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DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY

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Working Party on Innovation and Technology Policy

POLICY MIX FOR INNOVATION IN ICELAND

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FOREWORD

The effectiveness of innovation policy depends not only on the design and implementation of individual policy instruments for innovation (*e.g.,* tax incentives, public/private partnership programmes), but also on the way instruments are combined into policy mixes that offer complementary and mutually reinforcing support for national innovation systems. Policy mixes for innovation vary considerably from one OECD country to another, even if many of the policy instruments are quite similar.

To better understand how policy mixes for innovation differ among OECD countries and provide further insight into how such differences contribute to overall policy effectiveness, the OECD Working Party on Innovation and Technology Policy (TIP) agreed to implement a series of peer reviews that would examine policy mixes for innovation in a set of volunteer countries. The objectives of this activity are to: *i)* improve knowledge about policy mixes via cross-country comparison; and *ii)* provide feedback to countries under review for improving their own policy mix.

The report reviews the policy mix for innovation in Iceland. It draws on a background paper on Icelandic innovation policy and performance prepared by Arnold Verbeek of Idea Consult (Belgium) on behalf of the Icelandic Ministry of Education, Science and Culture, as well as on a series of interviews with the main stakeholders in Iceland's government, industry and the research community.[1] It takes into account the results of a peer review held in December 2005 as part of a meeting of the TIP Working Party, and in particular the contributions of three lead discussants at that meeting, the first two of whom participated in the interviews in Iceland: Jacqueline Allan of Forfás (Ireland), Alpo Kuparinen of the Finnish Ministry of Trade and Industry and Thomas Grosfeld of the Dutch Ministry of Economic Affairs.

The impetus for the review and responsibility for its implementation in Iceland came from Vilhjálmur Lúðvíksson from the Icelandic Ministry of Education, Science and Culture and Sveinn Thorgrimsson of the Ministries of Industry and Commerce. From the OECD Secretariat, the peer review was co-ordinated by Jerry Sheehan, with support from Byung-Seon Jeong and Sandrine Kergroach-Connan. It is published under the responsibility of the Secretary-General of the OECD.

[1] A list of organisations consulted during the review is contained in Annex 2 of this report.

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EXECUTIVE SUMMARY

Iceland has experienced marked improvements in it economic and innovative performance over the last decade. Per capita income was approximately 20% higher than the OECD average in 2003, up from 10% higher in 1995, and economic growth rates are expected to remain high in coming years. R&D spending has also increased significantly, rising from about 1.6% to about 3% of GDP during the same time period, as both government and industry invested more in R&D. Absolute spending levels are low because of the small size of the economy, but government funding of R&D exceeds that of all other OECD countries in relative terms, standing at almost 1.2% of GDP in 2003. Industry spending on R&D has grown rapidly, increasing from 0.6% to 1.3% of GDP between 1995 and 2003, and is on-par with OECD average, exceeding the EU average by a wide margin.

With this expanding R&D capacity have come changes in the governance of Iceland's innovation system and in the priorities established for its innovation policy. Under the new Science and Technology Policy Council (STPC), which was established in 2003 to improve government-wide co-ordination of science and technology policy and inform policy-making, emphasis has been placed on improving the efficiency of the Icelandic innovation system. The innovation policy objectives promulgated by the STPC aim to strengthen university-based research, restructure the public research institutes, improve support to business innovation and entrepreneurship, and enhance science and technology education (Box 1).

Box 1. Policy Objectives of the Icelandic Science and Technology Policy Council (2004)

- Establish strong research teams for working in an international environment by giving priority to the most competent individuals, institutions and firms.
- Increase the co-operation between research institutes, universities and business enterprises in forming knowledge clusters capable of attaining a strong position in international competition.
- Make research and development attractive to business enterprises, supporting the emergence of high-technology firms which to a large extend rely on research for their growth.
- Give increased weight to research training of young scientists in an internationally competitive research environment.
- Assure open public access to the results of publicly financed research, databases and other scientific and scholarly information, promoting the utilisation of these for added value to society.
- Pass laws encouraging scientists to protect their intellectual property rights through patents, and institutions and firms to introduce measures to properly manage the intellectual property of their employees.
- Regularly assess the quality of research conducted by universities and research institutes, by subject areas or fields of employment or knowledge clusters, and take the results of these into account when deciding on appropriations and priorities.

As a result, Iceland's policy mix for innovation is in the midst of considerable change. Efforts are underway not only to increase the share of competitive R&D funding in the innovation system, but to streamline and merge existing research institutes and link them better to the university system. In addition, new policy instruments have been put in place to foster development of high-technology industries, such as through increased public funding of business R&D, establishing the financial and legal framework for a public/private partnership on venture capital funding and increased advisory services to start-up and other entrepreneurial firms. New funding programmes have also been established to encourage innovation in

industries and technologies that are seen as important to Iceland's economic future, including the fisheries, nanotechnology and post-genomic biomedicine. Attention is also being dedicated to the development of human resources, in particular through the creation and expansion of graduate training programmes in Iceland. Regional and international dimensions of innovation policy are also receiving increased attention.

This report reviews the evolving policy mix for innovation in Iceland and identifies a number of issues for consideration in strengthening the policy mix. An early draft of this report served as the basis for discussion during a peer review of the Icelandic policy mix for innovation conducted by the OECD Working Party on Innovation and Technology Policy. The aim of the review is to both provide feedback to Iceland on ways in which its policy mix can be strengthened to further improve innovation performance and to identify common lessons that can be applied to a larger set of OECD countries as they develop their own policy mixes for innovation. A summary of key discussion issues is listed in Box 2.

Box 2. Main issues for Icelandic policy mix

Overall innovation system

- Improving the balance among support for R&D and innovation in universities, public research institutes and business.
- Ensuring strong international linkages (balancing domestic and global activities).

Science and technology base

- Increasing the share of competitive funding for R&D.
- Building critical mass in R&D while maintaining diversity.
- Encouraging multi-disciplinary research.
- Implementing priority setting mechanisms.

Business R&D and innovation

- Evaluating the mix of direct financing and tax incentives for business R&D.
- Improving the policy mix for support to entrepreneurship.
- Increasing the relative emphasis on diffusion of knowledge.

Industry-science linkages

- Formalising and strengthening industry-science linkages via multiple channels.
- Supporting technology transfer offices.
- Implementing public/private partnership programmes for innovation.

Human resources for science and technology (HRST)

- Improving domestic supplies of skilled workers and university graduates.
- Ensuring international linkages in the education and research system.

Governance of the innovation system

- Improving advisory and co-ordination functions.
- Increasing industry participation in governance mechanisms.
- Introducing and enhancing evaluation at all levels.

INTRODUCTION

Background and purpose

In recent years, increased attention has been devoted to the concept of policy mixes for innovation. The term *policy mix* refers to more than just the set of policies and programmes put in place in a particular country to foster innovation, but to the combination and balance of policy instruments that are used in complementary and mutually reinforcing ways to achieve desired objectives. A policy mix perspective places less emphasis on the design and evaluation of individual instruments of innovation policy (e.g., tax incentives for R&D and public/private partnerships) and focuses more on questions of completeness, balance and interaction among policy instruments, for example: Does the set of policies for strengthening industry-science relationships open a diverse set of channels for formal and informal linkages? Does the balance between policies to strengthen the science system and those to support business R&D reflect the capabilities of the innovation system? Does the mix of tax incentives and direct funding instruments for financing business R&D provide complementary forms of assistance to firms? Ideally, a policy mix will take into account interactions among instruments and ensure balanced support for the range of challenges faced by a nation's innovation system.

This report examines the policy mix for innovation in Iceland, drawing on a peer review conducted by the OECD Working Party on Innovation and Technology Policy in December 2005. The aim of the review is not to evaluate individual instruments or institutions of innovation policy in Iceland (*e.g.*, R&D funding programmes, research institutions, universities), nor to provide a detailed set of concrete policy recommendations for improving Iceland's innovation performance and policy; rather, the objectives are to: *1)* provide feedback to Icelandic policy makers on the existing policy mix for innovation, with the aim of identifying areas in which it can be strengthened; and *2)* identify common challenges that are addressed by a number of OECD countries in developing and implementing policy mixes for innovation, comparing different solutions that have been implemented. The use of a peer review approach allows for cross-country comparisons that can aid in identifying areas in which the Icelandic policy mix is incomplete or deviates substantially from international practice. It also offers opportunities for sharing national experiences in developing and implementing effective policies and programmes.

The report is broad in its scope. It provides a brief overview of the recent performance of the Icelandic economy and innovation system, both of which have seen significant changes in recent years. It outlines the main elements of the Icelandic innovation system and the policy objectives identified by Icelandic authorities for improving innovation performance. It then reviews the mix of policies in place for fostering innovation and comments on the policy mix, noting areas for further policy development and/or a shift in the policy mix. In doing so, the report draws comparisons with and examples from other OECD countries, in particular Finland and Ireland, which were judged to offer significant opportunities for mutual learning. The report examines elements of the policy mix that aim to support the science and technology base, stimulate business innovation and entrepreneurship, foster industry-science linkages and develop human resources for science, technology and innovation. It also examines structures and policies that aim to improve the governance of the innovation system.

The economic context for innovation

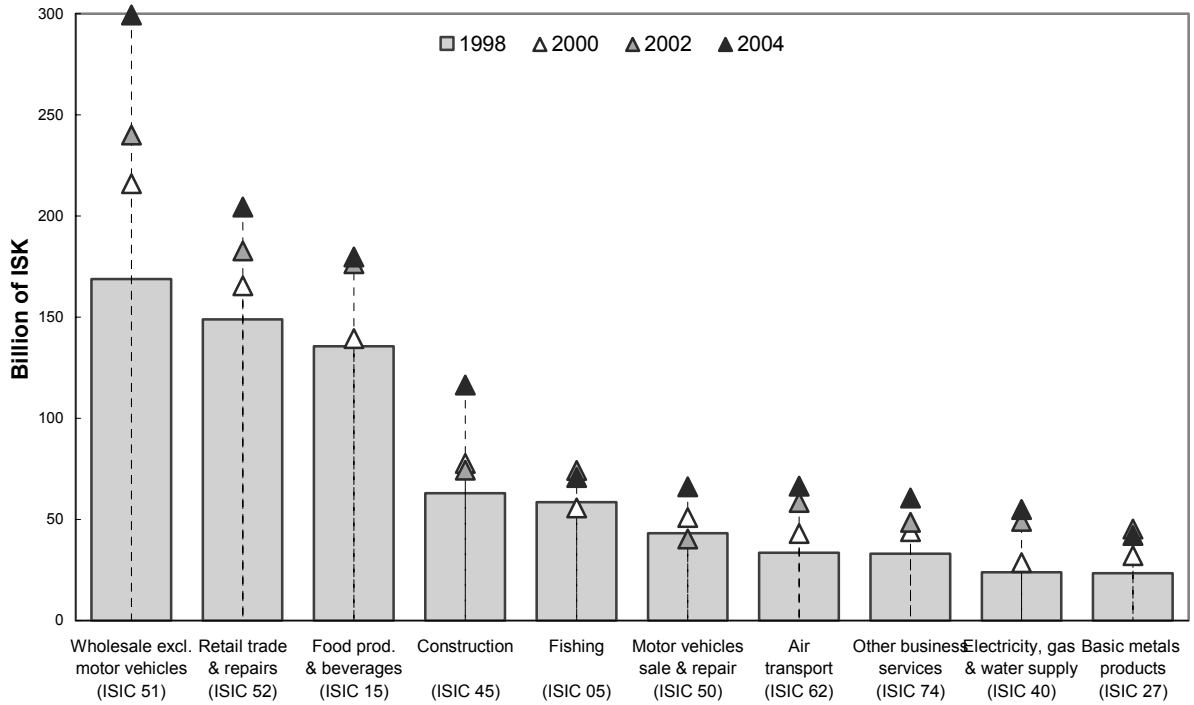
Iceland's economic performance has improved significantly over the past decade. With a GDP per capita of more than USD 36 000 in 2003, Iceland ranks among the ten wealthiest countries in the OECD. Between 1995 and 2003, per capita income in Iceland grew more rapidly than in other OECD countries (OECD, 2003a). Growth stagnated in the early part of the decade, but the most recent recovery, beginning in 2003, has been much more vigorous than expected (OECD, 2005). Growth is expected to top 5% a year between 2004 and 2006, again exceeding EU and OECD averages, but raising concerns about overheating. Much of Iceland's favourable performance in the last decade is attributed to the shift in policy towards financial stability and market liberalisation during the 1990s, as well as to a high labour participation rate, which offsets a lower level of labour productivity (per hour worked).

Sectoral contributions to the economy

Iceland's economic growth has been generated by an economy that is characterised by services, natural resource and low-technology manufacturing industries. The service sector accounted for more than two-thirds of total economic output in 2004, with manufacturing, construction and agriculture and fishing accounting for 12%, 9% and 7%, respectively. In terms of annual turnover the largest industry sectors are wholesale and retail trade, followed by food processing, construction, and fishing (Figure 1).

Figure 1. Iceland's ten largest industry sectors

Annual turnover (millions of ISK)

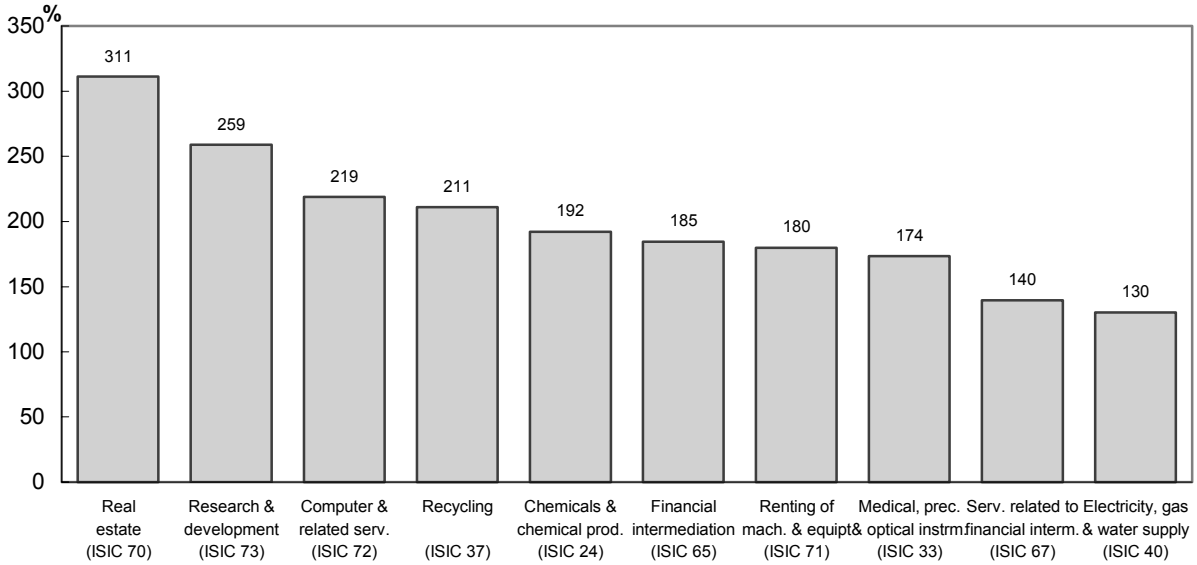


Source: Statistics Iceland (reworked).

The Icelandic economy is transitioning to a more knowledge-based economy. A clear shift is under way from resource-based industries and traditional manufacturing sectors to more knowledge-intensive sectors, including higher technology manufacturing and services. Between 1998 and 2004, the fastest growing sectors of the Icelandic economy included research and development services, computer and related services, chemicals and financial intermediation (in addition to real estate, which reflects a booming housing market) (Figure 2). The agriculture sector contracted during this time frame. The Federation of Icelandic Industries estimates that high technology firms (defined by the Federation as those firms with R&D expenditure of 4% or more of total revenues) represented 4% of Iceland's GDP in 2004 and 7% of export revenues, up from 1% and 3%, respectively, in 1998. The Federation projects that high-technology will account for 14% of Iceland's export revenues by 2010.

Figure 2. Fastest growing industry sectors in Iceland

Percentage growth in turnover, 1998-2004



Source: Statistics Iceland

International linkages and openness

International linkages are an important element of Iceland's national economy—and innovation system. Iceland is a geographically large country (over 100 000 square kilometers) with a small population (less than 300 000 in 2003) and thus a small internal market. This poses restrictions to local expansion, but also forms a stimulus for many companies to internationalise. The economy is generally open to competition through international trade and foreign direct investment, except in energy, agriculture and fisheries. The Icelandic government has actively encouraged foreign direct investment (FDI) in power-intensive industries, and Iceland is well-known for its net outward FDI, especially in sectors like food processing, fishing, chemicals (mainly pharmaceuticals) banking, retail and property. The average value of inward and outward investments totalled 1.7% of GDP in 2003, compared to 1.2% for the EU25. This figure declined slightly after 2000, reflecting a broader economic slowdown, but less-so than for the EU25, and preliminary statistics indicate a strong rebound in outward FDI in 2004.

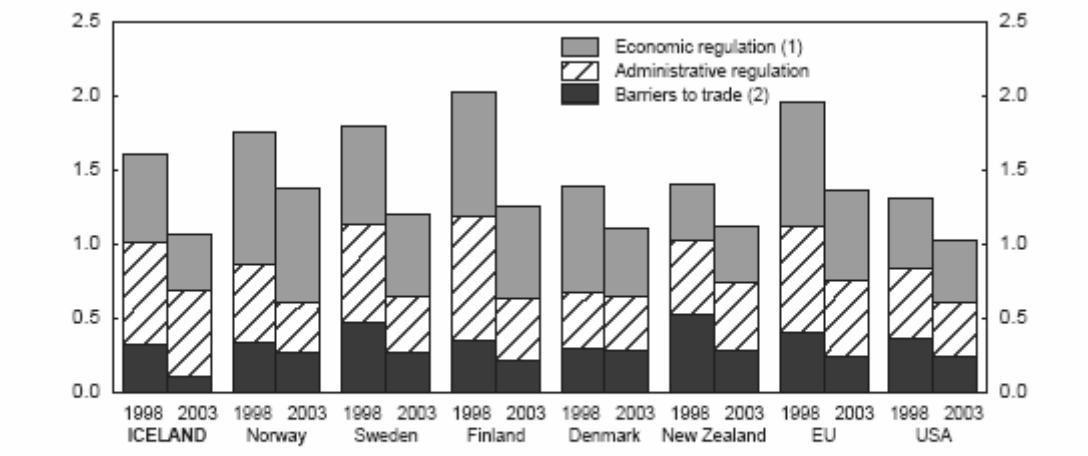
Trade has been another channel of internationalisation and offers clear signs of a knowledge based economy. The share of technology based exports (goods and services) has been rising rapidly as a share of total export value. In 2003, exports of goods from Iceland amounted to ISK 183 billion (USD 1.9 billion) and imports almost ISK 200 billion (USD 2.1 billion), resulting in a trade deficit of ISK 17 billion (USD 180 million), compared with a surplus of ISK 13 billion (USD 140 million) in 2002.[2] Currency fluctuations that have raised the value of the Icelandic krona against other currencies (including the US dollar and the euro) have had a significant effect on Icelandic imports and exports. Marine products constituted 62% of all exports, decreasing in value by 12% from the year before, at current prices. Manufacturing products amounted to 34% of total exports, decreasing in value by 8%. The largest import categories were industrial supplies, accounting for 27% of total imports; capital goods (except for transport), with 23% of total imports; and consumer goods, with a 20% share. Measured in Icelandic knónur, the increase in imports was largest in respect to capital goods, mainly related to large scale investments in new power-plants and associated power-intensive industries. The United Kingdom was the largest importer of Icelandic good in 2003, accounting for 18% of Iceland's total exports, while Germany accounted for the largest share of imports into Iceland (12%).

Market liberalization and reduced regulatory burdens.

As a whole, the Icelandic economy is quite open to competitive forces and has been following the OECD-wide trend over recent years towards further liberalization (OECD, 2005b). Nevertheless OECD data indicates administrative burdens to starting a new business remain relatively high compared to other Nordic countries and the United States, and have not diminished significantly in recent years. (OECD, 2005*b*). In contrast, barriers to trade, including tariffs and foreign ownership restrictions, are in general low by international standards, and have declined in recent years (Figure 3). Some exceptions do exist. The degree of openness is especially high in terms of non-tariff barriers, but less so in terms of tariffs, due largely to tariffs on agricultural products: the average MFN tariff rate for agricultural products in 1999 was 10.8% – more than four times the average rate for manufactured goods. Moreover, since there is no domestic production of many items, certain indirect taxes, such as the excise taxes on vehicles, act like a tariff. The Icelandic government is focusing on further liberalizing its economy through: 1) reduction in agricultural support; 2) further opening to foreign direct investment; and 3) public procurement and outsourcing of publicly funded services. The World Economic Forum ranks Iceland fifth on its Competitiveness Index, reflecting its healthy macro-economic environment and the high transparency and efficiency of its public institutions (Global Competitiveness Report, 2005).

[2] Throughout this report, currency values in Icelandic krónur (ISK) are converted to US dollars using OECD purchasing power parities (PPPs). For the year 2003, the conversion rate is ISK 93.91 per USD. PPPs for other years can be found in OECD (2005c).

Figure 3. Indices of regulation affecting product market competition



1. Includes barriers to competition and state control.
2. Includes trade and FDI restrictions.
Source: OECD calculations.

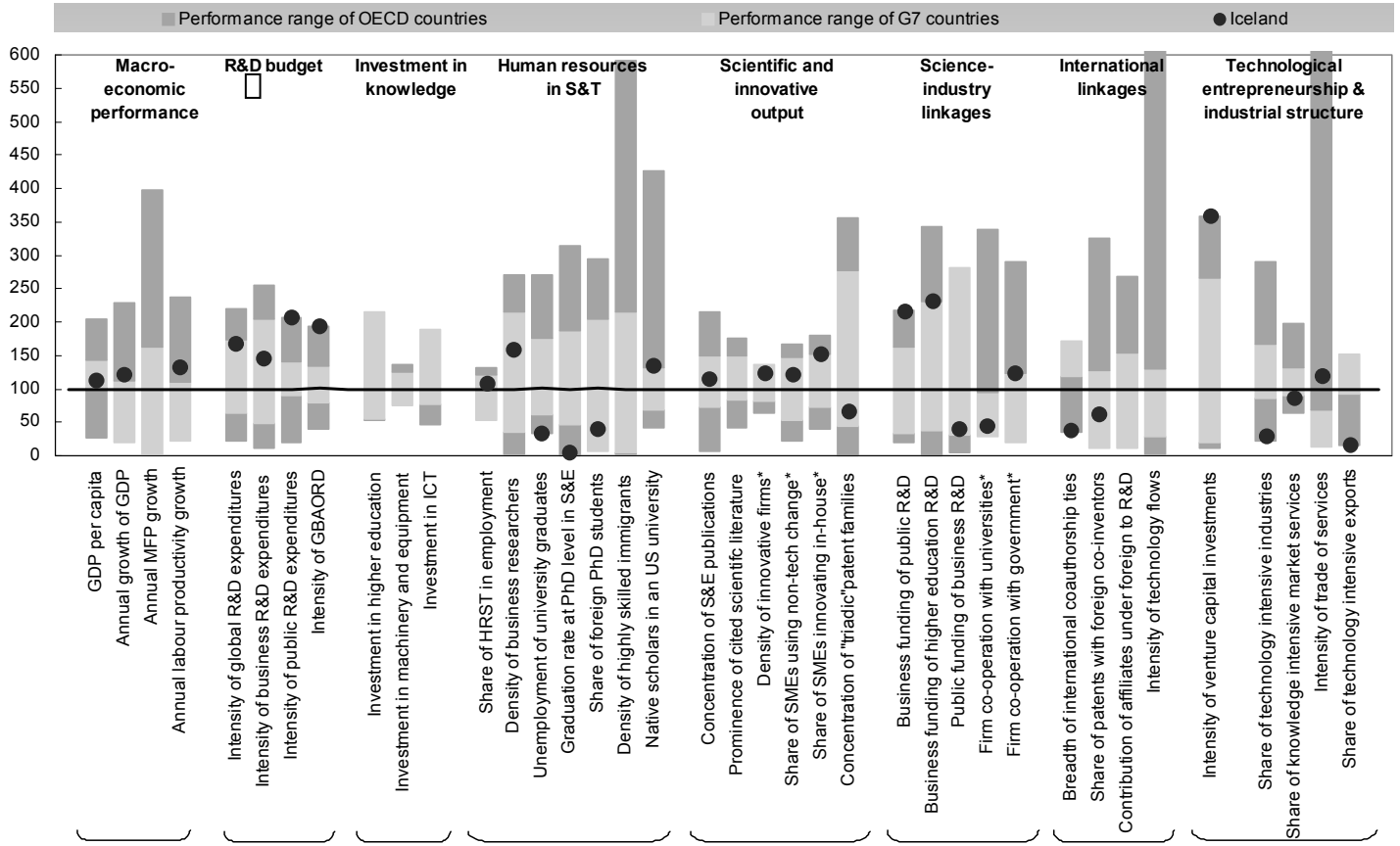
Innovation performance in Iceland

By many indications, the Icelandic innovation system has gained considerable ground in recent years. Most international comparative studies on innovation performance praise Iceland's innovation and economic performance in the last five to seven years. Iceland performs well above the EU-average and in many cases above the OECD average for many of the leading innovation indicators and is often referred to as a leading country in innovation – a situation very different from the one that characterised the country a decade or so ago. A cursory review of standardised performance indicators (Figure 4) shows that Iceland is above OECD averages in terms of its economic performance, R&D performance, scientific output and overall innovation performance (as measured by innovation surveys). Nevertheless, some challenges remain. Patenting levels, as measured by triadic patents remain below average, as do graduation rates in science and engineering and shares of foreign PhD students in Iceland (reflecting the fact that the education system relies on Icelandic students going abroad for their university education, particularly at the graduate level).[3] While firms appear to fund a significant share of public sector R&D, they report limited co-operation with universities. The Global Entrepreneurship Monitor (2005), reports that Iceland is performing very well in terms of entrepreneurial activity and spirit, and levels of venture capital appear high as a share of GDP. These topics are examined in greater detail below.

[3] For Iceland this has been viewed as a positive situation, as it has lead to workforce that is trained to international standards and with strong international networks.

Figure 4. Performance of Iceland national innovation system, 2004 or latest

Normalised index based on relative distance from the arithmetic average of values for all OECD countries



Note: The arithmetic average is assigned a value of 100 and country indexes are calculated as follows: 100 x (Value for the country / Arithmetic average of values).

R&D funding and performance

R&D performance has improved considerably in Iceland over the past decade. While in absolute terms Iceland retains the lowest level of R&D spending in the OECD area, with total R&D expenditures (gross expenditure on R&D or GERD) of USD 254 million,[4] its relative level of spending is one of the largest in the OECD, at approximately 3% of GDP. This differs dramatically from the situation as recently as in 1995, when R&D intensity in Iceland, at 1.6% of GDP, was significantly below OECD and EU averages. The change reflects the fact that since 1995, GERD has expanded at one of the fastest rates in the OECD over the past decade, rising at more than 12% annually, compared to a rate of 3.6% for the OECD as a whole.[5] Approximately half of Iceland's R&D is performed by the business sector, one-quarter by government research institutions, and one-fifth by universities.

Increased funding for R&D

Public spending on R&D is an important element of Iceland's overall R&D situation. Although absolute funding levels are low compared to other OECD countries, Iceland has the highest level of government-funded R&D in the OECD when measured as a share of GDP. Government R&D funding reached 1.2% of GDP in 2003, up from 0.9% in 1995 (Table 1). Since 1995, government funding for R&D has increase at a rate of 7.2% annually. This stands in contrast to most countries where public funding was already high (as a share of GDP) in 1995, in which government financing of R&D increased less rapidly than GDP growth. In recent decades, a marked shift can be seen in government R&D support, from applied research related to natural resources towards basic research, industrial technologies and, in particular, towards biomedical and health and biotechnology related research and development.

Industry-financed R&D has also increased rapidly in recent years, accounting for much of Iceland's overall growth in R&D. From a level of less than 0.6% of GDP in 1995, industry-financed R&D increased to 1.4% of GDP in 2001, before declining to 1.3% of GDP in 2003. These levels are far above the EU average of just under 1% of GDP and roughly equivalent to the OECD average, which stood at 1.4% of GDP in 2003. Industry financing accounted for about 44% of the Iceland's total R&D expenditure in 2003 (ISK 10.5 billion or USD 111 million).

Table 1. R&D expenditures by source of funding and performer

	1995	1997	1999	2001	2003
GERD (PPP per capita)	347	466	646	900	873
OECD GERD (PPP per capita)	495	553	612	691	730
Government-financed GERD (% GDP)	0.91	0.96	0.98	1.05	1.19
Industry-financed GERD (% GDP)	0.55	0.79	1.04	1.42	1.31
GOVERD (% GDP)	0.59	0.56	0.72	0.62	0.74
HERD (% GDP)	0.43	0.54	0.50	0.58	0.63
BERD (% GDP)	0.50	0.77	1.11	1.81	1.54
OECD BERD (% GDP)	1.39	1.45	1.51	1.57	1.53

Source: OECD, MSTI database, November 2005.

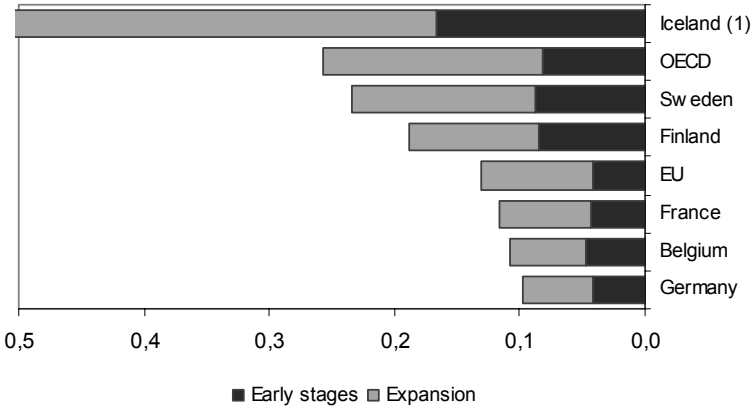
4 By way of comparison, Luxembourg spent USD 432 million and the Slovak Republic spent USD 414 million in 2003.

5 On a per-capita basis Iceland's R&D performance is strong. Between 1998 and 2003, Iceland's total expenditure on R&D per capita increased from USD 544 per capita to USD 903 – an increase of more than 66% in 5 years. It lies well-above the OECD average.

Venture capital investments are strong

Growth in industry financing has been further stimulated by growing venture capital investments. Iceland's venture capital investment (early stage and expansion) as a percentage of GDP is highest within the OECD (see Figure 5); however, careful interpretation is needed, as the data refer to the period between 2000 and 2002, when venture capital levels soared in many countries before retreating to much lower levels. The European Innovation Scoreboard indicates that the availability of early stage venture capital remains above the EU25 average (EIS 2005), but the availability of high-tech (start-up) venture capital lies below the EU average – which is confirmed by many observers in Iceland. Between 2000 and 2003, domestic firms in Iceland, Sweden, the United Kingdom and the Netherlands managed more venture capital than they received from international flows (OECD, 2005a). Besides the importance of classical venture capital, informal investment is an important source for funding new businesses After China, Iceland has the highest percentage of informal investment capital in relation to GDP, at about 3.5% (GEM, 2005).

Figure 5. Investments in venture capital, as a percentage of GDP, 2000-2003



1. Icelandic data for the period 2000-2002.

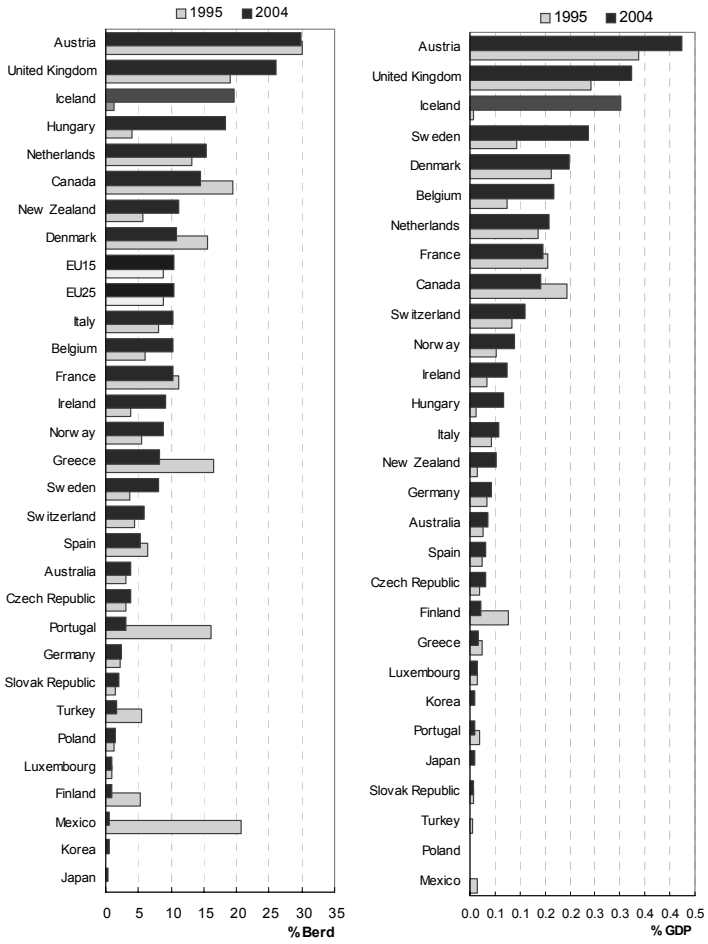
Source: OECD based on data from the European Venture Capital Association.

Funding from abroad

Foreign funding plays an important role in Iceland's innovation system. In 2001, 18% of Iceland's R&D was financed by foreign sources, compared to 8% on average in EU countries (in 2003, foreign funding accounted for 14.5% of Icelandic R&D). Sources from abroad also constituted 19.5% of Icelandic business R&D (BERD) in 2001 (Figure 6). The absolute amounts of foreign funding remains low, at USD 25 million, but they are high in relation to GDP, standing at 0.3% of GDP in 2001. In most OECD countries, foreign funding increased rapidly after 1995 but Iceland recorded the highest levels of growth.

Figure 6. Funding from abroad to firms, 2004 or latest

As a % of total business R&D expenditures and as a % of GDP



Source: OECD, MSTI database, November 2005.

Growing performance of R&D in the public and private sectors

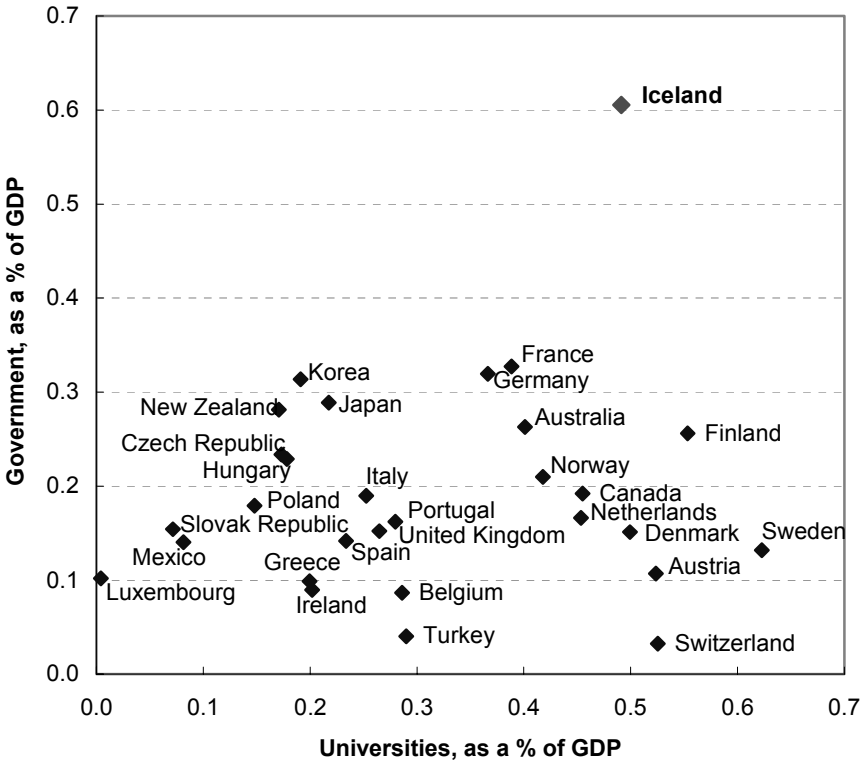
Increases in government spending on R&D have contributed to growth in the public research sector (*i.e.*, R&D performed in the higher education sector or government laboratories). Between 1995 and 2003, total R&D performed in the public sector grew, from 1% to 1.4% of GDP. R&D in the higher education sector (HERD) grew from 0.43% to 0.63% of GDP, while that in government laboratories (GOVERD) grew from 0.59% to 0.74% of GDP. As these figures illustrate, the government research sector remains larger than the university research sector in Iceland, even if the gap has narrowed somewhat in recent years.

Figures for HERD and GOVERD in Iceland remain well above OECD averages of 0.39% and 0.28% of GDP, respectively, attesting to the large size of the Icelandic public research system relative to the size of the economy. Indeed, the Icelandic government laboratory system remains the largest in the OECD as a share of GDP, at almost double the level of funding of GOVERD in the second-highest country, France, at 0.36% of GDP in 2003. Levels of HERD as a share of GDP, lag only those of Sweden (0.88% of GDP), Canada (0.69%) and Finland (0.67%). Although industry funds a significant share of the work carried out in these institutions, most of their funding comes from the government, and public expenditures on

government and university R&D in Iceland remain high in comparison to other OECD countries (Figure 7).

Figure 7. Public funding of R&D performed in the government and higher education sectors

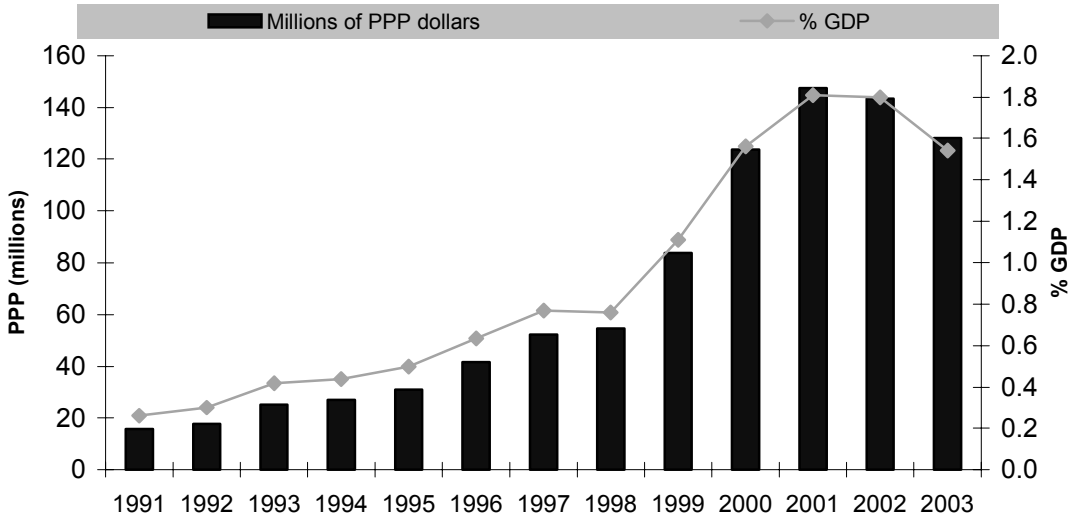
As % GDP, 2004 or nearest available year



Source: OECD, MSTI Database, November 2005.

Increases in industry-financed R&D have triggered rapid growth in business-performed R&D (BERD) in Iceland. Between 1995 and 2003, BERD increased from 0.50% to 1.54% of GDP, exceeding both OECD and EU averages (Figure 8). Today the business enterprise sector is the largest R&D performer in Iceland. Over 80% of this BERD is performed by firms in the service sector, with the balance combine largely from the pharmaceuticals and instruments industries. However, approximately half of total business expenditure on R&D is accounted for by a single biotechnology company, Decode Genetics, which spent more than USD 68 million on R&D in 2004.

Figure 8. Business R&D expenditures in Iceland, 1991-2003



Source: OECD, MSTI database, November 2005.

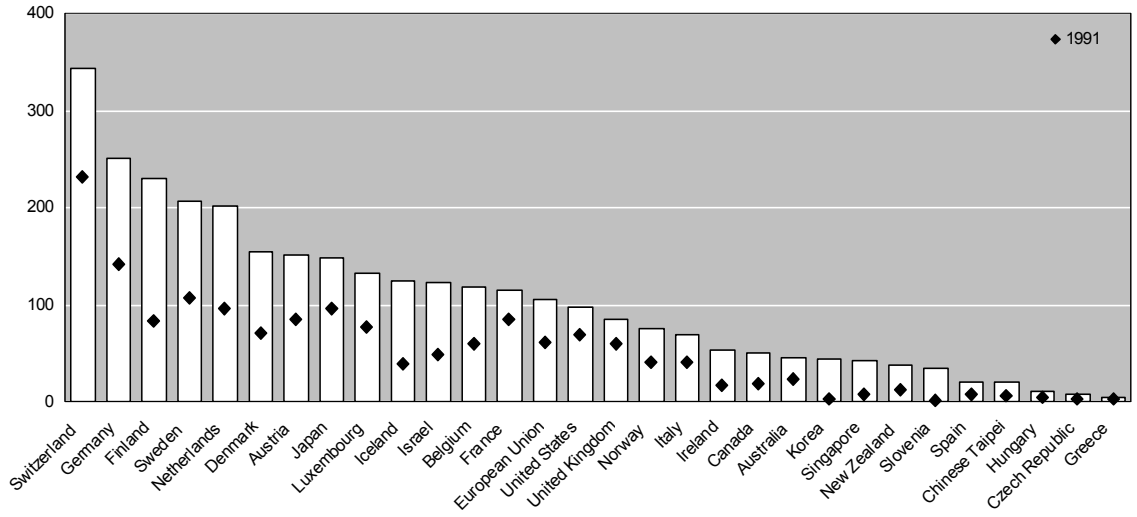
Innovation outputs

The results of Iceland's increased R&D activities are reflected in various output measures. The number of scientific and engineering publications in internationally recognised journals has increased at an average annual growth rate of 5.7% since 1998 (Science-Metrix, 2005). Between 1991 and 2001, the number of publications per million population increased by 50%, from 403 to 610, compared to averages of 416 and 556 in those same years in the EU15 (OECD 2004). Iceland ranks eighth in the number of citations per paper (worldwide).[6] Iceland has recently been named *most improved* in the field of engineering and a new entrant in the multidisciplinary fields. The most intensive research fields are those related to clinical medicine, geosciences, molecular biology & genetics, and pharmacology & toxicology. Citation indices show that Icelandic research has a combination of high output and high impact (quality) in clinical medicine and a combination of medium output and high impact in geosciences and plant and animal sciences.

Iceland's technological activity is modest in absolute size when measured in terms of patents. Nevertheless, a significant increase occurred in the second half of the 1990s. The number of Icelandic patent applications filed at the EPO grew from 11 in 1995 to 38 in 2002, or from approximately 30 to 132 per million population, which is ahead of the EU average and Ireland but below Finland (Figure 9). This situation is similar in terms of patents granted at the USPTO, which rose from 8 patent grants in 1995 to 29 in 2002, or 30 to 101 per million population (Figure 10). The recent changes in IPR-ownership in universities, and the adoption of the European Patent Convention are expected to further speed up Iceland's patenting activity.

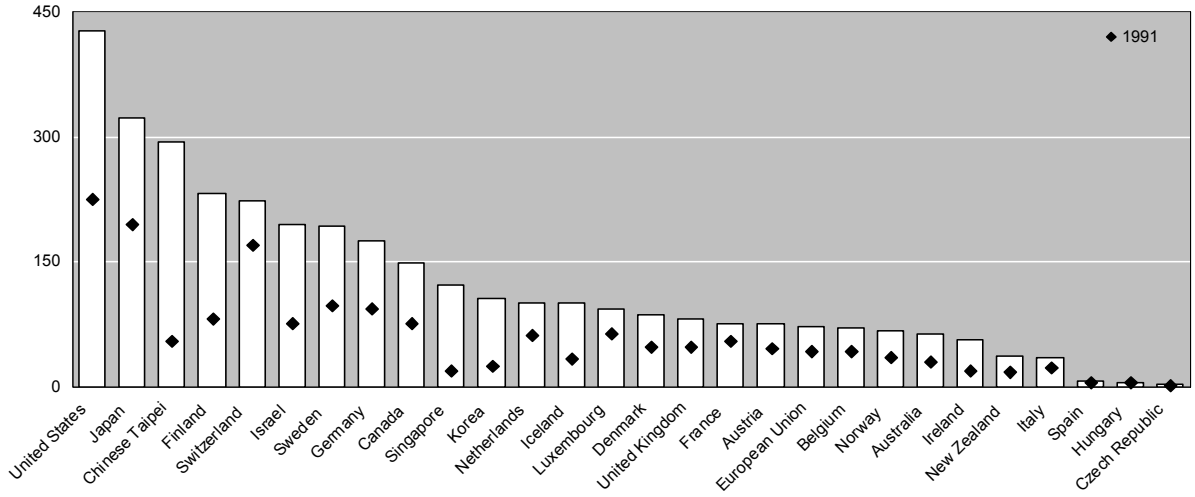
6 This statement is based on data from ISI Essential Science Indicators (Thomson-ISI).

Figure 9. Patent applications to the EPO per million population, 2002



Source: OECD, Patent Database, November 2005.

Figure 10. Patents granted at the USPTO per million population



Source: OECD, Patent Database, November 2005.

Results of recent innovation surveys indicate that the most innovative sectors in Iceland are machinery and equipment, and electrical and optical engineering industries. In terms of manufacturing specialisation, Iceland is specialised in medium-high-tech and medium-low-tech manufacturing. Business services are the most innovative service sector. Least innovative are the non-metallic mineral products, transport equipment and fabricated metal products industries.[7] In the food and beverages sector, some 52% of all firms do innovate in-house, the highest share among the benchmark countries. The same applies for textiles and textile products (59%), chemicals (89%), basic metals (62%), machinery and equipment (73%), and business services (76%).

[7] These results must be interpreted with caution due to limited data.

The majority of large companies (50-249 and >250 employees) innovate in-house; while large proportions of SMEs do not innovate in-house at all. Technology adopters play an important role in the Icelandic innovation landscape (over 35% of the companies). The second largest group of innovators are the so-called *intermittent innovators*, in which innovation is not regarded as a core activity. Strategic innovators, for whom innovation is a core activity, account for less than 5% of all innovative firms in Iceland. Also in relation to non-technical innovation, which is an important pre-condition to successful innovation, Iceland is performing well in comparison to the main EU and Nordic countries.

Industry-science linkages

Co-operation between public and private organisations (usually perceived as co-operation between industry and academia) is an important cornerstone in translating and applying research findings in a market driven context. According to recent innovation surveys, the most important source of information for the innovation process of Icelandic companies, both in the manufacturing and the service sector is the enterprise itself. The second most important source is customers. In the third place are suppliers in general (Table 2). Universities and other higher education institutes are judged most important by only 0.5% of respondents in the manufacturing sector and 4.8% of service sector respondents, possibly reflecting the large R&D services sector in Iceland.[8]

Table 2. Sources of innovation for Icelandic firms

Percentage of firms reporting that a source is of high importance to innovation

Sources of information reported as high importance	Manufacturing sector	Service sector
Within the enterprise	63.0%	78.1%
Other enterprises within the enterprise group	1.9%	5.3%
Suppliers of equipment, material, components or software	19.9%	18.7%
Clients or customers	48.6%	43.9%
Competitors and other enterprises from the same industry	15.7%	11.8%
Universities or other higher education institutes	0.5%	4.8%
Government or private non-profit research institutes	6.9%	3.2%
Professional conferences/meetings/journals	4.6%	10.7%
Fairs and exhibitions	16.7%	12.8%

Source: Statistics Iceland (CIS-3).

Some differences exist between large and small firms in this regard. Only 14% of the small companies see higher education institutes as a partner in innovation efforts. This percentage increases with the size of the company. Some 57% of the large companies do consider higher education institutes as partners in innovation efforts. Smaller companies work more closely with other companies within the same sector, clients, competitors, but also with government or private non-profit research institutes, the latter largely present in all company categories (small, medium and large). As to the geographical location of the partners, most of them are locally based; however, a significant proportion of partners is EU-based, followed by US-partners, which also illustrates the US orientation of Icelandic, mainly larger, companies.

[8] These results are generally consistent with the findings of innovation surveys conducted in other OECD countries.

Human resources for science and technology

Iceland benefits from a strong base of human resources for science and technology (HRST). Again, absolute numbers are small, but relative numbers compare well with other countries. In 2002, Iceland had a total of 2 940 R&D personnel and 1 900 researchers (full-time equivalents) active in public and private sector institutions. These figures more than doubled over the previous 10 years, up from 1 360 and 815, respectively. In relative terms, these figures compare well with other OECD countries. Iceland had 18.1 R&D staff per 1 000 in the labour force in 2003, which was almost double the EU25 average of 9.6, and above the levels in Denmark, Ireland and Sweden (but below Finland). Nevertheless, the share of R&D staff and researchers working in the business enterprise sector remains is below the EU25 and OECD averages, reflecting the relatively small share of business in total R&D performance in Iceland, the relatively low share of high-technology sectors in industry, and the large public research sector.

Iceland benefits from a highly educated population (and workforce). Just under one-quarter of Iceland's workforce had a tertiary education in 2002, which is approximately at the EU average, but below the OECD average of 29% and that of Nordic countries. The share of the workforce with tertiary education has grown quickly, however, in recent years, at a rate of more than 7% a year since 1998, which is considerably higher than total employment growth. In addition, life long learning, which is a precondition to creating a strong absorptive capacity necessary for internalizing external knowledge, is well-integrated in Icelandic society. A substantial number of those who pass the matriculation examination enter into tertiary education, or even vocational training, several years later.

Enrolments in higher education, although low, are increasing. Shares of science and engineering graduates among total university degrees remains low, at approximately 17% in 2002, compared to 23% on average across the OECD, and declined slightly since 1998, even as total numbers of gradates in these field rose. The number of graduates in engineering fields grew from 226 in the 1997-1998 academic year to 331 in 2002-2003. In the natural sciences the number of graduates increased from 177 to 275 during the same period. Enrolments in business education and teaching have also increased rapidly, straining the education system. Enrolments in tertiary-level science and engineering programmes are also comparatively low, at about 18% of total enrolments in 2002. This figure is about equal to that of Denmark, Norway and Canada, but is considerably lower than that in Finland and Ireland, which stood at 37% and 29%, respectively. Nevertheless, enrolments in science and engineering fields appear to be growing faster than total enrolments, by a margin of 17% to 12% annually between 1998 and 2002, second only to Denmark (OECD, 2004b). Whereas the number of professors and assistant professors increased marginally between 2000 and 2003 (from 169 professors in 2000 to 197 in 2003; from 167 assistant professors in 2000 to 178 in 2003), the number of lecturers increased almost, 72% from 150 in 2000 to 257 in 2003.

A particular feature of the Icelandic education system has been a long-time dependency of foreign university education and in particular on foreign PhD programmes. Until recently, Icelandic universities did not offer graduate-level instruction, and students wishing to study for masters and PhD level degrees were encouraged to enrol in programmes at foreign universities. This approach was seen as bringing positive benefits to Iceland: a large share of students that studied abroad returned to Iceland, bringing with them knowledge gained at top universities worldwide and creating strong international linkages and a multicultural environment among its small research community. In recent years, Icelandic universities have begun to offer graduate level instruction, first at the masters level and then at the PhD level. While providing the desired opportunity for domestic training, this development has also raised concerns about a weakening of international linkages and about the ability of Icelandic universities to offer international-calibre education in a range of disciplines. The number of PhDs awarded in Iceland is low but increasing; in 2004, 10 PhDs were awarded, compared to 2 in 1998.

Graduate education at the masters and doctoral level at the University of Iceland, the largest graduate level institution, has been growing at an explosive rate, on the average 25% annually. There were nearly 1 100 masters degree candidates and some 110 doctoral students enrolled in 2004. A number of the masters degree students have a part-time work with companies or institutions interested in their continuing education and advanced training. The University of Iceland programme of continuing education offers a wide variety of courses meeting a variety of retraining needs which contribute to flexibility in the HRST labour market (a fast growing segment within the University of Iceland). In addition, the University of Iceland has recently developed interdisciplinary curricula in the fields of human resource management, public administration, public health, fisheries studies, environmental studies etc.

Summary

Based on the previous discussion the strengths and weaknesses of the Icelandic innovation system can be summarised as in Table 3.

Table 3. Summary of strengths and weaknesses in Iceland's innovation system

Strengths	Weaknesses
Science base	
Above-average performance in R&D expenditure as a share of GDP.	Limited financial resources in absolute terms (size limitation)
Positive evolution of research quality (and international visibility)	Limited critical mass and fragmentation of institutes and funding, leading to a limited overall research capacity
Increasing levels of international scientific publications and patents (high international appreciation)	Lack of a systematic approach for identifying future opportunities (prioritization); *e.g.*, foresight studies
Growing expenditures for public sector R&D, in particular in higher education institutions.	
Business R&D and innovation	
Innovation performance well above the EU and OECD means for most indicators; Iceland is strongly moving ahead (EIS, 2004)	Fragmentation of Icelandic industry due to small size and small home market
BERD has increased significantly over time	Almost 50% of business expenditure on R&D is accounted for by a single company
As a percent of GDP Iceland has substantial venture capital (early and expansion) compared to other countries	Public R&D remains high in comparison to other countries
Technological performance (measured by patents) is increasing	The majority of SMEs (<50 employers) does not innovate in-house
The majority of the larger companies (>50 employers) innovate in-house; further improvement is possible	The share of so-called strategic innovators is less than 5%
With respect to non-technical innovation Icelandic companies score high	Only 0.5% of innovators in the manufacturing sector judge higher education institutions to be of high importance as a source (for the service sector companies this is 4,8%)
Companies succeed in finding foreign partners for their R&D efforts (due to absence perhaps of local capacity)	Smaller companies do not regard higher education institutions as potential partners for innovation

Table 3. Summary of strengths and weaknesses in Iceland's innovation system (Cont'd)

Human resources	
• Growing share of educated workforce and population • Strong performance in life-long learning • Increase in the number of S&T graduates • Above OECD average spending on education as a percentage of GDP • Increase in the number of S&E graduates • Increase in personnel at Icelandic universities (bottleneck in the past in terms of research capacity)	• Low share of graduates and enrolments in science and engineering disciplines • Stable evolution in the enrolment of students in agriculture, food and services. • Limited number of PhD specialisations (but an increase over time)

THE ICELANDIC INNOVATION SYSTEM: MAIN INSTITUTIONS AND POLICY OBJECTIVES

The concept of national innovation systems (NIS) rests on the premise that understanding the linkages among the main actors involved in innovation is central to improving innovation performance and, in the end, economic growth. The innovative performance of a country depends to a large extent on how the actors within the system relate to each other as elements in knowledge creation, diffusion and exploitation. These actors are primarily private enterprises, universities, public and private research institutes and different types of bridging institutions. Wiring-up the system and creating common objectives is among the key challenges policy makers are facing today.

Institutional configuration of the Icelandic innovation system

Although it is a small economy, Iceland has a complex and well developed innovation system that includes a variety of actors. Various ministries have a role in innovation policy due to the fact that Iceland's R&D institutions are organised under sectoral ministries (Ministry of Fisheries, Ministry of Agriculture, Ministries of Industry and Commerce,[9] Ministry of Health, Ministry of Environment and Ministry of Education, Science and Culture). There is also a wide array of higher education institutions (universities, business schools, etc.), a strong representation of industry (company research facilities and sector federations), and a strong financial system. The major actors in the Icelandic NIS are presented in Table 4. Iceland has a strong entrepreneurial spirit; it is a country of doers. This dynamism at the same time poses challenges to policy makers in achieving co-ordination among the different parties.

Knowledge institutes in Iceland consist of both universities and specialised research institutes. The University of Iceland is the oldest university in Iceland with a strong, diversified research and education portfolio. It has established research institutions under many of its faculties; the principal ones relevant to innovation are the University Science Institute, the Institute of Biology and the Engineering Institute. Many biotechnology firms have emerged out of molecular biology research associated with sciences faculty of the University of Iceland and the Medical School. The university is also involved in several innovation related projects with local and/or international partners. The University of Reykjavik, recently merged with the Technical University of Iceland, is a young institute with an exciting track record on entrepreneurial research.

Among government research institutes, the Technological Institute of Iceland (IceTec) has the primary function of transferring technology and expertise to business and industry and to assist companies in innovation. IceTec also operates a science park, the Biotechnology House, which has already led to the establishment of several biotech dedicated firms.[10] The Buildings Research Institute conducts research and technology services to the construction industry and the newly established Icelandic GeoSurvey provides research services to the Icelandic power industry. It previously was part of the National Energy Authority. These institutions all report to the Ministries of Industry and Commerce. As far as other important sector

[9] The Ministries of Industry and Commerce in Iceland are, according to law, two ministries under one Minister.

[10] Information on the Biotechnology House is available at http://www.iti.is/page2.asp?Id=1072.

specific knowledge centres is concerned, one of the main institutions is the Icelandic Fisheries Laboratories (IFL). Although IFL resides under the Ministry of Fisheries, it is a research and service organisation for the fisheries sector as well as other food industries. Other main actors or intermediaries from the public sector within the economic sphere are the Trade Council of Iceland (TCI) which reports to the Ministry of Foreign Affairs. The TCI plays a key role in supporting companies in their efforts to internationalise their business and establish foreign markets

Several organizations are tasked with stimulating and/or enabling entrepreneurship. The main organization is IMPRA, the Service Centre for Entrepreneurship and SMEs. IMPRA is operated as a semi-independent unit within IceTec and assists entrepreneurs in evaluating business ideas and provides counselling on start-up, growth and management of companies. The Research Liaison Office (RLO) of the University of Iceland is set up as a technology transfer office providing an interface between academia and industry. The Office promotes the University to industry and assists in contract negotiations between the University and enterprises and runs national offices for European co-operation programmes in research (6th Framework Programme) and vocational training (Leonardo da Vinci programme). Finally, the Office manages Tæknigarður, the Innovation Centre owned by the University and private companies, and a small seed capital fund, Tækniþróun, which funds start-up companies that originate within the University.

Several financial institutes are active to varying degrees in financing innovative activities. The most prominent actor is the New Business Venture Fund, an independent company owned by the government, which financially supports innovative projects, often in co-operation with private and other institutional investors. The Biotechnology Fund is an investment company (venture capital/private equity) primarily providing seed and early-stage funding within the fields of biotechnology, medicine, and pharmaceutics.

Within the private sector, the Federation of Icelandic Industries, which is a member of the Confederation of Icelandic Employers, and the Icelandic Chamber of Commerce are key players in influencing the development of manufacturing and service industries, respectively. The role of the Federation of is to give support to member companies in developing their business activities, interact with public authorities on behalf of their members interest and provide information on local and foreign research collaboration, to co-operate with IceTec and the New Business Venture Fund, and to help develop the innovation strategy by closely collaborating with the science and technology council. Furthermore, the Federation takes direct part in Nordic and European innovation and development projects.

The Trade Council of Iceland has introduced a program in 1997 called Venture Iceland, which aims at introducing the rising stars of the Icelandic technology sector to international investors. The program includes in-depth training in presenting and writing business plans. On the regional level the Institute of Regional Development supports regional innovative activities and initiatives (through the regional development agencies). There are also a number of private initiatives, *e.g.* Klak, a support centre for ICT-related entrepreneurship that draws upon the experience and facilities of Nyherji, a major Icelandic IT-company, to enhance the growth of start-ups in ICT. Klak is in fact an incubator/accelerator where start-ups have access to facilities, equipment, consulting, business relations and financing.

Notably absent from the Icelandic innovation system are think tanks, like those in Sweden, Finland and Denmark that operate in the public sector (*e.g.*, Vinnova, VTT and Fora); This is an issue to be aware of, but not to be overestimated. Tapping into international (mainly Nordic) knowledge can provide an alternative source of ideas, although this does require the availability of professionals that can translate foreign findings to the Icelandic situation. This process of broadening the national innovation system toward a Nordic context is essential. The international character of Icelandic citizens also forms an advantage in this respect.

Table 4. Key organisations in Iceland's national innovation system

Type of organisation	Name of organisation	Website
GOVERNMENT AND LEGISLATIVE BODIES		
	Prime Ministers Office	http://eng.forsaetisraduneyti.is/
	Ministry of Education, Science and Culture	http://eng.menntamalaraduneyti.is/
	Icelandic Patent Office	http://www.els.stjr.is/
	Ministry of Finance	http://eng.fjarmalaraduneyti.is/
	Ministries of Industry and Commerce	http://eng.idnadarraduneyti.is/
	Statistics Iceland	http://www.hagstofa.is/
	Science and Technology Policy Council (STPC)	http://www.vt.is
ENTREPRENEURSHIP		
	The Institute of Regional Development	http://www.byggdastofnun.is/
	Impra - Service Centre for Entrepreneurs and SMEs	http://www.impra.is/
	Trade Council of Iceland	http://www.icetrade.is
	Junior Chamber International (JCI)	http://www.jci.is/
	Research Liaison Office of the University of Iceland (Tæknigarður Innovation Centre)	http://www.rthj.hi.is
	Klak (Nyherji)	http://www.klak.is/
KNOWLEDGE INSTITUTES (R&D AND EDUCATION BODIES)		
	University of Akureyri	http://www.unak.is/
	University of Iceland	http://www.hi.is
	The University Science Institute, The Institute of Biology and the Engineering Institute, Institute of Earth Sciences[1]	http://www.norvol.hi.is/
	University of Reykjavik	http://www.ru.is/
	The Agricultural University of Iceland[2]	http://www.rala.is/
	Bifrost School of Business	http://www.bifrost.is
	Institute of Freshwater Fisheries	http://www.veidimal.is/
	Icelandic Fisheries Laboratories	http://www.rf.is
	Marine Research Institute	http://www.hafro.is/
	Rannís (The Icelandic Centre for Research)	http://www.Rannís.is
	Technological Institute of Iceland (IceTec)	http://www.iti.is
	The Icelandic GeoSurvey	http://www.isor.is
	Building Research Institute	http://www.rabygg.is/
INDUSTRIAL RESEARCH CENTRES AND INNOVATION INTERMEDIARIES		
	Trade Council of Iceland	http://www.icetrade.is/en
	The Federation of Icelandic Industries	http://www.si.is/english/
	Icelandic Chamber of Commerce	http://www.chamber.is/
FINANCIAL SYSTEM		
	New Business Venture Fund (Ministries of Industry and Commerce)	http://www.nsa.is
	Biotechnology Fund (Liftæknisjodurinn Inc)	http://www.mpbio.is/
	Landsbanki Íslands hf.	http://www.landsbanki.is
	Kaupthing Investment Bank	http://www.kaupthing.is/
	Íslandsbanki (Icelandic Investment Bank)	http://www.fba.is
	Invest in Iceland Agency	http://www.invest.is/
	The National Bank of Iceland	http://www.lais.is/

Notes:

1. Formerly Nordvulk, department of Geology and Geophysics of University of Iceland.

2. Formerly: Hvanneyri Agricultural University, Icelandic Horticulture College, Agricultural Research Institute.

Recent reforms to the innovation system in Iceland

Due mainly to its size, the Icelandic NIS is transparent and well-interconnected (close informal ties exist between the different actors). Contributing to this is the fact that the key persons in the system in many cases represent different organisations and are as such involved in different initiatives (necessary

overlap and coordination are ensured). Nevertheless, in recent years, important reforms have been introduced into the governance of the Icelandic innovation system that aim to improve co-ordination and governance of the system.

New legislation on the organisation of science and technology policy and the funding of research and technological development in Iceland was enacted by Parliament (Althing) at the end of January, 2003. The legislation is composed of three separate laws:

- Law on the Science and Technology Policy Council under the Office of the Prime Minister.
- Law on Public Support to Scientific Research under the Ministry of Education, Science and Culture.
- Law on Public Support to Technology Development and Innovation in the Economy under the Ministries of Industry and Commerce.

A primary result of this legislation was the creation of the new Science and Technology Policy Council (SPTC), headed by the Prime Minister and replacing the Icelandic Research Council (after 1994) (Figure 11). The Council provides for the permanent seat of three other ministers, the Minster of Education and Science, the Minister of Industry and Commerce and the Minister of Finance. Two other ministers with research in their portfolio can be added to the council at the discretion of the Prime Minister. Fourteen other members from the science and technology community are appointed to the Council through nominations from higher education institutions (four members), labour market organisations (two representing employers and two representing employees) and other relevant ministries (six members, not necessary employed by the ministries). The non-governmental members of the STPC are appointed to two subcommittees, a Science Committee and a Technology Committee. There are nine members in each committee and thus an overlap of 4 members between the two committees to ensure co-operation. The nomination of the STPC members is as follows:

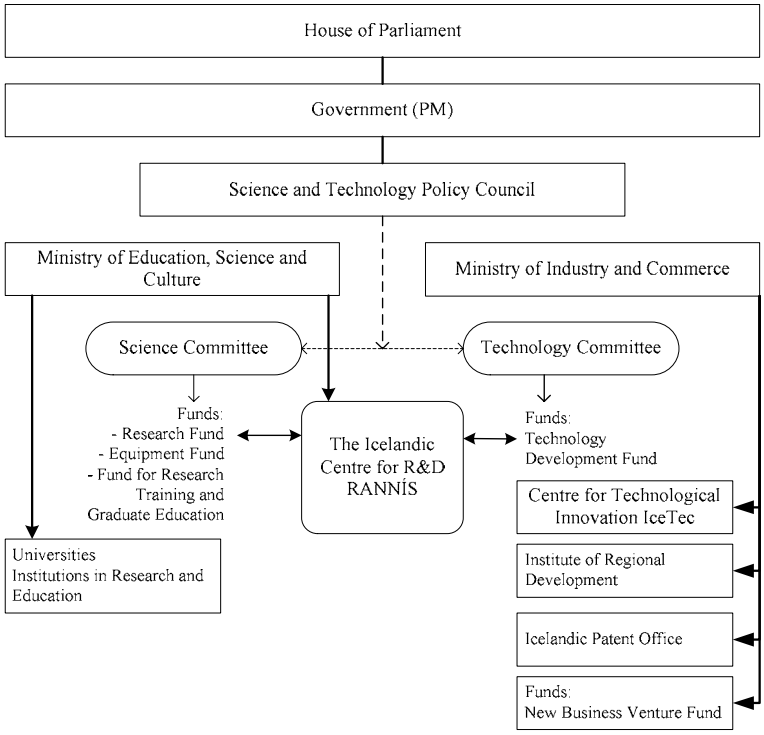
- 4 nominated by the coordinating committee of higher education institutions (representing 7 higher education establishments).
- 2 nominated by the Icelandic Association of Labour.
- 2 nominated by the Association of Icelandic Industries (Employers).
- 1 nominated by the Minister of Education, Science and Culture.
- 1 nominated by the Minister of Industry and Commerce.
- 1 nominated by the Minister of Fisheries.
- 1 nominated by the Minister of Agriculture.
- 1 nominated by the Minister of Health and Social Security Affairs.
- 1 nominated by the Minister for the Environment.

The mission of the STPC is to strengthen scientific research, scientific training and technology development in the country in support of Icelandic cultural development and increased economic competitiveness (see also the innovation specific measures further on in this report). The SPTC issues periodic guidelines (declarations) for public policies on science and technology.

Primary responsibility for assisting in the preparation of policy oriented papers is provided by the Ministry of Education, Science and Culture and the Ministries of Industry and Commerce, for the two respective committees. Overall co-ordination is provided by a secretary to the Science and Technology Policy Council, located within the Ministry of Education, Science and Culture. Administrative services for

the operation of the whole structure are provided by the Icelandic Centre for Research, Rannís, which was the secretariat of the previous Icelandic Research Council. It supports the committees and funding bodies, manage the international connections, monitors the effects and impacts of policies and provides intelligence and informed advice to the STPC and its committees and sub-committees. Rannís administers all the funding bodies.

Figure 11. The Innovation Governance Structure



Source: Rannís.

The Law on Support to Scientific Research establishes a Research Fund, which was created through the fusion of the Science Fund and the Technology fund that existed under the Icelandic Research Council. The Research Fund is governed by a board, whose chairman is also the chairman of the Science Committee of the STPC. Linked to the same committee is the Equipment Fund, which is financed by a 20% annual levy on net income from the University Lottery. Similarly the Law on the Support to Technology Development and Innovation has lead to the establishment of a Technology Development Fund which is governed by a committee chaired a person nominated by the Ministries of Industry and Commerce. The Technology Committee of the STPC provides advice on technology development and innovation policies.

The science committee includes representatives from academia, industry and government, and the policy is drawn up after consultation of these different parties and the other members of the STPC, among which also the labour unions can be found. In the implementation of the policy, the Icelandic Centre for Research (Rannís) plays an important role. The Ministry of Education, Science and Culture oversees international co-operation in scientific research although the Ministry of Foreign Affairs is responsible for the underlying negotiations.

The current organisation of the innovation policy delivery structure ensures the link between policy and implementation through funding. The changes in the innovation governance have made innovation an inter-ministerial issue; moreover innovation has become a matter of political responsibility. Coordination within the structure takes place formally but also informally. Ad-hoc meetings depending on whether

urgent issues occur take place frequently. A certain degree of flexibility in problem-solving and decision making is herewith provided.

Regional Innovation System

An area that generates much policy concern in Iceland is the depopulation of rural areas, which is occurring at a high and increasing rate. The migration has its roots in a very uniform occupational structure outside the capital area. As a result of the previously mentioned new laws, the Institute for Regional Development was moved to the Ministries of Industry and Commerce (the Department of Regional Affairs and Power-Intensive Industry) to increase synergy with the Regional Development Agencies and IceTec. Furthermore, a number of Regional Development Agencies, supported by the Institute of Regional Development are active on the local level, helping stimulate entrepreneurship and innovation. The function of the Department of Regional Affairs and Power-Intensive Industry is to develop and subsequently implement a policy on regional matters. The Althing (Parliament) approves such a Regional Plan for a period of four years. The regional plan describes the goals and measures of the government on regional issues and the relationship of regional policy to national policy.

Efforts are ongoing to boost education in telecommunications and information technology, and to enable people across Iceland to pursue education via distance learning; the indicators already show the effects of these measures. In addition, the Department handles matters pertaining to foreign investment in power-intensive industries. The Institute for Regional Development is subsequently responsible in implementing the policy. One of the innovation policy measures on this subject is the Act on the New Business Venture Fund that specifies that special emphasis shall be put on rural development when the Technology Fund invests in innovative projects within IT technologies. Apart from these, there are a number of regional development agencies which assist corporations and municipalities by infusion of capital for further development and provide consultation in terms of finance, technology and management. On a trans-regional level, Iceland is involved in several initiatives and projects. Iceland has been a member of the SAIL thematic network (Strengthening Academic and Industrial Links), which had 15 members from across Europe and the Associated States and was funded by the EC. The objective was to facilitate the trans-national exchange of knowledge and experience about academic and industrial co-operation between regions. Iceland is also involved in several projects within the framework of the Northern Periphery Programme. The Northern Periphery Programme (2000-2006) falls under a Community Initiative and aims to strengthen inter-regional co-operation in the European Union.

There are two levels of administration in Iceland: central and local government. The Local Government Act of 1986 divides the country into local authorities, which run their own affairs. Decision-making by local authorities is not dependent on the approval or supervision of other public bodies, as long as decisions conform within the law, and do not encroach on territory assigned to other bodies by law. Local authorities manage their own affairs under their own responsibility and central government has no authority to intervene in local government policy. If the Parliament and government make decisions that affect local communities in general, they are legally bound to consult the associations of local authorities. There is formal co-operation of local authority associations at both the local and regional levels. The Association of Local Authorities in Iceland is a federation of all local authorities.

Founded in 1945, by 1973 all local authorities in Iceland were members of the Association of Local Authorities, as they are now. The Association of Local Authorities in Iceland is recognised in the Local Government Act as a common representative of local authorities in Iceland and a special agreement has been signed between the government and the Association, which formalised the co-operation between the two parties. In accordance with this agreement, the government and the Association of Local Authorities meet twice a year, spring and fall. This provides a national forum for consultation for local authorities, government, and other bodies.

International linkages

International linkages are important to the formulation of science, technology and innovation policy in Iceland. Since the late 1950s, Iceland has looked to the OECD (and its predecessor, the OECE) for models and inspiration in formulation its policies and institutional framework for research and innovation. Three times is has been subjected to OECD reviews of its science, technology and innovation policies (1971, 1982 and 1992). Iceland's presence in the Nordic policy circles through the Nordic Council of Ministers and its subsidiary bodies such as the newly established Nordic Research Board – NordForsk and the Nordic Innovation Centre (NICe) – has also inspired Iceland's formulation of research and innovation policy at various sectoral levels. Over the last ten years the EU framework programme has played and increasingly important role where Iceland has participated actively and successfully. Other international developments (in the lap of the OECD, EU, UNESCO, WTO etc.) also form a source of inspiration not only to innovation policy but also to more general socio-economic issues. There is a systematic effort to get acquainted with and learn from other mainly Nordic but also EU initiatives. Bilateral links have been formed with several countries such as the United States, France, China and India. It seems important for Iceland to not limit its policy to the national innovation system only, but also to evolve towards a national innovation system with strong international ties.

Policy objectives for improving innovation performance

Within its new governance structure, Iceland has elaborated four main objectives for its science, technology and economic policy, deriving from resolutions of the STPC in December 2003 and June 2004. The long term (so-called Level 0) objectives are to:

- Increase sustainable utilisation of resources, creation of wealth, and generation of attractive job-opportunities in a knowledge society.
- Improve health and social security and encourage maturation of a civil society where freedom of enterprise and social equity reign.
- Reinforce the economic and cultural independence and thus the foundations for living in Iceland. And,
- Enhance the influence of Iceland in the international arena and facilitating the adaptation of Icelandic society to variable external conditions.

In order to realise these long term objectives, several short term (Level 1) objectives have been formulated. With respect to the S&T base these objectives are:

- *Increase public resources intended for allocation from competitive funds* and co-ordinate their operation to insure their optimum use for scientific and technical research and support to innovation in the Icelandic economy.
- *Reform the system of public research institutes by merging/streamlining their operations and strengthening their relationship with the universities* in order to create a critical mass of researchers, strengthen scientific training and thus promote knowledge based renewal in the economy (including regional development) and to generate a creative environment for interaction between the public and private sector.
- *Increase co-operation between research institutes, universities and business enterprises* in forming knowledge clusters capable of attaining a strong position in international competition.

- *Strengthen the role of universities as research institutions* by building up and encouraging diversity in research at Icelandic universities through competition between individuals and research teams for research grants from competitive funds.
- *Establish strong research teams* for working in an international environment by giving priority to the most competent individuals, institutions and firms.
- Give increased weight to *research training* of young scientists in an internationally competitive research environment.
- Encourage scientists to protect their *intellectual property rights* through patents, and encourage institutions and firms to introduce measures to properly manage the intellectual property of their employees, through reforms to patent law.
- *Strengthen the universities as research institutions* and promote studies and research based training in science and engineering in the ongoing reform of the higher education system.
- Review the organisation and work-methods of public research institutes, with the objective of uniting their strengths and co-ordinating their activities more closely with the universities and business sector.
- *Regularly assess the quality of research conducted by universities and research institutes*, by subject areas or fields of employment or knowledge clusters, and take the results of these into account when deciding on appropriations and priorities.
- *Assure open public access to the results of publicly financed research*, databases and other scientific and scholarly information, promoting the utilisation of these for added value to society.
- *Make research and development attractive to business enterprises*, supporting the emergence of high-technology firms, which to a large extent rely on research for their growth.

Related to these objectives is the recognised need to step-up human capital formation to ensure the competitiveness and development of new, high-technology industries, with a view to diversifying the Icelandic economy toward such high-value-added activities. The government has boosted education spending in recent years, but both educational outcomes and attainment are still falling short of those in many other OECD countries. Drop-out rates, in particular, are comparatively high. The government is planning appropriate reforms (including the shortening of upper-secondary education by including subjects in the compulsory curriculum) to try to tackle this problem (OECD, 2005a). Related to this challenge is the question about how best to develop domestic PhD programmes without losing the benefits gained from the international mobility of Icelandic students.

In addition to these general innovation objectives, a number of policy statements have also been issues in regard of specific fields of interest. A first one is Resources to Serve Everyone, related to the Information Society statement published by the Prime Minister's Office (Prime Minister's Office, 2004). It contains a vision on how information technology can provide individuals, industry and public service with opportunities to benefit from the resources contained in information, knowledge and innovation. Of particular interest to innovation are the statement on E-business and the employment sector, where IT "should be exploited to strengthen industry, create new employment opportunities, stimulate innovation, and nurture spin-off firms".[11]

[11] See http://eng.forsaetisraduneyti.is/information-society/.

Another important policy statement (related to the above mentioned purposes), already made by the end of 2003 by the Ministries of Industry and Commerce concerns the Hydrogen economy (Ministries of Industry and Commerce, 2003). Iceland has a long tradition of research on the possibilities of using renewable resources, and more specifically the use of hydrogen. In this vision the creation of international platforms for hydrogen research is central, as is creating an adequate framework for research and development.[12]

The different objectives are interconnected and as such form a coherent innovation strategy. The realisation of these objectives is in full progress when looking at the different measures taken in the field.

[12] See http://eng.idnadarraduneyti.is/media/Acrobat/Hydrogen__skyrsla.pdf.

THE POLICY MIX FOR INNOVATION IN ICELAND

The continued evolution of Iceland's economy and the introduction of recent reforms to the governance of its innovation system have resulted in a notable transformation of the policy mix for innovation in Iceland. This transformation can be seen at multiple levels in the system, from changes in the balance between overall policy domains (*e.g.,* support for the science base versus support to business innovation), as well as in the mix of policy instruments used within individual domains. This section of the report outlines key elements of the policy mix for innovation in Iceland and their evolution over time. It divides the policy mix into four main areas and describes the main policy instruments used in each: *i)* the science and technology base; *ii)* business R&D and innovation; *iii)* industry-science linkages; and *iv)* human resources for science and technology. Clearly, there are close linkages among these areas, and some policy instruments span several domains. Such interrelationships are a key element of the policy mix.

Policies for strengthening the science and technology base

The policy mix for supporting the Icelandic science and technology base is undergoing a fundamental change. Whereas considerable emphasis had been placed on increasing overall funding for the system, resulting in public research system that is well-funded by OECD standards (as a share of GDP), policies are now shifting to boost the efficiency and quality of the system, in particular through the introduction of more competitive funding instruments and efforts to streamline the system. One of the major factors influencing the current mix of policy instruments is the desire and necessity of Iceland to strengthen its knowledge base (by strengthening its research capacity) and hasten its transition to a knowledge-based economy. Another is a desire for differentiation; traditional sectors like the fisheries to benefit from new technologies and new research findings from dedicated research institutes, but new knowledge-based sectors like nanotechnology have not been well-funded within the traditional funding system. Another factor reflected in the chose policy mix, with respect to the science and technology base, lies in the country characteristics of Iceland. A small country with only 300.000 citizens and a limited economy in absolute terms, seeks for maximum efficiency, by for example creating synergies between and among research institutes, universities and industry.

Research funding

Public research in Iceland is funded through two primary mechanisms: basic institutional funding (in the form of block grants to universities and public research organisations); and competitively awarded funding, which is offered through several different programmes. In addition, public research institutions are accessing funding streams from industry. In recent years, an explicit effort has been made to boost competitively awarded funding as a share of total government R&D funding. Appropriations to public funds for science and technology sponsored by the Ministry of Education, Science and Culture, the Ministry of Fisheries, and the Ministries of Industry and Commerce (as well as for their administration), amounted to around USD 8.5 million (9 800 million) of the national budgets for 2003, or about 14% of total government R&D funding. The current government intends to increase allocations for these programmes to USD 18.6 million (ISK 1 750 million) by 2007.[13] No specific target has been set for

[13] This includes about USD 7.5 million (ISK 700 million) to funds within the Ministry of Education, Science and Culture. The Government of Iceland has made efforts to raise appropriations for these funds and their administration in the 2004 budget by about USD 4.3 million (ISK 400 million), of which approximately

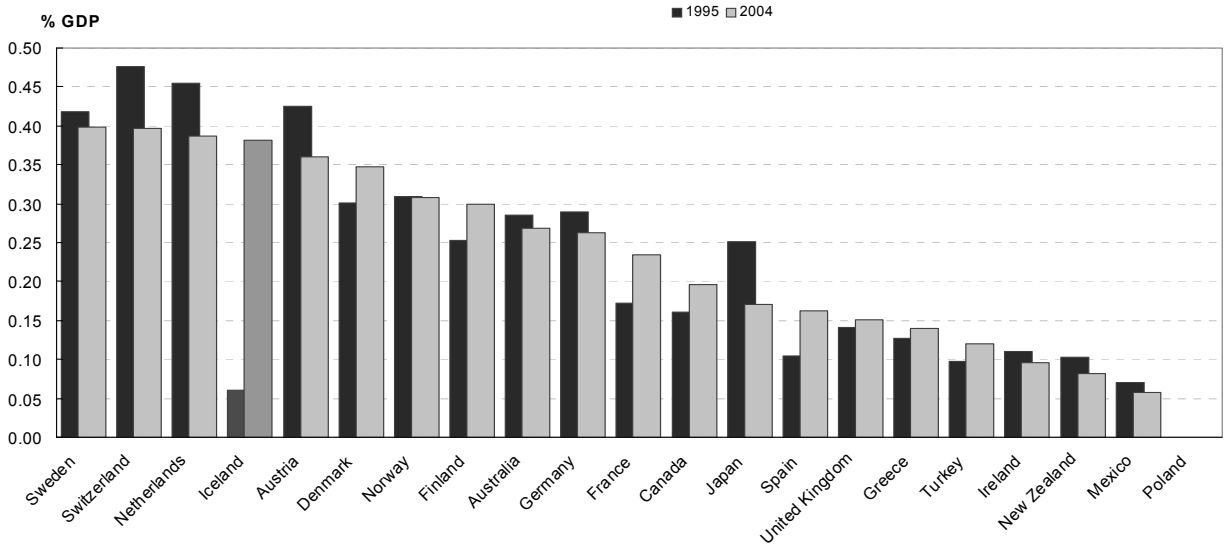
competitive funds as a share of total public funding and growth in the competitive funds will depend on the overall financial situation of the Icelandic government.

Institutional funding

Compared to other OECD countries Iceland maintains a high level of institutional funding for universities (general university funding, or GUF) as a share of GDP (Figure 12). Iceland devoted USD 39 million, or 0.38% of GDP to GUF in 2003. This represents the fourth largest budget for higher education R&D in the OECD (as a share of GDP), behind Sweden, Switzerland and the Netherlands. Institutional funding has increased significantly over the past decade, at a rate of 26% per year – the highest growth rate in the OECD area, where such grants increased in constant terms of 3.75% annually on average. In keeping with the desire to increase the share of competitive funding in the system, some suggestions have been discussed for making competitive some portion of the basic institutional funding, perhaps by linking it to an evaluation of university research, but no formal steps have been taken to do so.

Figure 12. General university funding as a share of GDP

1995-2004 or nearest year available



Source: OECD, S&T Database, November 2005.

Iceland's government research institutes operate in areas ranging from basic research to more applied, sectoral studies (Table 5). Total funding for these institutions increased from USD 32 million in 1991 to USD 56 million in 2003, in constant prices, or 0.66% of GDP. Historically, this funding was provided from direct government allocations, but increasingly, these institutions are being required to compete for funding. The Icelandic Fisheries Laboratory (which reports to the Ministry of Fisheries), for example,

USD 2.1 million (ISK 200 million) would be for funds within the Ministries of Industry and Commerce and USD 1.1 million (ISK 100 million) to a programme, under the auspices of the Ministry of Fisheries, for increasing the value added the fishing industry. The Government intends appropriations to public funds for the sciences and technology sponsored by the above-mentioned Ministries to rise by around USD 2.7 million (ISK 250 million) in 2005, about USD 2.1 million (ISK 200 million) in 2006 and approximately USD 1.1 million (ISK 100 million) in 2007. Thus appropriations for competitive funds and their administration will be about USD 18.6 million (ISK 1.750 million) at the end of this Government's term of office, *i.e.*, around USD 10.1 million (about ISK 950 million) higher than at the beginning of the term thus more than doubling the appropriations.

received about 45% of its funding via basic (institutional) funding in 2004, with about one-quarter coming from sales of services to business and one-third coming from competitive funds. The Buildings Research Institute receives about 30% of its budget from the government, but is responsible for competing for the remaining 70%, either from government programmes, international sources (such as the Framework programmes of the European Union) or from industry (buildings and construction is one of the largest industries in Iceland).

Competitive funding instruments aimed at the science base[14]

- *Research Fund.* This fund, which merges two previous funds (Science Fund and Technology Fund) offers grants in accordance with the priorities set by the Science and Technology Policy Council and the grant strategy defined by the Science Committee based on a peer review evaluation of research project quality. It finances basic and applied research, accepting proposals in all fields of science and technology, with no attempt to target particular areas.[15] The Research Fund had a budget of USD 4.5 million (ISK 420 million) in 2003. The target is to raise the available resources to USD 6.4 million (ISK 600 million) by 2007. Only about 25% to 30% of proposals win awards, suggesting that there is demand in the research community for additional funding. There were concerns in the first years of the Fund that the evaluation criteria worked to the disadvantage of proposals from the business community, but they have since been revised to better reflect industry's capabilities and needs.
- *Grants for Excellence*. The Grants for Excellence initiative aims to support the development of research centres of excellence through the allocation of larger-than-usual research grants to teams of researchers. The initiative has been administered by Rannís since 2002 under the rubric of the Research Fund. Project grants are provided for a three year period to stimulate the generation of larger research groups, but the scale of these grants remains limited, some USD 105 to 160 thousand (ISK 10-15 million) per year, versus USD 25 to 30 thousand (ISK 2.5 million on average) for standard grants from the Research Fund. Most of this funding supports the salaries of researchers, including graduate students, rather than infrastructure, which would be funded out of the Research Equipment Fund.
- *Research equipment fund*. This fund provides grants to universities and other public research institutions for the purchase of expensive and specialised equipment for research. It was funded at a level of USD 1.2 million (ISK 115 million) in 2005. Applications involving co-operation among research bodies on financing and the use of equipment purchases shall have priority. In this manner the Equipment Fund can deeply influence the economic returns and impact of investments on the one hand by a faster improvement of facilities and on the other hand by a reduction of unnecessary duplication in the purchase of scientific apparatus.
- *Nanoscience and -technology and post-genomic biomedicine fund*. This fund was initiated in 2005 by the Ministry of Education, Science and Culture, in collaboration with the Ministries of Industry and Commerce, to provide competitively awarded funding in these two broad fields. The programme is expected to run for five years, although funding has been allocated for the first two years only, at levels of USD 1 million (ISK 90 million) for 2005 and USD 1.2 million (ISK 110 Million) for 2006. The division of funding between nanotechnology and biomedicine is

14 Other competitive funding instruments have also been introduced in Iceland and are discussed in other sections of this report. The Technology Development Fund and Value-Added in Fisheries programmes are described in the section on business R&D and innovation; the Graduate Education Fund is discussed in the section on human resources.

15 Nevertheless, proposals to the Research Fund are reviewed and decided by panels in four thematic areas: Physics and Engineering; Natural Sciences; Life and Health Sciences; Humanities and Social Sciences

roughly 35% versus 65% in the first year, and 50% versus 50% in the second year. The main objective of the program is to strengthen Icelandic research in these fields and to find new ways of application. Collaboration between companies, research institutes and universities, nationally and internationally, is encouraged.

Improving the structure and organisation of research

A number of efforts are also being made to improve the efficiency of the public research system by altering the structure and organisation of research institutes and research activities. The STPC recommended that the division of labour between public research institutions and their relationship to the universities be revised and eventually redefined and reorganised. The goal is to increase co-operation, enlarge research groups, and improve the sharing of funds, knowledge and facilities to improve the comparative standing of the public research sector internationally. Research institutes and universities are encouraged to work closely together, for instance, on the training of scientists and engineers; research groups are encouraged to work on promising interdisciplinary projects that firms would not normally undertake. In addition, research institutes and universities are urged to work with centres of knowledge outside the capital city area in cases where this is appropriate and where professionally attractive prerequisites can be found and local initiative brought into play. While policy instruments, per se, can contribute to this restructuring, most will be the result of specific decisions to merge research institutes and forge alliances with the university system.

Table 5. R&D funding of main universities and research Institutions in Iceland

In thousands of ISK

Institution	Employees (FTEs)	R&D funding	Funding from Government	Funding from Industry
Research Institutes	*579*	*4 779 958*	*3 841 000*	*458 590*
Marine Research Institute	172	1 707 690	1 447 990	0
University hospital	87	802 000	741 610	44 900
National Energy Authority	37	433 255	283 255	150 000
Agricultural Research institute[1]	70	305 994	254 070	17 380
Iceland GeoSurvey	38	269 000	131 000	121 000
National Museum	16	263 736	263 736	0
Icelandic Institute of Natural History	41	255 269	194 640	60 630
Icelandic Technology Institute	37	242 582	226 580	16 000
Icelandic Fisheries Laboratories	22	136 608	82 840	12 130
Building Research Institute	23	128 583	49 400	20 560
Icelandic Meteorological office	18	123 979	107 550	0
Institute of Freshwater Fisheries	18	111 262	58 100	16 000
Private Non-Profit	*27*	*170 919*	*44 700*	*0*
Icelandic Heart Association	27	170 919	44 700	0
Universities	*682*	*4 785 572*	*3 721 000*	*458 810*
University of Iceland	465	4 160 347	*3 164 440*	421 600
University of Akureyri	153	296 460	289 410	0
Iceland University of Education	53	252 049	218 770	11 990
University of Reykjavik	11	76 716	48 860	25 220
Total	*1 288*	*9 736 449*	*7 606 950*	*917 400*

1. The Agriculture Research Institute is affiliated with the Agriculture University of Iceland.

2. Additional funding totalling ISK 1 billion comes from foreign sources and is not shown in the table. Almost half goes to the University of Iceland. One-quarter goes to the Marine Research Institute.

Source: Rannis.

Institutional mergers

A perhaps more significant change to the institutional landscape for R&D in Iceland will come from mergers of the research institutes that are being prepared and implemented by the STPC. A number of mergers between different research institutions have been proposed in order to increase research capacity (critical mass) and avoid duplication of effort.

- The Buildings Research Institute is expected to merge with IceTec (both are under the Ministries of Industry and Commerce) to create a new institute that will build on common strengths, such as in material science.
- The food related activities of IceTec and the agricultural and food part of the Environment and Food Agency, are expected to merge in 2006 to form a Government owned company Food Research, hf.
- The Hvanneyri Agricultural University, the Icelandic Horticulture College, and the Agricultural Research Institute were merged in 2004 to form the Agricultural University of Iceland.
- The National Hospital has through contract with the University of Iceland been operationally merged with the Medical School, with the ambition of improving health-related research (*e.g.,* by exploiting population databases) and strengthening post-graduate education. Challenges related to the relationship between research, medical training and provision of healthcare still need to be worked out.
- The Nordic Volcanology Institute (NVI) has been merged with the geosciences divisions of the University Science Institute to form a new Geosciences Institute with a strong international dimension. A special Governing Board with international representation will be appointed by the University of Iceland to guide its strategic development and link it to international interests in the field of earth dynamics.[16]

Centres of excellence

Centers of excellence in the generally accepted terminology (structural public funding, contract research, spin-off creations etc.) are not present in Iceland, although research institutes often serve as centers of excellence in their particular field. There is, however, a new *Icelandic Centre of Excellence in Theoretical Computer Science* (ICETCS). This is a recent initiative devoted to strengthening research in Theoretical Computer Science. It is the result of collaboration between the Division of Computer Science, Engineering Research Institute, University of Iceland, and the School of Computer Science, Reykjavík University, and is based at both institutions.

Strengthening the research function in universities

The second main recommendation of the statement from the STPC is that the universities should be strengthened as research organisations. This will partly depend on the formulation of their research strategies. The University of Iceland (UI) has over time through negotiations with staff developed an arrangement fixing the relative share of time to be used for teaching vs. research. The research output has been monitored through publications and other statistical measures and encouraged through a system of

[16] The Nordic Volcanology Institute (NVI) has until now not lead to the creation of a virtual or physically developed centre of excellence, but from a Nordic perspective was considered to be an excellence centre. As a result of changing policies by the Nordic Ministerial Council several Nordic research institutions, including NVI are now to be turned over to national responsibility and while they will retain a Nordic dimension, the Nordic budget contribution will be lowered by 50% by 2006.

remuneration against performance. Other university level institutions do not have a salary system that fixes the share of time devoted to research among their staff, and practice varies dramatically. At the private University of Reykjavik, institutional funding received from the government (on the basis of the number of students graduated annually) is allocated almost entirely to teaching time. Funding for research must come from other sources, which are currently limited, but increasing. Presently the fixed relation between research and teaching at UI is likely to be abolished or made more flexible to encourage a greater variety in the use of human resources and encourage excellence in research and research training.

Not only does the STPC call on the universities to formulate a clear policy for themselves on research, in accordance with the overall policy of the Council, but the Council also encourages increased co-operation among universities, research institutes and firms on research and research training. The participation of research institutes in master's and doctoral studies by providing research facilities and guidance is well suited to enhancing co-operation among these institutions and meeting the needs of the economy and society in general (cf. the recently increasing demand for PhD programs).

Evaluation

The STPC recommends systematic evaluation of research carried out by the universities to create a basis to link institutional appropriations to their research performance. The Ministry of Education, Science and Culture is working on the modification of regulations affecting the direct appropriations for university-level research. One of the alternatives being examined is assuring universities a specified basic appropriation for research (and internal development), but requiring them to compete for the remainder of their institutional funding. In this way increased appropriations to competitive funds would create the fresh opportunities for progress at universities, while competition would contribute to the necessary quality control. These changes are as seen necessary by the appropriating authorities in order to guarantee that funds are used optimally and are subject to systematic prioritisation within the universities themselves as well as by the funds supporting research. However, it is important not to disrupt the foundation of the ongoing scientific and research activities that merit public support. At the same time, investment must be continued in facilities, equipment and other infrastructure which is needed for the realisation of quality research work. The performance of the university has been subject of an independent evaluation (August, 2005).

Fostering international collaboration

International participation in work on science, technological development and innovation is one of the cornerstones in scientific and technological strategy and a prerequisite for blossoming Icelandic activity in this field. Participation in the EU Framework Programme on Research and Technological Development has been highly successful. Furthermore, interest is growing in Nordic regional co-operation within the framework of the European Research Area, as described in the Sixth Framework Programme of the EU. Sponsored by the Nordic Council of Ministers a white book (position paper) on the so-called Nordic Research and Innovation Area (NORIA) was published in 2003 calling for the Nordic Countries to use coordinate their resources to become a world leading area for research and innovation, which in the coming years may be expected to shape Nordic co-operation in this field.

In recent years, co-operation in the area of science and technology has also grown between Iceland and the United States and through memoranda and declarations of co-operation this has been brought into a more formal structure that link it to agencies that finance scientific research in the United States and in Iceland. Active participation in international co-operation on research provides backing to overseas marketing initiatives by the Icelandic companies. Supporting technological development in firms is a significant factor in Nordic and European co-operative programmes, building in many instances on co-operation among research institutes, universities and business firms.

While Iceland is active in international R&D programmes, it has limited mechanisms for specifically funding participation of Icelandic researchers in formalised international co-operation. The existing grant system, however, does provide a platform from which Icelandic scientists can start their participation in international co-operation. In the previous system, the Research Council made national contributions into common funds of the Nordic Centres of Excellence for which Icelandic researchers could then compete. Should this form of co-operation be expanded, such as through the changes in the Framework Programme proposed by the European Commission, additional instruments will be needed to provide additional flexibility in means of participation. Nevertheless, there are already some incentives in the Research Fund for international partnerships: such partnerships are given weight during project evaluation and thus improve the chance of success in Research Fund awards.

Table 6. Summary of identified challenges and measures taken for strengthening the Icelandic science system

Identified challenge	Measures and direct effects
Establish strong research teams for working in an international environment by giving priority to the most competent individuals, institutions and firms	Enlarge the competitive funds to increase quality and quantity of applications and, in the end, quality of research Establish programme on nanotechnology and -science & post-genomic biomedicine
Review the organisation and work-methods of public research institutes, with the objective of uniting their strengths and co-ordinating their activities more closely with the universities and business sector	Evaluate universities to increase the quality of education and research
Strengthen the infrastructure for science and technology	Establish Equipment Fund to improve the availability of specific equipment, like for nanotechnology research Strengthen university research via clustering, mergers, sharing of facilities
Increase numbers of S&E graduates	Expand programmes for science and engineering at the university level (including graduate studies)
Increase awareness of the importance of protecting IPR and as such increase patenting output of Iceland	Reform regulations affecting ownership of inventions resulting from publicly funded research. Accede to European Patent Convention

Source: EC TrendChart, 2005.

Policies for promoting business R&D and innovation

Although the Icelandic policy mix for innovation has had a strong leaning toward support for the science base, recent developments have tended to build up complementary support for business R&D and innovation. R&D investment and more in general innovation is to a large extent driven by the possibilities to exploit the results, technological and scientific. The market plays a crucial role herein. As the Icelandic market is small, the incentive of investing largely in R&D projects, due to longer pay-back times and lower pay-back ratios, is limited. This results in companies that internationalise and launch new product in foreign markets; this is also what characterises Icelandic industry: a strong internationalization drift. As a result, efforts have been augmented to aid firms in improving their innovation performance via innovation. This has resulted from both an increase in R&D funding for business-related research and from the extension of programmes aimed at supporting business innovation and entrepreneurship.

Public financing of business R&D

Historically, the Icelandic government has provided little direct funding of business-performed R&D (BERD) and offered no tax incentives for business R&D expenditure. While there remain no tax incentives for business R&D, direct funding has begun to climb modestly, in response to the establishment of several new, competitively awarded funding schemes. Whereas total government funding of BERD stood at about USD 1 million in 1995 and it exceeded USD 2 million in 2001, it grew to approximately USD 5 million (in constant 2000 PPP USD) with the introduction of the Technology Development Fund. With the introduction of additional instruments in 2004, such as the programmes on Added Value in Fisheries and on Nano-science and technology and Post-genomic medicine, it can be expected to increase further.

Technology Development Fund

The Technology Development Fund was established in 2003, with the aim of advancing technological development, innovation and related research in areas of interest to the nation's economic and competitive capabilities. The total size of this fund was USD 2.2 million in 2004, but it is expected to increase to USD 5.3 million (ISK 500 million) in 2007. This fund is implemented by Rannís and is governed by a Board of Directors, and the allocation of grants is subjected to extensive peer review processes. Awards can be made to researchers in the business, research institute or university sectors. An additional 20% of a project's costs can be financed by the Fund if it involved international co-operation. In order to stimulate entrepreneurship and the development of start-up firms, the Fund also has the authority to enter into partnerships with private venture capital investors for seed and early stage financing.

Program for added value from fisheries and marine resources

A new programme, Added Value from Fisheries, was launched in the beginning of 2004, with the aim of increasing the productivity and value added of Icelandic fishery and fish processing industry. It is funded by the Ministry of Fisheries and was prepared in co-operation with professionals and stakeholders both in fisheries and fish processing industry. For the first stage, this program was supported for five years with an annual budget of USD 1.1 million (ISK 100 million). Although aimed at R&D of relevance to the fisheries industry, the funding does not necessarily support R&D performed in the business sector. Of the 2004 funding, for example, more than 45% was awarded to the Icelandic Fisheries Laboratories, which works closely with the fisheries industry.

Nanotechnology and -science & Post-genomic biomedicine

The programme on Nano-science and technology and Post-genomic biomedicine, which was described in a previous section also has important implications for business R&D and innovation. Although much of the funding will be awarded to universities and research institutes the programme aims to stimulate collaboration between companies, research institutes and universities, nationally and internationally. Project evaluation criteria make this condition explicit. Project leader can be either from companies, universities or research institutes. There may, however, be less direct funding of companies than the level of co-operation with industry might justify; companies contribute mostly research time and in-kind services to the projects, rather than financing. This working method is characteristic of other programmes such as Added Value in Fisheries programme and the programme on Information Technology and Environmental Research described below.

Information and Environment Research Programme

In 1998 the Ministry of Education, Science and Culture initiated an Information and Environment Research Programme to increase progress within information technology and environmental technology, and to create synergy between the two areas. The programme ended in 2004. Researchers and consortia were able to apply for grants for up to three years for projects within the two areas. Applications were evaluated by experts from both public research and private companies. The total amount allocated to the programme was USD 6.2 million (ISK 580 million). Annual budgets for 2003 and 2004 were approximately USD 1.2 million per year. As with the Nanoscience and -technology and Post-genomic biomedicine programmes, this programme aimed at intensifying co-operation between research institutions, universities and companies.

Tax treatment of business R&D

Iceland offers no tax incentive for business R&D expenditure. Instead, efforts have been focused on reducing the corporate income tax, which has been lowered in recent years from 53% to 18% – the lowest level in Europe and among the lowest in the OECD – and a flat tax of 10% is applied to capital gains. The current taxation levels have met with generally favourable approval from the business community, with the result that companies have decided to expand their international operations from an Icelandic home-base rather than move abroad. Icelandic authorities have in past years worked toward simplifying tax rules and lowering tax percentages, so that firms retain a higher ratio of their income, thereby receiving indirect encouragement to engage in research and develop products bringing them future profits. The policy is not to use tax measures to encourage specific behaviour of companies. The plan is to continue on the same path, taking care when modifying tax rules that no imbalance appears between different forms of business organisations. In this regard consideration will be given to suggestions that inequalities exist among firms, public institutions and non-profit foundations in connection with the levying of value-added tax.

Research institutes for business-related R&D

Despite recent increases, direct support of business R&D in Iceland remains limited. Nevertheless, support to business innovation is provided through a number of research institutions that receive funding from the government (through competitive and non-competitive means) and from business for collaborative R&D projects or R&D services. Most of these institutes service more traditional Icelandic industries – agriculture, construction, energy and fisheries – that continue to play an important role in Iceland's economy. The research institutions related to these sectors employed 380 full time equivalent R&D staff and had combined R&D budgets of USD 33 million (ISK 3.1 billion) in 2003, about 11% of which was financed by industry.

Iceland also supports business R&D through the Icelandic Technological Institute (IceTec), which operates under the Ministries of Industry and Commerce. Its primary function is to transfer technology and expertise to business and industry, and to assist companies in innovation, productivity and R&D. The main services IceTec offers to the industries pertain to the fields of materials technology, production engineering, biotechnology, food technology, education and training, consultation, environmental technology and chemical analysis. It also provides information and advice to entrepreneurs and SMEs. It also operates an Incubator for innovative business ideas, and can house up to nine companies based on innovation and new business ideas – the main focus is on biotech companies. In 2003, IceTec employed 37 full-time equivalent employees and had an R&D budget of USD 2.6 million (ISK 243 million), of which USD 2.4 million (ISK 227 million) came from the government via institutional and competitive funding channels. As noted above, IceTec plans to merge with the Building Research Institute, which employed 23 full-time equivalent R&D personnel and had and R&D budget of (ISK 129 million) in 2003, approximately 16% of which was financed by industry.

Stimulating entrepreneurship

Over the past decade, Icelandic innovation policy has expanded support to entrepreneurship. While many of the policy instruments outlined above fund small and medium sized businesses, specific interest has developed around start-up firms, especially in emerging high technology business sectors. New instruments have been introduced, and existing ones refined to better target this population of firms. Issues of stimulating venture capital and encouraging entrepreneurship are the subject of thorough consideration by the Icelandic innovation policymakers, and more specifically the STPC.

Venture capital support

In 1998 Iceland's New Business Venture Fund began its operations. It is an independent company owned by the Icelandic Government. Overall supervision of the Fund is by the Minister of Industry and Commerce. The Fund is the outcome of a reorganization of the banking sector in 1997 in which four sectoral credit funds were merged into the Icelandic Investment Bank and New Business Venture Fund.[17] The purpose of the Fund is to strengthen the Icelandic economy and expand its internationalization. This is to be achieved through participation in innovation-oriented investment projects and by helping develop marketing skills in companies. The Fund provides start-up capital and invests in early stage and expanding companies in return for an ownership stake (typically 20% to 25% of the firm). Grants and loans are also provided. The main activities of the Fund are divided into segments:

- The Core Fund invests in new business ventures, supports research and development projects and awards venture capital loans for specific projects.
- The Product Development and Marketing Department offers funding for product development and marketing projects.
- The Information Technology Fund supports new business ventures and job creation in the fields of information technology and high technology, focusing on rural regions. The capital base is ISK 1 billion (USD 10.6 million).
- The Export Credit Guarantee Department guarantees loans, investments etc. related to exports and activities by Icelandic parties overseas.

The NBVF was provided an initial allocation of USD 53 million (ISK 5 billion) in 1998, but its investments fared poorly, due in no small part to the global decline in stock markets. The Fund received an additional USD 11 million (ISK 1 billion) in 2004, and is expected to receive an additional USD 27 million (about ISK 2.5 billion) in the 2007 to 2009 timeframe, with the requirement that the fund attract an equivalent amount of private sector funding, including from pension funds.

Secondary stock exchange

In order to help small, entrepreneurial firms access financing for growth and market development, the Icelandic Stock Exchange plans to establish a new exchange for small companies, similar to exchanges established in Denmark, Germany, Ireland and other countries. The goal is to establish exit conditions for small firms that will stimulate private sector investments in those firms. Some listing requirements have been relaxed for the exchange, but management must declare that the firm has sufficient financing for 12 months of operations. So far, four target firms have been identified for listing and efforts are in place to attract several internationally based seed firms. Three of the four target companies are graduates of other government financing schemes.

[17] In April 2000 the Icelandic Investment Bank merged with the private bank Islandsbanki.

Services for entrepreneurs

IMPRA (Service Centre for Entrepreneurs and SMEs) is a unit within IceTec but with an independent identity which assists entrepreneurs in evaluating business ideas and provides counselling with start-up, growth and management of companies. Its role is to intermediate between individuals, companies and public agencies. IMPRA co-operates with the New Business Venture Fund, managing numerous support projects intended to encourage innovation among entrepreneurs and SMEs. Furthermore IMPRA operates an Innovation Relay Centre established to encourage co-operation between Icelandic and European companies concerning technology transfer. The centre is part of a co-operative network of sixty centres under the auspices of the European Commission. In addition, IMPRA has made a special effort to encourage women entrepreneurs.

A regional office, the Northern Coast Innovation Centre, was established in Akureyri in 2002. The importance of the regional dimension of IMPRA is likely to increase in the future. Under the IMPRA innovation centre there are several initiatives aiming at stimulating innovation in Iceland. An example of such a program is the Innovation Competition, which is aiming at increasing knowledge about making business plans, and to bring out interesting ideas and projects. The measure includes seminars about how to make a business plan. Another action under the IMPRA umbrella is the Action for Innovation and Employment. The objective of the action is to support SMEs and entrepreneurs in Iceland. The initiative is aimed at increasing initiative, employment and production, and at improving the competitiveness of Icelandic SMEs and entrepreneurs. The aim is also to obtain an effective use of public funds for support initiatives on behalf of the Ministries of Industry and Commerce.

Step Ahead

The Step Ahead project is intended to facilitate leaders of small firms (micro and spin-off) in seeking guidance on marketing, finance, environmental product management and organisational matters in order to increase profitability of companies. The project started in 1998 and was initially was expected to last at least until 2003, but was subsequently extended. The overall budget is USD 43 thousand (ISK 4 million). In the project has been modified and extended.

Promotion of clustering and co-operation for innovation

At the initiative of the Federation of Icelandic Industries, a number of steps have been taken to establish permanent fora to promote information sharing and collaboration among firms with similar characteristics and between public and private interests across sectors of the economy. These have typically taken the form of Forums, such as those listed below:

- The *Fisheries Technology Forum* was established in 1992 and involves the Federation of Icelandic Industries, The Association of Fish Processors, The Association of Trawler owners as well as the Ministry of Fisheries and Ministries of Industry and Commerce. Its mission is to encourage co-operation between fisheries and industry (public and private actors) in order to reinforce the development of equipment that increases the production value of fisheries. The Forum focuses on development of equipment in the entire value chain from catching and processing to marketing. The Forum provides professional and financial support. The annual budget is USD 117 000 (ISK 11 million).
- The *Health Technology Forum* was established in 2001. The objective of the Forum is to encourage firms, institutions and individuals to increase domestic and foreign co-operation for development and marketing in the field of health technology. Besides the Federation of Icelandic Industries, the Ministry of Health and Social Security, Ministries of Industry and Commerce, Rannís, the New Business Venture Fund and the Icelandic Society for Biomedical Engineering

are involved in the project. The Forum evaluates and finances projects. The annual budget is USD 122 000 (ISK 11.5 million).

- The *Seed forum* is a more recent initiative that aims to help small, unlisted technology-based firms – often spinouts from R&D projects in universities, research institutions or other forms – achieve growth objectives (*e.g.*, exceed EUR 10 million in turnover – about USD 12 million) and become listed on the stock market. The forum aims to streamline the support system for seed companies, establish international linkages and push for improvements in the financial and regulatory environment. The Forum is still under organisational construction but will likely involve a similar constellation of public and private partners as the above mentioned fora.

The SPTC encourages the Technical Development Fund, the IMPRA Innovation Centre, and the appropriate governmental authorities, as well as associations in the employment sector, to engage in further co-operation on organising innovation clusters in Iceland.

Reforms to IPR laws

The increasing volume of scientific and research activity in Iceland raises the importance of protecting intellectual property and knowledge assets. Reforms have also been put in place to encourage innovation through the patent system. Iceland acceded to the European Patent Convention in the course of 2004. In preparation to this a resolution has been agreed by the Icelandic Parliament to confirm the EEA Joint Committee decision to make the European Parliament Council's directive no 98/44/EC part of the EEA agreement. Several changes to the Icelandic Patent Act have been made, including changes that allow studies and trials that are necessary to prepare an application for marketing authorization for a generic medicinal product.

In addition, efforts are being made to assist firms, especially small firms, in using the patent system to protect their inventions. IMPRA has a contract with the Icelandic Patent Office and a part-time employee stationed there in order to support training on IPR issue. A Web site has been created to provide firms with information on IPR issues and a manual on IP management and success stories was prepared. However, legal services or sector specific services are not supported yet. IMPRA has a plan to set up an IPR desk in co-operation with patent office so as to help enterprises get access to patent information.

Table 7. Overview of identified challenges and measures taken for business R&D and innovation

Identified challenge	Measures	Effects
Make research and development attractive to business enterprises, supporting the emergence of high-technology firms which to a large rely on research for their growth.	New Business Venture Fund	Increased venture capital available for high tech start-ups
	Program on nanotechnology and – science and post-genomic biomedicine	Increased activity in high tech sectors by finding new applications and stimulating new business creation
	Impra innovation centre	
	Fund for Graduate Training	Support technological development and innovation via R&D, outreach programmes and incubator facility
		Offers possibility to increase interest in tech-industries and to better fit the needs in these sectors

Table 7. Overview of identified challenges and measures taken for business R&D and innovation (Cont'd)

Review the organisation and work-methods of public research institutes, with the objective of uniting their strengths and co-ordinating their activities more closely with the universities and business sector.	Evaluate research institutions Merge research institutions	Evaluation of University of Iceland is completed (new agreements to be made). Several mergers have been completed: 1) Technical University and the Reykjavik University merged into Reykjavik University in 2005; 2) Nordvulk and University of Iceland (Geology and Geophysics department), formed the Institute of Earth Sciences in 2004; 3) Agricultural University, Icelandic Horticulture College and Agricultural Research Institute form the Agricultural University
Limited awareness of importance of protecting IPR and limited patent output.	Revise patent laws and join the European Patent Convention	Increase in patenting and interest in the use and exploitation of patents

Policies to strengthen industry-science linkages

Over the past decade most OECD countries have put significant emphasis on the development and implementation of policy instruments to strengthen the links between industry and the science system (both universities and national laboratories). Such efforts have taken many forms, including *i)* dedicated R&D funding programmes that require collaboration between firms and public research organisations; *ii)* formal public/private partnership programmes that engage industry and the public sector in identifying common innovation objectives and co-financing innovation programmes; and *iii)* reforms to regulations governing the ownership and management of intellectual property rights in public research organisations (often putting ownership and a responsibility to commercialise in the hands of public research institutions).

Formalised programmes to forge stronger industry-science linkages remain relatively under-developed in Iceland, although strong informal linkages can be found – a benefit of a small economy and research sector. Indeed, programmes such as the Technology Development Fund, Nanoscience and – technology and Post-genomic biomedicine, and Added Value in Fisheries aim to stimulate collaboration between the public and private sectors, although such collaboration is not required. Furthermore, the activities of many of the research institutes, such as IceTec, the Icelandic Fisheries Laboratory and the Building Research Institute are designed around industry needs – often with industry input, direction or funding.

In addition to these efforts, a number of specific steps have been taken and instruments implemented to foster industry science linkages:

- *Out of drawers programme*. The out of drawers programme is a co-operative project between the Research Liaison Office of University of Iceland and the New Business Venture Fund. The main objective of the project is to encourage personnel from higher education and public research institutions to bring forward their R&D results for further exploitation of the industry. The project has been in operation since 1998.

- *Science and technology parks*. The University of Iceland is an affiliate of the Tæknigarður Innovation Centre, while a Biotechnology Centre is operated by the applied research institutes. Several technology based firms have started operations at these locations. Recently the University of Iceland and other bodies have introduced more ambitious plans for technology parks founded on the idea of close relations between universities, applied research institutes and industry. The STPC considers proposals for technology parks and knowledge villages could fall well in line with the Council's policy and areas of priority.
- *Reforms to patent legislation*. During Iceland's current Parliament session, the Government presented a bill to amend laws regarding the inventions of employees, expecting the coming legislation to induce the further use of knowledge to economic advantage and also to encourage universities and research institutes to register patents more frequently. These institutions need to acquire the capacity to assess the patentability of research findings and to market the patents obtained along with the knowledge lying behind them.

Policies for human resource development

Iceland has implemented a number of policy measures that are specifically aimed at improving human resources, in terms of numbers, skills and match to market needs. These include efforts to increase educational opportunities, expand funding for training, improve interest in science and engineering and the relevance of training programmes, and to encourage mobility. In addition, several of the policy instruments to improve the country's science and technology base also have an effect on the availability of human resources in science and technology.

Increased funding for education and training

A first step in increasing supplies of highly skilled workers has been to increase financial support for education and for specific training programmes.

- *Increased education expenditure*. Public expenditure on education as a percentage of GDP has increased steadily in Iceland. In 2002 Iceland spent 3.56% of its GDP on education and has become a top-spender on education within the OECD (OECD, 2005a). At the same time, The Ministry of Education, Science and Culture has made fundamental changes in the financial relationship with its higher education institutions that include time-limited and performance-based contracts with objective ways to determine the funding of education (and to some degree also research) and transfer of operational responsibility to the institutions. Block grants for research have been given to the younger universities to start their research agendas providing a basis for competing for grants.
- *Fund for Graduate Research Training* was established with the aim of disbursing grants to research linked to graduate education. This fund has supported university graduates engaged in research studies in Iceland toward the master's degree and fulfilled a significant function in the recent rapid expansion of research based graduate education. In 2004 the resources of the Fund was increased by 25%, then amounting to USD 530 thousand (ISK 50 million). The Ministry of Education, Science and Culture has with the encouragement of the STPC decide to review the mission of the fund and make proposals for strengthening it in the coming years

Expanding opportunities for higher education

Recognising growing demand for higher education, the Icelandic government has taken steps to increased educational opportunities.

- *Creation of new institutions and programmes*. The Ministry of Education, Science and Culture established undergraduate training at two new universities, expanded undergraduate training at two existing universities and transformed a technical college to university level engineering school at the undergraduate level subsequently to merge it with one of the other universities.
- *Expansion of distance education programmes*. The Ministry has taken steps to broaden the access to higher education through an operational plan on e-learning and regional access through distributed learning centres linked to the formal Higher Education Institutions.

Improving interest in science and technology and reforming curricula and training

Several initiatives have been implemented to encourage more youth to pursue studies in science, mathematics and engineering. Whether or not these actions deserve the credit, the enrolment of secondary level students in science has been on a slow rise from 17% of total in 1992 to 19% in 2002. The participation of female students has at the same time risen from 45% to 50% of students in the science program at secondary level schools.

- *Outreach to youth.* Some years ago the Icelandic Research Council initiated an effort to draw interest of primary and secondary school pupils to science. This involves, *e.g.*, scientists visiting schools and visits by student groups to scientific institutions. Annual innovation competition and awards ceremonies are organised every year at all levels of the education system. However these events do not reach all regions equally well.
- *New working group*. The Minister of Education, Science and Culture appointed a working group whose roles included: *i)* proposing ways to stimulate interest among primary and secondary school students in university courses that involve research; *ii)* looking for ways to increase the diversity and quality of science teaching material in primary and secondary schools; and *iii)* evaluating the quality of curricula, teaching methods and facilities for science teaching in primary and secondary schools.
- *Improving the relevance of education and training.* EDUCATE-Iceland is a co-operation forum between the educational sector, employers, local authorities and others interested in education and training. The main focus of the work of EDUCATE is to gather and disseminate information and to facilitate transfer of knowledge and competences. EDUCATE carries out projects related to education and training and acts as a venue for discussion between the educational and employment sectors and policy makers. Other objectives include building trust between the various sectors involved in education and training, ensuring their active involvement and the importance of co-operation, strengthen schooling, especially secondary-level vocational training.
- *Outreach to women*. The Minister of Education, Science and Culture appointed a National Committee on Women in Science to coordinate the Icelandic national input into the monitoring exercise initiated by the European Commission for the period 2004-2008. While women have since the late 1990s outnumbered men in university enrolment (by a factor of 3:2), they make up 44% of the enrolment in natural science and mathematics and only 25% of the enrolment in engineering and technical sciences. An action program to strengthen the role of women in the labor market was initiated for the period 2000 – 2004 with public and private participants including the Ministry of Education, Science and Culture and the University of Iceland. This included special measures to encourage more female students to enter into studies in natural sciences, engineering and technology on the higher educational level. Efforts to encourage women to pursue science and technology careers are successful in the life sciences where 60% of the students are women, but less so in engineering, although the share of women in engineering has risen from 19% to 25% over the last 5 years. In medical studies their presence is particularly strong in recent years where they make up 59% of the medical students.

Stimulating inter-sectoral and international mobility

Given the concerns over a possible reduction in the international mobility of students as domestic PhD programmes are expanded, some efforts have been made to encourage both inward and outward mobility of students and workers.

- The *Student Loan Fund* provides loans on favourable terms for studies at foreign universities, although no specific programmes have been made to encourage their return.
- The *Research Fund* (like the Science Fund before it) has provided a limited number of post doctoral grants to encourage resettlement of high quality researchers, but the net effect of this is small.
- *Reforms to employment law*. The abolishing of lifelong tenure by public employees some years ago has had the effect of encouraging mobility in the government sector. The rise of several R&D intensive firms and structural change in the private sector has promoted this evolution further by creating new opportunities for researchers. The labour market in Iceland has in general developed towards increasing flexibility through recent agreements between the labour market partners.

The indicators presented in earlier in this report tend to show positive effects of the instruments put in practice, although more time seems necessary to review the real results. The notion of formal evaluations of programmes and institutions is a rather underdeveloped policy arena and as an instrument for policy implementation and follow-up. It has been introduced into the educational system at the primary and secondary level, and only recently at the tertiary level with the external evaluation of the University of Iceland (the result of the recommendation of the STPC). The evaluation of the research programme on information technology and environmental research has also been completed; the final report will be published in October 2005.

COMMENTARY AND DISCUSSION

Iceland has made great strides in strengthening its innovation system and its innovation policy mix in the last decade. The attitude toward innovation policy is positive, and there is a growing recognition that spending on research, development and innovation are investments that will bring future benefits to Icelandic society and the economy. Iceland is working consistently on the realisation of the objectives set by the STPC. Although these objectives were made explicit and stated publicly only a few years ago (in resolutions of 2003 and 2004), significant progress has already been made.

Iceland benefits from high levels of inputs to science, technology and innovation – at least when measured as a share of GDP; hence future evolution of the policy mix should aim at increasing the efficiency of expenditures on R&D and innovation and the overall productivity of the innovation system. This will include reconsideration of priorities, reorganisation of the means of implementing policy and the development of improved co-operation models. Insight from international experience in addressing similar challenges can inform reforms to the policy mix for innovation in Iceland and the specific instruments chosen. Particular issues to be addressed are outlined in Box 1 and discussed further in this chapter.

Box 1. Main issues for Icelandic policy mix

Overall innovation system

- Improving the balance among support for R&D and innovation in universities, public research institutes and business.
- Ensuring strong international links (balancing domestic and global activities).

Science and technology base

- Increasing the share of competitive funding for R&D.
- Building critical research mass while maintaining diversity.
- Encouraging multi-disciplinary research.
- Establishing broad-based priority setting mechanisms.

Business R&D and innovation

- Evaluating the mix of direct financing and tax incentives for business R&D.
- Improving the policy mix for support to entrepreneurship.
- Increasing the relative emphasis on diffusion of knowledge.

Industry-science linkages

- Formalising and strengthening industry-science linkages.
- Supporting technology transfer offices.
- Implementing public/private partnerships for innovation.

Human resources for science and technology (HRST)

- Enhancing domestic supplies of skilled workers and university graduates.
- Ensuring international linkages in the education and research system.

Governance of the innovation system

- Improving advisory and co-ordination functions
- Increasing industry participation in governance mechanisms
- Introducing and enhancing evaluation at all levels

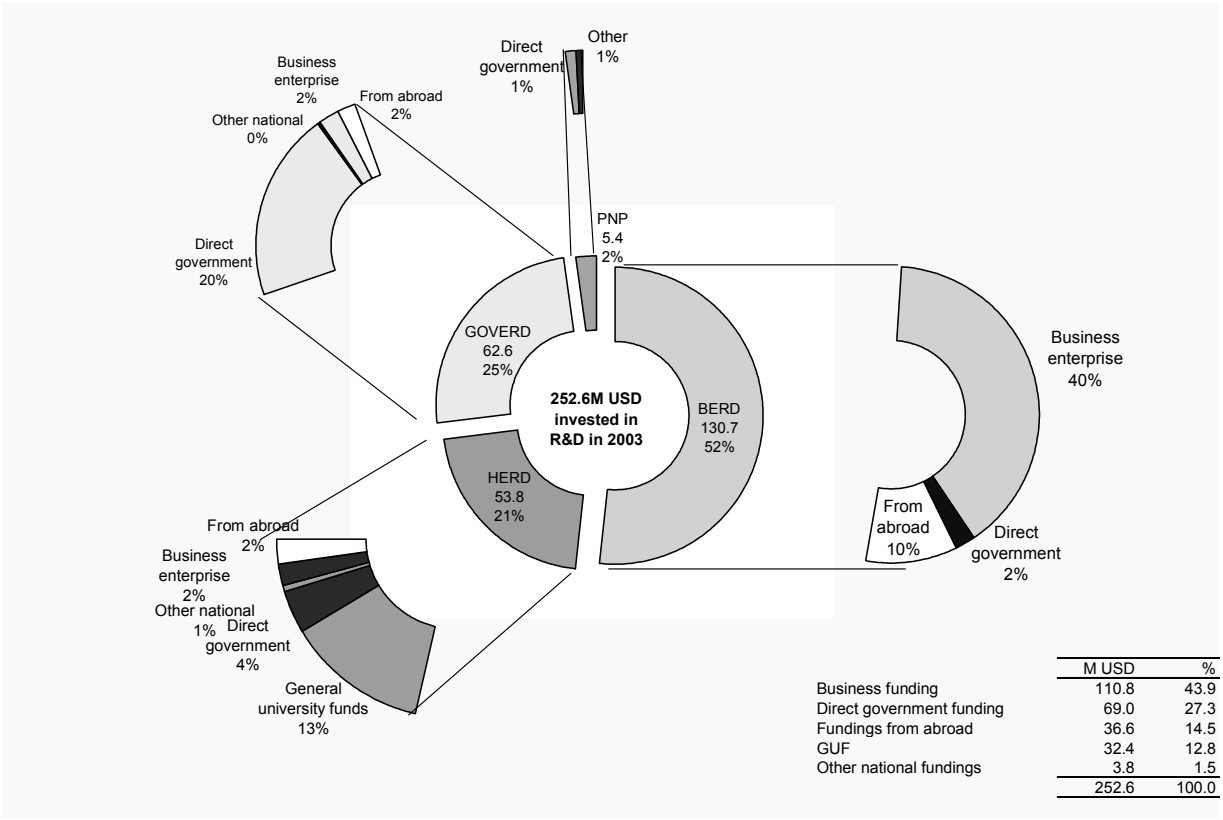
Overall balance of the policy mix for innovation

Rebalancing government support for R&D

In Iceland the balance of R&D performed by business, higher education and government differs from that of other advanced OECD economies. Most notably, just over half of total R&D is performed by the business sector in Iceland, compared with an average of two-thirds among OECD countries and 64% among EU countries (Figure 13).[18] In addition, compared to other OECD countries, Iceland has a larger share of R&D performed in government research organisations than in higher education institutions: 25% of R&D is performed by government organisations in Iceland – more than twice the OECD average of 11%. These patterns of R&D performance reflects patterns of government support for R&D. Iceland has historically provided little direct funding for business R&D and comparatively generous support for public research institutes, which are operated by individual government ministries that have a strong sectoral orientation.

Figure 13. R&D system in Iceland, 2003

Millions of current USD and share of total



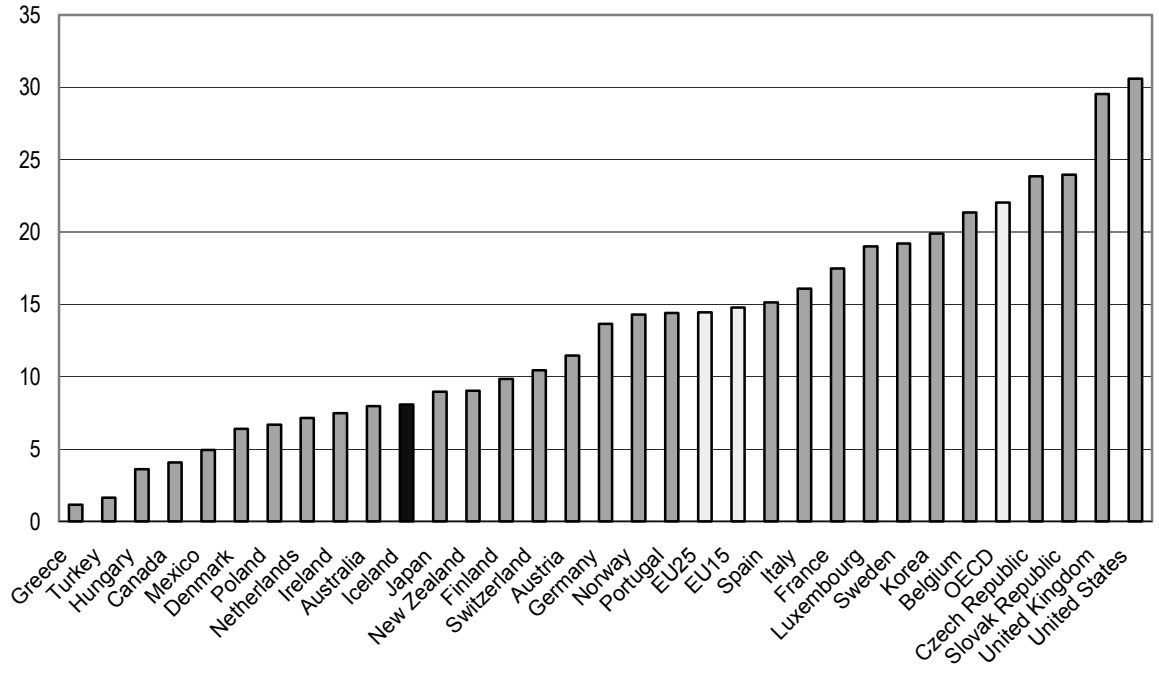
	M USD	%
Business funding	110.8	43.9
Direct government funding	69.0	27.3
Fundings from abroad	36.6	14.5
GUF	32.4	12.8
Other national fundings	3.8	1.5
	252.6	100.0

Efforts to boost Iceland's innovation capacity may entail a rebalancing of government R&D support toward the business sector. Despite recent increases in direct government funding of business R&D (*e.g.*, through the Technology Development Fund), the share of Iceland's total government R&D expenditure that is allocated to business remains below that of many other OECD countries (Figure 14). Admittedly, the business share does not differ significantly from that in Finland or Ireland, but Ireland also provides financial support to business R&D via R&D tax incentives, as do several of the countries that have lower

18 The share of business-performed R&D in Iceland is similar to that in the Netherlands and Norway.

shares than Iceland of government funding for business R&D (such as Australia, Canada, and the Netherlands). This observation, combined with the fact that approximately half of all business R&D in Iceland is performed by one firm, suggests a need to continue to shift the policy mix toward support for business performed R&D, which should also ensure that sufficient absorptive capacity develops in industry to benefit from the large investments in public research.

Figure 14. Share of government R&D funding allocated to the private sector



Source: OECD, MSTI Database, November 2005.

Internationalisation

Given the small size of Iceland's economy and innovation system, international co-operation will continue to play an important role in shaping Iceland's research capabilities and priorities. Remaining engaged in international activities will be necessary to further improve the domestic knowledge base for innovation policy. Iceland's policy mix contains a number of mechanisms to forge international linkages: it participates actively in Nordic, EU and OECD activities and has established bilateral co-operation agreements with countries including the United States. Further international linkages result from the structure of its higher education system (which relies to a large extent on foreign universities for graduate and post-graduate training), although there is some concern that these links could weaken as domestic education opportunities increase. Furthermore, evaluation of project proposals for both the Research Fund and the Technology Development Fund projects take into account and reward international partnerships. For the most part, trade and investment policies also promote international openness.

Because of the importance of international linkages to Icelandic science and innovation, the policy mix needs to give high priority to ensuring their strength in response to new opportunities or changing environments. One issue that arose in the course of interviews for this project is the need for specific mechanisms to fund participation in structured international activities. Some Nordic programmes, for example, establish common funds into which all participating countries are expected to contribute and out

of which collaborative international projects can be supported. The current system of funds administered by RANNIS (*e.g.*, Research Fund, Technology Development Fund) does not include mechanisms for such contributions. This issue is gaining in urgency as ERANET Plus and other international R&D efforts expand. It would seem that the policy mix needs to be modified in a way that provides more explicit support for such forms of international collaboration. Additional efforts may be needed to ensure the international mobility of students in science and technology, as described in the section on human resources.

The experience of other OECD countries suggests additional ways in which Iceland's policy mix might be modified to improve its ability to benefit from international expertise in science, technology and innovation. One would be to include international experts in the review of project proposals for competitive funding awards. While international peer review is included in Iceland's larger Grants of Excellence programme, most other competitive programmes include international peer reviewers only on an *ad hoc* basis. More regular inclusion of international experts might ensure the quality of a broader range of funded programmes. In addition, Iceland might experiment with ways of increasing international input into the development of its science, technology and innovation policy. While participation in international networks and organisations provides useful insight, Iceland lacks the types of institutions found in some other OECD countries (e.g., Finland, Sweden) that translate the findings of international research into the national context. It also lacks formal mechanisms or requirements to include international participants in advisory bodies, as Finland includes on its Science and Technology Policy Council.

The policy mix for the science and technology base

Iceland has a strong science and technology base that has continued to grow and develop as funding has increased. Iceland's public R&D funding was the highest in the OECD as a share of GDP in 2003 (1.19%), but it was the lowest in absolute terms at USD 253 million. Ensuring that such funding is used efficiently in a more competitive international environment requires that the policy mix continues to develop in ways that increase the efficiency of funding by improving the quality of research and building critical mass. The policy mix for supporting the science and technology base has begun to broaden already through the use of more competitive funding instruments for public R&D and the introduction of targeted funds for specific fields of science and technology (*e.g.*, nanoscience and technology). Such developments will need to continue – and additional policy mechanisms put in place – to further support and strengthen them.

Competitive funding vs. institutional funding

Given that competitive funding is one of the most dynamic factors for renewing innovation systems, priority should be given to continuing to increase competitive funds in Iceland. Within the innovation policy community and the public research sector, there is a recognised need to continue increasing the share of competitive funding to improve the quality and efficiency of research. While the share of competitive funding for public sector R&D in Iceland climbed to 14% of total funding in 2003, up from 10% a few years earlier, it remains very low compared to other OECD countries. In Ireland, for example, almost half of all public R&D funding was awarded competitively awarded in 2004 (including 38% of the funding for R&D performed in the government and higher education sectors), up from just 20% in 1998,[19] and in Finland competitive funding accounts for about 40% of total public research funding. Among other OECD countries, Canada also allocated about 40% of its funding through competitive processes; and in the United Kingdom the figure reaches 65% of total public sector R&D (OECD, 2003b).

[19] In 2004, more than EUR 280 million of the EUR 595 million in total public R&D funding was awarded (to business and higher education institutions) through competitive means. In 1998, competitive funding accounted for approximately 20% of total public R&D funding in Ireland (EUR 177 million).

The challenge, of course, is to determine how best to increase competitive funds. The approach used to date in Iceland is similar to that used in Ireland in recent years – establish new research funds that are awarded on a competitive basis.[20] A continuation of this approach in Iceland would appear sensible as long as overall government R&D expenditures can continue to increase. Given that Iceland already has the highest level of public R&D expenditure in the OECD as a share of GDP, and that budgetary pressures are growing, however, supplementary means of increasing the share of competitive funding should also be explored. One approach would be to introduce competition into the institutional funding stream and reward research institutions that achieve high performance by an agreed upon set of metrics. Such a suggestion has been made by the Science Committee to the Ministry of Education, Science and Culture. Another possibility would be to implement a requirement that recipients of competitive funding provide some degree of matching funds from their institutional allocation. Such a system has been put in place in for the Leading Technology Institutes in the Netherlands.

Increasing the size of research grants to support larger research teams:

To increase the size of research teams and build critical mass, efforts could also be made to increase the size of research grants awarded through the competitive funds. Despite the consolidation of research funding that resulted from the merger of the former Technology Fund and Science Fund into the new Research Fund, research awards remain relatively small, with typical grants on the order of USD 20 000 to 30 000 (ISK 2 to 3 million). Larger Grants of Excellence of USD 105 000 to USD 160 000 (ISK 10 to 15 million) represent a step in the right direction, but are limited in number. One solution would be to increase the size of the research grants awarded through the competitive funds by funding fewer, larger projects (*i.e.*, use the competitive funds to stimulate team-oriented research, rather than individual investigator research). An alternative would be to use the competitive funds as a means of facilitating greater co-operation between universities and research institutes in fields of common interest. In either of these models, institutional funding would remain the primary channel for funding individual-investigator research in universities, and the competitive funds would become a mechanism for raising quality and increasing the scale of research.

Target research funding to areas of importance to the national economy: Priority-setting

Due to the limited size of Iceland's economy, choosing priorities is of utmost importance, especially as international competition grows. Efforts to develop critical mass in research, innovation and industry need to be based on selectivity and concentration of resources. The Nanoscience and-Technology and Post-Genomic Biomedicine initiative and the Added Value in Fisheries programme were launched to direct funding to these fields, but these programmes remain relatively small, and most of the remaining competitive funding programmes are untargeted, as is the institutional funding allocated to universities. A number of OECD countries have taken steps to channel R&D funding to priority fields. In Ireland, for example, funding from the Science Foundation Ireland is aimed specifically at research in ICT and biotechnology. Finland, too, has used various approaches to identify priority areas for science and technology investments, in particular as relates to ICT and, more recently, services. In the Netherlands, R&D funding has been directed toward chemicals, ICT, biotechnology, materials and the flowers and food sectors, all of which are seen important to Dutch economic development and strong users of science and technology.

[20] In Ireland, growth in competitive funding resulted from the establishment of two large competitive programmes (there also being several smaller ones): Science Foundation Ireland and the Programme for Research in Third Level Institutions. This reflected a decision to increase total public funding through competitive means rather than through institutional funding.

Efforts to better target funding to specific fields of science and technology will require development of mechanisms for establishing priorities and allocating R&D funds in accordance with them. Such mechanisms are not currently part of Iceland's policy mix for innovation. While the STPC provides opportunities for discussing national priorities, it does not have the authority or mandate to set national priorities; individual ministries retain responsibility for policies linked to their respective (often sectoral) domains. Formulation of innovation strategy and innovation policy in other OECD countries is increasingly based on more systematic examinations and/or reviews of medium and long-term scientific, technological and/or market opportunities (*e.g.* foresight exercises) that draw input from a wide range of stakeholders in government, industry, the research community and civil society (OECD, 2003b). Use of such mechanisms to develop a shared strategic vision on the future areas of interest to Iceland would appear to provide opportunities to better utilise limited available (financial) resources for R&D and to direct efforts toward the realization of the chosen objectives. Recent exercises in Finland (e.g., the development of the R&D strategy for Tekes) and Denmark may provide inspiration for an Icelandic initiative.

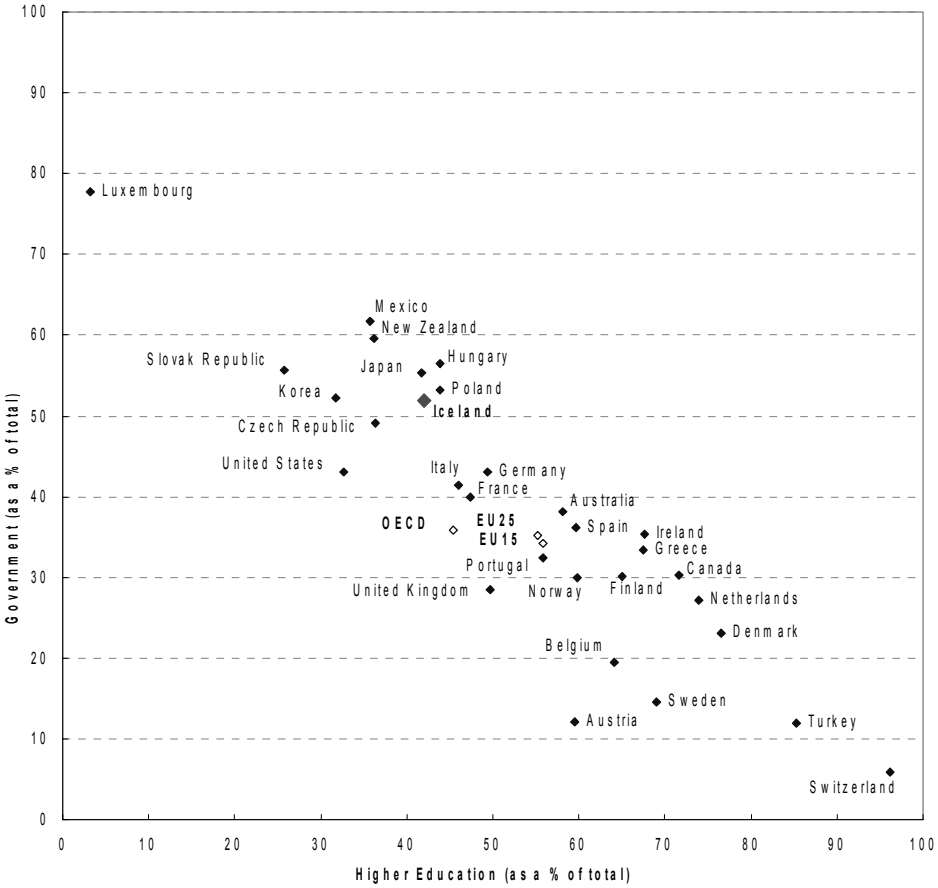
Diversification and flexibility

In smaller economies, specialisation goes hand-in-hand with flexibility. Flexibility allows resources to be re-allocated quickly to areas of emerging opportunity so that new specialisations can be developed as needed. Building flexibility into the Icelandic policy mix is an important priority. Despite recent efforts to improve cross-ministerial co-ordination of innovation policy, the ministerial structure in Iceland and the organisation of research institutions remain highly sectoral, linked to industries of historic importance, strength or speciality (*e.g.*, agriculture, fisheries, construction, and energy). For the most part, ministries retain authority for R&D policies in their specific domains, and a large share of government-financed R&D (more than 50%) is performed in government research institutions that reflect the strong sectoral focus of their parent ministries. In this regard, the Icelandic policy mix (and innovation system) is more similar to that of large, highly industrialised OECD economies (such as the United States, Japan and Korea) and Eastern European economies than of the other Nordic countries against which Iceland more often compares itself (Figure 15). In countries like Denmark Finland, Norway, and Sweden, as well as in Canada and Ireland, sectoral research institutes play a much smaller role in performing R&D than do universities, which tend to maintain R&D capabilities across a broader range of disciplines.

As innovation becomes more multi-disciplinary and is increasingly driven by advances in cross-cutting technologies, such as information and communications technology (ICT), biotechnology and nanotechnology, different approaches may be needed for organising research and ensuring that it can contribute to various national needs in Iceland. Areas of traditional strength will likely remain of particular interest to the Icelandic economy, but capacity will also be needed to ensure that resources can be allocated to areas of future growth and importance to the Icelandic economy (*e.g.*, knowledge based industries and cross-cutting technologies). A key question for Iceland today is how to modify or adapt existing institutional structures to accommodate this new challenge. Ongoing efforts to streamline the research system and merge research institutions will help address this challenge, but greater efforts may also be needed to improve co-ordination across ministries and research institutions (discussed below) or to establish institutional structures that increase the degree of diversity and flexibility in the research and innovation system.

Figure 15. Share of publicly funded R&D performed in universities versus government research

As % of total publicly funded R&D



Note: Shares of government financed R&D performed in the higher education and government sectors do not add to 100% because some government-financed R&D is performed in the business and private non-profit sectors.

Source: OECD, MSTI database, January 2006.

The policy mix for promoting business R&D and innovation

Iceland's policy mix for fostering business R&D and innovation has expanded in recent years to include a wider range of policy instruments for financing business R&D and entrepreneurship. As noted above, greater emphasis is now being placed on the business side of the Icelandic innovation system to ensure that knowledge produced in the science system can find commercial application and contribute to economic development. Framework conditions also seem to be conducive to business innovation as the economy has become more open to international and domestic competition and IPR regimes have been strengthened. At the same time, it is recognised that innovation is concentrated a limited number of firms and that the policy mix should aim to broaden the innovation base by encouraging innovation in the smallest of firms and supporting entrepreneurship. This entails not only funding for developing new knowledge but policies to stimulate diffusion of knowledge and good practice among a broad set of firms in a diverse set of manufacturing and service industries.

Mix of instruments for financing business R&D

Iceland continues to rely on direct government funding to finance business R&D; it does not use tax incentives. Among smaller OECD economies, this approach is consistent with current practice in Finland and New Zealand, but differs from that used in Australia, Ireland, the Netherlands and Norway, each of which uses a mix of tax incentives and direct funding. In Australia, Canada and the Netherlands, greater financial support is provided via tax incentives than direct funding (Table 8 and Figure 16).

Table 8. Financing of business R&D via direct grants and tax incentives in select OECD countries

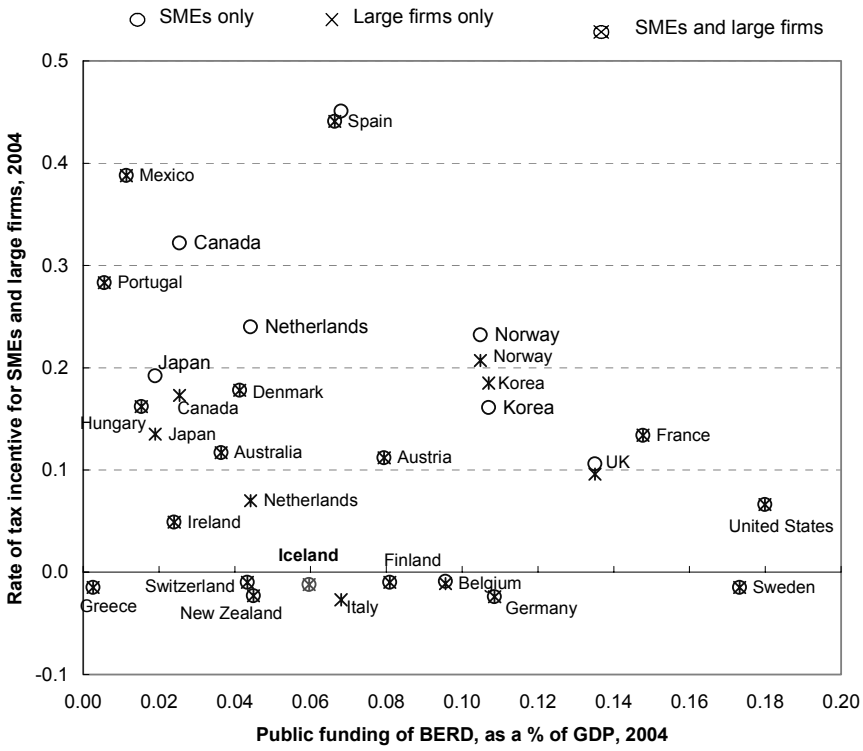
Millions of USD (PPP), most recent years available

Country	*Tax incentives claimed*	*Direct government funding*
Australia	328	219
Austria	154	193
Canada	1381	258
Finland	0	120
Iceland	0	5
Netherlands	470	175
Norway	24	178

Source: OECD, based on MSTI database and national statistics

While it is premature to judge whether or not Iceland should implement a tax incentive for R&D, efforts could be made to evaluate the potential costs and benefits of an Icelandic R&D tax incentive, such as by analysing the factors that limit innovation in different types of Icelandic firms in different industry sectors (*e.g.*, lack of financing, limited market incentives, lack of skilled personnel). Arguments against using tax incentives in Iceland include its already low corporate tax rate and its small population of R&D-performing firms. At the same time, there is interest within the Federation of Icelandic Industries for tax incentives and there is growing experience in OECD countries in designing and implementing tax incentives aimed at encouraging investment in small firms (*e.g.*, in the Netherlands, Norway and the United Kingdom), which tend to face more stringent financial constraints and are less likely to participate in direct funding programmes (OECD 2003c; OECD 2004b).

Figure 16. Public financial support to firms R&D, by instrument, 2004 or latest



Source: OECD, based on MSTI database, November 2005.

Policies to support entrepreneurship

Considerable policy development has taken place to improve supplies of venture capital to entrepreneurial firms. The establishment of the New Business Venture Fund and the proposed secondary stock exchange exemplify these efforts. Both have parallels to efforts undertaken in a number of other OECD countries. Central to their effectiveness is ensuring that they are well-match to the scale and scope of the Icelandic economy and well-linked to international financial markets. Given the need for broad investment portfolios to manage risk and ensure acceptable returns, for example, careful consideration must be given to the role of the New Business Venture Fund and the secondary stock exchange in the Icelandic policy mix and in the context of international venture funds and stock exchanges. Even in larger economies, such as Sweden, efforts to develop venture capital have been impeded by the lack of sufficient investment opportunities for investors. Such challenges could be even greater in Iceland's smaller economy, and efforts will be needed to boost demand for venture capital (*e.g.,* by creating new firms) as well as to boost its supply.

Along these lines, the policy mix for entrepreneurship needs to dedicated attention to the diffusion of knowledge and non-technological aspects of innovation (*e.g.*, organisational innovation, good business practice). Much of Iceland's policy mix for innovation is focused on the generation of new scientific and technological knowledge, *e.g.*, via support to public and private sector R&D. While this is important for stimulating innovation in both traditional and high-technology industries, it is not sufficient by itself for ensuring that the larger population of small firms in Iceland can innovate. Iceland's small population and regional concentration provide numerous opportunities for informal diffusion of knowledge, but formal channels may be a necessary complement, especially for reaching more outlying areas of the country. The

Icelandic Federation of Industries fills part of this role by linking firms with common interests in specific forums, such as the fisheries, health technology and seed forums. Additional opportunities for knowledge diffusion also take place in the context of multi-party R&D projects involving some of the larger research institutes. Nevertheless, few formal policies appear to exist for promoting diffusion. IMPRA is perhaps the most notable example, but it is a small part of a larger organisation focused on R&D services (IceTec); the Regional Development Agencies and Institute of Regional Development also have an important role to play in this area. Efforts to increase the synergies among these institutions would seem an effective means of maintaining balance across the policy mix for prooting entrepreneurship.

Policy mix for strengthening industry-science linkages

The policy mix for promoting industry-science linkages appears somewhat under-developed in Iceland, even though linkages themselves do exist. There are numerous examples of spin-offs from universities, and many researchers have established relationships with the private sector, reflecting the size and close-knit character of the research system. In addition, many research institutes co-operate with industry and universities in research programmes, to the extent that graduate students often conduct research in an industrial setting as part of a project organised by research institutes, and research institutes seek co-operation from industry in conducting R&D projects, often using an industrial setting to test new ideas. Nevertheless, few formal programmes exist to stimulate closer relationships between industry and the public science system, and much co-operation appears to occur on an ad-hoc basis, drawing on personal relationships. As Iceland continues its transition to a more knowledge-based economy, the strengths of its industry-science links will become more important to its overall innovation performance and more formalised policies may be needed.

Some elements of change are already in place. University administrators are giving higher priority to issues of technology transfer and the commercialisation of public research results. Recent changes in the regulations governing the ownership and exploitation of intellectual property resulting from publicly funded research appear to have been a positive step. Few regulatory obstacles impede researchers from starting companies that exploit patented inventions resulting from public support, but there is limited formal support from the university. The University of Iceland's Research Liaison Office, for example, aims primarily to inform researchers of funding and exchange opportunities in international programmes rather than to establish links to industry. A key question is whether more formalised mechanisms for promoting industry-science linkages are necessary at this point in time, or whether informal mechanisms will continue to suffice. Another question is whether additional financial support is necessary to enable universities and research institutes to expand their technology transfer activities.

A number of more formal modes of co-operation in R&D and innovation could be considered. Many OECD countries have established formal public/private partnership programmes to encourage industry-science linkages. Whether in the form of physical research centres or virtual collaborations among public research organisations and industry, public/private partnerships (P/PPs) can be effective ways of linking research to industry needs and a long-term commitment via joint funding of programmes. In the Netherlands, for example, P/PPs have been used to organise research in a number of industry-relevant fields by using a bottom-up and selection processes that drew from industry-led initiatives. Such an approach can ensure that research is linked to emergent industry needs and provide industry with a stronger voice in the innovation policy, as may be needed in Iceland. Other countries provide financial support and training to public sector technology transfer office to jump-start their operations and ensure they have needed skills. In several Nordic countries, including Denmark and Norway, legislation has made technology transfer a formal mission of universities (OECD, 2004b).

Policy mix for human resources for science and technology

The establishment and expansion of domestic programmes for graduate-level education seems to be a positive addition to the Icelandic policy mix. The availability of domestic programmes may make it easier for Iceland to attract more students into tertiary and graduate-level education and increase the overall numbers and qualifications of its skilled workforce (*e.g.*, students will have more opportunities to enrol in such programmes on a part-time basis), which are important policy objectives. It also offers opportunities for developing graduate programmes that are closely matched to the needs and interests of the Icelandic population. To ensure these objectives are met, the policy mix will also need to include provisions for ensuring the quality of education and research in new graduate programmes.

The development and expansion of graduate level education programmes in Iceland does raise some concern among various stakeholders that it may weaken the international linkages that have historically resulted from studying abroad. Indeed, the percentage of Icelandic students at university level registered at foreign universities has dropped in recent years. To some extent, the threat may not be as large as feared. Many university faculty members encourage or require PhD students to spend some time studying abroad during the course of their research and education programmes. At the same time, more foreign students appear to be coming to Iceland for their university studies. In recent years the inflows of foreign students have exceeded the numbers of Icelandic students that have left for other countries, reversing the previous long-term trend, and providing new opportunities for international linkages. The University of Iceland has 700 foreign students and considerable collaboration with researchers in other countries.

At the same time, some additional incentives and support may be needed to facilitate outward migration by Icelandic students and to encourage inflows of foreign students as domestic education programmes grow. Few specific instruments appear to be in place in Iceland to encourage such internationalisation of education and research. To date support tends to operate at the level of individual universities rather than the government. The University of Iceland, for example, plans to launch a new fund for foreign PhD students in 2006. The Nordic and European exchange programmes together provide channels for promoting exchange. To some extent strategies for promoting international mobility will need to be linked to the strategy that emerges for developing graduate programmes in Iceland: will universities focus on graduate training in areas in which Iceland has international comparative advantage, or will they aim to develop a broad-base of programmes in diverse fields.

Governance of the innovation system

Mechanisms for co-ordination and advice

Iceland has taken positive steps to improve the governance of its science, technology and innovation system through the establishment of the STPC. The STPC seems to have greatly improved the spirit of co-operation among ministries and has achieved considerable success in formulating consistent policy and raising the level of discussion of key science and technology policy issues. The culture of discussion and information sharing that has emerged has facilitated decision-making across the innovation system and should be encouraged. At the same time, there are several interrelated issues that could be addressed to further strengthen the coordination of government policy and the solicitation of expert advice.

The first relates to the composition of the STPC itself. There appear to be opportunities to broaden participation in the STPC to include a more complete set of ministries that play (or could play) an important role in R&D and innovation. Furthermore, as Iceland continues to develop knowledge-intensive industries and to harness scientific and technological advances to the benefit of more traditional industries, increased involvement of business leaders will be needed in multiple stages of the policy making and implementation process. Although representatives of the industry are included on the STPC (business and

labour have a combined total of 4 seats), the Federation of Icelandic Industry and Employers Association has sought greater participation on STPC. Such participation can help better align research to industrial needs and ensure that business is prepared to take up research results. Further advantages could be achieved by in increasing industrial participation on the boards of directors of other research institutes, as is common in some other OECD countries, such as Finland.

A second issue relates to the mission of the STPC. Not all participants appear to be clear about role, mission and authority of the STPC, and some important issues are not covered by STPC. For example, several institutional mergers were implemented without discussion in STPC because they involved institutions under the authority of individual ministries. Discussion of such issues within the STPC appears to remain voluntary, which contrasts with practices in countries such as Finland and Belgium (Flanders) where a stronger obligation exists to discuss important science, technology and innovation policy issues at the inter-ministerial level.

Part of the difficulty may result from the hybrid structure of the STPC. The STPC combines two functions: one of co-ordinating policy across government ministries, and one of providing expert advice to government officials. These two tasks are handled separately in some OECD countries. Ireland, for example, established a co-ordinating committee to improve inter-Ministerial communication and a separate Advisory Science Council to provide independent advice, including guidance for setting government priorities (Box 2). The United States also operates with separate co-ordination and advisory bodies.[21] That said, a number of countries (including Finland) continue to use hybrid structures similar to Iceland's, and governance structures across the OECD remain highly varied and idiosyncratic (OECD, 2005d). The key is ensuring that instruments exist for improving co-ordination and soliciting expert advice.

Box 2. Role of advisory committees in the Irish innovation system

Ireland has benefited from a series of S&T policy advisory committees, beginning with the *Science, Technology and Innovation Advisory Council (STIAC)* in the early 1990s, followed by *Irish Council for Science, Technology and Innovation (ICSTI)* (1997 – 2004) and currently the *Advisory Science Council (ASC)*. All three Councils have included stakeholder representatives from the education, research, industry and policy sectors and their remit has been assigned by the Minister for Enterprise, Trade and Employment. Below are some examples of the work done by the councils and the achievements to which they have contributed.

- The STIAC Report (1995) broke new ground in Irish research policy. In a time of still high unemployment, it set difficult targets, including the quadrupling of public funding for basic research, unprecedented investment in research equipment for higher education and research institutions and the doubling of business investment in research and development (R&D) by 1999. It also proposed new structures for the governance of science and technology and highlighted the importance of innovation.
- In 1996, informed by the STIAC recommendations, the first ever Government White Paper on Science, Technology and Innovation proposed that a Technology Foresight exercise should be undertaken in the context of new arrangements being put in place for the prioritisation of State investment in science and technology. Three new and inter-related infrastructural elements of those arrangements were to be established: an Inter-departmental Committee for Science and Technology; a Cabinet Sub-committee for Science and Technology and the Irish Council for Science, Technology and Innovation (ICSTI). In 2004, the position of Chief Science Adviser (CSA) was created as a fourth element of the structure for the prioritisation of public investment in S&T.

[21] In the United States, the National Science and Technology Council, chaired by the President, convenes the secretaries of the main R&D funding departments (ministries), along with the vice president and the President's Science Advisor, to improve intra-governmental co-ordination. The Presidents Committee of Advisors on Science and Technology gathers experts from industry and academia to provide advice to government on technology, scientific research priorities, and math and science education. Other co-ordination bodies exist in specific technical domains, such as ICT and nanotechnology, often with related advisory groups.

Box 2. Role of advisory committees in the Irish innovation system (Cont'd)

- ICSTI was established in 1997 and the following year it initiated the technology foresight exercise which, as its main outcome, resulted in the establishment of Science Foundation Ireland. ICSTI continued until 2004, providing policy advice on a diverse range of topics related to S&T in Ireland. This work is being continued by the Advisory Science Council.
- The Inter-departmental Committee for Science and Technology (IDC) is chaired by a senior civil servant (the Assistant Secretary) of the Department of Enterprise, Trade and Employment. The IDC has responsibility for working towards the prioritisation of S&T spending across Government Departments and for the preparation of an annual S&T spending plan which is submitted either to the Cabinet Committee or to Government for decision. The members of the IDC are drawn from 8 ministries with responsibility for science and technology including finance, health, marine, education, employment, agriculture and environment and the Taoiseach's (Prime Minister's) Department.
- The Cabinet Committee on Science and Technology is chaired by the Minister for Enterprise, Trade and Employment and attended by the Taoiseach. The Cabinet Committee has the responsibility of deciding national S&T priorities and budget allocations (*e.g.* the decision to create a Technology Foresight Fund which led to the establishment of Science Foundation Ireland).

Improving monitoring and evaluation

In Iceland monitoring and evaluation of innovation policy is increasing. For example, the external evaluations of the universities with respect to their research quality and results oriented contracts that the Ministries of Industry and Commerce has established with its research institutes. These are small but significant steps toward the possible development of a comprehensive system which looks more fully at policies as well as programmes. This would appear to be a timely moment for developing a monitoring and evaluation system that can provide policy makers with needed information, as the number of recent policy reforms is significant. It is equally important to ensure that the outcomes of the evaluations are integrated into the policy making process. One advantage of a relatively small system and a small economy is that there is the scope to be highly flexible, but there is also the possibility that change on too frequent a basis can lead to uncertainty and fragmentation of the research support system. Therefore, the changes need to be monitored on a timely basis.

There is considerable experience in other OECD countries on which to draw for developing evaluation systems that provide policy makers with necessary information, but without imposing burdensome reporting requirements.[22] Such efficiencies would be important in the Icelandic innovation system. Useful lessons could be gleaned from other small economies that have implemented evaluation processes. In New Zealand, for example, all government agencies involved in national innovation policy are required to undertake evaluations, and objectives are included in relevant legislation. In Ireland, there is increased evaluation activity in public sector funding agencies, some of which have established formal evaluation functions. In the Netherlands, every instrument needs to be evaluated every five years, and evaluations are required at various points in the policy cycle: ex ante evaluation of alternative policies, in-process monitoring of instruments, and ex-post evaluation of completed programmes (OECD, 2004a).

22 Over the last few years, Forfás has been engaged in evaluations of R&D funding programmes which are administered through the agencies of its parent ministry, the Department of Enterprise, Trade and Employment. These have drawn on the information gathered by those agencies (number of projects funded, regional distribution, efficiency measures such as time from application to decision, etc.) and on a variety of information gathered by other means. The evaluations have also been brought together in an overall examination of the current measures of support for industry R&D, both as a policy review and a public expenditure review. The purpose of this work has been to provide not just a measure of how efficient the system is in distributing money but also how relevant the programmes are in the Irish context and how well they fit together. Similarly the recent interim evaluation of Science Foundation Ireland has looked specifically at whether the programme is right for Ireland and how it contributes to the overall support system for research.

CONCLUSION

As this report illustrates, Icelandic innovation performance has improved considerably in recent years, and its policy mix for promoting innovation has continued to evolve, expanding in scope and complexity and increasing in its intensity. While the policy mix continues to favour support for knowledge creation in the public sector – and within the public sector, support to sectoral research institutions – the trend has been to enhance support for university-based research and business innovation through increased funding, more competitive funding mechanisms and support for entrepreneurship. Steps have also be taken to address the growing need for skilled workers (including scientists and engineers) through the establishment of graduate-level degree programmes at Icelandic universities, which will complement the country's long-standing reliance on foreign universities. New governance mechanisms have also been put in place, in the form of the Science and Technology Policy Council to advise policy makers and improve inter-ministerial co-ordination.

Achieving Iceland's longer term objectives of stimulating economic growth and welfare will undoubtedly require further evolution of the policy mix. Attempts to further diversify the economy and increased its flexibility in responding to new technological and market opportunities raise the importance of competition and critical mass in the Icelandic research system, as well as the need for entrepreneurship and effective diffusion of knowledge. While increases in competitive funding will remain important, reforms may be need to instil competition into institutional funding streams and link them better to national priorities. Mechanisms for establishing research priorities in an open, consultative fashion will also need to be added to the policy mix, as may more formalised structures for promoting and supporting industry-science linkages and ensuring effective technology transfer. Greater efforts may also be needed to bolster the diffusion of knowledge to small and medium sized enterprises as a complement to the additional funding now available for research and venture capital. More targeted mechanisms may also be needed to ensure strong international links in the education, research and innovation systems. Effective and efficient evaluation practices would be another strong addition to the policy mix for innovation.

In many of these areas, Iceland can learn much from the experience of other OECD countries.

REFERENCES

Arundel, A. and A. Geuna (2001), "Does Proximity Matter for Knowledge Transfer from Public Institutes and Universities to Firms?" SPRU Electronic Working Paper No. 73, University of Sussex, Brighton, UK. Available at http://www.sussex.ac.uk/spru/1-6-1-2-1.html

European Commission (2004), "Innovation in Europe - Results for the EU, Iceland, and Norway", Eurostat, theme 9: Science and Technology.

European Commission (2002), "European Innovation Scoreboard 2002", Commission staff working paper (http://trendchart.cordis.lu/)

European Commission (2004), "European Innovation Scoreboard 2004 - Comparative Analysis of Innovation Performance", Commission staff working paper (http://trendchart.cordis.lu/)

European Commission TrendChart (2005), Annual Innovation Policy Trends and Appraisal Report, Iceland, http://trendchart.cordis.lu/

Eurostat (2005), "R&D in the business enterprise sector of the European Union", Statistics in Focus , Science and Technology, http://epp.eurostat.cec.eu.int

Global Entrepreneurship Monitor (2005), Executive Report, Babson College and London Business School.

International Trade Canada (2005), "Potential for Scientific Collaboration between Canada and Nordic Counties", 1998-2003, Science-Metrix study, Canada.

Johnson, B. (1988), "An institutional approach to the small country problem", in: C. Freeman and D.-A. Lundvall (eds.), Small countries facing the technological revolution, 108(3), London: Pinter Publishers, pp. 279-97.

MAIT (2004), "Iceland's ICT industry", Country Intelligence, August (www.mait.com)

Ministry of Finance (2004), "Ný þjóðhagsspá fyrir árin 2004 - 2010", Nr. 6, http://www.fjarmalaraduneyti.is/media/Thjodarbuskapurinn/Urthjodarbuskapnum011004.pdf

Ministries of Industry and Commerce (2003), "Towards a Sustainable Hydrogen Economy, Iceland as an International Platform for Clean Energy Research".

Nordic Industrial Fund (2003), "Goodnip – Good Practices in Nordic Innovation Policies, Part 1: Summary and Policy Recommendations", STEP-Centre for Innovation Research, Olso.

OECD (1993), *Science, Technology and Innovation Policies: Iceland*, OECD, Paris.

OECD (2000), "The impact of public R&D expenditure on business R&D", STI Working Paper 2000/4, OECD, Paris. Available at www.oecd.org/sti/working-papers

OECD (2003a), *Economic Survey of Iceland*, OECD, Paris.

OECD (2003b), *Governance of Public Research: Toward Better Practices*, OECD, Paris.

OECD (2003c), *Tax Incentives for Research and Development: Trends and Issues*, OECD Paris. Available at www.oecd.org/sti/innovation

OECD (2004a), "Iceland Response to Policy Questionnaire for the STI Outlook 2004," prepared by Icelandic Ministry of Education, Science and Culture. Available at www.oecd.org/sti/sti-outlook

OECD (2004b), *Science and Technology and Industry Outlook 2004*, OECD, Paris.

OECD (2005a), *Economic Survey of Iceland*, OECD, Paris.

OECD (2005b), "Product Market Competition and Economic Performance in Iceland," Economics Department Working Paper No. 426, by: Thomas Lauback and Michael Wise.

OECD (2005c), *Main Science and Technology Indicators, Vol. 2005/2*, OECD, Paris.

OECD (2005d), *Governance of Innovation Systems, Volumes 1 and 2*, OECD, Paris.

Prime Minister's Office (2004), "Resources to Serve Everyone - Policy of the Government of Iceland on the Information Society 2004-2007".

Rannís (2005), "Doctorates and doctoral studies in the Nordic Countries – A short overview", Dr. Hans Kristján Gudmundsson, Director, The Icelandic Centre for Research.

Science and Technology Policy Council (2004a), "Science and Technology Policy, Agreed at a meeting of the STPC on December 18, 2003", Prime Minister's Office, Iceland.

Science and Technology Policy Council (2004b), "Resolution of the Science and Technology Policy Council", Iceland.

Statistics Iceland (2004), "External Trade", Statistical series, http://www.statice.is/series

Statistics Iceland (2004), "ICT and E-commerce in enterprises in 2003", Statistical series, http://www.statice.is/series

Verbeek, A. and T. Finnbjörnsson (2004), "Iceland's technology base: strengths, weaknesses and opportunities, Rannís, paper presented at a seminar at the Reykjavik University, 11-12 November 2004 (www.rannis.is/files/1604841437Arnold%20-%20pappír.doc)

Verbeek, A., J. Callaert, P. Andries, K. Debackere, M. Luwel, R. Veugelers (2002), "Linking Science to Technology - Bibliographic References in Patents: Volume 1, Science and Technology Interplay – Policy Relevant Findings and Interpretations", Report to the EC DG Research, project ERBHPV2-CT-1993-03, CBSTII action, Brussels (EUR 20492/1).

Verbeek, A., K. Debackere, M. Luwel, E. Zimmermann (2002b), "Measuring Progress and Evolution in Science and Technology: Part I: The Multiple Uses of Bibliometric Indicators", *International Journal of Management Review*, Volume 4, Issue 2, pp. 179-211.

World Economic Forum (2005), "Global Competitiveness Report 2005-2006", Executive Summary.

ANNEX 1. MAIN RESEARCH INSTITUTIONS IN THE ICELANDIC INNOVATION SYSTEM

The Icelandic Technological Institute – ICE TEC (www.iti.is)

IceTec is an Icelandic research and technological institution operating under the Ministries of Industry and Commerce. Its primary function is to transfer technology and expertise to business and industry, and to assist companies in innovation, productivity and research & development. The main services IceTec offers to the industries pertain to the fields of materials technology, production engineering, biotechnology, food technology, education and training, consultation, environmental technology and chemical analysis. Entrepreneurs and SMEs are provided with qualified information and guidance.

Impra (service centre for entrepreneurs and SMEs) (www.impra.is)

Impra (Service Centre for Entrepreneurs and SMEs) assists entrepreneurs in evaluating business ideas and provides counselling with start-up, growth and management of companies. Its role is to intermediate between individuals, companies and public agencies. Impra co-operates with the New Business Venture Fund (see below), managing numerous support projects intended to encourage innovation among entrepreneurs and SMEs. It also operates an Incubator for innovative business ideas, and can house up to nine companies based on innovation and new business ideas – the main focus is on biotech companies. Furthermore Impra operates an Innovation Relay Centre established to encourage co-operation between Icelandic and European companies concerning technology transfer. The centre is part of a co-operative network of sixty centres under the auspices of the European Commission.

The Building Research Institute – IBRI (www.rabygg.is)

The Building Research Institute is an independent institution responsible to the Ministries of Industry and Commerce and operating since 1965 according to statutes on research in the interests of industry and commerce. It is divided into a number of departments. The role of the institute is to provide assistance and advice on construction matters. To this end wide-ranging theoretical and applied research is conducted in various fields of construction. The main emphasis is on technical areas, but work is also done in the areas of financing and planning. Besides research material testing, quality control, certification of products and dissemination of technical information play an important role in IBRI's activities. IBRI takes an active part in European co-operation in its field. The main research fields are in concrete, building technology, including an acoustic laboratory and road construction.

The National Energy Authority (www.os.is)

Orkustofnun, The National Energy Authority, was formally established in 1967 with the passing of the Energy Act. The institute has the following main areas of responsibility: to advice the government on energy issues and related topics, to carry out energy research, and provide consulting and services relating to energy development and energy utilisation. Orkustofnun consists of two main organisational units; one in charge of energy information, advice and management and the other responsible for research. The Energy Management Unit contracts and supervises energy research projects financed under the national budget. It also monitors the energy consumption in Iceland and publishes forecasts for the energy market. The Unit operates in two departments, one for resources research management, the other for statistics and analysis. The United Nations University Geothermal Training Programme is operated as an independent

entity within the unit. The Energy Research Unit carries out research on a contract basis, either with the Resources Division, with power companies, or with others. The Unit is divided into the GeoScience Divison and the Hydrological Service.

The Agricultural Research Institute (www.rala.is)

The Agricultural Research Institute is an independent institution founded according to statutes from 1965 and is responsible to the Ministry of Agriculture. The institute is departmentalised and operates several experimental stations throughout the country, both on its own and in co-operation with other institutions. The Agricultural Research Institute is responsible for all governmentally sponsored research in the following areas:

- Research and experimentation for the expansion of theoretical and practical knowledge and experience in the fundamentals of land cultivation and animal husbandry.
- Research into the reasons for the deterioration and decreased productivity of land and into methods to reverse such developments.
- Research aimed at the optimal utilisation of agricultural products.
- Services to agriculture through research.
- The publication of the results of projects and other work of the institute in scientific journals.

The main aims of the institute are to enhance the quality of agricultural production while reducing costs, to increase the use of local material and products, and to encourage the correct use of the land's resources and to facilitate the work of the farmer. The Agricultural research Institute is now included in the Agricultural University (www.lbhi.is).

Icelandic Forest Research Station (www.skogur.is)

The Forestry Research Station is the research branch of the Iceland Forest Service, with its own governing board and operating under regulations set by the Ministry of Agriculture. Its headquarters are located at the base of Mount Esja, north of Reykjavík, but an office is also operated in Akureyri. Furthermore, it maintains many series of long- and short- term field experiments that are distributed throughout much of Iceland. The main focus and mission of Icelandic Forest Research is to conduct applied and basic research and to accumulate knowledge pertaining to deforestation, forest management, forest protection and carbon sequestration in forests and forest soils in Iceland.

The Marine Research Institute (www.hafro.is)

The Marine Research Institute in Reykjavík was established in 1965, when it took over the duties of the Fisheries Department of the University Research Institute dating from 1937. It is a governmental institute responsible to the Ministry of Fisheries and is financed through the national budget. The primary objective of the Marine Research Institute is to obtain knowledge of the sea around Iceland and its living resources. Research is carried out in most disciplines of modern oceanography, *i.e.*, physical and chemical properties of the sea, morphology and nature of the sea floor, environmental conditions and life history of algae, zooplankton, benthos and fish. Furthermore, studies in marine culture have recently been initiated. The greatest effort is, however, put into research pertaining to the exploitation of marine resources, including analysis of stock abundance and recommendations of catch quotas, fishing gear research and study of species as yet unexploited.

The Icelandic Fisheries Laboratories (www.rfisk.is)

The Icelandic Fisheries Laboratories is an independent research institute under the Ministry of Fisheries. It was founded by law in 1965 but has operated since 1934. The board of directors represents the Ministry of Fisheries and fish industry associations. The mission of the institute is to stimulate progress in the fish industry through research and development. About half of staff time is devoted to R&D projects, including some basic research areas: fish meal and fish feeds, shelf live of fresh fish, distribution of pathogens in processing environments, ripening of salted herring, sensors for on-line measurement of fish quality, sensory parameters of sea foods, toxic chemicals in fishery products, utilization of fish-by-products, new processing methods. About 60 scientists, in chemistry, microbiology, food science, engineering and aquaculture science and office staff is employed at the institute in Reykjavík and in the four branch laboratories in different parts of Iceland.

Institute of Freshwater Fisheries Research (www.veidimal.is)

Institute of Freshwater Fisheries (IFF) is a research institute. Research is conducted on rivers and lakes and their biota. Furthermore it performs research on freshwater fisheries. It also performs consulting studies regarding fisheries management and environmental assessments for construction projects affecting freshwater ecosystems. The main research field is salmonide ecology both in freshwater and at sea. There are also research activities in the field of aquaculture and salmon ranching. The Institute is financed through governmental funds; research grants and projects sold to rivers associations, hydropower companies and municipalities etc. In addition to the headquarters in Reykjavik the Institute maintains 3 branches in the rural areas of Iceland.

The Institute of Regional Development (http://byggdastofnun.is)

The Institute of Regional Development is a public body under the Ministries of Industry and Commerce, with the aim of contributing to the regional development of Iceland. The Institute co-finances investments, gives grants and assists the local authorities in planning. Two types of loans are available to commercial companies: investment loans on ordinary market terms, and high-risk loans to highly innovative projects. The institute is the main instrument in regional development policy.

Icelandic Institute of Natural History (http://www.ni.is/english/about.phtml)

Founded in 1889 by Hið Íslenzka Náttúrufræðifélag (The Icelandic Natural History Society) and managed by the Society until 1947 when acquired by the state. The Institute conducts basic and applied research on the nature of Iceland in the fields of botany, geology and zoology with emphasis in biology on taxonomy and ecology; maintains scientific specimen collections; holds data banks on Icelandic nature; assembles literature on the natural history of Iceland; operates the Icelandic Bird-Ringing Scheme, prepares distribution, vegetation and geological maps; assists in environmental impact assessments; advises on sustainable use of natural resources and land use, and assesses the conservation value of species, habitats and ecosystems.

Nordvulk (www.norvol.hi.is)

The Nordic Volcanological Institute was established in 1974. The initiative, which eventually led to the inter-Nordic political decision came from a group of Nordic geoscientists including Prof. Gunnar Hoppe and Prof Franz Eric Wickman in Sweden, Prof Tom Barth in Norway, Prof. Arne Noe Nygaard in Denmark and Prof. Sigurður Þórarinsson in Iceland. The basic idea behind the proposal was to strengthen the already well established earth science community in the Nordic countries by jointly exploiting the research opportunities evident in the active volcanism and tectonics of Iceland. Nordvulk is now part of the Institute of Earth Sciences under the University of Iceland (www.jardvis.is).

Iceland GeoSurvey (www.isor.is/page/profile)

ÍSOR, Iceland GeoSurvey, was established on the 1st of July 2003. ÍSOR is a service and research institute providing specialist services to the Icelandic power industry, the Icelandic government and foreign companies, in particular in the field of geothermal sciences and utilisation. ÍSOR took over all responsibilities of the former GeoScience Division of Orkustofnun, the National Energy Authority of Iceland, when established. Research on Iceland's indigenous energy resources goes back to the 18th century. Systematic energy research by Icelandic government institutes started in 1944 and has been carried out continuously ever since. ÍSOR and its predecessor have from the start played a key role in this work. This research and the activities of the Icelandic power industry have resulted in that over 50% of the primary energy use in Iceland at present has its source in geothermal energy. Iceland is currently devoting a lot of attention to the economic exploitation of geothermal activity.

ANNEX 2. ORGANISATIONS CONSULTED DURING THE REVIEW[23]

Government ministries, agencies and advisory groups

Prime Minister's Office
Ministry of Education, Science and Culture
Ministries of Industry and Commerce
Ministry of Finance
Icelandic Research Center – RANNÍS
Technology Commitee of the Science and Technology Policy Council

Research institutions

Buildings Research Institute
Icelandic Fisheries Laboratory
Icelandic Technological Institute including the Innovation Center IMPRA
National Hospital – University Hospital
Regional Development Institute

Higher education institutions

Agricultural College
Universtities of Akureyri
University of Iceland.
University of Reykjavik

Industrial organisations

Federation of Icelandic Industries
Employers Association
Marel, hf (food processing equipment)
ORF Genetics, hf (biotechnology start-up)

Finance community

Icelandic Stock Exchange
New Business Venture Fund

[23] Meetings were held in Iceland from 7-9 November 2005.