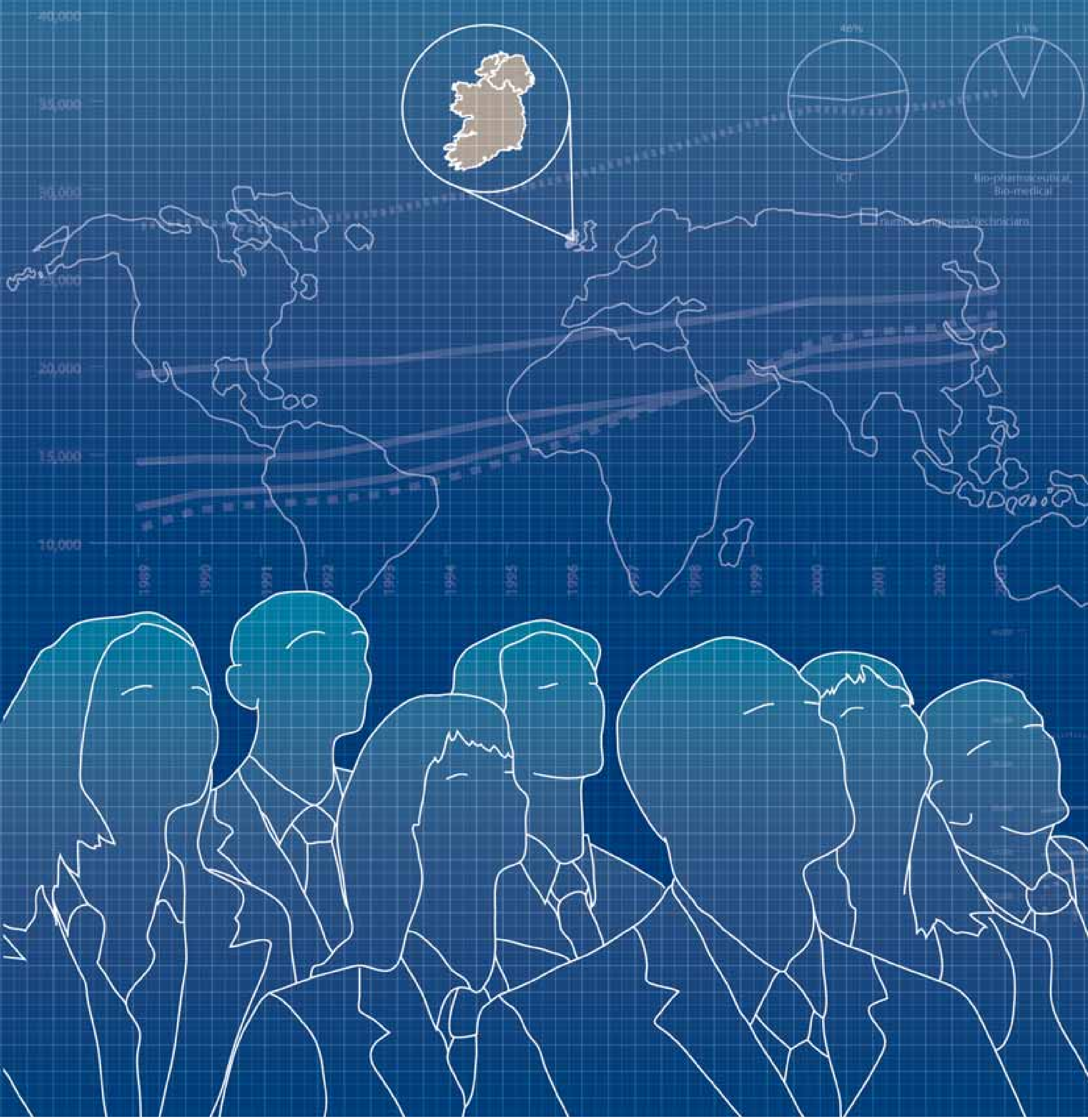
Engineering a Knowledge Island 2020



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Engineering a Knowledge Island 2020

Irish Academy of Engineering
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October 2005

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The Irish Academy of Engineering was established in 1997, and comprises over 100 engineers of significant achievement and wide experience. The Academy focuses on long term issues where the engineering profession can make an unique contribution to economic, social and technological development.

www.iae.ie
The Irish Academy of Engineering, 46 Merrion Sq, Dublin 2.
Tel: 00353 1 642 5588   Fax: 00353 1 642 5590

Engineers Ireland was founded in 1835, has over 21,000 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 Institution of Engineers of Ireland.

www.engineersireland.ie
Engineers Ireland, 22 Clyde Road, Ballsbridge, Dublin 4.
Tel: 00353 1 668 4341   Fax: 00353 1 668 5508

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www.intertradeireland.com
InterTradeIreland, Old Gasworks Business Park, Kilmorey Street, Newry BT34 2DE
From Republic Tel: 00353 (0) 48 3083 4100   Fax: 00353(0) 48 3083 4155
From NI/UK Tel: 0044 (0) 2830834100   Fax: 0044 (0) 28 30834155

Acknowledgement

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Members of Knowledge Island 2020 Task Force

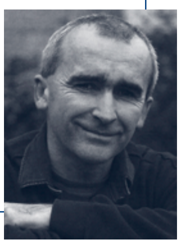
Liam Connellan FIEI, FIAE, Chartered Engineer is Past President of the Irish Academy of Engineeering and of the Institution of Engineers of Ireland; Chairman of three companies in Veolia Environment group in Ireland. Member of Irish Research Council for Science, Engineering and Techology; former Chairman of the National Roads Authority and Director General of the Confederation of Irish Industry.

Mohamed Al-Rubeai is Professor of Biochemical Engineering and Director of Cell Culture Engineering Research Centre at UCD. He is an adjunct Professor at the University of Birmingham, editor of "Cell Engineering" and author of over 250 professional papers that reflect his broad interest in Biotechnology.

Professor Eric Beatty OBE FIEI, FIAE has been involved in technology transfer, innovation and industrial development for over 40 years. He has been responsible for establishing and directing many of the links between Queen's University and industry as Director of the Northern Ireland Technology Centre and latterly as Director of the University's Regional Office.

David Croughan, BA, BBS, MA, is Chief Economist with the Irish Business and Employers Confederation. He is responsible for its Economics and Taxation Policy Committee and Editor of IBEC's Monthly and Quarterly Economic Trends newsletters. He is a member of the Economics and Financial Affairs Committee of UNICE.

Professor Pádraig Cunningham is an Associate Professor in the Department of Computer Science in Trinity College Dublin. Before joining TCD in 1992 he worked for Digital Equipment Corp. and Hitachi Europe Ltd.



Dr Peter Fitzgerald studied Biochemistry at the University of Strathclyde and did his PhD at the National Institute for Medical research in London. He was awarded two medical scholarships to study multiple sclerosis at Queen's Univeristy Belfast 1976-1982. He founded Randox in 1982 and has been MD since. The company employs 600 staff.

Una Halligan is the Government & Public Affairs Director for Hewlett Packard, Ireland . Una was appointed to the board of the EGFSN (Expert Group on Future Skills Needs), by the Minister for Enterprise,Trade and Employment. She is on the Discover Science and Engineering Taskforce and was appointed to the National Centre for Technology Development by the Minister for Education and Science.

Professor Bernie Hannigan is Pro-Vice-Chancellor for Research at the University of Ulster. She previously held the positions of Dean of Life and Health Sciences (1999-2004) and Head of School of Biomedical Sciences (1997-1999). Bernie was educated at Trinity College Dublin (Natural Sciences) and the Royal College of Surgeons in Ireland (Immunology).

Kevin Kernan, Chartered Engineer is the Director General of Engineers Ireland. Before joining as Industry Director in 2001, Kevin spent 14 years working with Siemens in both Germany and Ireland.

Professor John McCanny CBE FRS FREng is Director of the Institute of Electronics, Communications and Information Technology (ECIT) and Head of the School of Electronics, Electrical Engineering and Computer Science at Queen's University Belfast. He is an IEEE Fellow, a Fellow of the Royal Society, the Royal Academy of Engineering, the IEE, and the Institute of Physics.

Dr Daniel McCaughan FREng FIEI FIAE runs a technology consultancy, and is CTO of a VC-backed technology company based in New York. He was formerly Chief Scientist of Nortel Technology.

Dr Eileen McGloin is the Policy and Research Manager with InterTradeIreland. She is responsible for the development, planning, and delivery of InterTradeIrelands Research Agenda, a programme of economic and business research which supports the development of the island economy.

Robert Nolan, B Eng, MBA, MIEI. Director of Research & Development at Boston Scientific Corporation Ireland. Boston Scientific is the biggest single industrial employer in the west of Ireland and one of the largest healthcare companies in Ireland.

Declan Ryan FIEI has over 28 years experience in the Pharmaceutical industry Declan joined Wyeth in October 2000 as Site Project Director, overseeing the construction of the facility. He holds a BE in Chemical Engineering from University College Dublin and a Business Degree from Heriot Watt University.

Josh Walden, Vice President Technology & Manufacturing Group, Intel, is the Fab 24/Fab 24-2 Plant Manager. He is responsible for Intel's 90nm 300mm wafer manufacturing process and the construction/start-up and ramp of the 65nm technology scheduled to begin high volume production in Ireland 1H 2006.

Finbar McDonnell is a Senior Consultant with Hibernian Consulting. With qualifications in economics and business, Finbar has worked as a consultant for 13 years and acted as Facilitator to the Task Force.

Task Force Recommendations

- Adopt target for island of Ireland to be in Top 5 global economies, in terms of income per head, by 2020.
- Robust increase in supply of qualified engineers (7 per cent), IT staff (6 per cent) and PhDs (13 per cent) per annum.
- Develop world class centres of research linked to Engineering and IT schools that share resources.
- Promote engineering and science as career options much more intensively.
- Make greater efforts to attract women into engineering, targetting 50/50 gender distribution.
- Provide more substantial resources to increase graduate, and research output from higher educational institutions.
- Expand programmes supporting linkages between industry and third level institutions.
- Implement more programmes for continuing professional development and for obtaining higher level qualifications while remaining at work.
- Publish annual information on the number of computer engineering/science graduates.
- Support more complementarity between engineering and science studies.
- Attract and integrate engineering and IT professionals from abroad.
- Gather information on the engineering and IT qualifications of immigrants when they register with the social welfare systems on the island.

Foreword

The focus of this report is to propose a vision for a knowledge-based economy which would place the island of Ireland in the forefront of the most advanced economies by 2020. Achievement of this goal will require close collaboration in fulfilling the economic and skills development potential of the people of the island. The foundation blocks already exist: Inter*Trade*Ireland, one of the six cross-border bodies established in 1999, has a vision of a globally competitive all-island economy characterised by the optimal utilisation of the island's resources, particularly knowledge resources. This report seeks to indicate the trends in demand for people with engineering and information technology (IT) qualifications which will allow the target of reaching a ranking for the economy of the island in the Top 5 countries in the world to be achieved. This target is the benchmark against which the supply needs for engineers and IT specialists is assessed.

The Task Force believes that the target is achievable. At present, the combined economies of the island of Ireland rank about 14th in the world in per capita income. When account is taken of the forecast growth of the leading economies, the island economy would need to grow by about 4.5 per cent per annum – slightly less than that achieved over the last decade.

Sustainable economic growth is a complex phenomenon. A focus on maintaining a strong forward momentum increases the likelihood of success. This report examines the important contributions which the high-technology manufacturing and traded services and the construction sectors have made in the past, and are required to make in future. The fast growing high technology sectors have the potential to be key drivers of the required growth performance. Manufacturing and IT service activities will require a steadily increasing element of research, development and innovation. The Task Force is of the view that there will be an increased demand for engineers and computer scientists with higher qualifications to drive the process towards a high global ranking. A sustainable high economic growth rate is vitally dependent on strengthening the capacity of the Research and Development (R&D) base in business and higher education, and this has led to recommendations for a substantial increase in the output of trained PhD researchers. Already some countries, particularly in Asia, have established world leadership positions in niche areas of the IT sector. This is the environment in which the island must strive to achieve its goal.

The report estimates the orders of magnitude of increased engineering and IT staff with third- and fourth-level qualifications necessary to reach the economic target by 2020. This is not the only condition for success but it is a vital one. The Task Force recognises that reaching the supply targets will pose major challenges for the educational institutions at second- and third-level, for research bodies, for public authorities and for industry. A 6-7 per cent annual increase in overall supply will prove very difficult in the current climate of falling number of entrants to third-level courses in engineering and IT. Inward migration in the context of the wider European Union (EU) is likely to play a significant role.

The Task Force recommends that the limited resources of the universities, of the Institutes of Technology, and of the research units on the island be used to maximum complementary effect so that economies of scale, and world-class performance are realised.

The Task Force is confident that with sustained commitment by all the relevant authorities, and the appropriate and selective allocation of resources, the engineering and IT manpower development targets outlined in this report can be achieved. This would provide a key ingredient in raising the output and incomes of the citizens of the island to a ranking in the Top 5 countries in the world by 2020.

In conclusion, I wish to express my thanks to all the members of the Task Force who responded so generously to the invitation to participate in our work and gave their time on a *pro bono* basis to this important project. I also wish to thank particularly Finbar McDonnell of Hibernian Consulting, the Project Facilitator, for his assiduousness in ensuring that all of the main points raised at meetings of the Task Force are reflected in a coherent manner in the final document. Finally, I wish to thank Inter*Trade*Ireland for its active and wholehearted support.

Liam Connellan

Liam Connellan, Chartered Engineer
Past President of the Irish Academy of Engineeering
Chairman of the Task Force

October 2005

Executive Summary

The aim of this report is to propose a vision which would enable income per head on the island of Ireland to reach the level of the Top 5 economies in the world by 2020. Achievement of this target will require close collaboration in fulfilling the economic and skills potential of the people of the island. Collaboration already exists at the highest levels of government and policy, exemplified in the establishment of the cross-border institutions, particularly InterTradeIreland, whose mission is to enhance the global competitiveness of the island economy to the mutual benefit of the island, North and South.

A. Evolution of the Island Economy

The economies of Ireland and Northern Ireland have grown strongly in the past 15 years …

From a situation in 1989 where the average income per head on the island was 61 per cent of the OECD average, this figure had moved to 92 per cent by 2003. This was driven by strong growth in the economies of both Ireland and Northern Ireland relative to the OECD average.

… with key drivers of growth being high-tech manufacturing and construction.

Growth on the island has caused, and has been driven by, significant structural changes in manufacturing. Labour intensive sectors (such as textiles) have seen job losses, with growth in the output and employment of high-tech sectors such as IT and pharmaceuticals (especially in Ireland). As output per head tends to be much higher in high-tech sectors, this shift in the structure of manufacturing contributes to overall economic growth.

Growth in manufacturing output on the island has been supported by strong growth in construction activity over the past 15 years.

This has moved the island to a Number 14 position in the global economy …

The growth achieved from 1989-2003 meant that, excluding very small economies (such as Bermuda, the Caymen Islands etc.) that depend on financial services, Ireland rose to a number 10 ranking in the world economy in terms of income per head, with Northern Ireland ranked at number 19. The combined island economy had a ranking of 14 in 2003.

… - to reach the level of the Top 5 economies by 2020 would require average economic growth rate of 4.5 per cent per year.

If the island economy is to continue to climb the league table of global economies, it will need to continue to grow at a higher rate than the leading economies. Based on Goldman Sachs forecasts for the leading economies, the Task Force estimates that the island economy would need to grow at an average rate of 4.5 per cent per year between 2003 and 2020 to move into the Top 5 economies in terms of income per head. This would give the island the same level of income per head as the US and Japan by 2020.

Such growth will need to occur in the context of a much changed international economic landscape …

The growth of China, India and other Asian economies is changing the global economic context. While many of these countries are starting from a low economic base, they are moving aggressively into high-tech sectors and represent a threat to (as well as an opportunity for) the island in carving out global niches as a “knowledge island”. The emergence of these economies reinforces the urgency of the economic development strategies required by the island.

… and would require continued change in the economies of Ireland and Northern Ireland.

Moving to a Top 5 knowledge economy will require a range of strategies, most outside the scope of this report. However, the Task Force believes that exports (of manufactured goods and of services) will remain central to the island of Ireland's economic growth. It believes *all* manufacturing sectors will need to upgrade their processes, and move towards 'smart' and 'adaptive' practices. The size and scope of the high-tech sectors of ICT and bio-technology/ pharmaceuticals means these sectors are of particular strategic importance for development. Improving the productivity of the non-traded service sectors, and building the returns of companies from the island that operate overseas will also support economic growth.

While knowledge is increasingly embedded in processes, the Task Force believes that high-quality human resources are central to creating a 'knowledge island'.

B. Changing Demand for Engineering and IT Workers

The number of people in engineering and IT occupations on the island grew sharply between 1991 and 2001-2002 …

Growth in those working in science, engineering and IT occupations is shown below.

Table 1 Number of Workers in Science, Engineering and IT Occupations on the Island of Ireland, 1991 and 2001–2002

	1991	2001-2002	Change Percentage
Scientists and Science Technicians	14,317	24,100	68
Engineers and Associated Technicians	19,110	40,383	111
IT and Computer Workers	9,882	42,079	326
Total SET Workers	**43,309**	**106,562**	**146**
Total Labour Force	2,062,000	2,540,000	23

Figure 1 Number of Workers in Science, Engineering and IT Occupations on the Island of Ireland, 1991 and 2001–2002

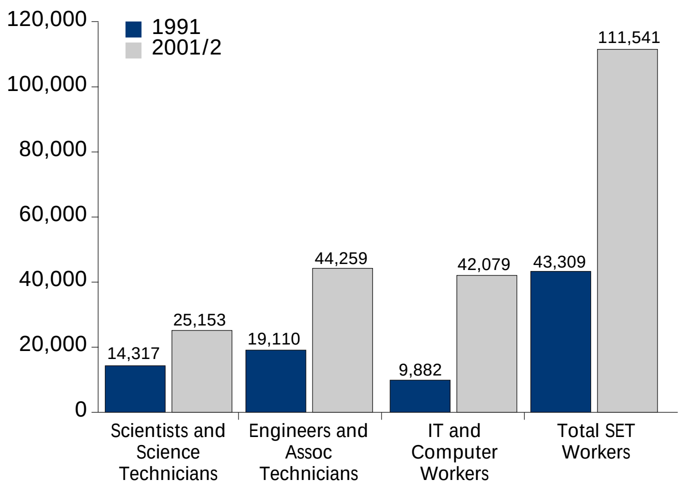
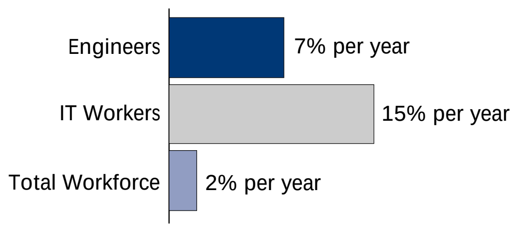


Figure 2 Average Annual Increase 1991 to 2001-2002



Over the 1991 to 2001-2002 period:

- The number of people working as engineers on the island grew by over 7 per cent per year;
- The number of IT workers grew by an average of almost 15 per cent per year.

… and was an important contributory factor to economic growth on the island.

Data from the Higher Education Authority in Ireland on the sectoral destination of graduates shows that between 50 per cent and 60 per cent of engineering graduates go into the ICT, bio-tech/bio-pharma and construction sectors. There is evidence that this figure reached 80 per cent in 2000. Thus, the sharp rise in engineering and IT personnel has been directly linked to key growth sectors in the economy.

Companies in leading economic sectors employ more people with engineering and IT qualifications than companies in other sectors ….

The above trend in relation to recruitment is confirmed by data from Engineers Ireland, which shows that a high proportion of the employees of companies in the ICT, bio-pharma and construction sectors are engineers and engineering technicians, relative to the wider economy.

…. and the profile of qualifications in leading companies is "flatter".

A survey of 12 leading companies in the three sectors mentioned, undertaken by the Task Force, shows a relatively strong tendency to employ people at sub-degree level (although primary degree level remains the most common point of graduate entry). The leading companies in these sectors also tend to employ more engineering, IT and science personnel with postgraduate qualifications compared to all companies. The bio-med/bio-pharma sector has the highest proportion of people with postgraduate qualifications – these tend to be science rather than engineering or IT graduates.

While qualifications at sub-degree level will remain important, the leading companies are employing more people with post-graduate qualifications.

The view of the leading companies surveyed was that they will require more people with postgraduate qualifications in the future, with one ICT company saying that the proportion of new recruits with PhDs could be 30-40 per cent by 2020 and a pharmaceutical/health care company estimating the figure at 15-20 per cent.

C. Creating a World Class R&D Capability

Building Research and Development capability is critical for a "knowledge island" …

The importance of innovation and R&D has been explicitly recognised in policy documents in Ireland and Northern Ireland.

… yet the island currently lags leading countries in its R&D spend.

The EU's Lisbon Agenda sets a target of 3 per cent of GDP for Gross Expenditure on R&D in EU Member States by 2010. Figures for 2001 show Ireland and Northern Ireland as both below 1.5 per cent of GDP. All of the Top 5 countries are ahead of the island on this measure, and four of the Top 5 had R&D expenditure of over 2.5 per cent of GDP in 2001 (with Japan at over 3 per cent).

Data for Ireland shows that it lags both in relation to business R&D and for R&D in higher education. In recent years, efforts have been made to close the gap in both of these areas. Northern Ireland also lags on business R&D spend but its higher education sector performs well on R&D by international standards.

To become a leading knowledge economy will require a large expansion in the number of researchers on the island between now and 2020 …

Based on a comparison of the number of researchers on the island with the numbers employed in leading global economies, a considerable expansion is required in the number of personnel engaged in R&D on the island.

… this will be aided by R&D centres of excellence that have emerged in recent years.

While the island lags the leading economies in R&D, it does contain centres of excellence. In Ireland, centres in the ICT and bio-technology/ bio-pharmaceutical sectors are driven by the HEA's Programme for Research in Third-Level

Institutions (PRTLI) and by Science Foundation Ireland's Centres for Science, Engineering and Technology (CSETs) programme. Centres of excellence in Northern Ireland build on the strong R&D in the higher education sector, with support from Invest NI's Centres of Excellence programme. Industry/academic links are supported by several initiatives and programmes.

D. Supply of Engineering and IT Graduates

The island produces 5,200 engineering graduates and 2,600 IT graduates each year …

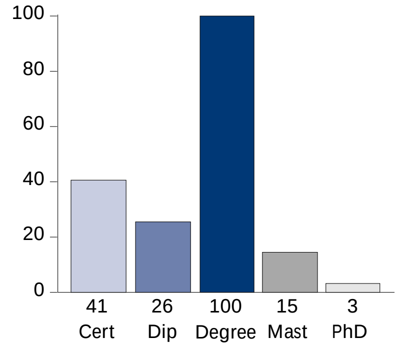
A breakdown of the approximately 5,200 engineering graduates is shown below.

Table 2 Current breakdown of Number of Engineers Graduating, by Level of Qualification in Ireland and Northern Ireland

	Certificate	Diploma	Degree	Masters	PhD
Ireland	1,128	703	2,339	238	51
Northern Ireland	30		475	170	40
Ratio	41	26	100	15	3

Table 2 includes some graduates in computer engineering. While precise figures are not available for computer science graduates, they are estimated to number a further 2,600 graduates per year.

Figure 3 Current breakdown of Number of Engineers Graduating, by Level of Qualification in Ireland and Northern Ireland



Note: Ratios relate to degree index at 100

… with the number receiving post-graduate qualifications higher in Northern Ireland.

In Northern Ireland, the ratio of those graduating at PhD level, and with post-graduate qualifications below PhD level, compared to the numbers graduating with primary degrees, is higher than in Ireland. There is also evidence of more specialisation in Northern Ireland, linked to areas of research excellence in Queen's University and the University of Ulster. However, funding of postgraduate studies in Ireland has grown considerably in recent years.

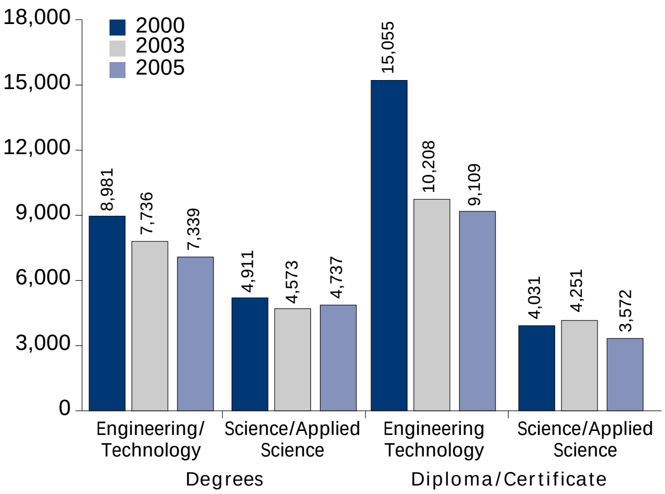
Data on student numbers shows evidence of some cross-border mobility ….

Cross-border mobility is higher from Ireland to Northern Ireland, in particular for post-graduate studies. One in eight post-graduate students in Northern Ireland comes from Ireland.

… but also that the numbers studying engineering and science courses have fallen sharply in recent years.

Available data shows that the numbers applying for, and studying, science, engineering and IT courses have fallen sharply since 2000, by as much as 25 per cent in Ireland and by a smaller amount in Northern Ireland.

Figure 4 CAO Applications for SET courses (first preferences)



E. Estimating Demand for Engineers and IT Workers to 2020

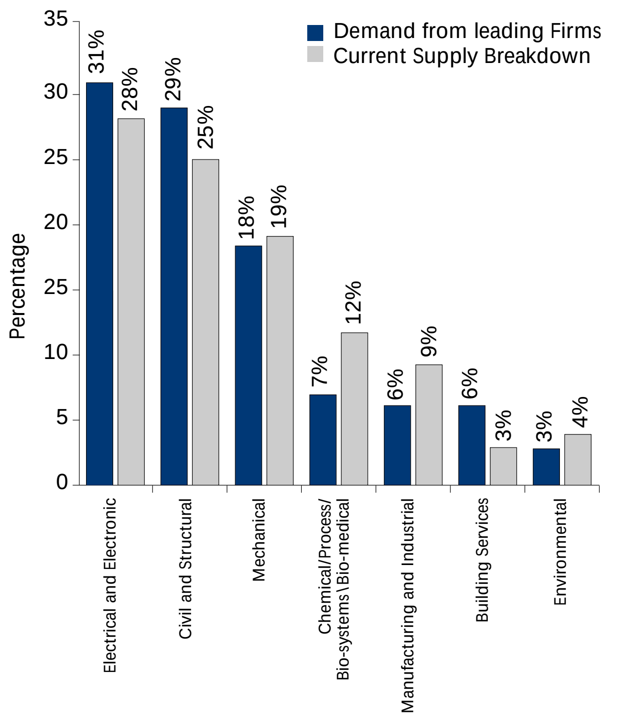
A "knowledge island" will require continuing significant growth in the number of people in engineering and IT occupations …

A number of trends seem set to continue on the island. Manufacturing continues to evolve towards high-technology sectors (in particular ICT and bio-pharma). The high-tech sectors are themselves upskilling over time. Construction activity is projected to remain strong. There is a requirement for all manufacturing sectors to upgrade their processes. The employment of engineers and IT personnel is expanding in non-industrial sectors of the economy. And the island requires a significant expansion in its R&D capability.

These trends suggest that the numbers in engineering and IT occupations will continue to increase strongly. In relation to engineering, there is no reason to believe the relationship between the rate of growth in the numbers of engineers and engineering technicians and the rate of growth of the economy will change. Furthermore, the current profile of demand from leading firms seems well aligned to the profile of engineers being trained per discipline. However, there is an emerging significant shortfall in the supply of electrical/electronic graduates. In relation to IT, the rate of growth in the numbers employed is likely to slow down, as the numbers grew from a small base in the 1990s and the period included the IT "boom". The relationship between the rate of growth in IT personnel and the rate of growth in the economy is more likely to approach the rate seen in relation to engineers.

If the scenario of a 4.5 per cent rate of growth required by the island economy to reach the level of the Top 5 global economies is to be achieved, the Task Force projects that the number of people in engineering occupations will be required to rise from 40,000 (in 2001-2002) to 110,000 (by 2020). The number in IT occupations will be required to rise from 42,000 to 115,000. This represents a compound annual rate of growth of 5.6 per cent.

Figure 5 Current Demand from Leading Firms for Engineers (by discipline) and Current Supply of Graduates from Ireland and Northern Ireland



… and in those with engineering and IT qualifications.

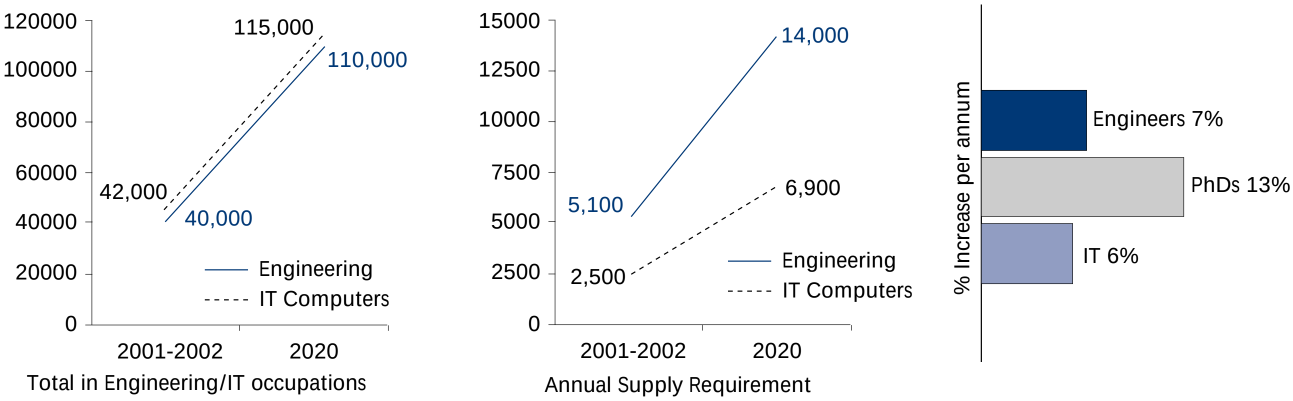
For a given number of engineers in the economy, a higher number of people with engineering qualifications is needed in the labour force, as a proportion of people with the relevant qualifications work in other jobs. Based on data from Ireland's 2002 Census, it is possible to project the numbers required with engineering and IT qualifications, in the labour force, by 2020, to meet the Top 5 growth scenario.

Table 3 Summary of Estimated Manpower Requirements for Engineering and IT on Island

	2001 – 2002	Percentage of Annual Growth Required	2020
Number of People in Engineering/IT Occupations			
Engineering	40,000	+ 5.6	110,000
IT/Computers	42,000	+ 5.6	115,000
Number of People with Relevant Third-Level Qualifications in Labour Force			
Engineering	73,000	+ 5.6	200,000
IT/Computers	42,000	+ 5.6	115,000
Number of New People Required to Enter Labour Force per annum			
Engineering	5,100	+ 7.0	14,000
IT/Computers	2,500	+ 6.0	6,900

Note: Growth rates in Number of New People Required to Enter Labour Force Each Year allow for attrition

Figure 6 Summary of Estimated Manpower Requirements for Engineering and IT on Island



The final part of Table 3 takes account of likely rates of retirement from the two sets of occupations. Once these are taken into account, the number of new people entering the labour force with engineering qualifications will need to rise by 7 per cent per year and those with IT qualifications by 6 per cent per year.

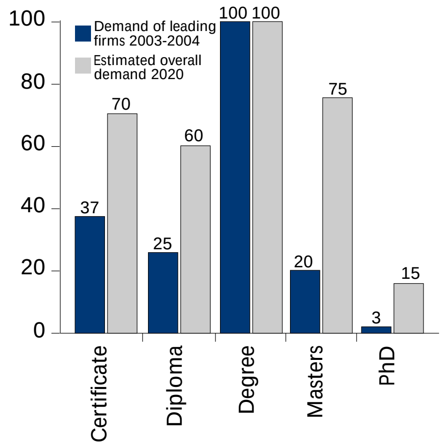
The island economy is likely to require a higher proportion of graduates at post-graduate and at sub-degree level, compared to today …

Based on the evidence of the leading companies today, there will be a different pattern of graduate demand by 2020. Table 4 shows the projected required ratios and how this would translate into required actual numbers graduating in 2020.

Table 4 Estimated Balance of Demand in 2020 by Level of Engineering and IT Qualifications and Estimated Number of New Labour-Market Entrants Required in 2020 by Level of Qualification

	Certificate	Diploma	Degree	Masters	PhD	Total
Ratio of Qualifications	**70**	**60**	**100**	**75**	**15**	
Engineering Grads	3,000	2,600	4,400	3,300	700	14,000
IT/Computing	1,500	1,300	2,200	1,600	300	6,900

Figure 7 Balance of demand by level of qualifications



Note: Ratios relate to degree index at 100

The projected requirement for people with engineering and IT qualifications to reach the level of a Top 5 economy by 2020 can be met in a number of ways.

Options include one or more of the following:

- More people graduating from engineering and IT courses on the island;
- More existing workers returning to education to upgrade or acquire skills in engineering or IT; and
- The recruitment of people with relevant qualifications from outside the island to the island labour force.

F. Task Force Conclusions

Top 5 Target attainable by 2020 with 4.5 per cent growth.

The target of having income per head on the island in the Top five globally with an expanded population can be achieved with a annual average GNP growth rate of 4.5 per cent. This would require lower average growth than has been achieved on the island in the past 15 years.

High-tech sectors are key growth drivers.

Key drivers of growth are expected to be the ICT and bio-pharmaceutical/bio-medical sectors, with the support of the construction sector.

Substantial increase needed in qualified engineering and IT staff.

The expansion of the high-tech sectors, and other sectors across the economy, will require a substantial increase in engineering and IT professionals. This will represent a continuation of a trend seen on the island since 1990, as the island becomes a 'knowledge economy'.

R & D resources a vital ingredient for the "knowledge island".

R&D expenditure and personnel on the island lag substantially behind the levels of the leading economies, and this gap will need to be closed to achieve a "knowledge island".

Competitive threats exist and are changing.

There is a threat to building a Top 5 economy from rapidly emerging Asian economies, such as China, India and Taiwan. The island will also receive a much lower level of EU Structural Funds from 2005 to 2020 compared to 1990-2004.

Almost three-fold increase in stock of qualified staff required.

There will be a need to increase the stock of people with engineering and IT qualification by a factor of 2.75, from its level in 2001-2002 to its required level in 2020.

Strong annual increase in supply of engineering and IT personnel necessary.

An increase in the number of those with engineering qualifications in the labour force of 7 per cent per year is required. An increase in the number of those with IT qualifications in the labour force of 6 per cent per year is required.

Distribution of engineering disciplines reflects expected demand.

The current distribution of graduates across the different engineering disciplines appears to broadly reflect expected demand patterns, at least in the medium-term.

Greater complementarity is needed between engineering and science.

There will be greater interaction between engineering and science disciplines in the key growth sectors. This reflects a convergence of science and engineering in sectors such as nanotechnology (which brings together biological and engineering sciences).

Demand for PhDs expected to increase almost ten-fold.

The opinions of the leading firms today suggest strong growth in demand for professionals with post-graduate qualifications. Demand for PhDs is expected to increase almost ten-fold by 2020.

A threat is posed by the sharp fall in number of applications.

While the annual supply of engineers and IT professionals is required to grow strongly (to achieve 'Top 5' economic status), this must be seen in the context of a sharp fall in the number of applications to IT and engineering courses since 2000.

A strong recovery in demand for IT professionals is evident.

There is international evidence in 2005 to indicate a sharp recovery in the demand for IT professionals after the slowdown in 2001-2003.

G. Task Force Recommendations[1]

Adopt target for island of being in Top 5 global economies by 2020.

The Task Force believes that the island can reach the level of the Top 5 global economies in terms of income per head by 2020. To this end, it believes achievement of a 4.5 per cent per annum economic growth rate for the island to 2020, and the creation of a 'knowledge island', should be adopted as feasible targets. The achievement of these targets will require close collaboration in fulfilling the economic and skills development potential of the people of the island. Collaboration already exists at the highest levels of government and policy.

Robust increase in the supply of qualified engineers, IT staff and PhDs needed.

Measures should be set in train by the relevant authorities on the island to increase the supply on the island by 2020 of

(a) Engineering professionals and technicians by 7 per cent per year;

(b) IT professionals and technicians by 6 per cent per year; and

(c) Engineering and IT PhDs by 13 per cent per year.

Develop world class centres of research linked to Engineering and IT schools that share resources.

Engineering and computer engineering/science schools on the island are small by international standards and do not have sufficient economies of scale. There should be intensive efforts both to develop world class R&D centres of excellence and to share resources to benefit from economies of scale.

Promote engineering and science as career options much more intensively.

A co-ordinated and adequately funded promotional campaign to attract applicants for engineering and science courses at third-level should be launched throughout the island (e.g. Ireland's Discover Science and Engineering Initiative and STEPS – Science, Technology and Engineering Programme for Schools). The resources required will be determined by the campaign's success in meeting the targeted number of course entrants. There should also be efforts to attract more

1 The Task Force recognises that some of these recommendations were addressed in a broader context in the Enterprise Strategy Group's 2004 report "Ahead of the Curve" and that some preliminary actions have been taken.

students at second-level into mathematics and science subjects, and to ensure consistently high standards of relevant second-level teaching and facilities.

Make greater efforts to attract women into engineering, targetting 50/50 gender distribution.

Particular attention should be given to attracting more women into engineering, and in supporting their careers, including through the development of more flexible career paths and working arrangements, with the aim of moving towards a 50/50 gender distribution by 2020.

Provide more substantial resources to increase graduate, and research, output from higher educational institutions.

Third-level institutions throughout the island should be allocated sufficient resources to enable them to achieve the sharp increase in annual graduate output required, including in supporting more students to progress to PhD level. The increase in resources should be sufficient to cover both R&D and teaching.

Expand programmes supporting linkages between industry and third level institutions.

The current successful programmes supporting linkages between industry and third-level institutions on the island should be expanded to involve a higher proportion of Masters and PhD graduates. This would assist integration between academic research and innovation in indigenous industry. Systems are needed to ensure that sufficient projects, companies and post graduates are attracted to achieve the necessary degree of expansion.

Implement more programmes for continuing professional development and for obtaining higher level qualifications while remaining at work.

The continuing professional development of engineering and IT staff should be intensified by industry, and complemented by the provision of better facilities, curricula and timetables by higher education institutions, to enable company employees to attain higher qualifications, up to PhD level, in a way that integrates work and learning.

Publish information on the number of computer engineering/science graduates annually.

Details should be published of the number of computer engineering and computer science qualifications awarded annually by higher education institutions on the island. Such information will enable third-level institutions and development authorities to assess the adequacy of the supply system.

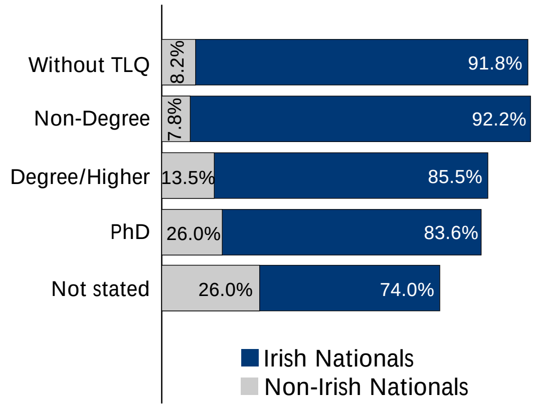
Support more complementarity between engineering and science studies.

Higher education institutions should take action to enable greater interaction between engineering and science qualifications to meet the needs of the key growth sectors.

Attract and integrate engineering and IT professionals from abroad.

To the extent that the supply of engineers and IT professionals from third-level institutions in Ireland falls below the required amount, the gap should be bridged through immigration, primarily from other EU Member States. It is recommended that clear and specific policies be developed by the relevant authorities to facilitate the integration of such migrants.

Figure 8 Breakdown of People in Ireland with Third Level Qualifications into Irish/Non-Irish Nationals



Gather information on the engineering and IT qualifications of immigrants when they register with the social welfare systems on the island.

Immigrant workers registering with the social welfare systems should be asked to provide information on their third-level qualifications, including in engineering and computer engineering/science, and a summary of the qualifications of these labour market entrants should be published annually. This will enable the development authorities to assess the degree to which immigration is supplementing the supply of graduates by the third-level institutions on the island.

Section 1: The Island Economy

1.1 Introduction

Section 1 reviews how the island economy has evolved in the past 15 years or so. It shows how, in terms of income per head, the economies of Ireland and Northern Ireland have grown faster than the Organisation for Economic Co-operation and Development (OECD) average, and how this has been driven by (and has caused) changes in the structure of the island economy. It sets out the task required if the island is to rank among the top global economies by 2020 and lists some of the changes that are likely to occur in the global economic context over the coming 15 years. Section 1 therefore sets out the context for the development of a "knowledge island" by 2020.

1.2 Where the Island Economy Rates Now

The past 15 years have seen strong economic growth for Ireland and Northern Ireland, especially the former. In terms of income per head, Table 1.1 shows that Ireland (using Gross National Product [GNP] per capita[2]) moved from 56 per cent of the OECD average in 1989 to 95 per cent of this average (itself increasing each year) in 2003. Northern Ireland (using GDP per capita) moved from 75 per cent of the OECD average in 1989 to 86 per cent of the OECD average in 2003.

Table 1.1 Income Per Capita (US$) for Ireland and Northern Ireland 1989-2003

	Ireland (GNP)	Northern Ireland (GDP)	Island of Ireland	OECD 26 (GDP)	United States (GDP)
1989	10,877	14,648	12,008	19,559	27,998
1990	11,991	14,836	12,845	19,989	28,200
1991	12,230	14,893	13,029	20,043	27,773
1992	12,482	15,084	13,263	20,268	28,321
1993	12,812	15,605	13,650	20,338	28,707
1994	13,600	16,302	14,411	20,788	29,514
1995	14,655	17,005	15,360	21,118	29,907
1996	15,766	17,602	16,317	21,586	30,667
1997	17,168	18,028	17,426	22,142	31,681
1998	18,375	18,542	18,425	22,521	32,636
1999	19,657	19,109	19,493	23,049	33,713
2000	21,374	19,890	20,929	23,704	34,575
2001	21,945	20,114	21,396	23,770	34,479
2002	22,210	20,333	21,647	23,924	34,775
2003	22,988	20,937	22,373	24,281	35,488

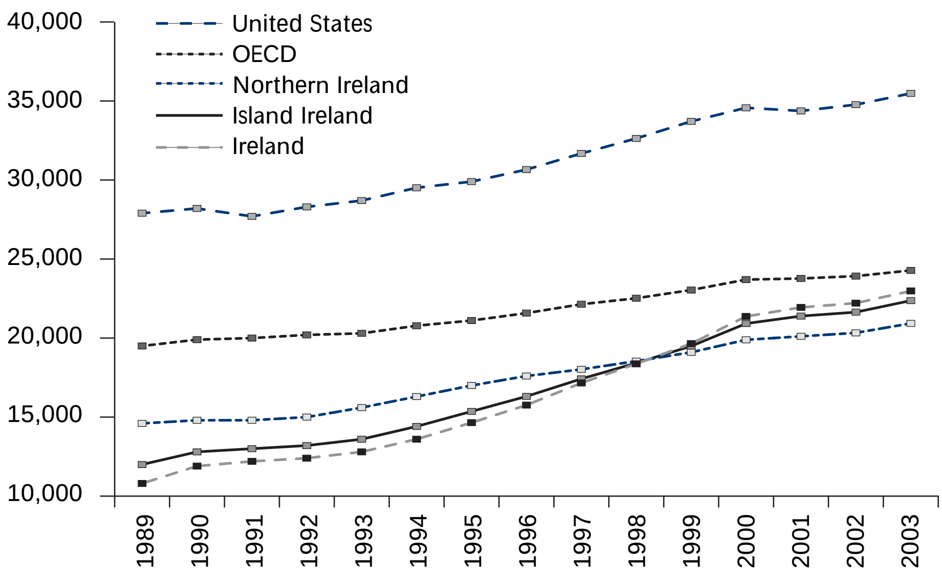
Source: OECD Database. GNP figures for Ireland calculated using OECD GDP figures and ratio for Irish GDP/GNP from Irish National Accounts for different years.

Note: (1) Figures are in US$ based on constant prices and exchange rates of 2000; (2) OECD average for 26 countries – excludes Czech Republic, Hungary, Poland and Slovak Republic. OECD average figure is for GDP per capita.

Table 1.1 shows that average income per head for the island as a whole moved from US$12,000 (in 2000 prices) in 1989 to almost US$22,400 (in 2000 prices) by 2003, an increase of 86 per cent in real terms in the 14-year period. This moved the island's average income per head from 61 per cent of the OECD average in 1989 to 92 per cent of the OECD average in 2003.

2 For Ireland, Gross National Product (GNP) is the best measure of income, as the unusually high importance of overseas companies in the economy means that almost 20 per cent of the Gross Domestic Product (GDP) generated flows out of the economy, mainly through profit repatriation.

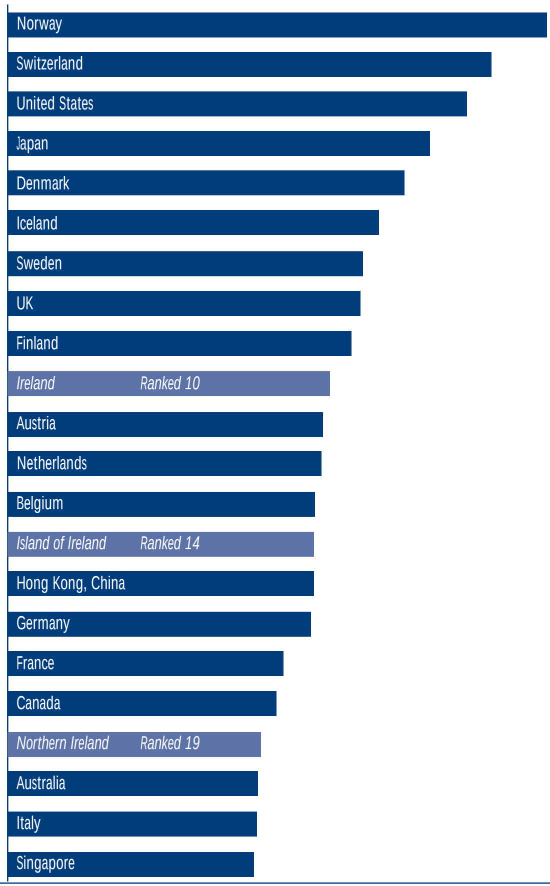
Figure 1.1 Income Per Capita (US$) for Ireland and Northern Ireland 1989-2003



It is possible to use data collected by the World Bank on Gross National Income (GNI) per head (very close to GNP per head) to compare income levels in different countries. Data for GNI per capita in 2003 is shown in Table 1.2.

Table 1.2 Gross National Income (US$) for Selected Countries, 2003

	GNI Per Capita 2003	Ranking
Norway	43,350	1
Switzerland	39,880	2
United States	37,610	3
Japan	34,510	4
Denmark	33,750	5
Iceland	30,810	6
Sweden	28,840	7
United Kingdom	28,350	8
Finland	27,020	9
Ireland	***26,960***	***Ranked 10***
Austria	26,720	11
Netherlands	26,310	12
Belgium	25,820	13
Island of Ireland	***25,778***	***Ranked 14***
Hong Kong, China	25,430	15
Germany	25,250	16
France	24,770	17
Canada	23,930	18
Northern Ireland	***23,020***	***Ranked 19***
Australia	21,650	20
Italy	21,560	21
Singapore	21,230	22



Source: World Bank, World Development Indicators Database, September 2004

Note: (1) GNI is Gross National Income, converted to US$ using the World Bank Atlas method, divided by mid-year population; (2) due to their particular natures, the table excludes the economies of Bermuda, Luxembourg, the Channel Islands, Liechtenstein, San Marino, the Caymen Islands and Monaco; (3) data in Table 1.2 are at 2003 prices and in Table 1.1 at 2000 prices.

Table 1.2 shows that, in terms of income per head, the island of Ireland ranked in 14th place in 2003. Norway, aided by its high oil revenues, was in the number one position. Ireland ranked behind the United States (US), Japan, Switzerland, the Nordic countries and several other EU countries. It was just ahead of Hong Kong, Singapore, Canada, Australia and a number of further EU economies.

The World Bank database shows that, while the relevant 2003 GNI per capita figure for South Korea was US$12,020, figures for China and India, with much larger populations, were a considerable distance behind (at US$1,100 and US$530 respectively).

As the data in Table 1.2 is income *per capita*, the relatively small population of the island of Ireland (some 5.7m in 2003) means that the total income (or output) of the economy of the island remains very small by international standards. Examples of the total sizes of several OECD economies in 2003 (US figure based on 2002 data) are as follows:[3]

- United States: $10,429bn[4] (2002)
- EU 15: $10,214bn
- Japan: $3,572bn
- Ireland $112bn (GNP)
- Northern Ireland: $39bn
- Island of Ireland: $151bn

This data shows that the size of the total island economy is between 1 and 2 per cent of the size of the US economy and of the EU 15 economy. It constitutes well under 1 per cent of the total OECD economy.

Data for 2004 shows that Ireland (estimated GNP growth of 5.5 per cent) and Northern Ireland (estimated GDP growth of 3 per cent) both grew by above the average for the Euro area (estimated GDP growth of 2.1 per cent). This is likely to have been sufficient for the island economy to overtake the Belgian economy, which would have ranked the island of Ireland 13th in terms of income per head in 2004.[5]

In summary, for 2003, compared to the Top 5 countries, and using the measure of GNI per person, the island of Ireland was:

- 68 per cent behind Norway
- 55 per cent behind Switzerland
- 46 per cent behind the United States
- 34 per cent behind Japan
- 31 per cent behind Denmark

1.3 Structural Evolution of the Economies on the Island

Growth in the economies of Ireland and Northern Ireland in the past 10–15 years has driven, and has been caused by, an evolution in the structures of the economies. This report is particularly interested in the key roles of the manufacturing and construction sectors.

Table 1.3 shows how the overall proportion of gross value added in the economy accounted for by industry (excluding construction) and by construction, evolved for Ireland and Northern Ireland between 1994 and 2002.

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3 Figures from OECD (2005), Section on Macroeconomic Trends. Northern Ireland figure taken as proportion of United Kingdom figure. Ireland's GNP figure from Central Statistics Office (CSO) (2004).

4 "Billion" is defined as a thousand million for the purposes of the report.

5 This ranking has come about over a short timeframe. While income levels are now comparable to those of countries such as Belgium, Austria etc., these countries' historically higher income levels mean an infrastructure deficit on the island (especially in Ireland) continues to exist.

Table 1.3 Contribution of Industry and Construction to Gross Value Added in Economies of Ireland and Northern Ireland, 1994, 1998 and 2002

		1994 per cent	1998 per cent	2002 per cent
Ireland	Industry	n/a	36.7	41.2
	Construction	n/a	5.8	5.2
	Total	**35.9**	**42.5**	**46.4**
Northern Ireland	Industry	24.1	23.5	20.4
	Construction	5.4	6.1	7.6
	Total	**29.5**	**29.6**	**28.0**

Source: CSO, National Income and Expenditure 2003 and 1998. Breakdown for Ireland taken from Tansey (2005), Table 27. Northern Ireland data from National Statistics (2004).

Note: n/a = breakdown not available.

Table 1.3 shows that the proportion of total output accounted for by industry and construction rose in Ireland from 36 per cent of GDP in 1994 to 46 per cent in 2002. This was mainly driven by a surge in manufacturing output, which was a key driver of the strong overall growth experienced by Ireland's economy over the period.[6]

In Northern Ireland, industrial output declined from 24 per cent to 20 per cent over the 1994–2002 period, with an increase to almost 8 per cent in the share of output accounted for by construction.

Further examination of the data shows strong growth in output in Ireland in specific sub-sectors of manufacturing.[7] The shift of manufacturing output towards high-technology sectors is shown in Table 1.4, for 4 specific sectors:

- NACE 223 – Reproduction of recorded media, including software;
- NACE 24 – Chemicals (including man-made fibres) sector;
- NACE 30 and 33 – Computers and Instrument Engineering, which includes computer hardware, associated equipment and medical devices; and
- NACE 31 and 32 – Electrical Machinery and Equipment, which includes communications equipment.

Table 1.4 Total and High-Tech Industrial Gross Value Added for Ireland, 1995, 1998, 2001 and 2003

	1995	1998	2001	2003
Total Industrial Output (incl. Construction)	**17,764**	**25,960**	**35,892**	**40,338**
which:				
Reproduction of Recorded Media	721	1,115	759	678
Chemicals (incl. man-made fibres)	3,498	7,758	13,516	17,991
Computers and Instrument Engineering	2,825	3,794	6,406	6,495
Electrical Machinery and Equipment	832	1,503	1,663	1,574
High-Tech 4 as percentage of Total Industrial Output	**44.3**	**54.6**	**62.3**	**66.3**

Source: CSO, National Income and Expenditure – 2001 and 2004, Table 4

Note: Figures at constant 1995 US$ prices.

If growth in industrial output has underpinned the strong economic growth of Ireland over the past decade, Table 1.4 shows that this growth has itself been driven by growth in the four high-tech sectors shown, with these sectors accounting for two-thirds of industrial output by 2003. Much of the output of these sectors is exported, providing a growth driver for a small open economy. Table 1.4 also shows that, by 2003, two sectors – chemicals and computers/instrument engineering – accounted for 61 per cent of industrial output in Ireland.

6 This information on economic output by sector is provided in relation to GDP, not GNP. Manufacturing output in Ireland may be overstated due to companies wishing to maximise the amount of value added accrued in Ireland for tax reasons.

7 The value of gross output and the value of sales are very similar, since output measures the value of goods produced while sales measures the value of goods sold. The sectoral classification system used is NACE Rev 1, which is much the same as the SIC 92 system.

Available data for Northern Ireland indicates that the high-tech sectors account for a lower proportion of output; 2003 data[8] shows that:

- 12.6 per cent of manufacturing added value was accounted for by Electrical and Optical Equipment, equivalent to NACE 30–33 inclusive (up from 8 per cent in 1998); and
- 7.1 per cent of manufacturing added value was accounted for by Chemicals (including man-made fibres), equivalent to NACE 24 (down from 8.1 per cent in 1998).

In terms of employment,[9] Table 1.5 shows the numbers employed in Ireland in all manufacturing and in specific sub-sectors.

This table indicates that manufacturing employment in Ireland was about 8 per cent higher in 2004 compared to 1994. However, high-tech manufacturing employment, as measured for the three sectors shown, rose from 55,600 in 1994 to 75,500 in 2004, an increase of 36 per cent. This increase was strongest in the late 1990s, with employment in these sectors peaking in 1999-2000 and falling back thereafter.[10] Employment in more traditional sectors is broadly similar to what it was in 1994, having increased in the 1990s and declined after 1999. The exception has been the ongoing decline in the textile sector.

Table 1.5 Ireland Manufacturing Employment – Total and Specific Sectors, 1994, 1999 and 2004

	1994	1999	2004
Total Manufacturing Employment	205,421	250,191	222,200
which:			
Selected High-Tech Sectors:			
Chemical Products (ind. man-made fibres)	17,459	22,958	23.200
Computers and Instrument Engineering	20,860	37,039	36,900
Electrical Machinery and Equipment	17,289	28,236	15,400
Selected Traditional Manufacturing Sectors:			
Food, Drink and Tobacco	44,346	48,355	47,000
Rubber and Plastic Products	8,847	10,590	9,600
Basic Metals and Fabricated Metal Products	12,486	15,681	15,500
Transport Equipment	7,677	7,982	9,000
Textiles and Textile Products	19,705	11,629	5,200

Source: CSO, Census of Industrial Production, 1994 and 1999, and Industrial Employment Series, March 2005

Note: (1) Data is for 'persons engaged' – includes proprietors and unpaid family members if applicable; December 2004 figures are provisional; (2) Computers and Instrument Engineering combines NACE Sectors 30 and 33. Electrical Machinery and Equipment combines NACE Sectors 31 and 32.

Employment in high-tech sectors in Ireland is even more important when ancillary services and related sub-sectors are taken into account. For example, a 2002 study by the Irish Medical Devices Association (IMDA) estimated that there were some 20,000 employees in the medical devices sector at end-2000.[11] The Enterprise Strategy Group report *Ahead of the Curve, Ireland's Place in the Global Economy* (2004) estimated that in 2002 there were 81,000 workers in the Irish information and communications technology (ICT) sector (including hardware, software, telecoms, support services, digital content and other areas). Data in relation to employment in telecoms and software services is shown in Table 1.6.

8 Northern Ireland Annual Business Inquiry, 2003. Detailed results, Table 2, available on website of Department of Enterprise, Trade and Investment (DETI).

9 Employment figures are defined according to the NACE Rev.1 system in Ireland and the SIC 92 system in Northern Ireland. These are very similar and, at this level of sectoral disaggregation, are effectively the same. Figures for Northern Ireland relate to employee jobs and exclude those who are self-employed.

10 The *rate* of growth of exports from these sectors was also slower after 2000. However, indications were that manufacturing employment in Ireland stabilised in 2004 and early 2005.

11 Irish Medical Devices Association (2002), Economic Impact Report 2000-2003. The IMDA is part of the Irish Business and Employers Federation (IBEC).

Table 1.6 Ireland-Telecoms Services, Software and Computer-Related Services Employment, 1994, 1999 and 2004

	1994	1999	2004
Employment in Identified Sectors	11,095	29,103	35,827

Source: *Data supplied to KI 2020 Task Force by Forfás*

Note: Sectors to which data applies are NACE 64.2 and 72.

In Northern Ireland, as in Ireland, the textiles sector has seen a major decline: in 1994, almost 1 in 4 Northern Ireland manufacturing jobs was in textiles and clothing; by 2004, this had fallen to 1 in 15 jobs. Table 1.7 shows some of the changes in the structure of manufacturing employment in Northern Ireland since 1994.

Table 1.7 Northern Ireland Manufacturing Employment – Total and Specific Sectors, 1994, 1999 and 2004

<table>
<tr><th></th><th>1994</th><th>1999</th><th>2004</th></tr>
<tr><td>Total Manufacturing Employment
which:
Selected High-tech Sectors:</td><td>102,610</td><td>105,750</td><td>87,930</td></tr>
<tr><td>*Chemical Products (incl. man-made fibres)*</td><td>3,950</td><td>3,170</td><td>3,220</td></tr>
<tr><td>*Computers and Instrument Engineering*</td><td rowspan="2">8,000</td><td rowspan="2">12,210</td><td>3,850</td></tr>
<tr><td>*Electrical Machinery and Equipment*</td><td>5,630</td></tr>
<tr><td>**Selected Traditional Manufacturing Sectors:**</td><td></td><td></td><td></td></tr>
<tr><td>*Food, Drink and Tobacco*</td><td>20,380</td><td>20,050</td><td>18,850</td></tr>
<tr><td>*Rubber and Plastic Products*</td><td>5,710</td><td>6,950</td><td>7,180</td></tr>
<tr><td>*Basic Metals and Fabricated Metal Products*</td><td>5,040</td><td>6,300</td><td>6,680</td></tr>
<tr><td>*Transport Equipment*</td><td>10,970</td><td>12,900</td><td>10,200</td></tr>
<tr><td>*Textiles and Textile Products*</td><td>25,400</td><td>18,240</td><td>5,890</td></tr>
</table>

Source: Department of Enterprise, Trade and Investment (2005), Northern Ireland Quarterly Employment Survey, Tables 1.3 and 1.7

Note: (1) All figures for December; (2) December 2004 figures are provisional; (3) Computers and Instrument Engineering combines NACE Sectors 30 and 33. Electrical Machinery and Equipment combines NACE Sectors 31 and 32. (4) Figures for 1994 and 1999 for Computers and Instrument Engineering, and Electrical Machinery and Equipment, are combined. (4) Figures for 1994 and 1999 shown for Electrical Machinery and Equipment refer to both that sector and the Computers and Instrument Engineering Sector together.

This table indicates that manufacturing employment in Northern Ireland increased in the second half of the 1990s but declined thereafter. A comparison of sales and employment data shows that in some high-tech sectors (e.g. electrical and optical equipment), there is evidence (as in Ireland) of rising sales per employee. The other most significant change in the composition of manufacturing employment was the decline in employment in the manufacture of textiles and textile products. Thus, in Northern Ireland, as in Ireland, there was a shift in manufacturing employment from more traditional sectors towards high-tech sectors, but with the process of structural shift going further in Ireland.

Tables 1.3 to 1.7 show that a key driver of strong economic growth in Ireland has been strong growth in high-tech manufacturing. While there has been some employment increase in these sectors, this has been nothing like the growth in gross value added contributed by these sectors (comparison of Tables 1.4 and 1.5). This implies that significant growth has occurred in sectoral productivity, i.e. output per person employed. The growth and productivity of high-tech manufacturing sectors have been key drivers of Ireland's economic performance.

This is not to understate the continued importance of employment in the non-high-tech manufacturing sectors in Ireland, which constituted two-thirds of manufacturing employment in 2004, producing one-third of manufacturing output.

Northern Ireland, while seeing higher economic growth than the UK average over the past decade, did not have the same growth in the output of its high-tech sectors. However, the share of its manufacturing output and employment accounted for by these sectors has grown. With the exception of textiles, its other manufacturing sectors have maintained their levels of employment over the period.

Table 1.8 shows how manufacturing employment on the island as a whole has evolved between 1994 and 2004.

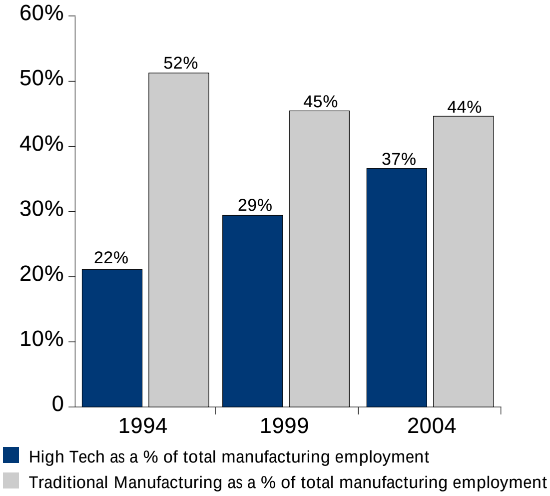
Table 1.8 Island of Ireland Manufacturing Employment – Total and Specific Sectors, 1994, 1999 and 2004

	1994	1999	2004
Total Manufacturing Employment *which:* **Selected High-tech Sectors:**	308,031	355,941	310,130
Chemical Products (incl. man-made fibres)	21,409	26,128	26,420
Computers and Instrument Engineering	46,149	77,485	40,750
Electrical Machinery and Equipment			21,030
Selected Traditional Manufacturing Sectors:			
Food, Drink and Tobacco	64,726	68,405	65,850
Rubber and Plastic Products	14,557	17,540	16,780
Basic Metals and Fabricated Metal Products	17,526	21,981	22,180
Transport Equipment	18,647	20,882	19,200
Textiles and Textile Products	45,105	29,869	11,090

Source: See Tables 1.5 and 1.7, this report

Note: (1) Data is for 'persons engaged' – includes proprietors and unpaid family members if applicable; December 2004 figures are provisional; (2) Computers and Instrument Engineering combines NACE Sectors 30 and 33. Electrical Machinery and Equipment combines NACE Sectors 31 and 32. (3) Figures for 1994 and 1999 shown for Electrical Machinery and Equipment refer to both that sector and the Computers and Instrument Engineering Sector together.

Figure 1.2 Island of Ireland Manufacturing Employment



This table indicates that total manufacturing employment in 2004 was almost the same as ten years earlier. Within manufacturing, the 'Textiles and Textile Products' category declined sizeably on the island but most of this was compensated for by an increase in high-tech employment. This was particularly true for Ireland, which experienced a greater 'modernisation' of its manufacturing employment than did Northern Ireland.

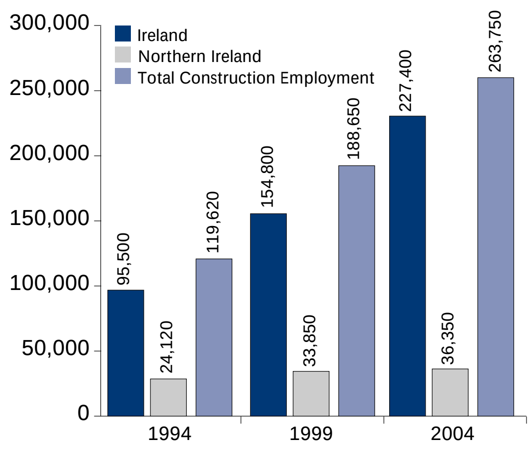
The decade to 2004 also saw a strong growth in construction employment in both parts of the island, as shown in Table 1.9.

Table 1.9 Construction Employment in Ireland and Northern Ireland, 1994, 1999 and 2004

	1994	1999	2004
Ireland	95,500	154,800	227,400
Northern Ireland	24,120	33,850	36,350
Total Construction Employment	**119,620**	**188,650**	**263,750**

Source: CSO, Quarterly National Household Survey (Various) and Department of Enterprise, Trade and Investment (2005), Northern Ireland Quarterly Employment Survey

Figure 1.3 Construction Employment in Ireland and Northern Ireland, 1994, 1999 and 2004



The exceptional growth in construction employment in Ireland reflects the infrastructure deficit that became apparent as the country became a high-income country very quickly. It also reflects a sustained housing boom over the period. The high level of construction activity is forecast to continue. In Ireland, a successor to the National Development Plan, which will continue to address infrastructure deficits, will start from 2007, and the government has indicated an investment of €90bn on strategic infrastructure projects over the coming decade.[12] Northern Ireland's Draft Investment Strategy for 2005-2015 envisages an investment of £16bn (about €24bn) on public infrastructure.[13]

1.4 Moving into the Top 5 by 2020

The Task Force which compiled this report took as its point of departure that the island economy would be in the Top 5 in the world by 2020 in terms of income per capita.

Defining the growth rate required to achieve this situation was assisted by a 2003 Goldman Sachs paper discussing economic trends to 2050. This provided GDP per capita forecasts for the US and Japan for 2020 (both existing Top 5 economies), as well as forecasts for the UK and Germany. Table 1.10 also shows figures for China and India, for comparison purposes.[14]

Table 1.10 Projected GDP per capita Growth Rates to 2020 and Projected GDP per capita Figures (US$) for 2020, Selected Countries

Country	GDP per Capita Growth 2005-10	GDP per Capita Growth 2010-15	GDP per Capita Growth 2015-20	GDP per Capita 2020
United States	1.7%	1.3%	1.3%	$48,849
Japan	0.9%	1.2%	1.8%	$42,359
UK	1.9%	1.9%	1.6%	$36,234
Germany	2.0%	1.6%	1.3%	$31,000
China	11.2%	9.2%	7.8%	$4,965
India	7.5%	7.4%	7.2%	$1,622

Source: Goldman Sachs (2003)

Note: Per capita figures expressed in US$, 2003 prices

12 Speech by Noel Treacy TD, Minister for European Affairs, at Inter*Trade*Ireland All-Island Construction Seminar, Dundalk, 27 May 2005.

13 Inter*Trade*Ireland has been working in 2005 to establish a cross-border construction forum to support collaboration between construction companies in meeting infrastructure needs of the island.

14 Their very low starting points mean that China and India are estimated to be well behind the leading countries in GDP per capita in 2020. However, the Goldman Sachs analysis shows that their high growth rates means the gap is closed considerably by 2050 (e.g. China at 64 per cent of German and 77 per cent of Italian GDP per capita).

While the Goldman Sachs paper does not make forecasts for Norway, Switzerland and Denmark (the remaining members of the Top 5 club in 2003), estimates published by the Brookings Institution (2004) for the euro zone show future growth scenarios for this zone as a whole are expected to be similar to historical patterns. As such, excluding unexpected factors, one could assume growth rates of 2–3 per cent per year for these economies. The economy for which an unexpected factor could arise is Norway, aided as it is by its high oil revenues.

An assumption that growth in Norway, Switzerland and Denmark will broadly continue at the same rate allows us to take the GDP per capita figures for the US and Japan (ranked third and fourth respectively for 2003 in Table 1.2) as proxies for where the island of Ireland will need to be in 2020. Given their projected figures of US$48,849 and US$42,359, it is safe to assume that the island will be in the Top 5 economies in terms of GNP per capita (i.e. GNI) by 2020 if it achieves a level of US$45,000 per year.

Per capita calculations require estimates of population and these are available for both parts of the island for 2020. Estimates by the CSO (for Ireland) and the Northern Ireland Statistics and Research Agency (NISRA) show that the populations for the island of Ireland are estimated to be 5.02m and 1.81m respectively by 2020, giving an all-island total projected population of 6.83m[15], an increase of 20 per cent over the estimated 2003 population[16].

Given that:

- the average estimated GNP per capita (i.e.GNI) for the island in 2003 was US$25,778 (as per Table 1.2) and would need to move to US$45,000 in 2020;
- the population of the island is expected to move from 5.7m in 2003 to 6.83m;
- total GNP for the island must therefore rise from some $146.9bn to $307.4bn (2.1 times bigger in real terms-figures at 2003 prices);
- average annual growth of approximately 4.5 per cent per year would be needed in island GNP over the 17 years from 2003 to 2020 for this outcome to be achieved.

Growth for the island economy in 2004 and 2005 has been at around this rate (i.e. 4.5 per cent), with growth somewhat higher in Ireland and somewhat lower in Northern Ireland. The challenge is to continue to achieve average growth at this rate for the next 15 years. Growth of this magnitude is in line with what the Economic and Social Research Institute (ESRI) (2003) considers Ireland's potential growth rate up to 2010 but higher than its 'benchmark forecast' thereafter.[17] Such growth might therefore require policy changes not currently factored into the ESRI assumptions, to ensure that congestion problems emerging in the economy are overcome. It may also require productivity growth in areas such as construction and the services sectors, and further structural evolution in the Northern Ireland economy to increase its economic growth potential. It will include returns to companies from Ireland and Northern Ireland on investments made outside the island – such 'Outward Direct Investment' is making an increasingly important contribution to GNP growth.

This growth required to reach the Top 5 level by 2020 is lower than the average growth achieved between 1989 and 2003, as shown in Table 1.1. Over that period, the population of the island expanded from an estimated 5.1m to 5.7m. Given this growth in population, the increase achieved in terms of income per capita (see Table 1.1) required a total increase in income of 108 per cent on the island over the period. This represented an annual average compound rate of growth on the island of 5.3 per cent over the 1989-2003 period.

1.5 Trends in Global Environment to 2020

In discussing the possible evolution of the Irish economy to 2020, the Task Force appreciates that the world economy itself will evolve considerably over that period. As such, the context in which the very small economy of the island of Ireland operates will be very different to the context in which rapid growth was achieved in the past decade. Depending on how these trends evolve, different detailed scenarios for the island's economic development will emerge. A number of high level trends in this regard are shown in Table 1.11, taken from a report commissioned by the US National Intelligence Council, which was based on consultations with non-governmental experts around the world.

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15 CSO (2004a) and Northern Ireland Statistics and Research Agency (2003). The figure for Ireland is based on the CSO scenario that assumes high inward migration and medium fertility rates, which the Task Force felt was the most realistic of the CSO scenarios.

16 2003 estimates for population were just under 4m for Ireland and 1.7m for Northern Ireland.

17 The 4.5 per cent growth figure to reach the Top 5 has been calculated by combining a GNP per capita target for 2020 with a CSO population scenario. A similar income per head could be achieved with a lower GNP growth rate if a somewhat lower population was envisaged.

Table 1.11 Aspects of the 2020 Global Economic Landscape

Relative Certainties	Key Uncertainties
Globalisation largely irreversible, likely to become less Westernised	Whether globalisation will pull in lagging economies; degree to which Asian countries set new 'rules of the game'
World economy substantially larger	Extent of gaps between 'haves' and 'have nots'; managing or containing financial crises
Increasing number of global firms facilitate spread of new technology	Extent to which connectivity challenges governments
Rise of Asia and advent of possible new economic middleweights	Whether rise of China/India occurs smoothly
Ageing population in established powers	Ability of EU and Japan to adapt workforces, welfare systems, and integrate migrant populations, whether EU becomes a superpower
Energy supplies 'in the ground' sufficient to meet global demand	Possible political instability in energy supply countries; supply disruptions
US will remain single most powerful actor – economically and technologically	Whether US loses its edge in science and technology

Source: Extract from Executive Summary of report by National Intelligence Council (2004)

Most, if not all, of these trends are already evident. However, their continuation will drive changes in how the global economy operates. As examples, the National Intelligence Council report, makes the following observations:

> *"It will be difficult … to turn off the phenomenon of entrenched economic interdependence, although the pace of global economic expansion may ebb and flow. Interdependence has widened the effective reach of multinational business, enabling smaller firms as well as multinationals to market across borders and bringing heretofore non-traded services into the international arena.*
>
> *As governments devote more resources to basic research and development, a rising Asia will continue to attract applied technology from around the world, including cutting edge technology, which should boost its high performance sectors. We anticipate … that the Asian giants may use the power of their markets to set industry standards, rather than adopting those promoted by Western nations or international standards bodies. The international intellectual property rights regime will be profoundly moulded by IPR regulatory and law enforcement practices in East and South Asia."*

1.6 Implications of Achieving a "Top 5 Growth Trajectory"

The Task Force believes the following to be the case:

- As the economy of the island is very small by international standards, and highly open to trade, exports are a fundamental long-term driver of growth.
- While exports of services (e.g. higher education, financial and engineering services) may become increasingly important, manufacturing output and exports will continue to be important drivers of the island's economic performance for the foreseeable future.
- As the levels of average income on the island rise, it becomes less and less viable for manufacturing sectors to compete internationally on cost.
- For *all* manufacturing sectors, this implies a need to upgrade processes, and to develop increasingly 'smart' and 'adaptive' manufacturing processes.
- It also means that a continuing evolution of manufacturing output and employment towards high-tech sectors is both likely and desirable.

- In particular, the Task Force believes that the size and scope of the broad sectors of ICT and bio-technology/pharmaceuticals mean these sectors are of strategic significance. If the island can continue to carve out niche positions in such sectors, it is much more likely to be able to achieve the medium-term growth required to reach the level of the global Top 5 economies by 2020.
- In relation to the ICT sector, the evidence in 2005, both internationally and on the island, is that the sector is once again experiencing strong growth.[18]
- These trends and requirements are reinforced by the growth of China, India, Taiwan and other emerging economies, which the Task Force believes will cause major changes to the structure of the global economy in the coming decades. This will be driven by low wage levels, rapid productivity growth, heavy investment in R&D and aggressive entry into high-tech sectors in the case of China and India and, in the case of Taiwan, aggressive plans to transition in the ICT sector from being a "rapid high-technology follower" to being a "leader". For the island of Ireland, this situation represents a threat (as well as an opportunity) in becoming a leading knowledge economy. Consequently, in the view of the Task Force, such a scenario reinforces the urgency of the strategies required to develop a "knowledge island".

The above strategies can be described as a move to knowledge-based industrial and manufacturing sectors. This is not a new insight – indeed it has been adopted as a core policy maxim of industrial policy in both Ireland and in Northern Ireland in recent years. For example, in Ireland the Enterprise Strategy Group (2004) states: "The challenge for Ireland in the next decade is to build distinct competitive advantages that will sustain high living standards in the face of intense global competition. The key to success lies in building knowledge and expertise to achieve leadership in our target markets." The *Economic Vision for Northern Ireland*, published by the Department of Enterprise, Trade and Investment (2005), has as its vision: "Northern Ireland as a high value-added, highly skilled, innovative and enterprising economy which enables us to compete globally leading to greater wealth creation and better opportunities for all."

The strategies can also be seen as a continuation of the process that has been ongoing for the past 15 years, i.e. employment in more labour-intensive, lower added-value sectors (such as textiles) being replaced by employment in high-tech sectors with much higher output per worker, and a general up-skilling across the economy. For Ireland, for the period 2005–2010, the ESRI's 2003 Medium-Term Review forecasts employment growth in the high-tech sectors of 1.1 per cent per year, with an employment decline of 0.8 per cent per year in traditional manufacturing sectors.

This is not to ignore other sectors of the economy, and the role of internationally traded sectors has already been mentioned above. Indeed, such sectors will also require knowledge-based workers and processes. Furthermore, Tansey (2005) points out that, for Ireland, productivity in *non-traded* service areas is low by international standards and improved productivity in such areas will also be important for medium-term economic growth. Such productivity increases can complement the evolution of a knowledge-based industrial sector.

The Task Force believes that if the island is to achieve a Top 5 ranking in the global economic order by 2020, a core requirement is for its manufacturing sectors to add more value through their activities ("move up the value chain") and embrace knowledge-based processes, both in traditional industrial sectors and through economic activity and employment in high-tech sectors. This implies not just that employment in traditional sectors will be replaced by employment in high-tech sectors but that employees in all sectors will need to have higher levels of education and skills, and correspondingly higher levels of productivity. This is consistent with the 'One Step Up' recommendation of the Enterprise Strategy Group (2004), which called for a formalised programme of lifelong learning across all economic sectors.

While knowledge can be embodied in processes, the Task Force believes that, in building a successful knowledge-based economy on the island, a central requirement will be high-quality human resources. Knowledge is ultimately embodied in people and the quality of human resources on the island will be a key determinant as to whether the island can achieve a Top 5 growth trajectory in the coming 15 years.

1.7 Key Points from Section 1

- Following a strong economic growth performance over the past 10–15 years, the economy of the island of Ireland was ranked 14 in the global economic order in 2003. It is anticipated that the island of Ireland achieved 13th position in 2004.

18 Evidence as regards growth in US IT jobs (which reached record levels in 2004) is available from *www.itaa.org* – in relation to Ireland, see research by DCU Computer School, reported on 27th May 2005.

- There remains a considerable distance (31–68 per cent) between the island and the leading 5 world economies in terms of GNP per capita.
- The past decade has seen an evolution of the manufacturing base on the island. Traditional labour-based sectors, such as textiles, have declined both in Ireland and Northern Ireland. More engineering-based sectors have broadly maintained their employment and seen some output growth. But the key drivers of growth in manufacturing output and productivity have been the high-tech sectors. In particular, in Ireland these have been a key driver of economic growth, although their role has lessened since 2000.
- Economic growth on the island in the past decade has driven, and has been supported by, steady growth in the construction sector. This is set to continue across the island in the medium-term.
- If the island is to achieve a Top 5 position in the world economic rankings by 2020, it would need to grow by just under 4.5 per cent per year. From the perspective of Ireland, this is at the top end of the range of ESRI growth scenarios. It is higher than the growth rate achieved in Northern Ireland in recent years.
- Achieving such growth will require a mix of policies (many – e.g. taxation - outside the scope of this report). In terms of sectoral mix, there will be an increasing role for internationally traded services, and productivity increases in non-traded services sectors will also contribute to growth. However, a central element of achieving a global Top 5 position will be a move to smarter, more adaptive processes and systems in all manufacturing sectors. This will be reinforced by a continuation of the increase in the proportion of manufacturing accounted for by high-tech, knowledge-based sectors, such as ICT and bio-technology/pharmaceuticals.
- Achieving a Top 5 global position for the island by 2020 will require moving to a knowledge economy – developing a “knowledge island”. Central to differentiating the island in this regard, and to succeeding in this objective, will be the quality of human resources - the knowledge-based workforce - available on the island.

Section 2: Changing Demand for Engineering and IT Workers

2.1 Introduction

Having established a goal of being in the Top 5 global economies by 2020, Section 2 moves back to the situation today. Sub-section 2.2 reviews the number of workers in science, engineering and technology (SET) occupations in Ireland and Northern Ireland, and the increase of these workers since 1991. Also reviewed is information on the number of engineers in companies in the sectors identified in Section 1 as especially important to economic growth and, based on data compiled by the Task Force, an analysis is given of the current engineering and IT workforce in 12 companies in these sectors. A number of opinions from these companies as to how they expect their recruitment of engineers and IT workers to evolve to 2020 is then presented.

2.2 Engineering and Science Graduates in Population and Labour Force

In terms of the numbers in the labour force in Ireland with a third-level qualification in an engineering or science subject, Census 2002 showed 117,000 such people. A breakdown is given in Table 2.1, and shows fewer than 4,000 (3.4 per cent) had PhD-level qualifications. A further 8.2 per cent were qualified to Masters level.

Table 2.1 Population Aged 15+ in the Labour Force in Ireland with Third Level Qualifications in Specific Science and Engineering Related Subjects, 2002

	Not Stated	Non-Degree	Degree/ Higher	Masters	PhD	Total
Life Sciences/Medical Lab Science	224	2,156	5,524	1,643	1,386	10,933
Physical Sciences/Chemistry	228	2,900	7,304	1,634	1,572	13,638
Mathematics/Statistics	241	532	2,637	448	239	4,097
Computing/Information Technology	4,116	13,739	14,173	1,633	155	33,816
Engineering/Architecture	3,494	19,668	26,304	4,202	578	54,246
Total	**8,303**	**38,995**	**55,942**	**9,560**	**3,930**	**116,730**
Ratios for those with Engineering/ Architecture Qualification		75	100	16	2	
Ratios for all those with SET Qualifications		70	100	17	7	

Source: CSO, Census 2002, Volume 7, Table 19. Supplementary data from unpublished Working Paper prepared for IRCSET by Dr Aidan Kane of NUIG.

Note: The 'Degree/Higher' column includes those with qualifications higher than degree level, such as Post graduate diplomas, but not those with Masters or PhDs.

The ratios shown in Table 2.1 set the number of people with a highest qualification of "Degree/Higher Diploma" at 100 and then compare the other levels of qualifications. It shows that for every 100 engineers qualified to degree level, there are just over 2 engineers with PhDs. The figure is higher for the wider SET population, at 7 per cent. The table also shows the large number of people in the labour force who have a third-level qualification in engineering or science at below degree level.

An analysis of Census 2002 data for all those in Ireland with third-level qualifications (i.e. not just those with SET qualifications) into Irish and non-Irish nationals is shown in Table 2.2.

Table 2.2 Breakdown of People in Ireland with Third Level Qualifications into Irish/Non-Irish Nationals

Qualification	Irish Nationals		Non-Irish Nationals	
Without TLQ	1,196,618	91.8%	106,740	8.2%
Non-Degree	125,298	92.2%	10,661	7.8%
Degree/Higher	230,413	86.5%	36,054	13.5%
Masters	38,879	83.6%	7,646	16.4%
PhD	6,699	74.0%	2,358	26.0%
Not stated	34,201			
Total	**1,632,108**		**168,825**	

Source: Analysis of CSO, Census 2002 data contained in unpublished Working Paper prepared for IRCSET by Dr. Aidan Kane of NUIG.

The general pattern shown in Table 2.2 is that the higher the level of qualification held by a person in Ireland, the more likely he or she is to be non-Irish, ranging from around 8 per cent for those with no third-level qualifications or a sub-degree level of qualification up to 26 per cent for those with PhDs. Further analysis of the 26 per cent of those with PhDs who are not Irish shows that in 2002:

- 17.5 per cent were from elsewhere in the EU;
- 3.2 per cent were from the US; and
- 5.3 per cent were from elsewhere in the world.

While Table 2.1 relates to SET qualifications, Table 2.3 shows the numbers working in a range of engineering, science and computer-related occupations. It shows a smaller total figure, as some of the people with SET qualifications in the labour force will be working in other areas.

Table 2.3 Number of Workers in Specific Science, Engineering and IT Occupations in Ireland, 1991, 1996 and 2002

	1991	1996	2002
Chemists	817	1,015	1,570
Biological Scientists	1,954	1,785	3,318
Physicists	466	359	562
Other Natural Scientists (not classified elsewhere)	622	1,063	1,727
Civil and Mining Engineers	3,111	3,207	5,066
Mechanical Engineers	1,235	1,776	1,888
Electrical and Electronic Engineers	668	2,659	3,958
Chemical, Production, Planning and Quality Control Engineers	2,237	2,135	3,157
Design and Development Engineers	533	1,070	1,569
Other Engineers and Technologists	501	2,330	5,627
Laboratory Technicians	4,001	5,113	4,989
Engineering Technicians	784	1,027	2,144
Electrical and Electronic Technicians	2,173	4,083	3,795
Architectural, Town Planning, Building and Civil Engineering Technicians	824	1,271	2,793
Other Scientific Technicians (not classified elsewhere)	1,375	2,921	5,977
Computer Systems Managers	1,125	3,425	9,632
Software Engineers	2,021	3,142	7,740
Computer Analyst Programmers	5,000	7,687	16,760
Total	**29,447**	**46,068**	**82,272**

Source: Census, Various Years, Volume 6-Occupations

Reflecting the employment figures in Section 1, Table 2.3 shows strong growth in certain occupational areas in Ireland between 1991 and 2002[19]. It indicates that the total number of workers in engineering, science and computer related occupations was 2.8 times higher in 2002 than in 1991. In specific disciplines:

- The number of civil and mining engineers rose from 3,111 to 5,066 (up 63 per cent), reflecting the construction 'boom' over the period;
- The number of electrical and electronic engineers rose from 668 to 3,958 (up almost six-fold);
- The number of software engineers rose almost fourfold over the period.

Table 2.3 also shows sizeable increases over the period in the numbers of engineering technicians and computer software workers, in part reflecting the growing output of the Institutes of Technology in Ireland during the 1990s.

A summary of Table 2.3, grouping the sub-categories, is shown in Table 2.4.

Table 2.4 Number of Workers in Science, Engineering and IT Occupations in Ireland, 1991 and 2002

	1991	2002	Change Percentage
Scientists + Science Technicians	9,235	18,143	96
Engineers + Assoc. Technicians	12,066	29,997	149
IT and Computer Workers	8,146	34,132	319
Total SET Workers	**29,447**	**82,272**	**179**

Source: Census 1991 and 2002, Volume 6-Occupations

Note: (1) Software engineers have been included with ICT and computer professionals; (2) Electronic and electrical technicians have been included with Engineers and Assoc. technicians

Table 2.4 shows that:

- the number of engineers and associated technicians in Ireland grew by 149 per cent in the 11 years to 2002; and
- the number of IT workers grew by over 300 per cent over the same period.

Northern Ireland has also seen a strong growth in the number of workers with science- and technology-based qualifications, as shown in Table 2.5. Here a similar growth pattern to Ireland can be seen, although with somewhat lower rates of growth.

Table 2.5 Number of Workers in Science, Engineering and IT Occupations in Northern Ireland, 1991 and 2001

	1991	2002	Change Percentage
Scientists + Science Technicians	5,082	5,957	17
Engineers + Assoc. Technicians	7,044	10,386	47
IT and Computer Workers	1,736	7,947	358
Total SET Workers	**13,862**	**24,290**	**75**

Source: Northern Ireland Census, 1991, Economic Activity Report, Tables 1A and 1B – 2001, specially commissioned table, available from NISRA

Note: (1) The categorisation of occupations changed between the 1991 and 2001 Censuses – figures shown for 2001 were built up from a lower level to approximate the 1991 categories. (2) "Science and Engineering Technicians (not classified elsewhere)" in 2001 is allocated 50/50 to science and engineering. There is only one technicians category in 1991 – "Scientific Technicians" – this is allocated 60/40 to science/engineering, similar to the breakdown of technicians in Ireland in that year

This table indicates that, over the 1991 – 2001 period, the number of SET workers in Northern Ireland increased by 75 per cent.[20] Specifically:

19 The total labour force in Ireland grew from 1.38m in 1991 to 1.80m in 2002 (Principal Economic Status definition).

20 The number of people defined as "Economically Active" in Northern Ireland rose from 682,000 in 1991 to 739,000 in 2001.

- the number of engineers and associated technicians increased by one-half; and
- the number of IT workers increased more than fourfold over the period.

Adding together the number of SET workers in Northern Ireland in 2001 (24,290) and the number of SET workers in Ireland in 2002 (82,272), we find that there were 106,562 SET workers on the island in 2001-2002, up from 43,309 a decade earlier. In other words:

- The number of engineers and associated technicians on the island rose by 111 per cent over the period; and
- The number of IT professionals rose by 326 per cent.

This rapid growth in the numbers of those with SET qualifications since the start of the 1990s is confirmed by occupational age profiles in the Census data:

- 79 per cent of those in Ireland in the intermediate occupations engineering and allied trades/ computer software/ scientific and technical were aged under 44 in 2002; and
- 67 per cent of those in Northern Ireland who were science and technology professionals or associate professionals were aged 39 or under in 2001.

2.3 Link between Growth in SET Occupations and Economic Growth

2.3.1 Economic Growth and Growth of SET Workers

Reviewing the above numbers in the context of the economic growth experienced by both jurisdictions of the island in the past 15 years (discussed in Section 1) shows that strong economic growth coincided with large increases in the number of engineering, science and computer-related workers. However, going beyond this general comparison, there is evidence that the large increase in SET workers has directly driven economic growth. This is based on:

- evidence that graduates in SET subjects are more likely to enter jobs in strong growth high-tech sectors; and
- evidence from companies in these sectors is that they tend to hire SET graduates.

The latter point is discussed here, in the context of data gathered by the Task Force from a number of companies in high-tech sectors. However, the former point is based on data on the 'first destination' of graduates. Data on the first destination of engineering graduates in Ireland is shown in Table 2.6.

Table 2.6 Sectoral Destination of Engineering Graduates (Primary Degrees), Ireland, 2001, 2002 and 2003

	2001	2002	2003
Sector		**Percentage**	
Pharmaceuticals	3.3	5.6	5.0
ICT	22.9	20.1	21.0
Construction	27.7	27.5	35.0
Total Percentage of Engineers going to these sectors	**53.9**	**53.2**	**61.0**

Source: Higher Education Authority, First Destination of Awards Recipients in Higher Education, Various Years. Figures for 2003 are provisional, as supplied to the KI 2020 Task Force by the HEA.

Note: Percentages are of people taking jobs with employers in Ireland following graduation.

The number of engineers taking employment in the pharmaceutical sector following graduation is low – this sector tends to recruit science graduates. However, Table 2.6 shows that between 50 per cent and 60 per cent of people receiving primary engineering degrees in 2001–2003 took jobs in the three sectors indicated.

The years shown in Table 2.6 coincided with relatively lower new IT employment compared to the late 1990s. This is demonstrated by an analysis undertaken by the Expert Group on Future Skills Needs (2003) in its report *The Demand and Supply of Engineers and Engineering Technicians*. The Expert Group undertook a detailed analysis of the first destination of engineering graduates in 2000, as shown in Table 2.7. Comparing this data to the destination of engineering graduates in the preceding years, the report states: "A more detailed analysis of data on graduate destinations for graduates of 2000 is likely to be reasonably representative of earlier years."

Table 2.7 Estimated Destination of Primary Engineering Graduates by Sector and Discipline, Ireland, 2000

Destination Sector	Civil	Chemical Process	Computer	Electronic	Mechanical	Manufacturing/ Industry	Other	Total
Software/IT Services	42	4	20	135	16	38	6	**261**
Electronic H/w and IC Prod.	0	8	7	57	26	79	6	**183**
IC Design	0	0	7	46	0	5	1	**59**
Telecom Services	5	0	1	39	0	0	10	**55**
Medical Services	0	0	0	2	16	13	5	**36**
Pharmaceuticals	0	20	0	2	3	4	1	**30**
Other Manufacturing	5	12	0	0	47	34	21	**119**

Source: Expert Group on Future Skills Needs (2003), Appendix A – Statistical Appendix

The analysis of the Expert Group for 2000 shows that:

- medical devices and pharmaceuticals accounted for 8 per cent of engineering graduates;
- the ICT sector (first four rows combined) provided jobs for 49 per cent of those graduating with a primary degree in engineering in 2000; and
- construction accounted for 25 per cent of engineering graduate jobs.

The ICT, biotechnology/pharmaceutical and construction sectors employed over 80 per cent of new engineering graduates in Ireland in 2000 and regularly employ over 50 per cent of engineering graduates.

The 2000 data also provides a pattern across different engineering disciplines:

- the ICT sector mainly employs electronic engineers, with smaller numbers of civil, manufacturing/industrial, computer and mechanical engineers;
- of the engineers it recruited, the medical devices sector mainly employed mechanical and manufacturing/industrial engineers, and the pharmaceutical sector mainly employed chemical/process engineers; and
- the construction sector mainly employed civil engineers, with lesser numbers of chemical/process and mechanical engineers.

Having reviewed the movement of engineering graduates into different sectors of the economy, the Expert Group states: "There is a close correlation between the sectors where employment growth has occurred and the sectors which mainly recruit engineers."

This is not to oversimplify the relationship between the production of SET graduates and economic growth. For example, part of the picture is the ability to attract inward investment to match the graduate skills available, and this has been a challenge in both Ireland and Northern Ireland. There is also a longer-term relationship between investment in third-level education and productivity/economic growth.[21]

2.3.2 Importance of Engineers in Key Sectors

Section 1 identified the ICT and bio-pharmaceutical/bio-medical sectors as important to the future of manufacturing on the island of Ireland, with construction continuing to have a major supporting role in economic development. Table 2.8 looks at a sample of some 20 companies in these sectors on the island of Ireland in 2005 and shows the proportion of their current workforce comprised of engineers. The 22 companies are part of the Engineers Ireland Continuous Professional Development (CPD) Programme, and are thus likely to be conscious of the importance of engineering skills to their work. They represent some of the largest manufacturing companies in Ireland and together provide a sample number of employees of approximately 25,000.

21 See, for example, the paper by Hamilton (2005) on the role of education in the strong economic growth in Ireland in the 1994–2003 period.

Table 2.8 Proportion of Engineers and Engineering Technicians in Companies in ICT, Bio-pharmaceutical/Bio-medical and Construction sectors, based on Engineers Ireland membership, 2005

Sector	Number of Employees	Number of Engineers	Engineers as Percentage of Employees
ICT	10,960	5,090	46
Bio-pharmaceutical, Bio-medical	9,172	1,164	13
Construction	4,447	973	22
Total	**24,579**	**7,227**	**29**

Source: Engineers Ireland

Note: Participating companies covered: ICT – Analog Devices; HP European Software Centre; HP Inkjet Manufacturing; IBM International Holdings; Intel; Lucent Technologies; Motorola; Xilinx. Bio-medical/bio-pharmaceutical – Bausch & Lomb; Bayer Diagnostics; Boston Scientific; Bristol Myers Squibb (Swords Lab); Depuy Johnson & Johnson; GlaxoSmithKline; Inamed Aesthetics; Pfizer, Wyeth. Construction – Arup; Ascon/Rohcon; Kirk McClure Morton; PJ Hegarty; Project Management Group.

Figure 2.1 Percentage of Engineers and Engineering Technicians in Companies in ICT, Bio-pharmaceutical/Bio-medical and Construction sectors, based on Engineers Ireland membership, 2005

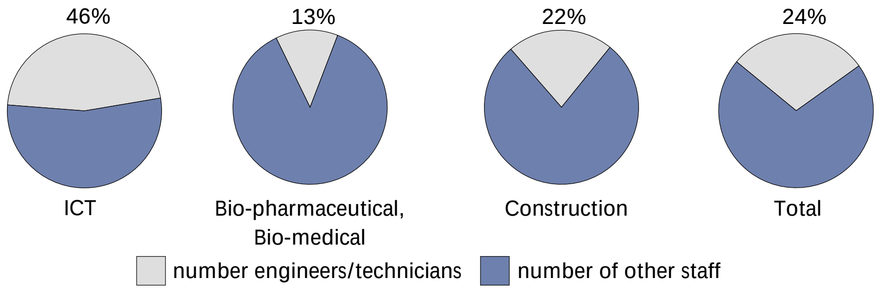


Table 2.7 shows a high demand for engineers and engineering technicians in the ICT sector, where 46 per cent of employees have these occupations. This supports the data presented earlier showing that a high proportion of graduate engineers tend to move into employment in the ICT sector. The proportion of engineering employees in the bio-medical/bio-pharmaceutical sector is smaller (13 per cent), reflecting a tendency to hire science graduates. The 22 per cent figure for the construction sector reflects the demand for engineers from construction and consulting engineering companies.

2.4 Employment Pattern of SET Workers in Leading Companies

2.4.1 Current Employment Patterns in Leading Sectors

The Task Force was interested in the following question: If manufacturing industry on the island is to grow in ways which will maximise overall economic growth, how is the demand for engineers likely to evolve? To this end, the Task Force sought data from a number of leading companies on the types of engineers employed, and their level of qualifications. The hypothesis adopted was that these companies (in high-tech areas and in construction) are more likely to reflect future requirements for engineers than companies in other sectors. Tables 2.9, 2.10 and 2.11 are not intended to be representative of the wider sectors – they constitute an indicative profile of the disciplines and level of qualifications of workers with engineering and science qualifications in 12 leading companies across the three sectors. These include large companies and small and medium enterprises (SMEs).

Table 2.9 shows the profile of such workers for 4 companies in the ICT sector.

Engineers in the ICT companies surveyed were mainly electronic engineers and computer scientists/engineers. There were relatively large supporting numbers of electrical engineers and manufacturing/industrial engineers. The ratios show the importance of sub-degree qualifications in the ICT sector. They also show that, for every 100 SET workers with primary degrees, about 13 have a Masters and 5 have PhDs. The Masters figures are similar for the engineering and IT workers, but the proportion of these workers with PhDs is lower.

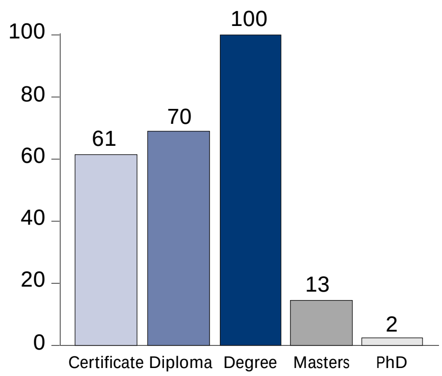
Table 2.9 Breakdown of Engineers and IT workers in 4 Leading Companies in ICT Sector, May 2005

	Certificate	Diploma	Degree	Masters	PhD	Total
Electrical + Electronic	59	249	280	41	8	637
Computers + Computer Science	168	46	223	17	0	454
Mechanical	61	49	16	4	0	130
Chemical + Process	0	0	2	3	1	6
Bio-medical	0	0	0	0	0	0
Bio-systems, Food & Agriculture	0	0	2	0	0	2
Structural	0	0	0	0	0	0
Civil	0	0	0	0	0	0
Environmental	0	0	0	0	0	0
Manufacturing/Industrial	18	36	15	3	3	75
Materials	0	0	0	1	1	2
Building Services	0	0	0	0	0	0
Aeronautical	22	1	1	0	0	24
Mechatronics/Electromechanical	0	0	3	0	0	3
Science-Physics	0	1	16	1	11	29
Science-Chemistry	0	0	4	3	2	9
Science-Biology	0	0	0	0	0	0
Mathematics	0	0	6	1	1	8
Total – All SET in Table	*328*	*382*	*568*	*74*	*27*	*1,379*
Total – Engineers + IT	*328*	*381*	*542*	*69*	*13*	*1,333*
Ratio – All SET in Table	**58**	**67**	**100**	**13**	**5**	
Ratio – Engineers + IT	**61**	**70**	**100**	**13**	**2**	

Source: Information collected for KI 2020 Task Force

Note: (1) Based on data from Xilinx, Motorola, FISC Ireland and Intel (data from Intel is for new hires over the period start-2004 to April 2005); (2) Ratio for engineers and IT workers calculated from first 14 rows in table.

Figure 2.2 Breakdown of Engineers and IT workers in 4 Leading Companies in ICT Sector



Note: Ratios relate to degree index at 100

Table 2.10 shows the same data for 5 companies from the bio-pharmaceutical/ bio-medical sector.

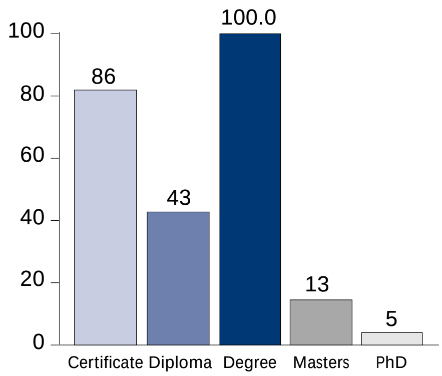
Table 2.10 Breakdown of Engineers and IT workers in 5 Leading Companies in Bio-pharmaceutical/Bio-medical Sector, May 2005

	Certificate	Diploma	Degree	Masters	PhD	Total
Electrical + Electronic	109	40	23	0	1	173
Computers + Computer Science	44	25	44	5	1	119
Mechanical	128	29	94	9	3	263
Chemical + Process	4	14	111	9	5	143
Bio-medical	0	3	13	4	3	23
Bio-systems, Food & Agriculture	2	15	10	4	0	31
Structural	0	0	1	0	0	1
Civil	1	1	1	0	0	3
Environmental	0	4	5	2	3	14
Manufacturing/Industrial	51	29	78	13	2	173
Materials	3	3	10	6	0	22
Building Services	0	5	0	0	0	5
Aeronautical	0	2	0	0	0	2
Mechatronics/Electromechanical	3	1	12	0	0	16
Science-Physics	1	7	20	0	0	28
Science-Chemistry	49	138	179	26	101	493
Science-Biology	27	21	131	28	10	217
Mathematics	11	26	11	0	0	48
Pharmaceutical/Bio-technology	2	9	52	21	6	90
Total – All SET in Table	*435*	*372*	*795*	*127*	*135*	*1,864*
Total – Engineers + IT	*345*	*171*	*402*	*52*	*18*	*988*
Ratio – All SET in Table	**55**	**47**	**100**	**16**	**17**	
Ratio – Engineers + IT	**86**	**43**	**100**	**13**	**5**	

Source: Information collected for KI 2020 Task Force

Note: (1) Based on data from Boston Scientific, Wyeth, Pfizer, Bausch & Lomb (Waterford), Elan; (2) Pharmaceutical/bio-technology row not in other tables but was added by the companies surveyed; (3) Ratio for engineers and IT workers calculated from first 14 rows in table.

Figure 2.3 Breakdown of Engineers and IT workers in 5 Leading Companies in Bio-pharmaceutical/Bio-medical Sector



Note: Ratios relate to degree index at 100

This table indicates a much larger proportion of people in the bio-technology sector with science backgrounds. The single largest cohort is chemists, followed by mechanical engineers (mainly technicians), biologists and manufacturing/industrial engineers.

Analysis of the level of qualifications across the companies surveyed again shows a high level of people at sub-degree level. There is a higher number with postgraduate qualifications present than in the ICT sector and this is particularly true for those with science backgrounds. The figure for employees with a science background who have PhDs is particularly high.

Table 2.11 shows the same data for 3 companies from the construction sector.

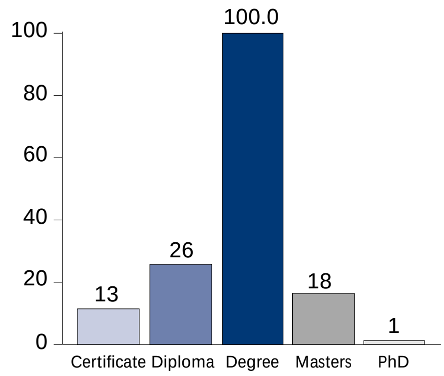
Table 2.11 Breakdown of Engineers and IT workers in 3 Leading Companies in Construction Sector, May 2005

	Certificate	Diploma	Degree	Masters	PhD	Total
Electrical + Electronic	10	16	22	3	0	51
Computers + Computer Science	4	4	12	1	0	21
Mechanical	9	8	97	6	0	120
Chemical + Process	3	1	37	3	2	46
Bio-medical	0	0	0	0	0	0
Bio-systems, Food & Agriculture	1	0	5	1	0	7
Structural	1	8	15	10	0	34
Civil	28	39	229	32	1	329
Environmental	0	2	15	19	1	37
Manufacturing/Industrial	1	4	8	2	0	15
Materials	0	1	1	1	0	3
Building Services	2	38	32	6	0	78
Aeronautical	0	1	1	0	0	2
Mechatronics/Electromechanical	1	1	3	0	0	5
Science-Physics	0	0	5	1	0	6
Science-Chemistry	1	2	8	2	1	14
Science-Biology	0	0	0	0	0	0
Mathematics	0	0	3	0	0	3
Total – All SET in Table	*61*	*125*	*493*	*87*	*5*	*771*
Total – Engineers + IT	*60*	*123*	*477*	*84*	*4*	*748*
Ratio – All SET in Table	**12**	**25**	**100**	**18**	**1**	
Ratio – Engineers + IT	**13**	**26**	**100**	**18**	**1**	

Source: Information collected for KI 2020 Task Force

Note: Based on data from Cement Roadstone Holdings, Project Management, and Arup; (2) Ratio for engineers and IT workers calculated from first 14 rows in table.

Figure 2.4 Breakdown of Engineers and IT workers in 3 Leading Companies in Construction Sector



Note: Ratios relate to degree index at 100

The data for the construction sector indicates that 43 per cent of SET workers are civil engineers, with a further 10 per cent employed as building services engineers. Almost 16 per cent are mechanical engineers. Given the companies involved, the results may overemphasise the profile of consulting engineering companies.

This table indicates that the focus on the degree level is highest in this sector, with almost two-thirds of SET workers being recruited at that level. There are relatively fewer people employed (in the companies surveyed) at sub-degree level. The ratio of workers with Master qualifications, compared to those with primary degrees, is slightly higher than in the other two sectors, but the proportion with PhDs is lower. The companies employ a low number of science graduates.

2.4.2 Trends in Hiring of SET Workers by Leading Companies

Tables 2.9, 2.10 and 2.11 show the pattern of employment of SET workers in companies in sectors important to the future of the island economy. Data from leading companies in these sectors are indicative as to how other companies' workforces will need to evolve. However, the profile of the workforce in the leading companies will also continue to evolve to 2020. A number of the companies which provided data for these tables commented on how their pattern of employment was evolving. A sample of their comments follows:

- "In terms of applications, we are hiring more at Masters level over time. We are seeing more people applying with a combination of IT and a business studies element, as opposed to pure computer science." *(Large ICT company)*
- "We see PhDs increasing in 2020 in our hiring pool to 30-40 per cent; Masters 30-40 per cent, the rest BS degrees. This is the profile for our engineers – we will also need IT people with the continued increase in automation complexity, and Cert/Diploma technicians. The required graduates will come from the more traditional science world of physics, chemistry and perhaps even biology, with material/surface sciences playing a key role. We will also need a new breed of graduates from a nanotechnology[22] world." *(Large ICT Company)*
- "There is a move from mechanical engineers to specialised bio-medical graduates, who can integrate into the company's work more quickly. There is also a move to hire more science graduates. We see a consequent up-skilling of workers in sub-supply companies." *(Large medical devices company)*
- "There is a strengthening of qualifications over time, as our Irish operation expands, and as manufacturing processes become more sophisticated. The proportion of engineers and science graduates in the company will rise over time and the proportion of new engineering and science graduates with PhDs could be as high as 15–20 per cent by 2020. There is also a process of up-skilling employees with lower levels of skills over time." *(Large pharmaceutical and health-care company)*
- "We are hiring fewer people with diplomas and certificates over time, with the majority now having degrees and some areas, such as Environmental Engineering, having a Masters qualification as the entry requirement. Over time, the number of employees with Masters Qualifications will increase." *(Consulting Engineering Company)*

2.5 Key Points from Section 2

- In Ireland, in 2002 there were 117,000 people with SET qualifications in the labour force, of which 54,000 had engineering qualifications.
- For every 100 with primary engineering degrees, there were 75 with sub-degree qualifications, about 16 with a Masters degree and just over 2 with PhDs.
- The figures for postgraduate qualifications are higher for workers with science qualifications than for workers with engineering qualifications.
- For all people with third-level qualifications in Ireland, the higher the qualification, the higher the proportion from outside Ireland;
- Between Ireland and Northern Ireland, there were over 40,000 people working as engineers or engineering technicians in 2001–2002 – an increase of 111 per cent since 1991.
- In 2001-2002, there were 42,000 IT workers on the island, up 326 per cent since 1991.
- The link between the growth of SET workers and wider economic growth can be seen through the pattern of SET graduates taking employment in strong growth sectors. This has been confirmed by the Expert Group on Future Skills Needs.
- Data from Engineers Ireland on the employment patterns of companies from these growth sectors on its CPD Programme show a high proportion of engineers in the workforce of these companies. This indicates that companies in growth sectors have higher numbers of graduates than the generality of companies.

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22 The branch of technology that deals with dimensions and tolerances of less that 100 nanometers, particularly the manipulation of individual atoms and molecules.

- Data from specific companies in leading sectors show the importance of graduates to their work. The ratio of people with Masters and PhDs is not dissimilar to the wider population, perhaps because these sectors account for the employment of many people with such qualifications. As the wider population also includes those in academic work, the data from the leading companies indicate a higher level of qualifications in their workers than in the average company.
- As in the wider population, the proportion of workers in leading companies with a postgraduate qualification (especially a PhD) is higher for people with a science background than for those with an engineering background.
- Comments on future recruitment trends by leading companies express the view that the proportion of their total workforce made up of graduates will increase further, and the proportion with postgraduate qualifications will increase. One large pharmaceutical company stated that, by 2020, up to 20 per cent of its SET graduate employees could have PhDs, and one large ICT company said the figure for its workforce could be as high as 30 per cent.

Section 3: Creating a World Class R&D Capability

3.1 Introduction

Section 1 suggested that the future of manufacturing on the island will be linked to higher value-added activities, including 'smart' and 'adaptive' manufacturing. This is true for the strong growth sectors of ICT and bio-technology, and also for other manufacturing sectors using ICT in their core processes. The move to higher value-added activities, and the general move to a 'knowledge economy' is closely linked to investment in research and development.

The importance of R&D is recognised at policy level in Ireland and in Northern Ireland. In Ireland, an *Action Plan for Promoting Investment in R&D to 2010* was published in July 2004 (Inter Departmental Committee on Science, Technology and Innovation, 2004). This states: "Sustained investment in R&D is an essential foundation to maintain the competitiveness of the enterprise base and to develop Ireland as a knowledge-based society." This commitment has been backed by significant R&D spending in recent years, including in the National Development Plan. The Northern Ireland Economic Council (NIEC) stated in 1999: "It is vital that Northern Ireland has an R&D and innovation strategy, given the close connections between research and development, innovation and economic performance." A Regional Innovation Strategy for Northern Ireland (Think/ Create/ Innovate) was subsequently published by an Inter-Departmental Working Group (IDWG, 2003) and an Action Plan to implement this strategy is now in operation.

Section 3 looks at how the island is currently positioned as regards its spending on R&D, in industry and in higher education, and on the numbers of researchers it has compared to the leading global economies. It also reviews emerging Research and Technology Development (RTD) centres of excellence on the island, including examples linked to higher education institutions and examples from industry. In doing so, it focuses both on a strategic area of importance for the island's economic development, and on a specific area of growing demand for graduates with science, engineering and IT qualifications.

3.2 Reviewing the Island's R&D Positioning

3.2.1 Existing Targets for Research and Development Expenditure

Overall R&D spend in an economy is measured by Gross Expenditure on Research and Development (GERD). As part of the 'Lisbon agenda', EU Member States have a target for GERD of 3 per cent of GDP by 2010. This compares to an EU figure for GERD in 2002 of 1.9 per cent of GDP. Two-thirds of the required increase in R&D should come from the business sector. GERD incorporates:

- Business Expenditure on R&D (BERD);
- Higher Education Expenditure on R&D (HERD); and
- A small amount of other government expenditure on R&D.

Figures for the island of Ireland show GERD well behind the EU 2010 target of expenditure of 3 per cent of GDP, with Ireland having an estimated a figure of 1.38 per cent (of GNP) and Northern Ireland having an estimated figure of 1.43 per cent of GDP in 2001. The proportion of total output of the economies of both parts of the island spent on R&D therefore would need to more than double to reach a 3 per cent level.[23] Given expected GDP growth on the island over the period, real expenditure will have to increase by significantly more than this. The Top 5 economies mentioned in Section 1 as economies the island should match by 2020 all have GERD figures well above that of Ireland, with Japan spending above 3 per cent already and the US, Switzerland and Denmark all above 2.5 per cent. Indeed, Sweden (not a current Top 5 country) has a figure of over 4 per cent.[24]

The next two sub-sections look at current research expenditure and levels of R&D personnel on the island, and the increases required in expenditure and personnel if the island is to approach a global Top 5 position.

23 In 2004, the Irish government adopted a target for GERD of 2.5 per cent of GNP by 2010.

24 Data taken from OECD (2004) – Main Science and Technology Indicators.

3.2.2 Business Expenditure on R&D

Details of BERD expenditure on the island is shown in Table 3.1. The most recent data shows EU-average BERD at 1.24 per cent and the OECD-average BERD at 1.54 per cent of GDP. Both Ireland and Northern Ireland were below the 1 per cent level.

Table 3.1 Business Expenditure on R&D (BERD) – Ireland and Northern Ireland – Current Prices, 2001- 2003

	Ireland		Northern Ireland	
	2001	2003	2002	2003
BERD	€900m	€1,076m	£157m (€231m)	£121m (€178m)
BERD as percentage of GNP/GDP	0.93 (GNP)	0.97 (GNP)	0.82 (GDP)	0.55 (GDP)

Source: Forfás (2005); Department of Enterprise, Trade and Investment NI (2004). Preliminary figure for NI GDP taken from UK regional accounts.

BERD in Ireland has risen steadily in the past decade, from a base of €343m in 1993 (in current prices). In Northern Ireland, there was a fall-back in BERD in 2003; the data suggests this was linked to a fall in R&D expenditure by a number of large firms. The ten biggest spenders in 2003 accounted for 46 per cent of Northern Ireland business R&D expenditure – compared to 69 per cent in 2001.

There is a somewhat different pattern of R&D expenditure between Ireland and Northern Ireland as regards the sectors in which BERD occurs.

Table 3.2 Top 5 Sectors for BERD, Ireland and Northern Ireland, 2003

Ireland per cent			Northern Ireland per cent		
1.	Software/Computer related	35.2	1.	Electrical and Optical Equipment	39.8
2.	Electrical/Electronic Equipment	19.7	2.	Chemcials, Fibres	17.8
3.	Pharmaceuticals	17.7	3.	Food, Drink and Tobacco	15.4
4.	Instruments	10.8	4.	Machinery and Equipment	8.8
5.	Food, Drink and Tobacco	3.9	5.	Transport Equipment	5.3

Source: Forfás (2005); Department of Enterprise, Trade and Investment NI (2004)

Note: The electrical and optical equipment sector in Northern Ireland is broadly defined and contains elements of Sectors 1, 2 and 4 in Ireland

Table 3.2 shows a concentration of BERD expenditure in Ireland in high-tech sectors, with 85 per cent of BERD in 4 sectors. R&D in Northern Ireland is spread across more sectors, with spend in traditional sectors continuing to feature, complementing spend in technology sectors. To some extent, this mirrors manufacturing employment on the island, as outlined in Section 1.

The BERD surveys provide information on the number of researchers and research personnel (i.e. technical and support staff) engaged in business R&D.[25] In Ireland in 2003, there were 9,280 people employed in BERD research, comprising:

- 396 researchers with PhDs (4.3 per cent of total);
- 5,616 researchers without PhDs (60.5 per cent);
- 1,909 technical staff (20.6 per cent); and
- 1,359 support personnel (14.6 per cent).

Of these people, 78 per cent were male (ranging from 82 per cent of PhD researchers down to 69 per cent of support personnel). Of the total, some 42 per cent were employed in the software/ computer sector, 21.8 per cent in the electrical and electronic equipment sector, 6.4 per cent in pharmaceuticals, and 8.5 per cent in the instruments sector, meaning almost 80 per cent came from these 4 sectors.

25 Data in this section refers to the number of 'Full-time Equivalent' employees.

In Northern Ireland, there were 2,770 full-time equivalent personnel working in business R&D activities in 2003:

- 1,910 scientists (69 per cent);
- 460 technicians (17 per cent); and
- 400 other employees (14 per cent).

Using the international benchmark of "Business Researchers per 1,000 Industrial Employment" Forfás reported in 2003 that Ireland had a ratio of 4.5 business researchers per 1,000 people in industrial employment. Using the same measure, the equivalent figure in Northern Ireland was approximately 4.75 business researchers. (These figures do not include technicians or support personnel.)

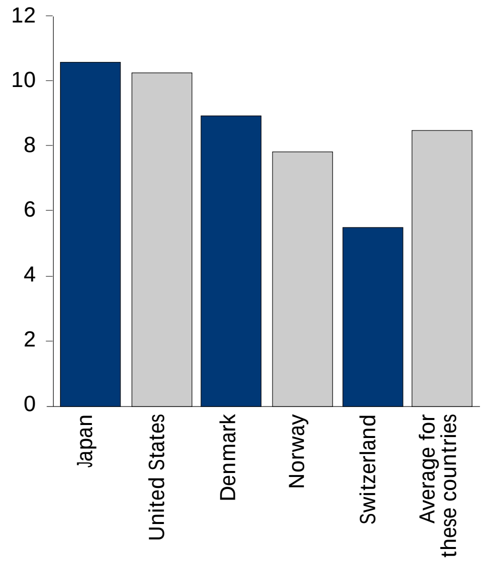
In comparison, the EU average figure for business researchers per 1,000 people in industrial employment is 3.8 and the figure for the OECD is 5.9. The island is therefore placed between these two averages. However, when a comparison is made with the Top 5 leading economies (as identified in Section 1, and which this report proposes that Ireland would match by 2020), a different picture emerges.

Table 3.3 Business Researchers per 1,000 Industrial Employment in Top 5 Economies, 1993 and 2003

	1993	2003
Japan	7.5	10.5
United States	9	10.1
Denmark	3	8.8
Norway	5.2	7.9
Switzerland	4.5	5.4
Average of these countries	**5.8**	**8.5**

Source: Forfás (2005); data taken from OECD (2004)

Figure 3.1: Business Researchers per 1,000 Industrial Employment in Top 5 Economies, 1993 and 2003



The island of Ireland therefore lags well behind the leading world economies in terms of the proportion of its workforce made up of R&D researchers. (Indeed, it also lags behind other economies such as Sweden, with a figure of 10.5, and Finland, with a figure of 13.5) On this measure, to reach a level today where the island was Top 5 world economy, the number of researchers as a proportion of industrial workers would need to double.

Again on this measure, taking into account the fact that the figures for the leading economies are continuing to increase, one can cautiously project that, by 2020, the island of Ireland would need to have in the region of 12 business researchers per 1,000 people in industrial employment to be in the first rank of economies. Indeed, this assumes some slowing down in the growth of this measure in the economies listed in Table 3.3. In other words, a sizeable increase is needed in the number of researchers on the island by 2020.

For Ireland, this fits with a figure quoted by the National Action Plan for R&D, published in 2004, which draws on research[26] showing that the number of BERD researchers in Ireland would need to increase from 5,800 in 2003 to 11,100 in 2010, i.e. almost double over in that period alone.

3.2.3 Higher Education Expenditure on R&D

The latest data on HERD is available for 2003 in Northern Ireland and (in more detail) for 2002 in Ireland.

Table 3.4 shows that, in contrast to the BERD data, Northern Ireland leads Ireland on R&D expenditure in higher

26 McIver Consulting (2004).

education. In both parts of the island, the HERD figures are increasing, in real terms and as a proportion of national income.

Table 3.4 Higher Education Expenditure on R&D (HERD) –Ireland and Northern Ireland – Current Prices, 2000-2003

	Ireland		Northern Ireland	
	2000	**2002**	**2002**	**2003**
HERD	€238m	€322m	£106m (€156m)	£128M (€188m)
HERD as percentage of GNP/GDP	0.27 (GNP)	0.31 (GNP)	0.55 (GDP)	0.58 (GDP)

Source: Forfás (2004a); Department of Enterprise, Trade and Investment NI (2004). Preliminary figure for NI GDP taken from UK regional accounts

Data for Ireland show that, in 2002, of total HERD expenditure:

- engineering accounted for 17 per cent (or €53.5m);
- natural sciences accounted for 36 per cent, of which biological sciences made up the largest single segment (14 per cent); and
- medical sciences accounted for 16 per cent.

In Ireland, for engineering, 51 per cent of the expenditure is on basic or experimental research, with 49 per cent on applied research. For natural sciences, 63 per cent of expenditure is on basic or experimental research, with 37 per cent on applied research.

Internationally, the EU average HERD figure for 2002 was 0.41 per cent of GDP, meaning that Ireland was behind this figure and Northern Ireland was ahead of it. Figures for the Top 5 economies identified in Section 1 were:

- Switzerland – 0.59 per cent of GDP;
- Denmark – 0.58 per cent of GDP;
- Norway – 0.45 per cent of GDP;
- Japan – 0.43 per cent of GDP; and
- US – 0.42 per cent of GDP.

In addition, other countries showed a high level of HERD – Sweden (0.83 per cent), Finland (0.66 per cent) and Canada (0.63 per cent). To reach the level of the Top 5 economies in the world, the level of HERD would therefore need to increase considerably in Ireland, and by a lower amount in Northern Ireland.

As regards number of researchers (excluding technicians and support personnel), and looking at the areas of engineering and natural sciences, there were 1,564 full-time equivalent researchers in Ireland in HE research areas in 2002:

- 606 members of academic staff (39 per cent);
- 93 contract lecturers (6 per cent);
- 235 post-doctoral fellows (15 per cent); and
- 630 research assistants (40 per cent).

Of the researchers engaged in HERD activity in Ireland in 2002 (in all disciplines), 62 per cent were male and 38 per cent female. Of the 1,564 in areas of relevance to this report, 488 were in engineering research and 1,076 in the natural sciences.

In Northern Ireland, there were 730 full-time equivalent academic staff engaged in HE research (all disciplines) in 2003.

Comparing internationally, the EU average figure for HE researchers per 1,000 people in the labour force in 2002 was 2.0. The equivalent figure for Ireland was 1.5 and for Northern Ireland (2003), approximately 1.8. By comparison, figures for the Top 5 world economies are shown in Table 3.5.[27]

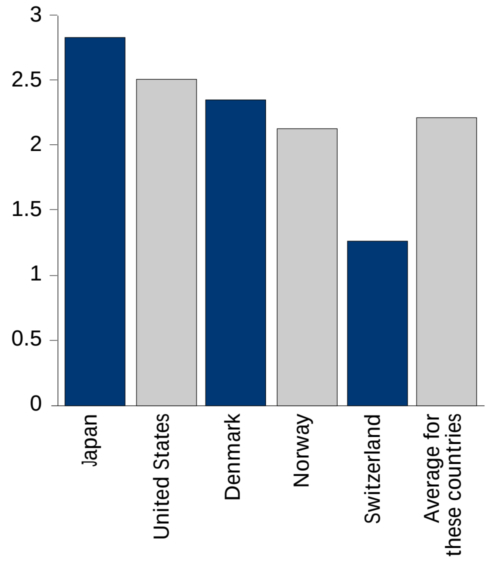
27 As with BERD, other countries such as Sweden (at 3.5) and Finland (at 4.7) are also well ahead of the island of Ireland on this measure.

Table 3.5 Higher Education Researchers per 1,000 Labour Force in Top 5 Economies, 1992 and 2002

	1992	2002
Japan	1.5	2.7
United States	3.4	2.5
Denmark	2.0	2.4
Norway	1.8	2.1
Switzerland	0.9	1.3
Average of threse countries	**1.9**	**2.2**

Source: Forfás (2005); data taken from OECD (2004)

Figure 3.2: Higher Education Researchers per 1,000 Labour Force in Top 5 Economies, 1992 and 2002



To achieve the level of the leading economies today, the number of HE researchers on the island would need to increase by some 30 per cent. As the trends in the leading economies are for the proportion of researchers in higher education to increase, one can predict that, by 2020, to be in the Top 5 economies on this measure, the island would need to have a ratio of perhaps 3 HE researchers per 1,000 in the labour force. As with the figures for BERD researchers, this implies a sizeable increase from today's figures.

As with BERD, a significant increase in HE researchers in Ireland is quoted in the National Action Plan for R&D, which draws on research showing that the number of HE researchers (in all areas) would need to increase in Ireland from 3,800 in 2003 to 6,400 in 2010[28].

Across the island, the presence of R&D in higher education is not necessarily an indication that the outcomes will transfer into business innovation. The processes of technology and knowledge transfer are a means to enhance that transfer. In both jurisdictions, there is a debate as to how to enhance and upgrade such processes. Such enhancement may require more people, and more PhDs, but will be important to ensure the wider economy gains from increased HERD investment.

In addition to the BERD and HERD statistics, there is a third, smaller area included in the overall GERD statistics – public sector R&D. For Ireland alone, it is projected that the number in this area will need to increase by 250 between 2003 and 2010, creating further pressure on the supply system.[29]

3.3 RTD Centres of Excellence

3.3.1 Defining RTD Centres of Excellence

The above sub-sections suggest that a significant expansion in both R&D expenditure and personnel would be needed if the island is to become one of the leading global economies, based on the model of a "knowledge island", by 2020. A starting point for thinking about how and where such an expansion could occur is to look at existing centres or clusters of research excellence.

There is no single definition of an RTD centre of excellence, but the European Commission states: "A centre of excellence is a structure where RTD is performed of world standard, in terms of measurable scientific production (including training) and/or technological innovation." It lists several features that should be part of a centre of excellence:

- a 'critical mass' of high level scientists and/or technology developers;
- a well-identified structure (mostly based on existing structures) having its own research agenda;

28 McIver Consulting (2004)

29 McIver Consulting (2004), Table 8

- capable of integrating connected fields and to associate complementary skills;
- capable of maintaining a high rate of exchange of qualified human resources;
- a dynamic role in the surrounding innovation system (adding value to knowledge);
- high levels of international visibility and scientific and/or industrial connectivity;
- a reasonable stability of funding and operating conditions over time (the basis for investing in people and building partnerships); and
- sources of finance which are not dependent over time on public funding.

Both Ireland and Northern Ireland have made efforts in recent years to develop such RTD centres of excellence and a number of centres already in place are listed below. Other RTD centres of excellence exist that are not mentioned here – the aim is to show the kind of centres that exist, and are emerging, as an input into thinking about how such centres can be further strengthened and developed.

Links between universities in Ireland and in Northern Ireland are mentioned below in relation to individual RTD centres of excellence. These are supplemented by programmes such as the FUSION programme of Inter*Trade*Ireland, an all-island network between industry and academia. Each FUSION project brings together a company and an academic institution and funds a project manager on a specific technology-related issue. The matching of company and educational institution takes place on an all-island basis, and FUSION plans to support 130 projects between 2004 and 2008.

3.3.2 RTD Centres of Excellence – Ireland

In Ireland, there has been a significant increase in research spending in the past decade, both through higher education and by business.

The involvement of higher education institutions has been facilitated by a number of programmes, particularly:

- the HEA's Programme for Research in Third Level Institutions (PRTLI);
- Science Foundation Ireland's (SFI's) programme of funding Centres for Science, Engineering and Technology: Campus-Industry Partnerships, or CSETs; and
- funding from IRCSET, which provides financial support to researchers and research students through its Embark Initiative.

Funding under the PRTLI programme aims to establish 33 research centres, including multisite collaborative centres, with most in science and engineering areas. The first centres were funded in 2001, e.g. the Biotechnology and Environmental Science Centre at the Cork Institute of Technology and the Institute of Biopharmaceutical Sciences at the Royal College of Surgeons of Ireland. Centres subsequently funded include a number of bio-medical- and bio-science- based centres; a National Nanofabrication Facility at University College Cork (UCC); a Research Institute in Networks and Communications Engineering in Dublin City University (DCU); and the Conway Institute of Biomolecular and Biomedical Research at University College, Dublin (UCD).

The PRTLI programme has funded a number of projects with links to higher education institutions in Northern Ireland. By end-2003, there were links with Queen's University, Belfast (QUB), the University of Ulster (UU) and the Armagh Observatory. Funding has been provided for co-operation between DCU and QUB in developing a web-based Graduate Diploma/Masters in Plasma Science and Vacuum Technology.

Grants under the SFI CSETs programme normally range from €1m to €5m per year for 5 years, and can extend for up to 10 years. In particular, SFI funds CSETs (and other grants and awards) that underpin bio-technology and ICT, i.e. sectors identified by this study as key to the evolution of Irish manufacturing. The CSET programme creates centres formed by clusters of internationally competitive researchers from the third-level sector and industry, particularly Irish-based industry. It aims to facilitate collaboration within and among campuses, industry, other research bodies, private-sector research laboratories, and internationally. While led by higher education institutions, CSETs must include partners from industry.

Five CSETs were established in 2003 and 2004:

- National Centre for Human Proteomics, led by the Royal College of Surgeons;
- The Alimentary Pharmabiotic Centre, based at UCC;
- NUI, Galway's Digital Enterprise Research Institute (DERI), mainly focusing on semantic web research;
- partnership between Trinity College Dublin (TCD), UCC, NUI, Galway and Intel through the Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), based in a specialised nanoscience research facility at TCD and spanning both ICT and bio-technology; and

- co-operation between NUI,Galway, Medtronic Vascular and others through a regenerative medicine institute (REMEDI).

The SFI has also funded other projects, such as:

- Bell Labs/Lucent R&D centre in Blanchardstown in Dublin, linked to Centre for Telecommunications Value-Chain-Driven-Research (CTVR) in TCD;
- Wyeth's Neuroscience Discovery Group, UCD's Conway Institute and TCD's drug research project established in February 2004;
- The Tyndall Institute, comprising the National Microelectronics Research Centre (NMRC) and the photonics groups at UCC and the Cork Institute of Technology, which focuses on semiconductor devices and optical communications; and
- The National Institute for Bioprocessing Research and Training (NIBRT), which brings together industry partners with UCD, TCD, DCU and the Sligo Institute of Technology to work on bio-technology and cell biology issues.

In addition to these programmes, company-led RTD centres of excellence are supported by IDA Ireland and Enterprise Ireland, which have a range of schemes to support private-sector R&D programmes.

3.3.3 RTD Centres of Excellence – Northern Ireland

As in Ireland, RTD centres of excellence in Northern Ireland involve both collaborations between higher education institutions and industry, and research centres developed by companies.

In relation to those that are primarily academic-based, major examples are:

- Biomedical Sciences Research Institute, based at the UU, which has a research group of almost 150 academic staff;
- The Electronics, Communications and Information Technology (ECIT) Institute, part of QUB, which aims to have 175 researchers by 2008;
- NanotecNI – Northern Ireland Centre for Nanotechnology. Established as a joint enterprise by UU and QUB, this centre built on the work of the Northern Ireland Centre for Advanced Materials (and its strong links to Seagate Technology). The centre involves engineers, chemists, physicists and bio-medical scientists from UU and QUB.
- Centre for Cancer Research and Cell Biology. Based at QUB, this cross-faculty and multidisciplinary centre has over 250 clinical and basic researchers; and
- The International Research Centre for Experimental Physics, a purpose-built laboratory and office space in QUB linked to the School of Mathematics and Physics.

These RTD centres of excellence tend to link to academic centres of excellence. The two Northern Ireland universities- QUB and UU- are part of the UK Research Assessment Exercise (RAE). In 2001, a number of departments of interest to this study were awarded ratings of 5 and 5*, indicating research excellence, as shown in Table 3.6. The achievement of these ratings reflects a sustained effort by the universities in Northern Ireland to improve the quality and quantity of their research since the RAE process was introduced in 1986.[30]

Table 3.6 University Departments in Northern Ireland rated 5 and 5* in the RAE, 2001

Bio-medical sciences	University of Ulster
Built environment	University of Ulster
Civil engineering	Queen's University, Belfast
Electrical and electronic engineering	Queen's University, Belfast
Mechanical, aeronautical and manufacturing engineering	Queen's University, Belfast
Physics	Queen's University, Belfast

Source: RAE (2001)

30 In the RAE area of 'Mechanical, Aeronautical and Manufacturing Engineering', QUB is one of only 3 UK universities to receive a 5* grade rating in both 1996 and 2001. The UU is the only university in the UK to receive a 5* grade rating in 'Other Studies and Professions Allied to Medicine' in both 1996 and 2001.

The RAE findings complement the RTD centres of excellence. They link to the relatively high number of engineering PhDs in QUB and of bio-medical and bio-science PhDs in the UU (see Section 4). Furthermore, the total output of engineering PhDs in Northern Ireland over the last two years was only slightly below the equivalent figure in Ireland.

A 2004 report by Arthur D Little Consultants reviewed these RAE scores and stated: "It is interesting to note the very strong engineering base at Queen's that supports local industry in aeronautical and manufacturing engineering." The consultants talk of how Northern Ireland universities have achieved a high "responsiveness to priority sectors identified by local business" in their research activities.

As well as these major academic-based research centres, RTD centres of excellence exist in major Northern Ireland companies, with almost half of business R&D spending in 2003 located in 10 companies. Examples of centres with strong academic links are:

- Nortel Networks, which has a Northern Ireland Telecoms Engineering Centre with upwards of 120 engineers in advanced telecoms; and
- Seagate Technology, with its skilled R&D centre specialising in magnetic heads, which is a global focus of excellence in this area for the company.

In addition, Invest Northern Ireland has a specific programme which supports smaller-scale RTD centres of excellence. Between 1994 (when the programme was founded) and 2004, 18 centres were established, assisted by Invest NI funding of £34m. Information on these centres is available on the Invest NI website.[31] They include:

- Virtual Plant for Industrial Process Control;
- Engineering Composites Research Centre;
- Pharmaceutical Formulation Research Centre Galen plc.;
- Next Generation Mobile Infrastructure.

3.4 Key Points from Section 3

- In recent years, Ireland has seen increases in R&D expenditure both from businesses and higher education. Northern Ireland has seen an increase in higher education R&D but business R&D spend has not increased.
- Northern Ireland starts from a higher level of HERD than Ireland (almost twice the level as a share of GDP), although this gap is closing. This higher HERD in Northern Ireland is associated with excellence in specific areas of research relevant to developing a knowledge economy and with a higher proportion of engineering and computer science graduates studying to postgraduate level (see Section 4).
- While the island contributes a small share of global R&D expenditure, given its tiny size in relation to the global economy, it also under-spends in relation to the proportion of its GDP spent on R&D. To reach the level of R&D expenditure and personnel of the Top 5 world economies, R&D expenditure on the island needs to expand significantly.
- In terms of personnel, based on comparisons with the leading global economies, a significant expansion is needed in the number of researchers on the island, in both the business and the higher education sectors. There has been some progress in relation to the latter in recent years – see Section 4.
- Recent years have seen progress in establishing RTD centres of excellence on the island. Areas of expertise are starting to emerge and provide a basis for the further expansion of R&D. Work to date shows that collaboration between companies and higher education institutions is possible, with the potential that different higher education institutions and regions on the island can specialise in areas in which they have a specific expertise.

The Action Plan for R&D in Ireland makes the following comment, which would hold true for the island as a whole:

- Small open economies cannot be competitive or develop the required critical mass in all areas of science and technology. There is a need for focus and for expenditure to be prioritised within an overall coherent framework that promotes national development objectives. It is most important to use Technology Foresight to identify key areas for national investment. …In addition, enterprise needs a good balance of strategic oriented research and near to market research. An important factor in deciding key areas of investment will be the current and future development priorities of the enterprise sector.

31 For full information, see:
http://www.investni.com/index/develop/dv-invest-in-rdt/technology_development_programme.htm

Section 4: Supply of Engineering and Science Graduates

4.1 Introduction

Having looked at the increasing demand for SET graduates and postgraduates from the perspectives of industry and of the research sector, Section 4 turns to the supply of SET graduates. It reviews the numbers of SET graduates and postgraduates in Ireland and Northern Ireland, the trends in these numbers over time, and reviews briefly the mobility of students on the island.

4.2 Graduates in Ireland

4.2.1 Data on SET Graduates in Ireland

Table 4.1 shows the number of people graduating with engineering qualifications (at different levels) in Ireland in recent years.

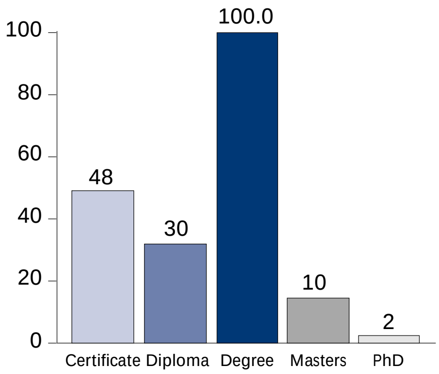
Table 4.1 Breakdown of Number of Engineers Graduating, by Level of Qualification in Ireland, 2001- 2003

	Certificate	Diploma	Degree	Masters	PhD
Engineers – 2001	1,327	827	1,891	173	40
Engineers – 2002	1,150	656	2,157	202	52
Engineers – 2003	1,128	703	2,339	238	51
Ratio – 2003	48	30	100	10	2

Source: HEA, First Destination of Awards Recipients in Higher Education, reports from 2001 and 2002. Data for 2003 provided pre-publication by the HEA to the Task Force.

Note: (1) Figures for Masters combine research and taught Masters figures; (2) figures for certificates include one-year and two-year certificates; (3) figures for computer engineering are included in Table 4.1 but figures for computer science are not – these are aggregated with the wider science data by the HEA.

Figure 4.1 Ratio of number of Engineers Graduating 2003



Note: Ratios relate to degree index at 100

This table indicates that the main level of engineering qualification obtained in Ireland is at primary degree level, with just over 10 per cent of those obtaining primary degrees receiving Masters, and the number of PhDs at just over 2 per cent of the number of primary degrees. The table also shows that the total number receiving certificates and diplomas in 2002 and 2003 was about 80 per cent of the number obtaining degrees.

The same HEA data shows that 3,605 people graduated with primary degrees in science in 2002, with 264 people graduating with PhDs in science in 2002. This indicates 7.3 PhDs per 100 primary degrees, showing the proportion of science graduates progressing to PhD level is 3–4 times the proportion of engineers progressing to PhDs.

As stated in the note to Table 4.1, the information is incomplete for computer science, as those people classified under 'science' are not included. However, in its First Destinations Report for 2000, the HEA stated that there were 654 primary degrees in computer science in that year, i.e. about one-third of the figure for primary degrees in engineering in that year.

The Task Force was interested in the engineering disciplines being studied. Table 4.2 is built on information supplied by the engineering departments of the universities in Ireland. As such, it is not directly comparable to Table 4.1, which includes data from the Institutes of Technology. Different definitions of courses and faculties mean that the breakdown is not precise, but shows the general distribution of university graduates in engineering disciplines.

Table 4.2 Estimated Breakdown of Number of Engineers Graduating – by Type and Level of Qualification, Selected Universities in Ireland, 2004

	Diploma	Degree	Masters	PhD	Total
			Percentage		
Electrical + Electronic	0.0	20.9	1.9	0.8	23.6
Computers + Computer Science	1.1	12.8	7.5	2.6	24.0
Mechanical	0.0	13.5	1.5	0.4	15.4
Chemical + Process	0.0	2.0	0.1	0.2	2.3
Bio-medical	0.0	1.2	0.1	0.1	1.4
Bio-systems, Food and Agriculture	0.0	0.4	0.2	0.1	0.7
Structural	0.0	0.9	0.0	0.0	0.9
Civil	0.0	17.0	1.6	0.5	19.1
Environmental	0.0	0.9	0.1	0.0	1.0
Manufacturing/Industrial	0.0	4.7	2.2	0.2	7.1
Materials	0.0	0.0	0.0	0.0	0.0
Building Services	0.0	0.0	0.0	0.0	0.0
Aeronautical	0.0	1.5	0.0	0.0	1.5
Mechatronics/Electromechanical	0.0	3.0	0.0	0.0	3.0
Total Percentage (Rounded)	**1.0**	**79.0**	**15.0**	**5.0**	**100.0**

Source: Compiled by universities in Ireland for the KI 2020 Task Force

Note: (1) Figures are estimates by the 7 universities in Ireland; (2) Figures for University of Limerick (UL) and DCU are for 2002 and include primary degrees but not Masters/PhDs; (3) In some cases, data was only available for merged disciplines - the table therefore shows broad areas of activity rather than being fully accurate at the level of each discipline.

This table indicates that there are four main disciplines in which engineers are trained in the Ireland – electrical/electronic; mechanical; computer and computer science; and civil. Of those obtaining primary degrees from the institutions surveyed in 2004, 82 per cent graduated in these four areas. The single strongest discipline for postgraduate research is computers and computer science, both in terms of Masters and PhDs.

4.2.2 SET Postgraduate Schemes in Ireland

There has been significant effort in recent years to increase the funding of postgraduate degrees in Ireland in SET areas. The data presented in Tables 4.1 and 4.2 may not capture this, as students benefiting from this initiative are still studying to obtain their PhDs.

The Embark Initiative is operated by the IRCSET. Data supplied by IRCSET to the Task Force show that, between 2002 and 2004, it had 2,354 applications for funding – the vast bulk (estimated at 85 per cent) relating to PhD funding. Of these applications, 22 per cent were from people wishing to undertake postgraduate studies in engineering, with a further 19 per cent applying for funding in computer science. In total, 480 students were funded over these three years, with 23 per cent in engineering and 18 per cent in computer science. In addition, 76 people were funded for postdoctoral research.

The IRCSET data show that:

- There is a cohort of people in SET subjects who wish to undertake postgraduate work but do not currently get a chance to do so – demand is greater than available funding. IRCSET states that good quality applications have to be turned down due to the limited number of places available; and
- this demand is not just in 'pure' science areas but in engineering and computer science as well.

Although IRCSET funding is open to students from Northern Ireland (and from all other EU areas), there is a low take-up by students from Northern Ireland.

A second programme is the HEA's Programme for Research in Third Level Institutions (PRTLI). Started in 1998, the PRTLI was assessed by an international committee in 2004, which found that almost 1,000 postgraduates were funded between 1998 and mid-2003. Of these, the main areas were bio-sciences/bio-medicine (36 per cent); environment (21 per cent); chemical and physical sciences (19 per cent) and ICT (11 per cent).

While making a number of suggestions about the future of PRTLI, the assessment was strongly supportive of the programme:

> Knowledge and intellectual capital provide the foundations for the new innovation economy. This being so, Ireland must have both the ambition and the capacity to generate and to commercialise more of its own technology, domestically. A significant strengthening and development of advanced research and education capabilities will be central to the achievement of this important objective. In other words, Ireland must establish an internationally competitive '4th level' within its third level education system. PRTLI attempts to meet this objective. Following decades of relative impoverishment of the domestic research base, it represents a significant step forward in public research policy and in funding.

The Embark Initiative and the PRTLI are not the only sources of funding for SET postgraduates in Ireland. They are mentioned here to acknowledge recent efforts to increase funding for fourth-level SET studies in Ireland.

4.2.3 Trends in SET Undergraduate Student Numbers

The Task Force collected numbers of first-year and fourth-year students, from 4 of the 7 universities in Ireland enrolled in engineering courses in 2004–2005. For the 4 universities surveyed, there were 889 students in fourth year and 657 students in first year, i.e. there were 26 per cent fewer first-year students. Allowing for some drop-out of students between first and final years, this indicates that the number of people studying engineering courses has fallen in Ireland by perhaps one-third in the past 5 years.

This conclusion is supported by data from the Central Applications Office (CAO), which processes applications in Ireland for entry into third-level courses.

Table 4.3 shows that there was a fall of 25 per cent in the number of first preference CAO applications for SET courses between 2000 and 2005. Together with the data collected by the Task Force, this confirms that there has been a significant fall in undergraduate demand for engineering, IT and science courses in Ireland since 2000.

Table 4.3 Number of CAO Applications for SET courses (First Preferences), 2001, 2003 and 2005

Degrees	2000	2003	2005
Engineering/Technology	8,981	7,736	7,339
Science/Applied Science	4,911	4,573	4,737
Diploma/Certificate			
Engineering/Technology	15,055	10,208	9,109
Science/Applied Science	4,031	4,251	3,572
Total	**32,978**	**26,768**	**24,757**

Source: CAO web-site – www.cao.ie

The above fall in numbers has taken place despite the efforts of the Science, Technology and Engineering Programme for Schools (STEPS) Programme, which was established in late-1999, and which encourages students to study science and engineering.

4.3 Graduates in Northern Ireland

Table 4.4 shows the number of engineering, computer science and wider SET graduates at higher education institutions in Northern Ireland in recent years.

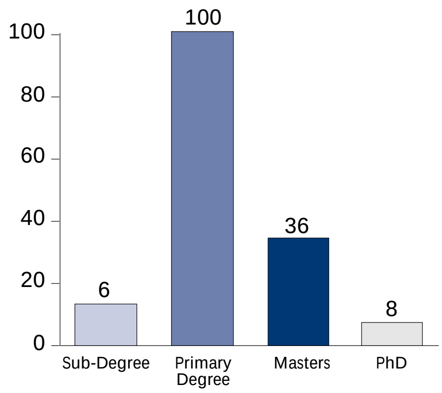
Table 4.4 Students Gaining Qualifications at Northern Ireland Higher Education Institutions, 2002 - 2003 and 2003 - 2004

	Sub-Degree	Primary Degree	Masters	PhD	Total
Engineering/Technology – 2002-2003	46	489	134	56	725
Engineering/Technology – 2003-2004	30	475	170	40	715
Ratio – 2003-2004	**6**	**100**	**36**	**8**	
Computer Science – 2002-2003	208	555	508	12	1,283
Computer Science – 2003-2004	230	570	265	10	1,075
Ratio – 2003-2004	**40**	**100**	**47**	**2**	
Wider SET – 2002-2003	290	1,848	824	170	3,132
Wider SET – 2003-2004	285	1,885	630	130	2,930
Ratio – Wider SET – 2003-2004	**15**	**100**	**33**	**7**	

Source: Department of Employment and Learning, Statistical Bulletin, Students Gaining Higher Education Qualifications: Northern Ireland, Various Years

Note: (1) Figures for 'Masters' refers to number for postgraduate qualifications excluding PhDs. (2) Wider SET includes: engineering and technology; computer science; biological sciences; physical sciences; mathematical sciences. The titles of these disciplines changed slightly over the period. Those graduating in 'Subjects Allied to Medicine' are not included.

Figure 4.2 Engineering/Technology Students Gaining Qualifications at Northern Ireland Higher Education Institutions, 2003 - 2004



Note: Ratios relate to degree index at 100.

The table indicates that over 700 people per year qualify with engineering qualifications from higher education institutions in Northern Ireland, with almost 500 of these at degree level. In addition, over 1,000 people graduate with qualifications in computer science, with about half of these graduating at primary degree level.

The ratios in Table 4.4 indicate that there is a relatively higher proportion of Masters (based on data for postgraduate qualifications excluding PhDs)[32] and PhD students in Northern Ireland compared to Ireland. However, there is a lower level of sub-degree qualifications.

32 There are a number of kinds of Master degree courses in Northern Ireland. These include MSc taught courses (varying from conversion courses to technically specialist courses), Masters by research (typically lasting 18 months to 2 years) and Undergraduate Masters, e.g. Master of Engineering or MEng (where undergraduates undertake an extra year of study as part of their primary degree course and receive a Masters degree).

The Task Force received data from UU and QUB on their engineering graduates by discipline, as shown. Given definitions of faculties and courses, data in Table 4.5 is not directly comparable to the previous table.

Table 4.5 Estimated Breakdown of Number of Engineers Graduating - by Type and Level of Qualification, from Universities in Northern Ireland, 2004

	Diploma	Degree	Masters	PhD	Total
			Percentage		
Electrical + Electronic	0.2	7.0	2.5	0.3	10.0
Computers + Computer Science	2.0	22.7	8.7	0.4	33.8
Mechanical	0.9	2.5	1.1	0.4	4.9
Chemcial + Process	0.0	0.6	0.0	0.2	0.8
Bio-medical	0.0	3.0	8.8	1.5	13.3
Bio-systems, Food and Agriculture	0.0	3.0	1.7	2.1	6.8
Structural	0.0	2.5	0.6	0.0	3.1
Civil	0.0	3.7	1.1	0.3	5.1
Environmental	0.2	5.7	2.6	0.1	8.4
Manufacturing/Industrial	0.0	1.9	1.4	0.0	3.3
Materials	0.0	0.0	0.0	0.3	0.3
Building Services	0.0	8.1	0.6	0.1	8.8
Aeronautical	0.0	1.0	0.0	0.1	1.1
Mechatronics/Electromechanical	0.0	0.0	0.0	0.0	0.0
Total Percentage (Rounded)	**3.3**	**61.7**	**28.9**	**5.8**	**99.7**

Source: Data supplied by QUB and UU to the KI 2020 Task Force

Note: (1) QUB – Numbers for Bio-systems, Food and Agriculture comprise all awards by the School of Agriculture and Food Science which forms part of QUB. Numbers for Structural Engineers comprise all awards from QUB School of Architecture. Awards exclude MPhil awards (Research Masters) and postgraduate certificates and diplomas; (2) UU - Masters completed online by overseas students are excluded, as graduates not available for labour market on the island. Research Masters are included.

This table shows that computers and computer science constitute the single largest area of study, with bio-medical, building services, electrical and electronic, and environmental engineering the other main engineering disciplines.

Detailed data from the two universities show that, at postgraduate level, QUB is relatively stronger in electrical, mechanical, chemical/process, civil and aeronautical engineering. The UU is relatively stronger in the bio-medical and bio-systems/food/agriculture areas (although QUB also has a strong presence in the latter). Both universities are strong in computer engineering and computer science.

As in Ireland, there is evidence of a decline in the number of applications to study engineering and science, with evidence from QUB suggesting a fall of approximately 4 per cent in the numbers applying to study both engineering and computer science since 2000.

4.4 Student Mobility on the Island

Data on the origin of SET students in Ireland is compiled by the Department of Education and Science, and shown in Table 4.6 for two recent years.

Table 4.6 Students from Northern Ireland in Ireland Higher Education Institutions

Year	Total (Full-Time) Students in Ireland	Students with Domicillary Origin in Northern Ireland
1999-2000	122,395	1,107 (0.90 per cent)
2002-2003	137,323	1,093 (0.80 per cent)

Source: Compiled by the Department of Education and Science – available on HEA web-site – www.hea.ie

Note: Data for students enrolled on full-time courses.

This table indicates that there has been some 1,100 full-time SET students from Northern Ireland enrolled on courses in higher education institutions in Ireland in recent years. While this number has been steady, the proportion of students from Northern Ireland has declined slightly as Ireland's total full-time SET student population grew.

The Northern Ireland Department of Employment and Learning publishes statistics on the number of students from Ireland studying in Northern Ireland. Table 4.7 shows this data for 2003 – 2004.

Table 4.7 SET Students from Ireland in Northern Ireland, Higher Education Institutions, 2003 – 2004

	Number	All Students in Northern Ireland percentage
Undergraduates	2,780	5.2
Postgraduates	1,540	13.1
Total	**4,320**	**6.6**

Source: Department of Employment and Learning, Statistical Bulletin – Student Enrolments on Higher Education Courses: Northern Ireland 2003 – 2004

This table indicates that 1 in 20 undergraduates in Northern Ireland comes Ireland, as does 1 in 7 postgraduate students.

Data on students from Northern Ireland show that 6,715 such students graduated with first degrees in Northern Ireland in 2003 – 2004, compared to 2,795 graduating from institutions in Britain. Of this sizeable proportion studying in Britain, very few return after graduation. By contrast, of those who study in Northern Ireland, almost all subsequently stay in Northern Ireland or work in Ireland. A 2005 report by the UK's official graduate career service found that 97 per cent of graduates from Northern Ireland universities in 2003, working in the UK six months after graduation, were working in Northern Ireland (i.e. very low mobility to Britain). The report also states that graduates from Northern Ireland were "far more likely to go to work elsewhere in the EU than to work in another part of the UK. The data does not allow us to say with certainty, but this could well represent moves to Ireland".

4.5 Key Points from Section 4

- Based on recent data, approximately 2,800 people receive primary degrees in engineering per year – approximately 2,300 in Ireland and 500 in Northern Ireland.
- In addition, about 1,800 people qualify as engineers at sub-degree level each year on the island, with 500 people qualifying at postgraduate level (of whom 90 gain PhDs).
- This means that almost 5,200 people per year receive engineering qualifications on the island.
- These figures include people qualifying in computer engineering but not those qualifying in computer science. Based on the partial data available for computer science, there appears to be perhaps a further 1,200 people qualifying at primary degree level each year. This does not include people receiving qualifications at sub-degree level. There are several hundred people receiving postgraduate qualifications in computer science. One could estimate that, on top of the engineering figures, there are up to 2,500 people per year extra graduating in IT/computer science.
- Computers and computer science is the single largest SET area of study in both Ireland and Northern Ireland. Electronic, civil and mechanical engineering are the next most important disciplines in Ireland – electrical engineering and building services are the next most important in Northern Ireland. Areas related to bio-medicine and bio-systems are also important in Northern Ireland.
- There is some evidence of specialisations in particular universities. This is especially true in Northern Ireland.
- The ratio of sub-degree graduates (certificates and diplomas) to degree graduates is higher in Ireland, driven by the Institutes of Technology.
- The ratio of postgraduate qualifications to primary degree qualifications is higher in Northern Ireland than in Ireland. In Northern Ireland, for every 100 primary engineering degrees, there are 36 postgraduate diplomas or Masters, and 8 PhDs. In Ireland, the respective figures are approximately 10 and 2. This reflects a high level of postgraduate studies in specific disciplines in Northern Ireland, such as IT and the bio-science areas. It also reflects an attraction of students at a postgraduate level from outside Northern Ireland for specific courses.
- There have been efforts in recent years to increase the number of SET postgraduates, especially in Ireland, where major new initiatives have been launched.
- More people want to do postgraduate research in science, engineering and technology than are currently funded.
- The number of people applying to study engineering and IT courses has fallen sharply since 2000.
- There is a certain amount of cross-border student mobility, although there would appear to be potential to increase this further. There is more mobility from Ireland to Northern Ireland than in the other direction.

Section 5: Demand and Supply Requirements of Engineers to 2020

5.1 Number of Engineering and IT Workers Required in 2020

5.1.1 Engineering/IT Workers and Economic Growth, 1991 to 2001–2002

The number of workers in science, engineering and IT occupations grew significantly on the island between 1991 and 2001–2002, as shown in Table 5.1.

Table 5.1 Number of Workers in Science, Engineering and IT Occupations on the Island of Ireland, 1991 and 2001–2002

	1991	2001-2002	Change (Percentage)
Scientists and Science Technicians	14,317	24,100	68
Engineers and Associated Technicians	19,110	40,383	111
IT and Computer Workers	9,882	42,079	326
Total SET Workers	**43,309**	**106,562**	**146**
Total Labour Force	2,062,000	2,540,000	23

Source: Ireland Census 1991, 2002, Volume 6; Northern Ireland Census – 1991, NISRA (1993), Tables 1A and 1B – 2001 data from a specially commissioned table, available from NISRA

Note: See notes to Tables 2.4 and 2.5. Figures for 2001-2002 are for 2001 in Northern Ireland and 2002 in Ireland, reflecting different census dates.

This tables indicates that:

- the number of people working as engineers on the island grew by 111 per cent, or 7.4 per cent per year, between 1991 and 2001-2002;
- the number of IT workers grew by 326 per cent, or 14.8 per cent per year, in the same period.

Over the same period, total economic output on the island rose from just $66.5bn to $121bn – a growth of 82 per cent[33], or a compounded annual average rate of growth of 5.9 per cent. Comparing the annual average economic growth rate and the annual average increase of people employed in engineering and IT occupations on the island shows that:

- For every 1 per cent of economic growth, the number of engineers grew by 1.25 per cent; and
- For every 1 per cent of economic growth, the number of IT workers grew by 2.5 per cent.

5.1.2 Projecting the Number of Engineering/IT Workers Required by 2020

Section 1 showed that, for the economy of the island to be a Top 5 world economy by 2020 from a perspective of income per head, it will need average economic growth of just under 4.5 per cent per year from 2003 to 2020. To compare the growth required to the occupational data in Table 5.1, one could assume a 4.5 per cent growth requirement from mid-2001.

Achieving this level of growth will require a mix of policies and inputs, most of which are outside the remit of this report. However, one implication of achieving such growth is an increase in the number of people required in engineering and IT occupations. This Task Force believes that average annual growth of 4.5 per cent would require significantly more people in such occupations, for the following reasons:

- High-tech sectors such as the ICT and bio-pharmaceutical/bio-medical sectors are likely to account for a greater proportion of manufacturing employment and total economic output in the future. These sectors have a higher than average number of engineers and IT professionals (see Section 2).

33 Figures are GNP for Republic of Ireland and GDP for Northern Ireland – end figures taken for 2002 for Republic and for 2001 for Northern Ireland, reflecting the occupational data.

- Within these sectors, the evidence from this study shows that the leading firms have a higher proportion of engineers and IT workers than all companies in these sectors – over time, it is likely that the profile of the workforce will increasingly mirror the situation in these leading firms (see Section 2).
- The study also shows that the leading companies themselves believe that their workforces will become more qualified over time – one aspect of this will be an increasing number of qualified engineers and IT personnel (see Section 2).
- The island lags behind the leading economies in terms of R&D expenditure and personnel, both in industry and in higher education – addressing this will require a considerably higher number of qualified personnel (see Section 3).
- In other (non-high-tech) manufacturing sectors there will be an upgrading of processes, requiring more qualified IT and engineering workers (see Section 1).
- There is likely to be continued strong construction activity in both parts of the island, with a consequent continued demand from this sector for qualified engineering personnel (see Section 1).
- Engineers and IT workers are employed across many other sectors of the economy besides manufacturing and construction, and demand from the wider economy is also likely to continue to increase (see Section 2).

Although the number of IT workers required is likely to continue to increase, the *rate of growth* is likely to slow, as the growth rate of IT workers in the 1990s was from a very low base, and the period included the IT boom/bubble of the late-1990s. In the US, where the IT sector is relatively more mature the projected rate of growth in IT workers for 2002 – 2012 is just under 3 per cent a year.[34] This is similar to annual forecast US GDP growth, implying around a 1 per cent growth in IT workers per 1 per cent economic growth in the more mature US economy.

The Task Force is therefore of the opinion that:

- The number of people in engineering and IT occupations required by the island will continue to increase in the future.
- The relationship between the number of extra engineers and engineering technicians and economic growth is likely to be similar to the relationship of 1.25 per cent for every 1 per cent of economic growth in the 1990s. This prediction may be conservative due to the accelerating pace of technological change, giving rise to accelerating demand for engineering manpower; and the increasing share of national output expected to be accounted for by high-tech sectors, which themselves are more engineering manpower intensive.
- The number of IT professionals and technicians will continue to grow but their growth per 1 per cent economic growth will be lower than in the 1990s. Their rate of growth is likely to be closer to that of the engineers and engineering technicians.

For engineers and engineering technicians, if the 4.5 per cent growth scenario is to be achieved, and if the relationship of 1.25 per cent growth in their numbers applies per 1 per cent economic growth to 2020, this would mean an annual growth in such workers of 5.6 per cent over the period. This would imply an increase in the number of engineers and engineering technicians on the island from 40,000 (in 2001-2002) to 110,000 (in 2020).

Applying the same ratio for IT professionals and technicians (i.e. 1 per cent of economic growth associated with a 1.25 per cent growth in numbers) would mean an increase in people in IT occupations on the island from 42,000 in 2001-2002 to 115,000 in 2020.

Combining the two categories means a required growth in the number of engineers/ engineering technicians and IT professionals/technicians from 82,000 in 2001-2002 to 225,000 in 2020. This represents growth of 5.6 per cent per year. This compares to growth in the (shorter period) from 1991 to 2001-2002 in the numbers in these occupations from 29,000 to 82,000, when there was annual growth of between 7 per cent and 15 per cent in the number in these occupations.

5.1.3 'Reality Check' for Number of Engineering/IT Workers Required by 2020

(A) Engineering/IT Workers as a Proportion of the Overall Labour Force

In 2001 – 2002, the labour force of the island of Ireland was 2.54m (1.8m in Ireland and 0.74m in Northern Ireland). The number of people in Engineering/IT occupations was 82,462, representing 3.25 per cent of the total.

The CSO's labour force projection for Ireland for 2016 is 2.374m people.[35] One can assume that Ireland's labour force will

34 US Department of Labor, Bureau of Labor Statistics, 2002 – 2012 Employment Projections, Press Release of 11 February 2004 – see www.bls.gov/emp - the figures project a cumulative growth of 35 per cent in 'Computer and Mathematical' occupations in the decade to 2012.

35 As in Section 1, this follows the CSO forecast based on the higher of its two immigration scenarios.

reach 2.5m by 2020. (This is based on a projected population of 5.02m.) For Northern Ireland, a population projection for 2020 of 1.81m people has been made by the NISRA. If one uses the 50 per cent of population ratio of Ireland, this would give an estimated Northern Ireland labour force in 2020 of 0.9m people (compared to 0.74m people in 2001).

These figures give a total estimated labour force on the island of 3.4m people in 2020. If there were 225,000 people in engineering/IT occupations, these would account for 6.6 per cent of the total workforce.

(B) International Benchmark for Proportion of Engineering/IT Workers

Based on data collected by the European Commission (2002) and by Eurostat (2003), there is some evidence that the share of science and technology (S&T) graduates on the island is low by international standards.

Table 5.2 shows two sets of statistics. The left-hand data column shows the number of science and technology workers with third-level qualifications working in science and technology occupations, as a proportion of the total labour force. It shows Ireland at approximately 17 per cent. The right-hand data column shows the proportion of all graduates in the labour force accounted for by science and technology graduates. In the case of Ireland, 49 per cent of graduates in the labour force have a qualification in science or technology.

Table 5.2 Comparisons of Science and Technology Graduates in Ireland with Selected other Countries

	Labour Force with S&T Qualifications and in S&T Jobs (2001)	All Graduates in Labour Force that are S&T Graduates (2002)
	Percentage	
Ireland	17	49
Sweden	21	60
Denmark	21	64
Finland	22	51
UK	17	52
Norway	23	N/A
Switzerland	17	N/A

Source: First data column from European Commission (2002), Figure 4.2.14. Second data column from Eurostat (2003), Figure 4.11
Note: n/a= not available.

The table indicates that, compared with a number of its European neighbours, Ireland scores somewhat lower on these two indicators. These combine with the points made in the previous sub-section (on the proportion of the labour force accounted for by people in engineering and IT occupations) to suggest that there is 'room', at least in relation to Ireland, to increase its share of workers in these occupations, especially in the context of a move towards a knowledge economy.

(C) Comparison with FÁS/ESRI Labour Market Forecast

In 2002, FÁS and the ESRI produced detailed forecasts for Irish occupations up to 2015. These forecasts are based on the economic growth forecasts contained in ESRI's 2001 *Medium-Term Review*. As such, the nature of the exercise is different to the exercise in this report – the FÁS/ESRI figures are forecasts based on specific assumptions and beliefs about how Ireland's economy will evolve. This study is starting from a point of defining a growth rate that the island economy *would need to achieve* to be in the Top 5 economies of the world by 2020, and what changes in occupations would need to happen to support this growth rate.

The FÁS/ESRI forecast is shown in Table 5.3.

Table 5.3 FÁS/ESRI Forecasts for Selected Occupational Areas, 2000, 2005 and 2015

	2000	2005	2015	Change	Change (Percentage)
Engineering and Science Professionals	32,000	43,500	58,800	26,800	+ 83.8
Engineering/ Science Assoc. Professionals	37,000	48,500	65,000	28,000	+ 75.7
Total Labour Force	1.588m	1.753m	1.989m	400,900	+ 25.2

Source: FÁS/ESRI Manpower Forecasting Studies – Occupational Employment Forecasts 2015, Table A3.1 (March 2002).

The FÁS/ESRI occupational definitions are somewhat different to those used in this report. However, their forecast predicts:

- growth of just over 4 per cent per year between 2000 and 2015 for engineering and science professionals; and
- growth of 3.8 per cent per year for science and engineering technicians.

An updated (2004) forecast from FÁS/ESRI (for 2010) provides similar annual forecast growth rates. The FÁS/ESRI forecast is therefore that the growth in science, engineering and IT occupations will be faster than the growth in the overall labour force. Their *forecast* is lower than the figures in this study, which are based on a *target* of achieving an island economy in the Top 5 global economies by 2020. The difference is due to the economic growth rate underpinning their forecasts being lower than the 4.5 per cent target growth rate adopted in this report to meet the Top 5 requirement (this is particularly true post-2010).

5.1.4 Number of Qualified Engineers/IT People Required in Wider Labour Force

Building an estimate of the number of people required in engineering and IT occupations in 2020 (to meet the 'Top 5' objective) is a crucial, but only partial, input into the 'stock' of people with engineering and IT qualifications required in the island's workforce. This is because:

- a proportion of those people qualified to work as engineers or in IT in fact work in other occupations; and
- a proportion of people with engineering and IT qualifications currently in the labour force will have exited the labour force by 2020.[36]

In relation to the former proposition, it is possible to estimate the stock of people with engineering and IT qualifications in the labour force on the island in 2001 – 2002. Indeed, the figure is provided by the Census in Ireland and, for Northern Ireland, figures are provided for occupations. Applying the ratio from Ireland to Northern Ireland, i.e. ratio for [People holding relevant third-level qualifications in Labour Force: people working in Engineering/ IT occupations] gives total stock figures for 2001 – 2002 for the island of:

- 73,000 people with engineering qualifications; and
- 42,000 people with IT/computer qualifications.

These numbers will need to increase by the same rate of growth as the numbers in the occupations (i.e. by 5.6 per cent per year), to ensure there is a sufficient stock of people in the wider labour force with the requisite qualifications to guarantee the occupational numbers. This means that, by 2020, the island's labour force will require:

- 200,000 people with engineering qualifications; and
- 115,000 people with IT/computer qualifications.

The second issue relates to the fact that a proportion of those currently employed as engineering or IT workers will have exited the labour force by 2020, mainly through retirement. The Censuses of 2001 – 2002 in Ireland and Northern Ireland show that the current engineering and IT workforce is relatively young (see Section 2). Based on the 2002 Census in Ireland, 27 per cent of engineers and 9 per cent of computer workers will be aged over 63 in 2020 – to account also for other reasons people leave the labour force, it is assumed that approximately 30 per cent of engineers and 12 per cent of IT workers enumerated in 2001 – 2002 will have exited the island's labour force in 2020. This implies that:

- approximately 1.5 per cent of people in engineering occupations will leave the labour force each year; and
- approximately 0.5 per cent of people in IT occupations will exit the labour force each year.

Accounting for these attrition rates due to people exiting the labour force means that a higher annual rate of growth is required in the supply of new people into engineering/IT occupations than the rate of growth required in the number of people working in the occupations. Instead of the 5.6 per cent figure mentioned above:

- an annual increase of approximately 7 per cent will be required for people with engineering qualifications; and
- an annual increase of approximately 6 per cent will be needed for people with IT qualifications.

36 These factors will affect the number of people with engineering and IT qualifications working in these occupations. This relates to people working fulltime. If a greater proportion of people were working part-time or taking more career breaks (as would be likely with increased female participation, for example), the number of people qualified in engineering and IT would need to be higher again.

Given the figures for the current stock of people with relevant qualifications in the labour force, these calculations suggest that:

- there was a supply requirement of some 5,100 new people in engineering in 2001-2002 – this will rise to a supply requirement of 14,000 new people by 2020; and
- there was a supply requirement of some 2,520 new people in IT in 2001-2002 – this will rise to a supply requirement of 6,900 new people by 2020.

The different estimates from this section are shown in Table 5.4.

Table 5.4 Summary of Estimated Manpower Requirements for Engineering and IT on the island of Ireland.

	2001 – 2002	Percentage of Annual Growth Required	2020
Number of People in Engineering/IT Occupations			
Engineering	40,000	+ 5.6	110,000
IT/Computers	42,000	+ 5.6	115,000
Number of People with Relevant Third-Level Qualifications in Labour Force			
Engineering	73,000	+ 5.6	200,000
IT/Computers	42,000	+ 5.6	115,000
Number of New People Required to Enter Labour Force			
Engineering	5,100	+ 7.0	14,000
IT/Computers	2,500	+ 6.0	6,900

Note: Growth rates in Number of New People Required to Enter Labour Force Each Year allow for attrition

5.2 Breakdown of Engineering and IT Workers Required in 2020

5.2.1 Level of Qualifications Required for New Engineers and IT Workers

A breakdown of the current workforce of engineers and IT workers in 12 leading companies across the island was presented in Section 2 (see tables 2.8, 2.9 and 2.10). It provided ratios as shown in Table 5.5.

Table 5.5 Ratio of Levels of Engineers and IT Workers in Sample of Leading Companies

Sector	Certificate	Diploma	Degree	Masters	PhD
ICT Sector	61	70	100	13	2
Bio-pharmaceutical/Bio-medical	86	43	100	13	5
Construction	13	26	100	18	1

Source: Based on information presented in Section 2, Tables 2.9 – 2.11

Section 4 provided information on engineering graduates, as shown in Tables 5.6.

Table 5.6 Ratio of Engineering and IT Graduates by Level of Qualification, 2003 – 2004

	Certificate	Diploma	Degree	Masters	PhD
Ireland	48	30	100	10	2
Northern Ireland	12	12	100	42	5
Weighted Total	**37**	**25**	**100**	**20**	**3**

Source: Based on information presented in Tables 4.1 and 4.4. Information from Table 4.4 combines data for Engineering/Technology and Computer Science for 2003 - 2004

Note: (1) Weights based on total graduates in Ireland and Northern Ireland for most recent year; (2) Figures for Ireland include computer engineering but not computer science; (3) Figures for Northern Ireland for sub-degree level (260 people) have been allocated evenly between certificate and diploma level.

In terms of current supply, Table 5.6 indicates that at present:

- the leading companies appear to have a higher relative demand for people at diploma level than is being provided by the educational systems; and
- there is a somewhat higher production of people at PhD level, but this also needs to cater for entry into the public sector and educational sector.

While tables 5.5 and 5.6 provide a snapshot of today's situation, the evidence suggests that the level of qualification required will increase:

- The leading firms in key identified growth sectors with which discussions were held for this study say that the people they will need in the future will have higher levels of qualification. A large pharmaceutical company said that the proportion of new engineering and science graduates with PhDs could be 10 – 15 per cent by 2020; – a large IT company put this figure at 30 – 40 per cent.
- Section 2 indicates that firms in advanced manufacturing sectors already have a higher proportion of qualified engineers than all manufacturing companies – in the future, other areas of manufacturing will have to reach these levels.
- Data for science graduates show that a higher proportion progress to obtain PhDs than is the case for engineering graduates.
- The evidence from Section 3 is that a significant expansion of research capacity is required, and is starting to be put in place, on the island – both in business and in higher education.
- An expansion of people with postgraduate qualifications in the higher education sector will be needed, both to work on research in this sector and to support a greater throughput of graduates in engineering and IT.

While the above trends indicate a move towards higher qualifications, the Task Force believes there will be a strong ongoing need for people at sub-degree level. The evidence from the leading companies is that they have both a higher proportion of workers with postgraduate qualifications and with sub-degree qualifications (relative to those with degrees), compared to the wider economy.

Based on today's situation, and the trends identified by the Task Force and listed above, Table 5.7 estimates the required ratio of the different levels of qualification (where primary degree is set at 100) for the engineering and IT graduates of 2020 (if the island is to move to the level of a Top 5 global economy).

Table 5.7 Estimated Required Level of Qualifications for Engineering and IT Graduates in 2020

	Certificate	Diploma	Degree	Masters	PhD
Qualifications in 2020	70	60	100	75	15

Source: KI 2020 Task Force

For consistency, and to avoid confusion, Table 5.7 (and the wider report) uses the titles for engineering qualifications which applied up to 2004. However:

- Significant changes in the titles for engineering qualifications have taken place in Ireland in 2005, under the National Framework for Qualifications.
- The Bologna Declaration of 1999 will also result in significant changes in engineering education over the coming years. The main change will be that the professional engineer will be educated through an integrated, five-year, two-cycle programme leading to a Master degree. At the end of the first cycle, a Bachelor degree may be awarded. The adoption of the Bologna Declaration across the island is a further factor driving an increase in the level of engineering and IT qualifications.

Further information on the National Framework for Qualifications and the Bologna Declaration is contained in Annex 1.

Based on the above estimates for level of qualification required (Table 5.7), and the estimates in Table 5.4 for the total new supply requirement for 2020, Table 5.8 shows the required breakdown of new labour-market entrants in 2020, by level of qualification (the current supply situation is shown in Table 5.10).

Table 5.8 Estimated Number of New Labour-Market Entrants Required in 2020 by Level of Qualification

	Certificate	Diploma	Degree	Masters	PhD	Total
Engineering	3,000	2,600	4,400	3,300	700	14,000
IT/Computing	1,500	1,300	2,200	1,600	300	6,900

Source: Calculated from Tables 5.4 and 5.7

5.2.2 Disciplines Required by Engineering Graduates

Table 5.9 shows information gathered from the 12 leading companies on the disciplines of engineering they employ (weighted) and compares it to the information on the supply of engineers from Section 4. As the latter information (by discipline) came from different faculties, with different boundaries, the second column is also weighted, using the figures for the total numbers of engineering graduates (at degree level and higher) in Ireland and in Northern Ireland, as published by the HEA and the (Northern Ireland) Department of Employment and Learning.

Table 5.9 Current Demand from Leading Firms for Engineers (by discipline) and Current Supply of Graduates from Ireland and Northern Ireland

	Demand from Leading Firms	Current Supply Breakdown
	Percentage	
Electrical and Electronic	31	28
Civil and Structural	29	25
Mechanical	18	19
Chemical/Process/Bio-systems/Bio-Medical	7	12
Manufacturing and Industrial	6	9
Building Services	6	3
Environmental	3	4
Total	**100**	**100**

Source: Based on data gathered from survey of leading companies by Knowledge Island Task Force (presented in Section 2) and data supplied to Task Force by university Engineering Departments (presented in Section 4)

Note: Demand from leading firms weighted by level of demand across the three sectors for engineers, as taken from the HEA First Destination data for 2003. Graduate figures weighted based on number of engineer qualifications (degree and upwards) in most recent year.

This table indicates that the current profile of demand from leading firms is very similar to the current profile of engineers being trained by discipline. There is a slight oversupply of people in the chemical/bio areas but, given the growth in these areas, that seems appropriate. On the assumption that demand from leading firms in the ICT, bio-technology/bio-pharmaceutical and construction sectors is likely to reflect demand more widely in the future, the current breakdown of supply by discipline seems adequate. However, it must be noted that the fall-off in applications for engineering courses since 2000 is largely concentrated in the electrical/electronic discipline which will lead to an imbalance between supply and demand in this sector.

5.3 Current Supply of Engineers and IT Workers

Section 4 presented the numbers graduating in engineering in Ireland and Northern Ireland and these are shown below.

Table 5.10 Current breakdown of Number of Engineers Graduating, by Level of Qualification in Ireland and Northern Ireland

<table>
<tr><th></th><th>Certificate</th><th>Diploma</th><th>Degree</th><th>Masters</th><th>PhD</th></tr>
<tr><td>Ireland</td><td>1,128</td><td>703</td><td>2,339</td><td>238</td><td>51</td></tr>
<tr><td>Northern Ireland</td><td colspan="2">30</td><td>475</td><td>170</td><td>40</td></tr>
<tr><td>Ratio</td><td>41</td><td>26</td><td>100</td><td>15</td><td>3</td></tr>
</table>

Source: Tables 4.1 and 4.4

Note: (1) Data for most recent year available – 2003 for Ireland and 2003-2004 for Northern Ireland.

This table indicates that, in engineering, some 5,200 people graduated on the island in the most recent year for which data was available.

The data includes people graduating as computer engineers. However, data for computer science graduates is not fully available, as a portion of such graduates in Ireland is aggregated with wider science graduates. Available data shows that:

- 1,075 people graduated in computer science in Northern Ireland in 2003 – 2004 (with about half of these being at primary degree level); and
- 650 people graduated with primary degrees in computer science in Ireland in 2000.

Assuming the number in Ireland has remained roughly similar since 2000 (and it may have fallen) and adding an estimated figure for non-primary degree graduates in Ireland means that the number of computer science graduates on the island is perhaps half that of the number of engineering graduates, i.e. in the general region of 2,600 people per year.

5.4 Bridging the Gap between Demand and Supply

Sections 5.1 to 5.3 indicate that a significant number of engineering and computer graduates is needed on the island in the next 15 years if the island is to reach the level of a Top 5 global economy by 2020, and become a 'knowledge island'. Logically, this supply requirement can be filled in several ways:

- The capacity of university courses in engineering and computer science can be gradually, but steadily, expanded. This implies that it will be possible to obtain the requisite numbers of people to enter and complete these third-level courses (numbers have been falling in recent years).
- People currently in the labour force can be encouraged and supported in up-skilling. Such a lifelong learning agenda fits with existing training and human resource policies in both Ireland and Northern Ireland. Such lifelong learning could either occur for employees on a part-time basis while working or could involve returning to take up a full-time college course.
- People with engineering and computer science qualifications could be attracted from outside the island to join the labour force of the island.

5.5 Key Points from Section 5

- The strong economic growth of the 1990s was associated with strong growth in the number of engineers and IT professionals in the island economy.
- There are a range of reasons why the Task Force believes that this relationship will continue, i.e. that achieving the target of reaching the Top 5 economies in the world by 2020, with average annual economic growth of almost 4.5 per cent, will require a continued increase in the number of engineering and IT professionals.
- Specifically, the Task Force believes that the relationship between the increase in the number of engineers required and economic growth will remain the same as it was in the 1990s. The rate of increase is expected to slow for IT workers as their numbers grew from a low base in the 1990s.
- The Task Force believes that achieving the Top 5 target by 2020 will require 110,000 people working as engineers and engineering technicians, and 115,000 people working as IT professionals and technicians, by 2020.
- These figures combined would represent 6-7 per cent of the labour force.
- Reaching these figures will require a growth in the number of engineers and IT professionals of 5.6 per cent per year.
- Taking account of people who will retire, the number of engineers will need to increase by 7 per cent per year and the number of IT workers by 6 per cent.
- Relative to the profile of the current output of graduates, and based on the views of leading companies, there will be more people required both at post-graduate level and at sub-degree level.
- The current output of engineers by discipline appears to be broadly in line with demand from industry on the island.
- Meeting the projected increased demand for engineers and IT workers in the island economy can be met through increasing the number of young Irish people gaining relevant qualifications, up-skilling of existing workers or attracting workers with the appropriate qualifications into the island labour force from outside.

Section 6: Key Conclusions and Recommendations

6.1 Key Task Force Conclusions

Top 5 target attainable by 2020 with 4.5 per cent growth.

The target of having income per head on the island in the top five globally with an expanded population can be achieved with a annual average GNP growth rate of 4.5 per cent. This would require lower average growth than has been achieved on the island in the past 15 years.

High tech sectors are key growth drivers.

Key drivers of growth are expected to be the ICT and bio-pharmaceutical/bio-medical sectors, with the support of the construction sector.

Substantial increase needed in qualified engineering and IT staff.

The expansion of the high-tech sectors, and other sectors across the economy, will require a substantial increase in engineering and IT professionals. This will represent a continuation of a trend seen on the island since 1990, as the island of Ireland becomes a 'knowledge economy'.

R & D resources a vital ingredient for the "knowledge island".

R&D expenditure and personnel on the island lag substantially behind the levels of the leading economies, and this gap will need to be closed to achieve a "knowledge island".

Competitive threats exist and are changing.

There is a threat to building a Top 5 economy from rapidly emerging Asian economies, such as China, India and Taiwan. The island will also receive a much lower level of EU Structural Funds from 2005 to 2020 compared to 1990-2004.

Almost three-fold increase in stock of qualified staff required.

There will be a need to increase the stock of people with engineering and IT qualification by a factor of 2.75, from its level in 2001-2002 to its required level in 2020.

Strong annual increase in supply of engineering and IT personnel necessary.

An increase in the number of those with engineering qualifications in the labour force of 7 per cent per year is required. An increase in the number of those with IT qualifications in the labour force of 6 per cent per year is required.

Distribution of engineering disciplines reflects expected demand.

The current distribution of graduates across the different engineering disciplines appears to broadly reflect expected demand patterns, at least in the medium-term.

Greater complementarity is needed between engineering and science.

There will be greater interaction between engineering and science disciplines in the key growth sectors. This reflects a convergence of science and engineering in sectors such as nanotechnology (which brings together biological and engineering sciences).

Demand for PhDs expected to increase almost ten-fold.

The opinions of the leading firms today suggest strong growth in demand for professionals with post-graduate qualifications. Demand for PhDs is expected to increase almost ten-fold by 2020.

A threat is posed by the sharp fall in number of applications.

While the annual supply of engineers and IT professionals is required to grow strongly (to achieve ‘Top 5’ economic status), this must be seen in the context of a sharp fall in the number of applications to IT and engineering courses since 2000.

A strong recovery in demand for IT professionals is evident.

There is international evidence in 2005 to indicate a sharp recovery in the demand for IT professionals after the slowdown in 2001-2003.

6.2 Task Force Recommendations[37]

Adopt target for island of being in Top 5 global economies by 2020.

The Task Force believes that the island can reach the level of the Top 5 global economies in terms of income per head by 2020. To this end, it believes achievement of a 4.5 per cent per annum economic growth rate for the island to 2020, and the creation of a ‘knowledge island’, should be adopted as feasible targets. The achievement of these targets will require close collaboration in fulfilling the economic and skills development potential of the people of the island. Collaboration already exists at the highest levels of government and policy.

Robust increase in the supply of qualified engineers, IT staff and PhDs needed.

Measures should be set in train by the relevant authorities on the island to increase the supply on the island by 2020 of

(a) Engineering professionals and technicians by 7 per cent per year

(b) IT professionals and technicians by 6 per cent per year

(c) Engineering and IT PhDs by 13 per cent per year

Develop world class centres of research linked to Engineering and IT schools that share resources.

Engineering and computer engineering/science schools on the island are small by international standards and do not have sufficient economies of scale. There should be intensive efforts both to develop world class R&D centres of excellence and to share resources to benefit from economies of scale.

Promote engineering and science as career options much more intensively.

A co-ordinated and adequately funded promotional campaign to attract applicants for engineering and science courses at third-level should be launched throughout the island (e.g. Ireland’s Discover Science and Engineering Initiative and STEPS – Science, Technology and Engineering Programme for Schools). The resources required will be determined by the campaign’s success in meeting the targeted number of course entrants. There should also be efforts to attract more students at second-level into Maths and science subjects, and to ensure consistently high standards of relevant second-level teaching and facilities.

Make greater efforts to attract women into engineering, targetting 50/50 gender distribution.

Particular attention should be given to attracting more women into engineering, and in supporting their careers, including through the development of more flexible career paths and working arrangements, with the aim of moving towards a 50/50 gender distribution by 2020.

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37 The Task Force recognises that some of these recommendations were addressed in a broader context for Ireland in the Enterprise Strategy Group’s 2004 report “Ahead of the Curve” and that some preliminary actions have been taken.

Provide more substantial resources to increase graduate, and research, output from higher educational institutions.

Third-level institutions throughout the island should be allocated sufficient resources to enable them to achieve the sharp increase in annual graduate output required, including in supporting more students to progress to PhD level. The increase in resources should be sufficient to cover both R&D and teaching.

Expand programmes supporting linkages between industry and third level institutions.

The current successful programmes supporting linkages between industry and third-level institutions on the island should be expanded to involve a higher proportion of Masters and PhD graduates. This would assist integration between academic research and innovation in indigenous industry. Systems are needed to ensure that sufficient projects, companies and post graduates are attracted to achieve the necessary degree of expansion.

Implement more programmes for continuing professional development and for obtaining higher level qualifications while remaining at work.

The continuing professional development of engineering and IT staff should be intensified by industry, and complemented by the provision of better facilities, curricula and timetables by higher education institutions, to enable company employees to attain higher qualifications, up to PhD level, in a way that integrates work and learning.

Publish information on the number of computer engineering/science graduates annually.

Details should be published of the number of computer engineering and computer science qualifications awarded annually by higher education institutions on the island. Such information will enable third-level institutions and development authorities to assess the adequacy of the supply system.

Support more complementarity between engineering and science studies.

Higher education institutions should take action to enable greater interaction between engineering and science qualifications to meet the needs of the key growth sectors.

Attract and integrate engineering and IT professionals from abroad.

To the extent that the supply of engineers and IT professionals from third-level institutions in Ireland falls below the required amount, the gap should be bridged through immigration, primarily from other EU Member States. It is recommended that clear and specific policies be developed by the relevant authorities to facilitate the integration of such migrants.

Gather information on the engineering and IT qualifications of immigrants when they register with the social welfare systems on the island.

Immigrant workers registering with the social welfare systems should be asked to provide information on their third-level qualifications, including in engineering and computer engineering/science, and a summary of the qualifications of these labour market entrants should be published annually. This will enable the development authorities to assess the degree to which immigration is supplementing the supply of graduates by the third-level institutions on the island.

Annex 1: Changes in Engineering Education in Ireland

National Framework for Qualifications

The National Framework for Qualifications was launched by the National Qualifications Authority of Ireland (NQAI) in 2003. The ten-level framework provides for the development, recognition and award of qualifications in Ireland. The Higher Education and Training Awards Council (HETAC) has responsibility for the titles of the Named Awards for qualifications in Institutes of Technology (excluding Dublin Institute of Technology), and has introduced several important changes. Table A-1 summarises these changes with regard to titles for engineering qualifications.

Table A-1 Relevant Levels of NQAI Framework for Engineering and Existing/New Awards – Ireland

Framework Level	Existing Awards (to 2004)	New Awards (from 2005)
Level 6	National Certificate in Engineering	Higher Certificate in Engineering
Level 7	National Diploma in Engineering	Bachelor of Engineering Degree
Level 8	Bachelor of Engineering Degree Bachelor of Technology Degree Certain BSc degree programmes	Honours Bachelor of Engineering Degree

Source: Engineers Ireland

The educational standard for ordinary membership of Engineers Ireland (MIEI) and the Chartered Engineer title of Engineers Ireland is a Level 8 Honours Bachelor of Engineering Degree, accredited by Engineers Ireland.

Bologna Declaration

The Bologna Declaration, underwritten by more than 40 countries, was first signed by 29 countries in June 1999. Its context was the development of a Europe of knowledge through the enhancement of European higher education systems and the creation of a European Area of Higher Education in which students can easily move from one programme to another and from one country to another.

The 6 objectives of the Bologna Declaration are described as:

1 Adoption of a system of easily readable and comparable degrees
2 Adoption of a two-cycle higher education system
3 Establishment of a system of credits
4 Promotion of mobility of students and staff
5 Promotion of European co-operation in quality assurance
6 Promotion of the European dimension in higher education.

The second of these objectives, "Adoption of a two-cycle higher education system", is of particular importance. Following extensive consultation, and in accordance with the European engineering academic community's views on the Bologna Declaration, Engineers Ireland recommends that the education of the professional engineer should be through an integrated, five-year, two-cycle programme leading to a Masters degree, accredited by Engineers Ireland. Graduates of the programmes will be deemed by Engineers Ireland to have satisfied the educational standard for the title of Chartered Engineer. At the end of the first cycle, a Bachelors degree may be awarded.

The education of the engineering technologist should be through a three-year engineering technology programme leading to a Bachelors degree which satisfies the accreditation criteria of Engineers Ireland.

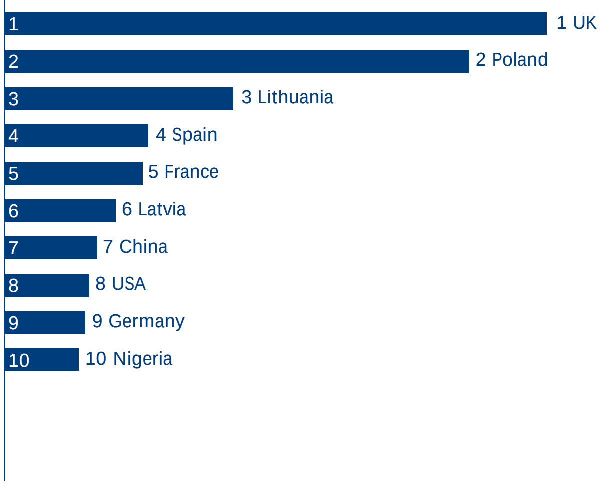
Engineers Ireland considers the two-year National/Technician Certificate in Engineering an extremely important qualification and recognises the essential role of engineering technicians in the development of Irish industry. Accredited programmes leading to this qualification should continue to be offered in Irish colleges.

Annex 2: Allocation of PPS Numbers by Nationality in 2003-2004

Table A-2 shows the main countries of origin for people from outside Ireland who registered for Personal Public Service (PPS) Numbers in Ireland in the two years of 2003 and 2004 combined. (A PPS number is equivalent to a Social Security number in Northern Ireland. It allows people to access benefits and information from public service agencies, e.g. tax, social welfare, health and education).

Table A-2 Nationality of Applicants for PPS Numbers in Ireland, 2003 and 2004, Top 10 Countries (excluding Ireland)

Nationality of Applicant	Number	% of Total
1 United Kingdom	36,927	15.5
2 Poland	31,123	13.1
3 Lithuania	15,196	6.4
4 Spain	9,376	3.9
5 France	9,010	3.8
6 Latvia	7,496	3.2
7 China	7,233	3.0
8 USA	6,205	2.6
9 Germany	6,024	2.5
10 Nigeria	5,768	2.4
Total of Top 10 Counries	**134,358**	**56.4**
Total PPS Numbers to Non-Nationals in 2003-2004	**237,956**	**100.0**



Source: Department of Social and Family Affairs, Press Office – information supplied to KI 2020 Task Force.

Annex 3: Abbreviations used in Report

BERD	Business Expenditure on Research and Development
CAO	Central Applications Office
CPD	Continuous Professional Development
CRANN	Centre for Research on Adaptive Nanostructures and Nanodevices
CSET	Centre for Science, Engineering and Technology
CSO	Central Statistics Office
CTVR	Centre for Telecommunications Value-Chain-Driven-Research
DCU	Dublin City University
DERI	Digital Enterprise Research Institute
ECIT	Electronics, Communications and Information Technology
ESRI	Economic and Social Research Institute
EU	European Union
FÁS	Foras Áiseanna Saothair – Ireland's National Training and Employment Authority
GDP	Gross Domestic Product
GERD	Gross Expenditure on Research and Development
GNI	Gross National Income
GNP	Gross National Product
HE	Higher Education
HEA	Higher Education Authority
HERD	Higher Education Expenditure on Research and Development
HETAC	Higher Education and Training Awards Council
ICT	Information and Communications Technology
IDA	Industrial Development Agency
IMDA	Irish Medical Devices Association
IRCSET	Irish Research Council for Science, Engineering and Technology
IT	Information Technology
MIEI	Member of the Institution of Engineers of Ireland (Engineers Ireland)
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne (i.e. statistical classification of economic activity in the European Community)
NIBRT	National Institute for Bioprocessing Research and Training
NIEC	Northern Ireland Economic Council
NISRA	Northern Ireland Statistics and Research Agency
NMRC	National Microelectronics Research Centre
NQAI	National Qualifications Authority of Ireland
NUIG	National University of Ireland, Galway
OECD	Organisation for Economic Co-operation and Development
PRTLI	Programme for Research in Third Level Institutions
QUB	Queen's University, Belfast
R&D	Research and Development
RAE	Research Assessment Exercise
REMEDI	Regenerative Medicine Institute
RTD	Research and Technology Development
SET	Science, Engineering and Technology

SFI	Science Foundation Ireland
SME	Small and Medium-sized Enterprise
STEPS	Science, Technology and Engineering Programmes for Schools
TCD	Trinity College Dublin
UCC	University College Cork
UCD	University College Dublin
UK	United Kingdom
US	United States
UU	University of Ulster

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The Irish Academy of Engineering
46 Merrion Square
Dublin 2.
Tel: 00 353 1 642 5588
Fax: 00 353 1 642 5590
www.iae.ie

Engineers Ireland
22 Clyde Road
Ballsbridge
Dublin 4.
Tel: 00 353 1 668 4341
Fax: 00 353 1 668 5508
www.engineersireland.ie

Inter*Trade*Ireland
Old Gasworks Business Park
Kilmorey Street
Newry
BT34 2DE.
From Republic
Tel: 00 353 (0) 48 3083 4100
Fax: 00 353(0) 48 3083 4155
From NI/UK
Tel: 00 44 (0) 2830834100
Fax: 00 44 (0) 28 30834155
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