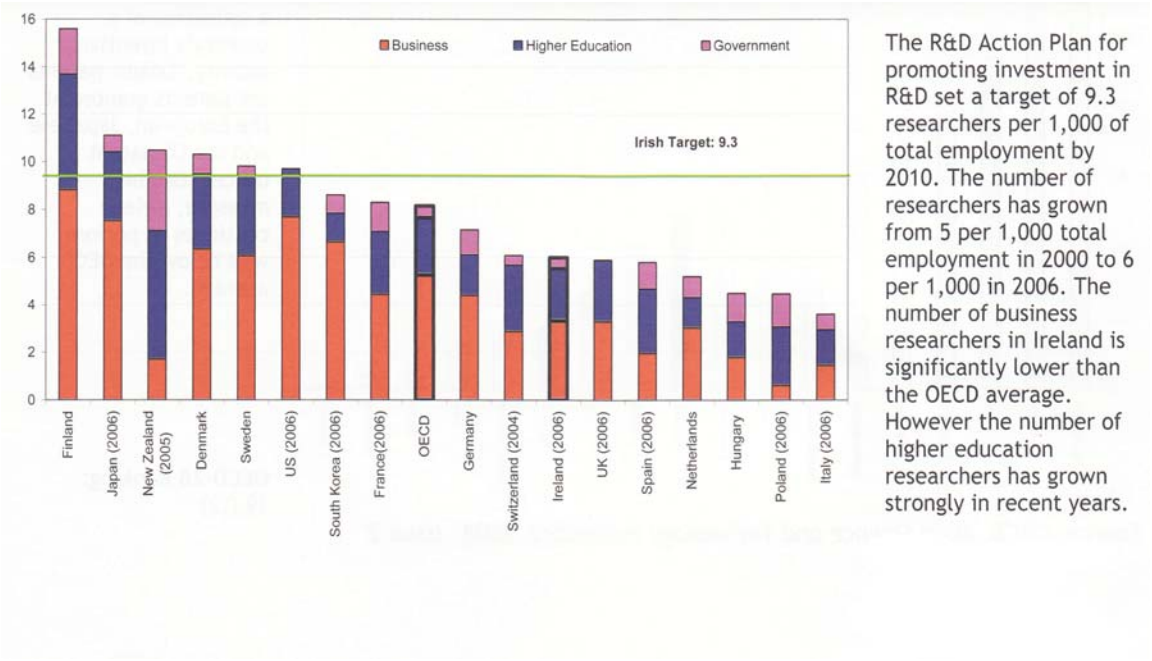
Figure 8.2 Researchers per 1,000 Total Employment, 2007



The R&D Action Plan for promoting investment in R&D set a target of 9.3 researchers per 1,000 of total employment by 2010. The number of researchers has grown from 5 per 1,000 total employment in 2000 to 6 per 1,000 in 2006. The number of business researchers in Ireland is significantly lower than the OECD average. However the number of higher education researchers has grown strongly in recent years.

Source: Forfás National Competitiveness Council Annual Report 2009

additional national output over the last decade or so. An increase in the age participation rate to over 66% is projected by 2015 but this will require a significant improvement in the retention rates of pupils from economically disadvantaged backgrounds. The participation rate may exceed 70% by 2030. Third-level participation rates for Northern Ireland in 2006/2007 were estimated at 54%.

8.2.2 Research

R&D activities will play an increasingly important role in developing the island economy of the future. These activities generate high incomes and employ highly qualified staff led by senior executives having PhD and post-doctoral qualifications. Already they account for almost one quarter of new FDI in Ireland. In 2008 investment in new FDI projects in RDI (research, development and innovation) in the Republic showed an increase of 22% over the previous year and accounted for more than one-fifth of all FDI in the same year. R&D projects are more likely to locate in the largest cities, which have strong educational, research and connectivity infrastructure.

However, Ireland is in the lower half of nations in terms of researchers per thousand employed (**Figure 8.2**). Despite great progress made under the two National Development Plans, it lags behind nations considered to be excellent examples of creativity-led economies such as Finland and Sweden.

The Irish Academy of Engineering 2005 report "*Engineering a Knowledge Island 2020*" recommended an increase in the output of engineering and IT PhDs of 13% per annum through to 2020 to meet the needs of an expanding island economy.

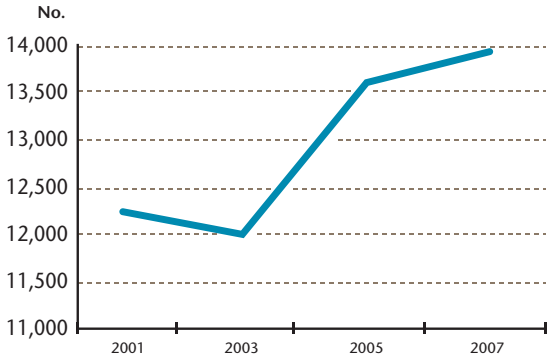
This is expected to lead to a steady improvement in the number of researchers. The evidence of the period from 2001-2007 shows that there was a 10% per annum increase in the number of science and engineering PhDs employed in industry (**Table 8.4**).

PhDs comprised 9% of the research personnel engaged in industry in 2007, implying that employment of one PhD supports the employment of 11 other researchers,

Table 8.4 PhDs Employed in Industry

Year	2001	2003	2005	2007
PhD researchers	420	466	830	1191
Total research personnel	12,320	12,037	13,621	13,861

Figure 8.3 Headcount of Research Personnel, 2001-2007



Source: Forfás BERD Report 2007/2008

technicians and support staff. **Figure 8.3** shows the increase in the overall headcount of research personnel in industry in Ireland over the period. It will be necessary to sustain a continued high rate of increase in the number of researchers to meet the needs of an island of eight million people

Great advances have been made in the research intensity, clustered around the major universities north and south. There is a good match between the geographic distribution of these research strengths and the eight cities. Progress has been made in supporting the emergence of specialisation in specific areas. However, it is clear that a process of consolidation will take place, focusing resources on those research domains in which Ireland can be competitive with best exemplar locations internationally.

The number of science, engineering and technology PhD scholars in universities is indicative of the degree of research taking place in these universities. Universities accounted for some 95% of over 900 PhD scholarships awarded by IRCSET over the period from 2006-2009. In the same period IRCSET (ROI) awarded 245 Post Doctoral Fellowships. The total number of science, engineering and technology PhDs graduating in 2006/07 in Ireland was 976, and in Northern Ireland was 210 (excluding medical).

The dynamics of the population changes, along with the successful implementation of the "Smart Economy" strategy, will demand increased emphasis on continuing and further education as the skills required for employment change. Information technologies will undoubtedly play a much larger role in supporting the delivery of education services to a wider population. Important leverage of the formative effect of the research nodes can be expected from effective deployment of these tools.

8.2.3 R&D Clusters

Table 8.5 shows the business expenditure on research and development as a percentage of gross value added in the Republic and Northern Ireland:

The Inter*Trade*Ireland Report "*Mapping Study of Research and Technological Development Centres on the Island*" shows the distribution of mainly publicly-funded centres usually associated with third-level institutions on the island by location (**Figure 8.4**).

The top six City Regions on the island accounted for 88% of the all R&D centres led by Dublin (31%) and Belfast (27%). Research activity in these publicly-funded organisations is concentrated in four disciplines: ICT; life and health technologies; agri food; and, environmental, which accounted for 78% of total research.

The distribution of business expenditure on R&D in Ireland in 2005 was focused on five sectors which make up 85% of the total expenditure (**Figure 8.5**).

Similarly, as shown in **Table 8.6**, in Northern Ireland 87%

Table 8.5 Business Expenditure on R&D

Year	Ireland	Northern Ireland
2001	0.85	0.74
2003	0.86	0.52
2005	0.93	0.54

Table 8.6 Northern Ireland R&D Expenditure, 2003

Electrical and optical	40%
Chemicals and fibres	18%
Food, drink and tobacco	15%
Machinery and equipment	9%
Transport	5%

of research expenditure in 2003 was spent in five sectors. The great majority of FDI R&D projects choose to locate in the high population regions. In Ireland 86% of projects are located in the four nodes with highest population (**Table 8.7**).

These figures correspond quite closely to the distribution of PhD scholars in higher education institutions.

RDI activity, which is a key driver of economic growth, has increased significantly in recent years and must continue to be supported. The number of PhDs graduating annually per thousand of population is now in line with the EU average. Business expenditure on R&D continues to increase.

In addition, the key enterprise clusters should continue to be supported by associated investment in high skills (particularly research Masters and PhD) and research and technological development (RTD) capacity. The complementary nature of the major research capabilities should be supported by all-island grant and incentive mechanisms, particularly those facilitating the trend towards increased enterprise–academia collaboration.

Table 8.7 Location of FDI R&D Projects

Dublin	50%
Cork	16%
Limerick	10%
Galway	10%

Figure 8.4 Distribution of Research and Technological Development Centres

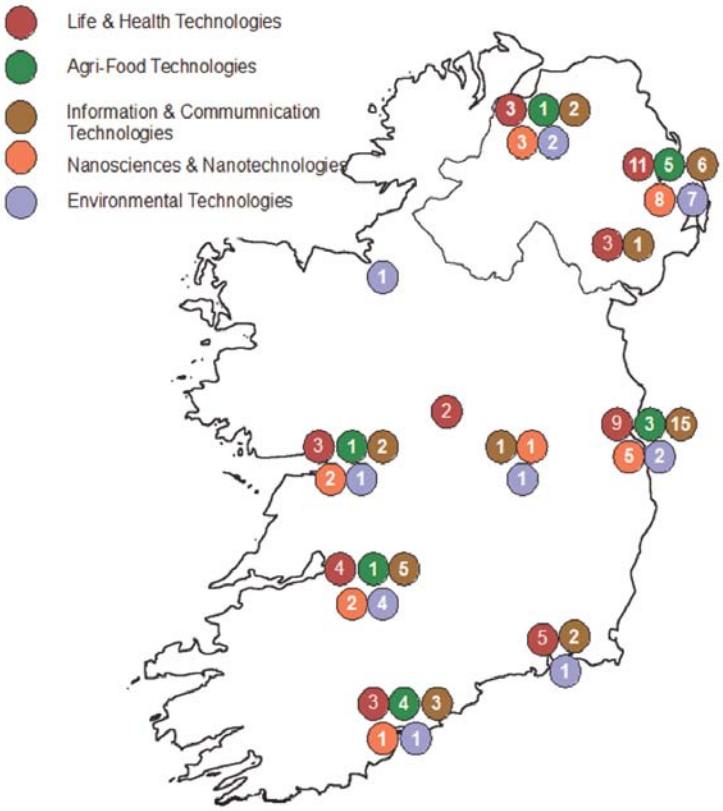
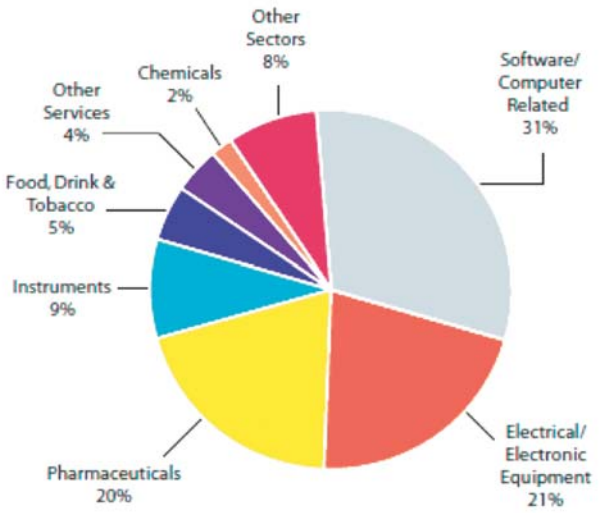


Figure 8.5 Forfás: R&D Performance in the Business Sector

R&D Sectoral shares (% total 2005)



Chapter 9
ENGINEERING FOR HEALTH

Key Recommendation

Build an advanced IT infrastructure within the healthcare system linked to the broadband network, which will enable the use of sophisticated personal-use diagnostic devices and allow for early detection of life-threatening events.

9.1 Introduction

Consideration of the critical elements of infrastructure required on the island of Ireland, to cater for an increased population of eight million and to support a world class competitive economy, must include recommendations in relation to an appropriate health infrastructure to support this scenario.

9.2 Preventive Health & Safety Measures

Some of the greatest improvements in public health have come from social and public engineering initiatives such as the provision of clean water in the 19th century and the switch to smokeless fuels in the 20th century.

Good engineering design and practice will deliver improved road safety, improved workplace safety, especially in construction and farming, and improved air quality in towns and cities by removing particulates and emissions from vehicle exhausts.

9.3 Life Expectancy

Life expectancy at birth will continue to increase, probably reaching an average of 82 years by 2030. As families become smaller and more dispersed there will be fewer people to care for elderly relatives. New monitoring and sensing devices for use at home and advanced IT will be important in this regard. The proportion of the population over 65 will increase from 11% in 2007 to approximately 22% in 2030. This major demographic change will create an increased demand for healthcare in all service areas including day care, in-patient hospital care, general practitioner care and out-patient services. There will also be an increased demand for long-term care in residential facilities with approximately 30,000 additional places required.

9.4 Specialisation

The treatment of major diseases, such as cancer and cardiovascular disease, will be concentrated in a limited number of specialised centres with alliances formed between different hospitals. The location of some of these specialised centres will be associated with medical research and development (R&D) clusters. Access by patients to the centres will be facilitated by high quality road and rail transport links between cities.

9.5 Opportunities

Today the island is a world manufacturer of pharmaceuticals and medical devices. However, once products become commoditised it becomes easier to manufacture them in low cost locations. To continue to grow the economy it will be necessary to switch from being investment driven to being innovation driven. R&D will be crucial as we deliver new and better products and services to the market. The pharmaceutical, chemical, medical devices and diagnostic sectors will provide good opportunities for growth while also contributing to improvements in national health and well being.

9.6 Education and Training

As outlined in Section 8, education will be a key factor underpinning future success in the medical technology sector with a need for a substantial increase in the numbers studying science and engineering subjects at third level and in the numbers of graduates proceeding to fourth level (Masters and PhD).

9.7 ICT Infrastructure

An advanced IT infrastructure linked to the broadband network has the capacity to bring significant benefits to the population and to the delivery of healthcare on the island.

When harnessed, advanced IT and communications technologies have the potential to improve efficiencies, reduce errors, free up staff to concentrate on patient care and reduce costs of provision. The availability of sophisticated personal-use diagnostic devices will allow for early detection of life-threatening events. They will also allow chronic diseases to be controlled more effectively. This will require an integrated patient record system, an integrated IT system linking GPs, diagnostic laboratories, hospitals and clinicians and community care centres using an advanced national broadband network. This will allow the healthcare system to become more patient centred with more emphasis on care in the home.

The IT infrastructure will also provide more support in the home including hand-held monitors and wearable sensors which transmit information to central care centres. In addition, high bandwidth and very high speeds of transmission will enable video images of medical procedures to be transmitted to central interpretive centres in real time, reducing the need for patients to travel long distances and will reduce the cost of service provision. The most skilled medical staff will be able to concentrate on functions appropriate to their professional expertise.

It is likely that the necessary IT facilities will be provided in the main cities. Highly specialised centres of excellence will be located in the larger and more densely populated cities which deal with large numbers of patients with specific ailments.

"Some of the greatest improvements in public health have come from social and public engineering initiatives."

Chapter 10
INFRASTRUCTURE INTEGRATION

Key Recommendation

Adopt an integrated approach to all infrastructure planning to ensure improved efficiency and effectiveness, and competitiveness at minimum cost.

10.1 Road and Rail Integration

The planning of road and rail infrastructure must be co-ordinated so that each will play its appropriate role in transport between the cities and in access to and within cities. For example, there will be an optimum economic choice between adding new lanes to a motorway and upgrading the railway track. This will be particularly relevant on routes having high traffic volumes.

10.2 Gas Storage, LNG, and Oil Distillate Storage at Power Stations

The island is highly dependant on natural gas for electricity production. The three gas interconnectors to Great Britain pass through a single distribution point in Scotland. The island is vulnerable either to a sudden breakdown in the supply of gas, or the depletion of supplies from the North Sea. A liquified natural gas (LNG) terminal would diversify supply sources and also provide storage facilities. Most of the gas fired electricity power stations can be switched to operate on oil distillates. There will be an optimum economic balance between gas storage, LNG and oil distillate storage.

"The planning of road and rail infrastructure must be co-ordinated so that each will play its appropriate role in transport."

10.3 Electric Cars and Wind Energy Storage

The electricity used by electric cars can be supplied largely through night charging of batteries. This offers the possibility of using electric cars as a means of storing electricity generated from wind energy at night. This will influence the economics of using electric cars and of the production of wind energy.

10.4 Increased City Density and District Heating

Many European cities are now retrofitting district heating (DH) schemes to reduce energy consumption and greenhouse gas emissions. Increasing residential density in cities will create the opportunity to introduce DH schemes powered either by combined heat and power plants or by waste to energy (WTE) plants. Decisions to increase city density will incorporate the appropriate form of heating for optimum efficiency and cost.

10.5 Increased City Density and Energy Use in Transport

There is a strong relationship between high city density and reduced energy use in transport. Decisions to improve the quality, frequency, speed and reliability of public transport will prove economically effective when combined with regulations regarding land use.

10.6 Tidal Barriers and Transport Infrastructure

The level of sea water and river water is expected to increase significantly by 2030. This will require adaptation measures in coastal cities, most of which are also located on river estuaries.

The cost of construction of embankments and tidal barriers should take account of the possibility of using such embankments as a foundation for road and possibly rail infrastructure. An integrated approach will be more cost-effective in some cases.

10.7 R&D, Education and the Development of Strategic Industrial Sectors

An integrated approach to combining research and development, education and training and the development of the most important strategic industrial sectors will increase the possibility for synergy between all three activities at optimum cost.

"Decisions to improve public transport will prove economically effective when combined with regulations regarding land use."

Chapter 11
ECONOMIC ASSESSMENT

Key Recommendations

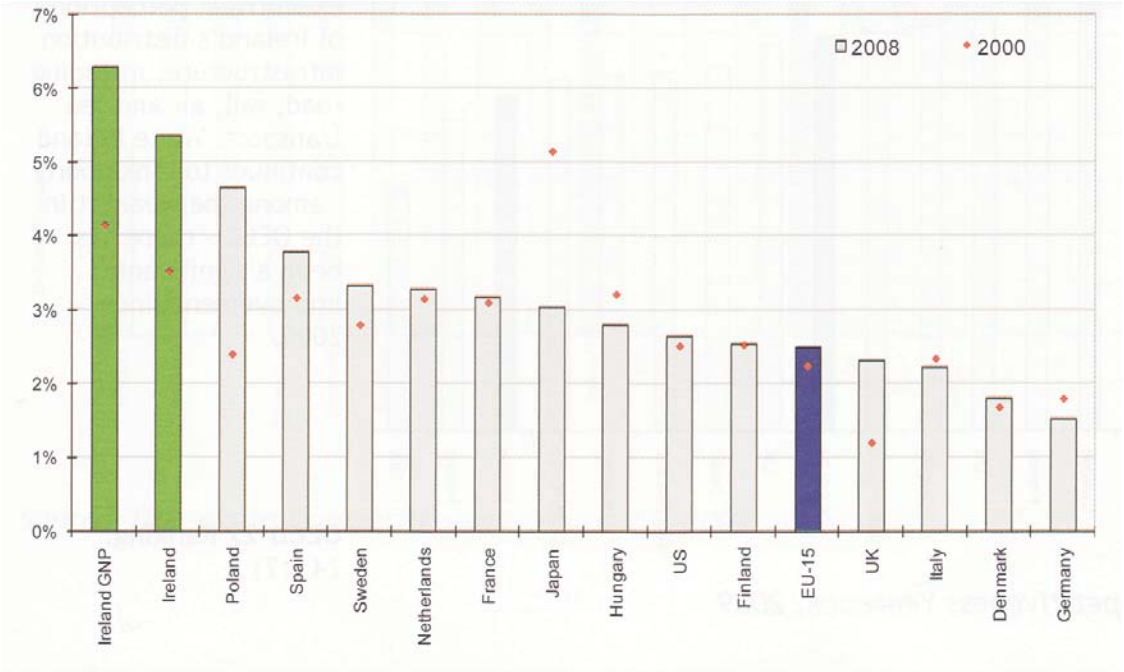
1. Finance the development of infrastructure using a combination of innovative financing sources including the Exchequer, public private partnerships, a possible island of Ireland infrastructure bank, capital markets and the European Investment Bank.
2. Develop a framework which will allow the private sector to increase its share of investment in the provision of infrastructure.

11.1 The Context

Over the past decade the annual rate of investment in gross fixed capital formation in Ireland has been about 25% of gross domestic product (GDP). This comprises all investment in productive machinery, buildings and infrastructure and includes both public and private investment.

The scale of total capital investment in Ireland increased significantly as a share of GDP in the period 1985 to 2007. From 1985 to 1995 gross domestic fixed capital formation (GDFCF) averaged around 17% of GDP. In the following eight years to 2003 it rose to 22%, and in the four years to 2007 it averaged 26%. The bulk of investment is carried out by the private sector in dwellings, commercial property and plant and equipment, which typically accounts for close to 80% of total GDFCF. The remainder, around 22%, is carried out through the exchequer funded Public Capital Programme.

Figure 11.1 General Government Gross Fixed Capital Formation as % of GDP, 2008



Source: European Commission, AMECO Database in Forfás National Competitiveness Council Annual Report 2009

The growth of productive investment raises the future potential growth rate of the economy, while at the same time directly contributing to growth and employment in the year in which the investment is undertaken. Not all investment is productive; much of the increased share of investment in GDP in recent years was attributable to house building.

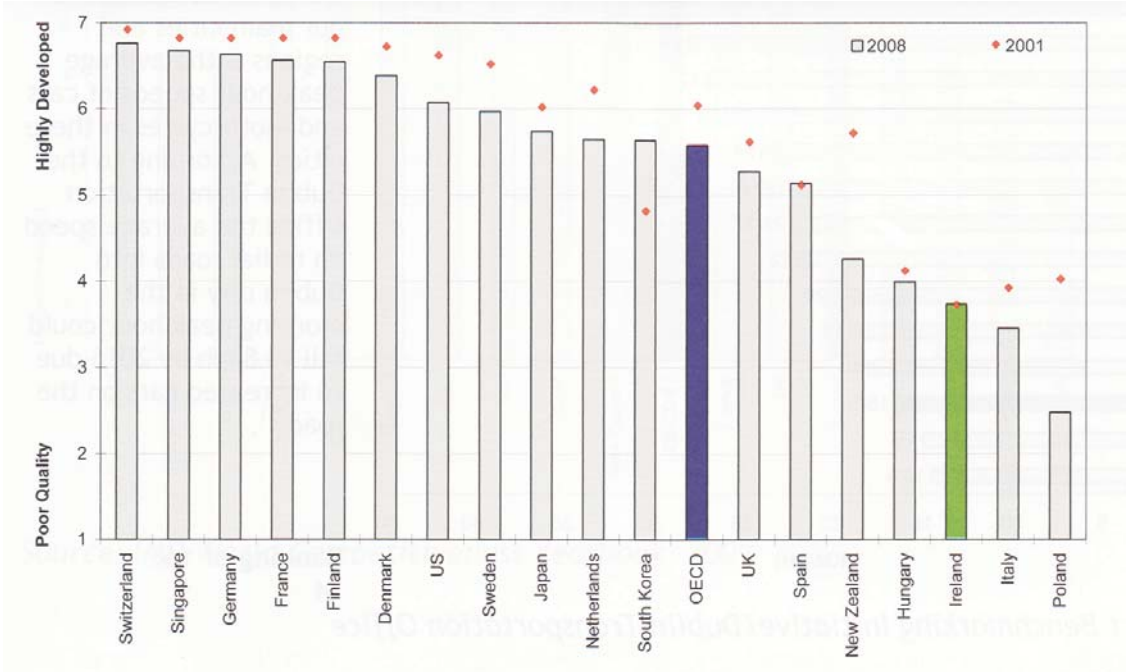
There has been historically a long-term deficit in the levels of infrastructure investment on the island of Ireland. Executives' perception of Ireland's infrastructure places Ireland significantly below the OECD average (**Figure 11.2)**.

In this study all the investment is focused on productive physical infrastructure; more precisely, it is focused on infrastructure which we believe will be essential to facilitate the growth of eight City Regions, concentrating on connectivity and the essential infrastructure for commuting and doing business. A number of competitiveness surveys point to the significant infrastructure gap on the island. Although Ireland's relative investment in infrastructure compares well with other countries, it is still perceived by the business community to be inferior to that of competing countries as it is coming from a lower base.

"To achieve infrastructural quality it is of critical importance that the island continues to invest on average over 5% of its combined GDP annually over the next 20 years."

The *Allianz European Jobs and Growth Indicator 2009,* published under the auspices of the Lisbon Council, gives cause for concern. Referring to overall competitiveness it said "*by contrast, Ireland fell the farthest – and the hardest. It leaves the ranking of top European performers, falling nine places in the European Growth and Jobs Monitor to No. 13, just ahead of Italy, the perennial laggard"*. It further made the point that "*extra public funds channelled into infrastructure and energy efficiency are investments in the future in that they increase Europe's longer-term economic growth potential and, in so doing, contribute to sustainable prosperity*".

Figure 11.2 Perception of overall infrastructure Quality (Scale 1 – 7) 2008



Source: WEF Global Competitiveness Report 2008/09 in Forfás National Competitiveness Council Annual Report 2009

Over the last decade there has been a significant shift in the public finance made available for capital investment within both jurisdictions, rising to between 4% and 5% of GDP annually in fixed capital investment in civil infrastructure in Ireland and, more recently, in Northern Ireland. In addition to this, commercial state bodies such as ESB and CIE in Ireland may fund a further 1-2% of GDP through their own resources or borrowings.

The total annual level of public investment in infrastructure in 2008 on the island of Ireland was more than 5% of GDP which was about twice the rate in the OECD, and was the highest rate in the EU 15.

To achieve infrastructural quality comparable with the best in the developed OECD countries it is of critical importance that the island continues to invest on average over 5% of its combined GDP annually over the next 20 years either directly by means of Government funding and/or through mechanisms such as public private partnerships and/or, where appropriate, by direct private investment.

It is worth noting that in a study published earlier this year the Council for Science and Technology in the UK anticipates that 65% of UK infrastructure funding will come from the private sector; 6% from PPPs and the balance of 29% from public funds over the next decade or longer. It is readily apparent that this contrasts with the experience on the island of Ireland. We believe that it would be helpful if some research was undertaken to explore the implications of this difference on the competitiveness of the island of Ireland.

11.2 Additional Projects and Potential Sources of Funding

The additional projects recommended in this report would, if financed solely from Government funds, account for approximately one-twentieth of the public capital programme over the 20-year period to 2030. Before proceeding with each project a rigorous analysis of the cost and benefits to the economy should be undertaken. Many projects could be financed in whole or in part from the menu of options as outlined in **Annex 2**.

11.3 Funding the Island's Infrastructure Investment

There is now intense competition for finance across the globe. The funding environment over the past two decades has been remarkably conducive to funding long-term capital investment with financial institutions able to lend long-term whilst being funded through short-term borrowings.

The financial crisis of the past two years has however radically altered this business model. It will be critical therefore to identify better "matched" funding between long-term assets and long-term liabilities. The pension industry in particular provides such a match and increasingly is recognising infrastructure as a suitable asset class. More needs to be done to explore new sources of funding and it is recommended that consideration be given to the development of an infrastructure bank on the island to provide long term funding for infrastructure projects.

Such an initiative would clearly require the support of both governments although it would be important to ensure that state control/ownership did not result in its commitments being classified as public expenditure. In addition, it would also need the support of institutions including the pension funds and the European Investment Bank, which is increasingly supporting infrastructure investment on the island of Ireland. Consideration could be given potentially to some tax advantages for investors and there are a number of international models to inform the model that could be developed.

Because public finances on the island are likely to be constrained for a number of years it is essential that alternative sources of finance are investigated with some urgency as at times, when exchequer finances are under pressure, capital expenditure may bear the brunt of cutbacks.

In conclusion, the magnitude of the challenge to reach and sustain the necessary rate of infrastructure investment to achieve a world-class competitive economy will require the use of new and innovative approaches to funding such public infrastructure.

ANNEX 1
Indicative Costs of Projects having an Island Emphasis

The following are indicative costs of additional investment projects over the next 20 years recommended in this report.

Project	Cost
Dublin–Belfast High-Speed Rail Track and Trains:	**€2.5bn**
Motorway Development: 200km fourth lane to motorway and 500km third lane to motorway	**€5.0bn**
Water Mains Network: Water mains linking Shannon and Lough Neagh to Dublin and Belfast including water treatment plants.	**€1.5bn**
Information Highway: High-speed large capacity information highway linking the eight City Regions, including fibre to home.	**€1.5bn**
District Heating Pipe Network in Cities:	**€250m**

ANNEX 2
Menu of Funding Options

Infrastructure can be funded and delivered in a variety of ways including:

- Commercially-driven, user-paid infrastructure, e.g., unregulated airport and ports where it is for the developer to decide what and when infrastructure is built. Any development is then paid for by consumers. Prices are not regulated because competition exists.
- Commercially driven, user paid but price-regulated infrastructure such as airports, electricity generation and transmission, and gas transmission. Price-regulated businesses where independent regulators play a role in determining the level and nature of investment.
- Price-regulated business that is funded by the taxpayer and users, e.g., toll roads, and rail, where the regulator sets efficiency targets and prices for the business. In recent years €2bn has been invested by the private sector in road construction public private partnership (PPP) programmes in Ireland without which these roads would not have been built. This investment is remunerated from toll charges. User charges also have the advantage of rationing the use of scarce resources
- Publicly-funded infrastructure such as non-tolled roads. In this case, public authorities decide where they should go, when they should be built and pay for them.

In many sectors the main action required to stimulate appropriate capital expenditure will be regulatory or public legislative measures. For example, urbanisation and the density of residential accommodation in cities will be determined by the need to comply with planning and land use requirements. Developers will then ensure that the buildings they construct will be in compliance with the legislative requirements.

Examples of additional funding sources:

Public Private Partnerships (PPPs): Elements of infrastructure may be designed, built, financed and operated by the private sector but ultimate ownership of the facility is retained by the public authorities. Remuneration may be received through user and other annual charges over a long period of time. This method of funding is common in many European Union Member States.

Infrastructure Bank: An infrastructure bank would borrow long and lend long and may be funded from private or public resources or a combination of both. This type of bank exists in Australia (Infrastructure Australia) and Germany (KfW). The Nordic Investment Bank is owned by the Governments of Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway and Sweden. This type of bank places a particular emphasis on infrastructure and uses its position to lever further funds from private investors.

European Investment Bank (EIB): The EIB is owned by the EU Member States. Its mission is to contribute to the EU's policy objectives by financing sound investment. Though a not-for-profit organisation, it is self-financing, raising its funds by borrowing on capital markets. The EIB provides long-term finance for up to 50% of the cost of infrastructure projects and has a long history of financing PPPs. All projects benefit from at least one form of EIB financial value added such as a low cost of funding, longer maturity or grace period and diversification of funding. The EIB has financed many public sector infrastructure projects and PPPs in areas such as roads, energy, water and sewerage and education on the whole island.

Mutual Funding Model Finance: This is suitable for a major project which is capital intensive and which has a protected income such as through the process of regulation. Funding is totally by debt and can be provided by capital markets. Interest and capital payments are made each year. Projects have a long life, usually 25 to 50 years. Northern Ireland Energy Holdings is an example that currently has £350m capital and has been operating successfully for four years.

ANNEX 3
Proposed Transport Solutions

Figure A3.1 Greater Dublin Area Rail Network

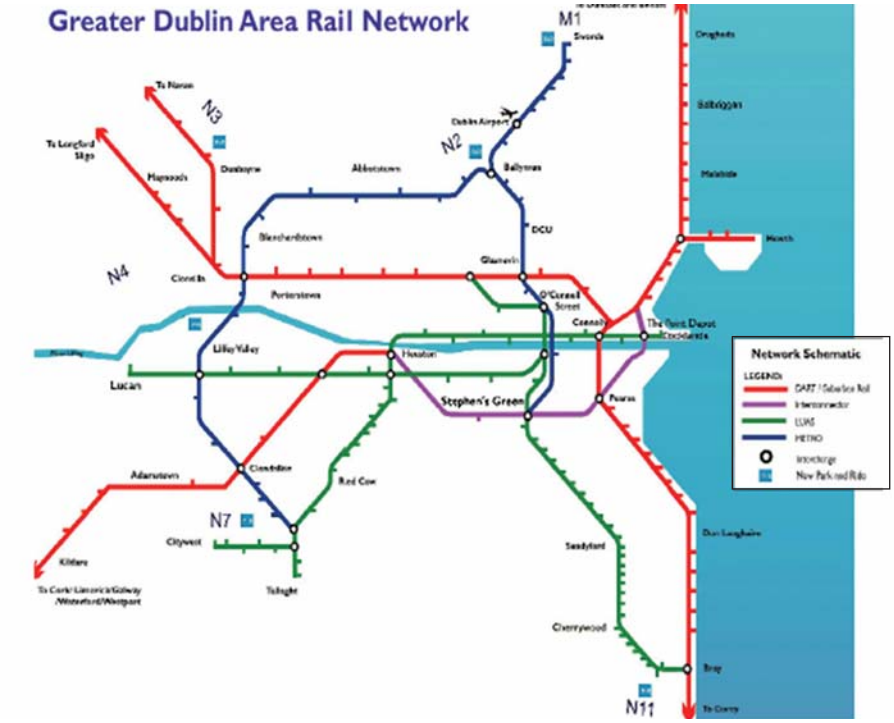


Figure A3.2 Possible Rapid Transit Network for Belfast

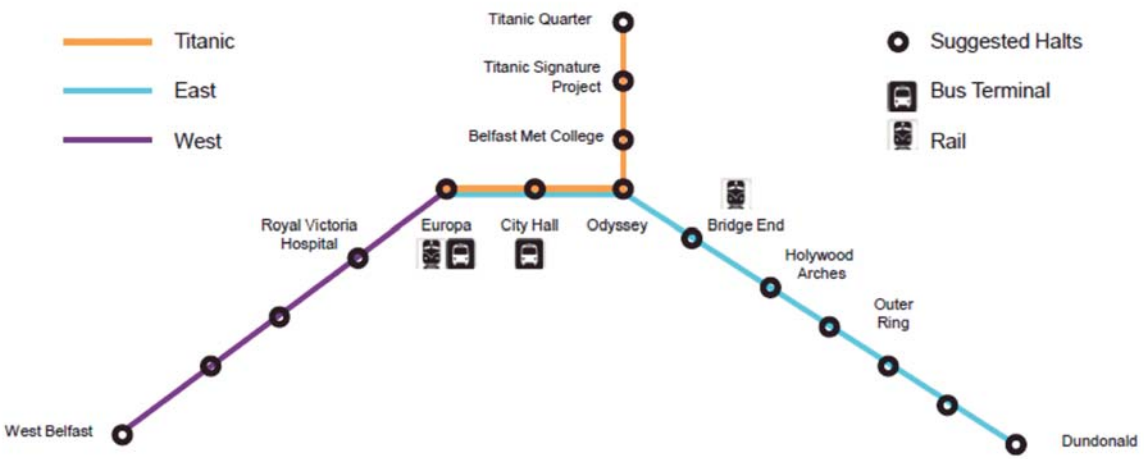
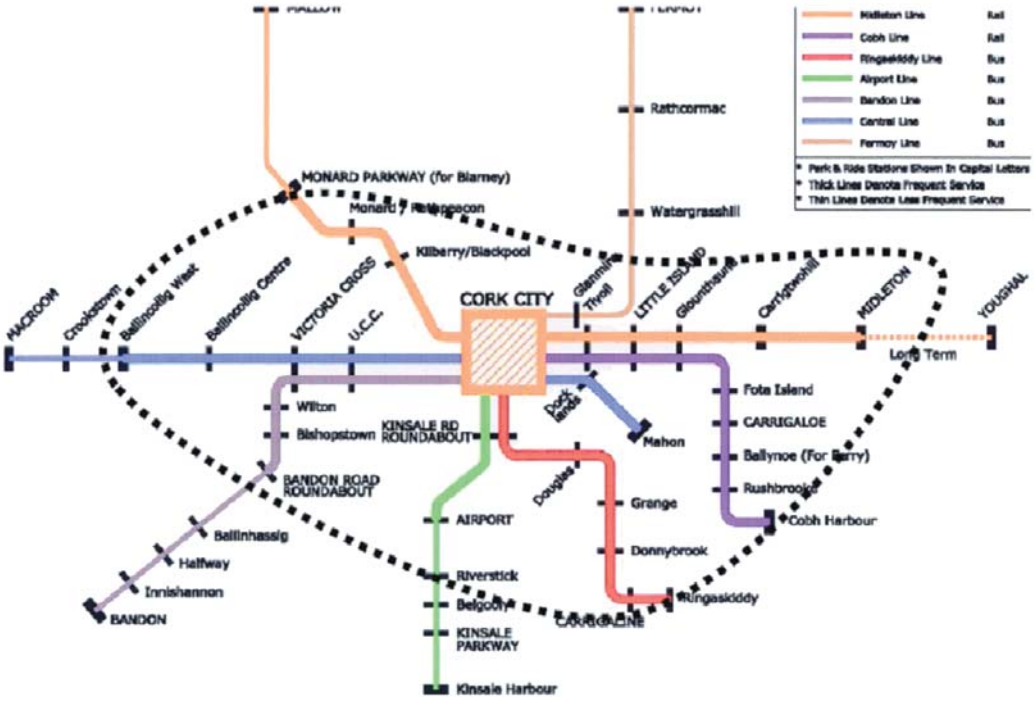
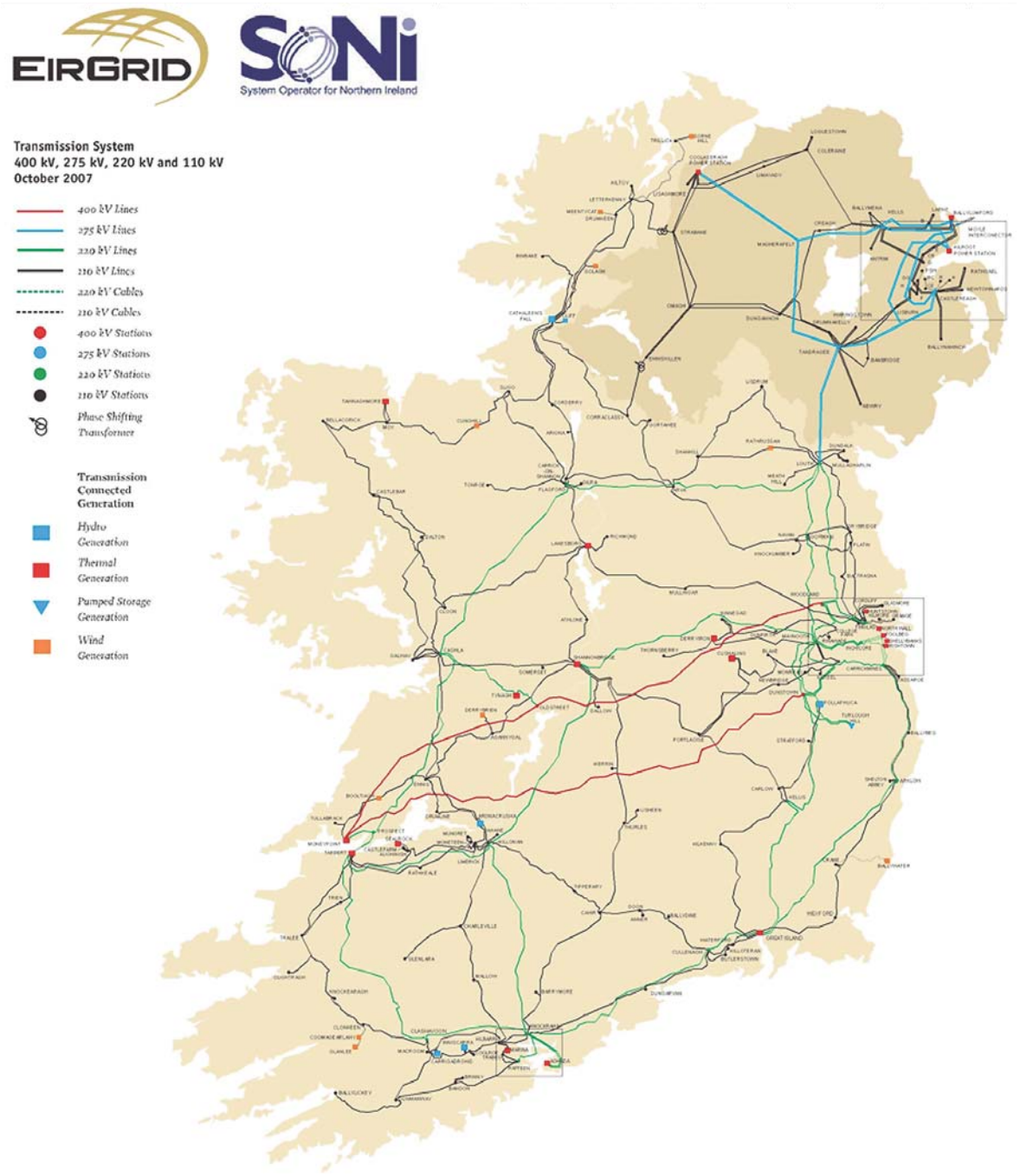


Figure A3.3 Integrated Transport Solution for Cork Region



ANNEX 4
Electricity Transmission System



ANNEX 5
List of Acronyms

BRIC	Brazil, Russia, India, China
CCGT	Combined cycle gas turbine
CCS	Carbon capture storage
CHP	Combined heat and power
DH	District heating
EU	European Union
EU ETS	European Union, Emission Trading System
FDI	Foreign direct investment
GDFCF	Gross domestic fixed capital formation
GDP	Gross domestic product
GHG	Greenhouse gases
GVA	Gross value added
IAE	Irish Academy of Engineering
ICT	Information and communications technologies
IGCC	Integrated gasification combined cycle
IRCSET	Irish Research Council for Science, Engineering & Technology
LNG	Liquified natural gas
Lo-Lo	Lift on lift off
NI	Northern Ireland
NSS	National Spatial Strategy
PPP	Public private partnership
PWS	Public Water Supplies
RDI	Research, Development and Innovation
RDS	Regional Development Strategy
ROI	Republic of Ireland
RoRo	Roll on roll off
RTD	Research and Technological Development
SuDS	Sustainable drainage systems
WTE	Waste to Energy

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