

Luxembourg Strategy for Smart Specialisation

Introduction:

This document aims to provide an overview of the specialisation policy in Luxembourg as at August 2014.

A new Government came into office in December 2013. Performance contracts were concluded for the period 2014-2017 between the Government on the one hand and research bodies, the National Research Fund and Luxinnovation, on the other, in June and July 2014.

This document aims mainly to assess the progress made in adopting the procedure suggested in the Guide to Research and Innovation Strategies for Smart Specialisation (RIS3) (March 2012 / European Union – Regional Policy – Smart Specialisation Platform: <http://s3platform.jrc.ec.europa.eu>).

It should be noted that this document will be submitted to the Government Council of the Grand Duchy of Luxembourg for approval in the first half of 2015.

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1 Analysis of regional context and the potential for innovation

1.1 Main stages in setting up the national research and innovation system:

The table below shows the key stages of this research policy over the last decade.

| | |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1999 – 2004 | Government objective to invest 0.3 % of the GDP in public research |
| 2003 | Foundation of the University of Luxembourg |
| 2004 – 2009 | Government objective to invest 1 % of the GDP in public research over the long term |
| 2004 | Framework Law for innovation in the SME sector |
| 2005 | Luxembourg joins the European Space Agency |
| 2006 | Examination of Luxembourg's innovation policy by the Organisation for Economic Co-operation and Development (OECD) |
| 2006 – 2008 | Implementation of the OECD's main recommendations |
| 2007 | Definition of national priorities for public research following projections drawn up by the National Research Fund (FNR) |
| 2007 | Luxembourg joins the European Molecular Biology Laboratory |
| 2008 | First performance contracts (2008-2010) with PRCs (Public Research Centres), CEPS (Population, Poverty and Socio-economic Policy Study Centre [<i>Centre d'Etudes de Populations, de Pauvreté et de Politiques Socio-Economiques</i>]), the FNR and Luxinnovation come into effect |
| 2008 | Law on Training and Research Grants |
| 2009 | Law on promoting research, development and innovation (private sector) |
| 2010 | Target of 2.3 %-2.6 % of GDP for research and innovation (all sectors) in 2020 (in terms of expenditure) |
| 2014 | Third wave of performance contracts (2014-2017) with PRCs, CEPS, the FNR and Luxinnovation come into effect |

1.2 Trends in R&DI investment:

The trend in state spending (see Graph 1) on research, technological development and innovation (RDI) in both the public and private sectors has been continued growth, from EUR 28 million in 2000 (corresponding to 0.13 % of GDP) to EUR 280 million in 2012 (corresponding to 0.66 % of GDP). These trends in budgetary allocations alone show the Government's willingness to invest in RDI and to develop a sustainable policy to encourage the country's development and diversification.

Graph 1: Trends in budgetary allocations for research and innovation from 2000 to 2011. Left abscissa: absolute values in EUR; right abscissa: percentage compared to GDP (points)

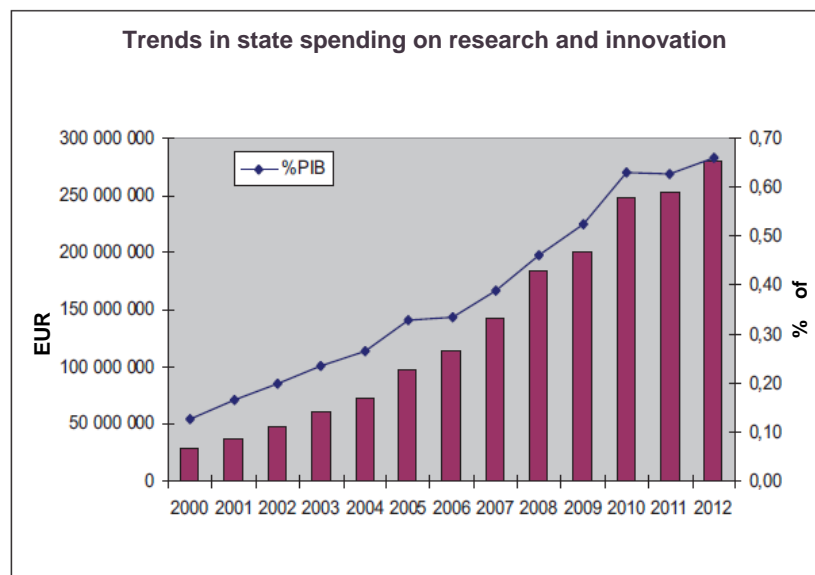


Table 1 shows that research in the private sector plays and continues to play a predominant role.

Table 1: Trend in gross domestic expenditure on research by sector

| Years | Public research (EUR million) | Private research (EUR million) | Total | % of GDP |
|--------------|------------------------------------------|-----------------------------------------------|--------------|-----------------|
| 2000 | 27.5 | 337 | 364.5 | 1.66 |
| 2005 | 64.0 | 408 | 472.0 | 1.56 |
| 2007 | 96.6 | 495 | 591.6 | 1.58 |
| 2009 | 149.6 | 471 | 620.3 | 1.74 |
| 2010 | 191.6 | 400 | 591.6 | 1.51 |
| 2011 | 182.1 | 416.2 | 598.4 | 1.43 |
| 2012 | 196.1 | 429.1 | 625.2 | 1.46 |

Research in the private sector represents two thirds of all research spending (in 2010) at national level. It should however be noted that the proportion of public research has continually grown over the last decade, from 7.5 % of all research spending in 2000 to 31 % of all research spending carried out on national territory in 2012. This development is the result of government policies implemented since 1999, including but not limited to: setting targets for research intensity (articulated in terms of spending targets), founding the University of Luxembourg, joining international organisations such as the European Space Agency and the European Molecular Biology Laboratory and introducing performance contracts.

Table 2: R&D staffing trends (FTE) by sector

| | 2007 | 2009 | 2011 |
|------------------------|-------------|-------------|-------------|
| Companies | 3 671 | 3 318 | 3 388 |
| Public research | 934 | 1 393 | 1 600 |
| TOTAL | 4 605 | 4 711 | 4 988 |

Table 2 shows staffing trends in research, in both the public sector and the private business sector. Generally speaking, R&D staffing levels are rising in Luxembourg, particularly due to the way public research is structured. This trend should continue with the construction of the *Cité des Sciences* (Science park) at Esch-Belval.

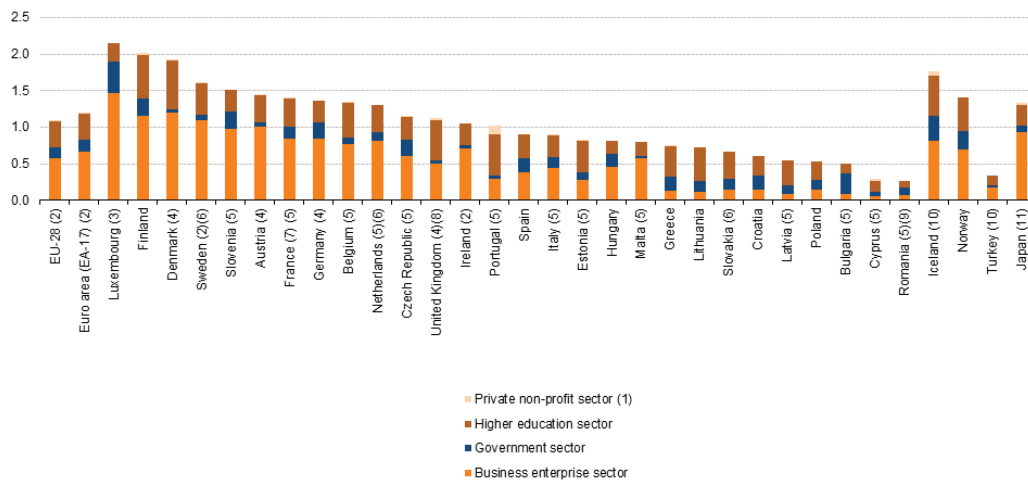
In contrast, however, private research is falling significantly (down 8 %), while investment in a technological research organisation type structure should improve the transfer of basic knowledge to the country's business sector.

1.3 A knowledge-based economy

A significant proportion of the working population is employed in knowledge-intensive activities, mainly focusing on the service economy (European leader, with 56.6 % of the working population in 2012, ahead of Sweden with 43.3 % of the working population – source: Eurostat 2012).

R&D personnel (all sectors) account for 2.2 % of the working population in Luxembourg (2010 figures), ahead of Finland (2.0 %) and Denmark (1.9 %). The European average (EU-28) is estimated at 1.1 % of the working population (see graph below).

Proportion of research and development personnel by sector in 2012



(1) Germany, Ireland, Latvia, Lithuania, Luxembourg, Hungary, the Netherlands, Norway and Turkey: not available.

(2) Includes estimates.

(3) 2010, except for business enterprise sector (2012).

(4) Includes estimates and provisional data.

(5) Includes provisional data.

(6) Government sector: definition differs.

(7) 2011, except for business enterprise sector (2012).

(8) Higher education sector: definition differs.

(9) Business enterprise sector: definition differs.

(10) 2011.

(11) 2010.

Note: when definitions differ, see http://app.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/rd_esms.htm.

Source: Eurostat (online data code: tsc00002), OECD

Apart from the intensity of R&D in terms of personnel, Luxembourg also stands out in terms of the proportion of its exports represented by high-tech products, ranking second in Europe at 26.2 % (Eurostat 2012).

1.4 The challenges for Luxembourg:

1.4.1 Dependence on financial services:

The direct economic contribution of financial services in Luxembourg is significant in many respects: contribution to added value (25 % of GDP), tax receipts (25 % of the total, according to the Luxembourg bankers' association ABBL) and employment (12 %). Financial and insurance activities continue to play a key role in the Luxembourg economy despite a fall in economic impact in the wake of the economic and financial crisis.

The expansion of the fund sector has led to the development of ancillary activities in the financial sector and currently the share of these in total added value is substantially higher than the euro-zone average.

Regarding problems relating to the large size of its financial sector, Luxembourg could also benefit from the development of information technologies and business services, given that this expertise could encourage the expansion of other activity sectors. The country could aim for greater intrasectoral diversification, which would limit exposure to a small number of activities in the financial sector. Manufacturing activity in the country remains a significant platform but requires reorientation to very high value added products through an even more effective innovation system.

1.4.2 Concentration of private R&D:

In the private sector, Luxembourg is faced with the challenge of a very high concentration of R&D spending in large corporations (83.4 % of R&D spending is by companies with more than 250 employees, source: Eurostat, Science, Technology and Innovation in Europe 2013, 2010 figures), while a very large proportion of businesses are involved in innovation: 68 % of businesses are involved in innovative activities, ranking Luxembourg second in Europe after Germany (source: Eurostat, Science, Technology and Innovation in Europe 2013, 2008-2010 figures). The majority of R&D spending is concentrated in a handful of major R&D centres.

Luxembourg is also characterised by a very high proportion of companies under foreign control. The share of employment attributable to companies under foreign control is 39.4 %, by far the highest dependency in Europe as regards foreign decision-making centres.

Private sector R&D indicators are indeed particularly sensitive to the economic climate or to the strategies of certain companies. The example of R&D expenditure in the financial sector is telling: R&D investment tripled between 2003 and 2007 before falling 27 % in the period 2007-2009 (source: Research and Innovation performance in EU Member States and Associated countries, 2013). As this report also points out, the intensity of private sector R&D, close to the European average, should be seen as particularly high against a backdrop where the manufacturing industry accounts for some 6.5 % of added value, the lowest in Europe. The decline of the Luxembourg manufacturing industry has now been defined as a significant risk, given its impact on direct and indirect employment.

Finally, a degree of caution is required as regards statistical information, which is often subject to value adjustments and is also non-exhaustive. For example, no survey has been carried out on companies with fewer than 10 employees, where R&D spending is considered nil. The investment dynamic observed among start-ups (over 30 % of projects benefiting from public aid) is therefore not reflected in these statistics.

1.5 Initialising a Smart Specialisation approach:

1.5.1 OECD appraisal of the national RDI scheme:

To ensure the efficient implementation of the Lisbon strategy, in 2005 the Government asked the OECD to analyse and evaluate the national RDI scheme, with particular emphasis on the public research mechanism. The aim of this study was to obtain concrete recommendations to optimise the system in place and to provide guidance on future national policy as regards RDI. The study was tasked with identifying the strengths and weaknesses of the national system and suggesting strategic targets and guiding principles for future Government initiatives.

While supporting the Government's ambitions as regards RDI policy, the recommendations of the study report mainly focused on three aspects:

- 1) improving the management and governance of the national research system;
- 2) improving complementarities between the various RDI stakeholders;
- 3) strengthening links between private sector and public sector research activities.

As regards improving system governance, the report recommended the following in particular:

- readjusting the **role of stakeholders** by clarifying the roles of different stakeholders and ensuring **regular appraisal** of their respective roles and functions;
- improving **coordination** between the various political stakeholders, particularly between the main ministries;
- improving **governance capabilities**: to this end, performance contracts between the Government and the various public-sector research stakeholders were proposed;
- strengthening **RDI activities** by concentrating these activities in a limited number of domains, following a process combining "bottom-up" and "top-down" approaches.

As regards improving complementarities between the various stakeholders in research and innovation, the report called for a clearer definition of their missions and objectives, and for these missions and objectives to be implemented through performance contracts.

In order to create sustainable links between public and private research systems, the OECD recommends setting up an ambitious programme of skills centres to concentrate national research efforts in a limited number of key domains.

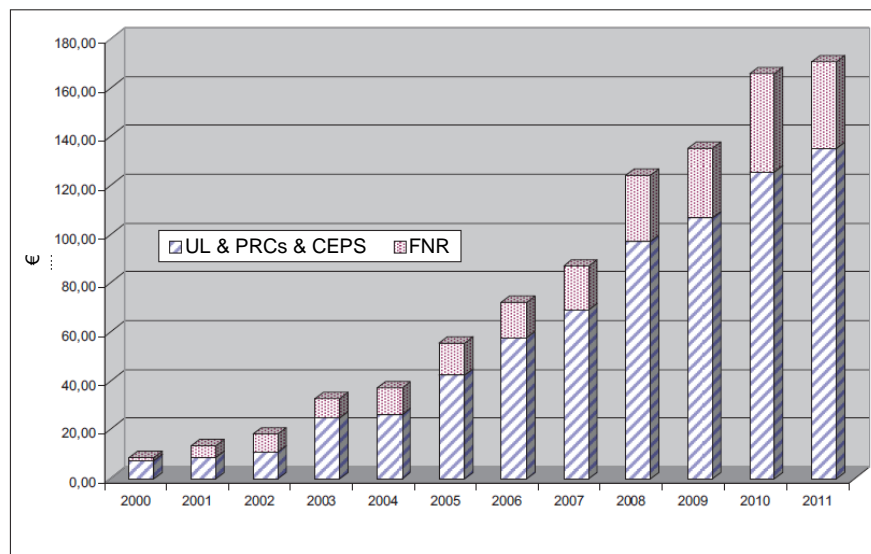
The conclusions of this report were widely discussed by stakeholders in research at national level. In 2006, the Parliament unanimously approved a motion calling on the Government to implement the recommendations made in this report. The rest of this document sets out the achievements made in this area.

The national RDI system appraisal mechanism was updated in the summer of 2014. Its conclusions will be available by the end of the year.

1.5.2 Foresight Study conducted by the National Research Fund:

The FNR supports public sector research through a diversified portfolio of instruments, including theme-based or structural research programmes, support measures, training and research grants and instruments to promote scientific culture.

*Graph 2: Trends in budgets dedicated to public research
The FNR budgets are marked by dotted lines*



Graph 2, above, shows the growing importance of the role played by the FNR in the national public research system, with a share of about 20 % in recent years. For the period 2014-2017, the FNR will be able to commit up to €228m in funding, representing an annual average of €57m, a considerable increase. Commitments were capped at €45m in 2012 and €52m in 2013.

One of the impacts of the Fund over the last decade has been the concentration of activities in a limited number of theme-based domains. Another impact of the FNR has been the process of ex ante scientific evaluation of projects by international experts, meaning that only projects meeting the highest international standards are funded by the FNR.

As part of its remit, the FNR is required to draw up multi-annual activity programmes based on the selected thematic priorities and, through this, contribute to drawing up a national multi-annual R&D programme. In this context, the FNR decided in May 2005 to conduct a prospecting study of R&D skills, potential and opportunities at a national level, with a view to drawing up multi-annual research programmes.

This study, entitled FNR-Foresight, ultimately led the Government to define thematic priorities for public research in 2007. The **priority** research domains are:

- Development and performance of financial systems
- Higher quality and more productive business services
- Information security and fiduciary management
- Sustainable management of water resources
- Labour market, educational requirements and social protection
- Identities, diversity and integration
- Functional and smart materials and surfaces
- Age-related illnesses

The Government has also defined a number of **essential** research domains, which have lower priority than those defined above:

- Telecommunications and media
- Biodiversity and understanding ecosystems
- Use and natural sustainable energy sources
- Sustainable management of agro-systems
- Spatial and urban development
- New sensors
- Public health

1.5.3 Diversification of the economy: implementation of particular action plans favouring priority areas

The Government is implementing an active policy to develop and diversify the fabric of the economy according to a "multi-specialisation" strategy to reduce dependence on the financial sector, which remains the predominant pillar of the economy. These diversification efforts will be focused on a number of specific sectors to increase visibility.

The pillars set out in the Coalition Agreement presented in December 2013 cover:

- industry;
- eco-technologies, with a particular emphasis on eco-building, sustainable mobility and the circular economy;
- logistics, principally high added-value logistics;
- healthcare technologies by capitalising on the large-scale investment in terms of public research which has developed a critical mass of skills around the common theme of personalised medicine;
- information and communication technologies, particularly in the distribution of electronic content and data storage in a highly secure environment. The ICT sector is also a point of commonality between the various diversification sectors, because it is highly interconnected both with the eco-technology sector (e.g. smart grid and IT management), logistics (e.g. e-commerce), biotechnology (e.g. data archiving and management) and the industrial and financial sector (e.g. high-performance cloud computing).

A relative specialisation in ICT activities has emerged in Luxembourg. In 2008, 11.4 % of added value (excluding financial activities) was in ICT, i.e. first place in Europe (source: Eurostat, Relative specialisation by Member State in terms of value added, 2008).

2 Governance – the specialisation strategy as a public policy tool

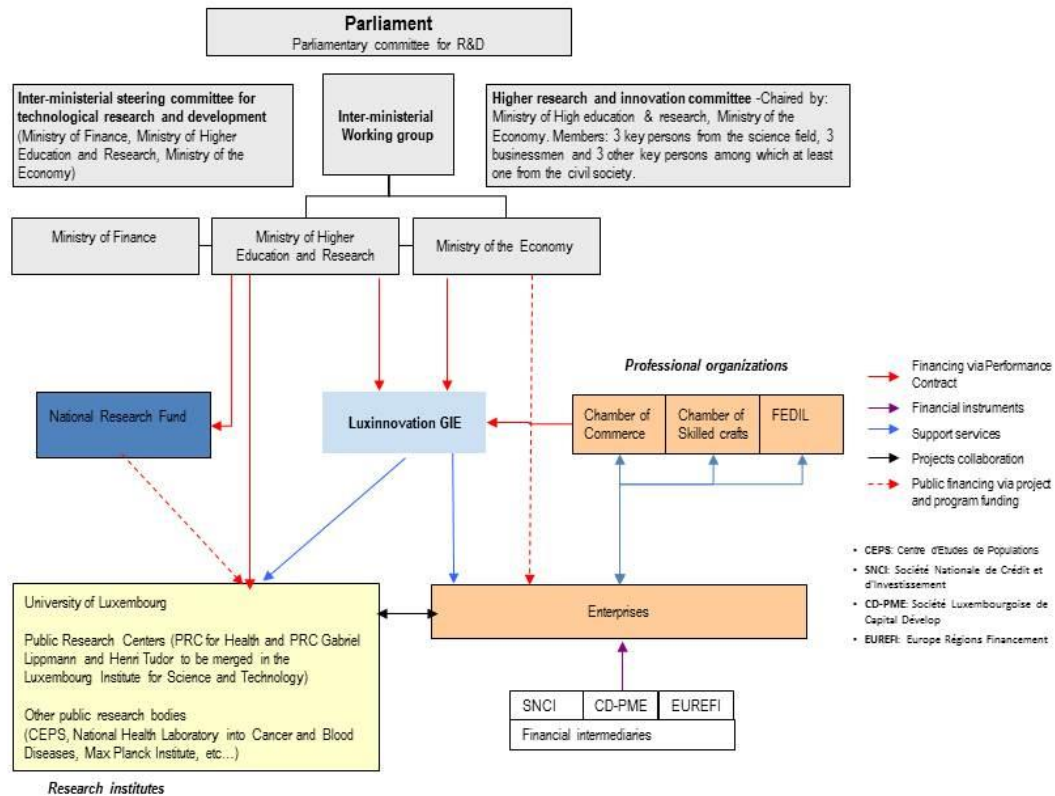
Reviewing and facilitating the Luxembourg specialisation strategy comes under the remit of ministers with economics and research portfolios. The Ministers consult within the interministerial coordination committee for R&D and can rely on support from the RIS3 steering committee.

This steering committee is made up of representatives of the two above-mentioned Ministries and representatives of the National Research Fund (FNR) and the National Agency for Innovation and Research, Luxinnovation.

By the end of 2014, the steering committee will propose a detailed action plan for implementing RIS3, coupled with performance indicators.

The specialisation strategy is subject to approval by the Luxembourg Government at a Government Council meeting in 2015.

The performance contracts as set out in Section 6 will measure and improve governance of the Luxembourg research and innovation system and the national smart specialisation strategy.

Chart showing the National Research & Innovation System**System Model: The National Innovation System (NIS)**

Source: Luxinnovation, August 2014

3 Vision for the future of RDI in Luxembourg**3.1 A firm commitment to encourage R&DI activities:**

R&D and innovation are fundamental in a small, very open economy. The specific structural features of Luxembourg – its size, industrial history, the prevalence of services and very small businesses in its production facilities, and the presence on its territory of a large number of subsidiaries of multinational companies – have an impact on R&D activities, their development and their measurement using monitoring indicators (including the indicator of gross domestic expenditure on R&D as a percentage of GDP).

The government has set a target of 2.3 % to 2.6 % of GDP as a national objective for R&D intensity in the context of the Europe 2020 strategy. Sub-targets for 2020 include a target of 1.5 % to 1.9 % for the private sector and 0.7 % to 0.8 % for the public sector. The government has set an intermediary target of 2 % for all sectors combined for 2015. The trend in state spending on RDI, for both the public and private sectors, has been continued growth, from EUR 28 million in 2000 (0.13 % of GDP) to EUR 280.1 million in 2013 (0.62 % of GDP). These trends in budgetary allocations alone show the Government's willingness to invest in RDI and to develop a sustainable policy to encourage the country's development and diversification.

3.2 SWOT Analysis (Strengths, Weaknesses, Opportunities & Threats):

| | <i>Research, innovation and technology</i> |
|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Strengths</u> | <ul style="list-style-type: none"> - Steady rise in the budget allocated to R&D since 2009 and development of the University of Luxembourg provided for in the Government's Stability and Growth Programme for the period 2012-2015 - Creation and expansion of business incubators for "innovative" start-ups - Development of tools particularly adapted to the needs of SMEs, to support innovation, R&D and economic development strategies: strategic and personalised support offered by Luxinnovation, the National Agency for Innovation and Research (help drafting business plans, technology transfer support, assistance in sourcing partners, etc.), under the Law of 5 June 2009 on the promotion of R&D and innovation - Geographic clustering of the University and Public Research Centres within the <i>Cité des Sciences</i> on brownfield sites in Belval-Ouest (project under way) - Important innovation in the private sector (between 2008 and 2010, 68 % of industrial and services companies were engaged in innovation-related activity, ranking Luxembourg second in the EU27 after Germany, Eurostat, 2012). - Growing public and private investment in sectors with future potential (life sciences / biotechnologies, eco-technologies, etc.) - Clear strategy and priorities within clusters managed by the State since the launch of the Luxembourg Cluster Initiative led by Luxinnovation (business development, branding, internationalisation, flagship projects). - Presence of many specialists in information and communication |

| | |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <p>technologies (Luxembourg is the OECD country with the highest proportion of ICT specialists in its working population at 4.7 %).</p> <ul style="list-style-type: none"> - Quality telecommunications infrastructure (high-speed network, fibre optics, etc.), providing high-performance connectivity with major European internet centres. - Presence and major investment by ICT companies (Amazon, eBay, Skype, Sony, etc.) and gaming companies since the early 2000s. |
| <u>Opportunities</u> | <ul style="list-style-type: none"> - Many information and awareness-raising campaigns led by PRCs and Luxinnovation: training, conferences, innovation competitions (innovation awards, the interregional business plan competition 1, 2, 3 Go, Creative Young Entrepreneur Luxembourg [CYEL], etc.) - Public research currently being restructured: public research centres being concentrated and merged (merger of Gabriel Lippmann and Henri Tudor PRCs under way). - Internationalisation of R&DI activities reflected through increased Luxembourg participation in Community programmes and initiatives (Seventh Framework Programme for R&D (RDFP) and Horizon 2020, Competitiveness and Innovation Programme (CIP), initiatives under Art. 185/187 of the Treaty and European Space Agency (ESA) programmes). - The National Luxembourg Reform Programme aims to increase aggregate public and private investment in the R&D sector from 2.3 % to 2.6 % by 2020. - Geographical position at the heart of the <i>Grande Région</i> |
| <u>Weaknesses</u> | <ul style="list-style-type: none"> - R&D undertaken by large corporations, focused around a handful of multinationals (Goodyear, Delphi, I.E.E., Dupont de Nemours, etc.) but often lacking in the SME sector. - R&D mainly concentrated in the private sector: in 2009, private R&D expenditure was over three times as high as public R&D expenditure (National Reform Programme, 2012). - Lack of interaction between PRCs and the private sector (PPP – public-private partnership) and lack of critical mass in the areas covered. - Relative youth of public research in Luxembourg. Efforts in this area must be maintained in order to reap the expected future benefits. - Research lacks visibility at international level. |
| <u>Threats</u> | |

| | |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | <ul style="list-style-type: none"> - Growing international competition from emerging countries in terms of R&D and technological innovation. - Increasing social and regional imbalances related to ICT (the digital divide) if the use of these technologies does not involve the entire population, businesses and public administrations. - Risk that R&D activities will be concentrated in certain sectors (specifically industry) and in certain regions (specifically urban). - Drop in public revenues meaning that the planned investment in R&DI cannot be sustained - Drop in R&DI investment by multinationals operating in Luxembourg - Lack of qualified resources to implement R&DI projects in Luxembourg |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

3.3. Trends in public research and stakeholders in the national innovation system:

The aims, priorities and performance indicators for major stakeholders in the national innovation system were defined in performance contracts concluded for the periods 2014-2017 (see Chapter 3.3.2). But in addition to these performance contracts, the Government has made a number of legislative changes to provide a more coherent and appropriate framework for future challenges. A range of bills has been submitted aiming to reclarify the missions and priorities of public research stakeholders (see Chapter 3.3.1).

The aim of all these efforts to build a structural framework is to overcome the weaknesses and threats that Luxembourg faces or will face in the coming years:

- Increase investment and the number of stakeholders involved in an R&DI procedure;
- Concentrate investments in priority development sectors and pool resources to increase excellence and critical mass;
- Greater coverage of the R&DI value chain through stepped-up investment in commercialising research findings and PPPs;
- Attract talent and invest in the training of scientific personnel;
- Create strategic partnerships in international research projects and the creation of centres of excellence.

3.3.1 Adapt the legislation governing investment in public research:

The bill amending the Law of 31 May 1999 as amended (**setting up a National Research Fund (FNR)** in the public sector) aims to update the FNR public body; there are four different types of proposals:

- 1) update the **FNR's missions**: the bill reformulates the FNR's missions by underlining its role as a financial backer and its importance as a central instrument for implementing government policy. The FNR is also now expected to contribute actively to commercialising public research findings. The FNR's activities in support of research and researchers will be complemented in the future by initiatives and schemes to commercialise findings in order to maximise economic, social and cultural impact,

- 2) redefine the framework of **organisations eligible** for FNR assistance: three categories of beneficiary will now have access to FNR financing – public institutions whose main remit is research; public organisations and departments undertaking research activities in their areas of competence; non-profit associations and foundations undertaking research activities in their areas of competence,
- 3) improve **governance**: the bill stipulates that relations between the FNR and the State will be governed by a multi-annual agreement focusing on the FNR's general policy, strategic choices, activities and targets, as well as on the resources provided by the State.
- 4) introduce collective **training and research grants**: the bill introduces the option of providing collective training and research grants (AFR). In the case of collective AFR grants, it is the host institution that applies for them. This application will be based on a multi-annual training and research programme which is to describe in detail the aims and size of graduate schools in terms of trainee researchers for a period of three to four years;

The bill to **organise public research centres** and set up Luxembourg Institute of Science and Technology (LIST), Health and CEPS public research centres. There are four types of proposed change relative to the Law of 9 March 1987:

- 1) the **status** of Public Research Centres (PRCs): the purpose of the bill is to define a general framework for PRCs and to set up each PRC as a public institution on an individual basis. In addition, the PRCs will henceforth have financial, scientific and administrative autonomy, justified in particular by the critical mass of the PRCs in terms of budgets and personnel,

- 2) **PRC missions:** the bill restates and clarifies most of the general PRC missions set out in the Law of 9 March 1987. The main mission of PRCs is to undertake RDI activities in order to promote knowledge and technology transfer and scientific and technological cooperation at national and international level. The bill also defines specific missions for the three PRCs to highlight the complementarity of these three public institutions,
- 3) the **PRC structures and governance:** the bill provides that relations between the PRC and the State will be governed by a four-year multi-annual agreement focusing on the PRC's general policy, strategic choices, activities and targets, and the resources provided by the State.
- 4) the section on PRC **personnel** is not directly linked to the specialisation strategy.

In addition to the above, the bill has two more elements:

- 1) the **merger of the Gabriel Lippmann PRC and the Henri Tudor PRC:** Despite some undeniable success on the part of these two PRCs, appraisals carried out at the request of the Ministry of Higher Education and Research over the last three years showed that there were notably failings in terms of partial overlap of RDI activities, lack of critical mass and international visibility, and insufficient strategic consultation.
To this end, in April 2012, the boards of both PRCs adopted a joint declaration of intent to merge both institutions into one and create a national interdisciplinary skills centre with international scientific recognition and a significant impact on innovation according to the European Research and Technology Organisation (RTO) model. The merger of the Gabriel Lippmann PRC and the Henri Tudor PRC is envisaged under this bill and will be effected in phases from April 2012 (public merger announcement) to December 2014 (fully integrated operations),
- 2) the incorporation of the **Integrated BioBank of Luxembourg (IBBL)** into the Health PRC: in 2008, the government approved the setting up of a biobank under the Biotech initiative. The IBBL was set up in September 2008 with the legal status of a foundation and with the three PRCs and the University of Luxembourg as founding members. The bill proposes incorporating the IBBL within the Health PRC, while ensuring that it retains a clearly identified structure and a certain degree of autonomy within the PRC, specifically through a specific multi-annual agreement and independent management, although the IBBL will operate under the control of the Health PRC board of Directors.

3.3.2 Performance contracts for public research and innovation stakeholders:

Following the OECD's 2006 recommendations, the Luxembourg Government set up a range of contracts covering all multi-annual allocations granted to the major stakeholders implementing R&DI policy in Luxembourg: the three Public Research Centres (Health, Lippmann & Tudor), CEPS, the National Research Fund and Luxinnovation.

The third round of performance contracts for the above-mentioned stakeholders, covering the period 2014-2017, have just been signed.

In addition to the changes and mergers due to be implemented, there are specific provisions requiring them to cooperate very closely to ensure complementarity and optimal coherence in the work conducted in most of the priority areas in Luxembourg (see Section 4). These relate to:

- Materials and nanotechnologies,
- Sustainable development,
- ICT and High Performance Computing (HPC),
- Biomedicine,

Although priorities have been set to ensure optimal use of public investment in these priority sectors, public research stakeholders will continue to capitalise on the work carried out over the last two decades, particularly in the area of finance, law, humanities and social sciences (employment, education and other societal challenges).

The same applies to R&DI support structures: the FNR will continue to reinforce skills in the social sciences while stepping up its investments in strategic priorities.

Luxinnovation will support these priorities, notably by fostering the development of technology clusters.

At European level, public research stakeholders have committed themselves to stepping up participation in international research projects, notably under the Horizon 2020 programme. Increasing critical mass and reinforcing scientific excellence in priority areas should enable Luxembourg to improve its international visibility and success rates in these Community programmes. Strategic partnerships are also planned with laboratories and centres of excellence or research teams abroad. Luxembourg's eligibility for the new programme "Spreading Excellence and Widening Participation" (Widespread) is an unprecedented opportunity to restructure public research. The aims of the teaming instrument are perfectly aligned with those of the future LIST (Luxembourg Institute for Sciences and Technology) which plans to set up a centre of excellence in the field of materials and nanotechnologies. The twinning and ERA-Chair instruments will help create or reinforce strategic partnerships with institutions of excellence in fields falling within the remit of public research institutions (see above).

3.3.3 Trends in private research:

As suggested by its title – National Plan for Innovation and Full Employment (2005) – the national reform and action plan (PNIPE) attaches great importance to innovation policy in the wider sense. The National Plan for Innovation and Full Employment is regularly adjusted under the National Reform Programme. The Luxembourg 2020 Strategy was published in April 2011.

Its main pillars are as follow:

- improving the range of measures to encourage RDI, particularly in the private sector;
- increasing the level and effectiveness of public expenditure on RDI (leveraging);
- reinforcing cooperation with existing and future centres of excellence, particularly in the area of sustainable construction, materials and nanotechnologies;
- improving cooperation and technology transfer between public research organisations and private companies (public-private partnerships);
- developing innovation support services, in particular for technology dissemination and transfer;
- creating and developing innovation partnerships and regional and local clusters comprising universities, research organisations and companies;
- improving access to national and international financing;
- promoting the spread of ICT in public services, SMEs and households;
- encouraging the development technology and content-producing businesses and infrastructure in the field of information and communications;
- ensuring the security of information systems;
- undertaking initiatives based on public-private partnerships to mitigate the risks of failure for new technologies and markets by setting up and developing regional and local technology clusters with greater involvement of SMEs;
- centring promotion and economic diversification policy on the establishment of new businesses bringing advanced technologies to fields and sectors defined as priorities.

Particular effort should be made to promote R&D-Innovation efforts, especially in SMEs.

The findings outlined in Section 5.1.1. show the effectiveness of the tools implemented to address this issue. The Law of 5 June 2009 on the promotion of research, development and innovation in the private sector will be extended in 2014. The various partners involved will be consulted through the Luxembourg legislative procedure. The Law will be extended to involve professional chambers such as the chambers of commerce and trades, and employers' associations such as FEDIL (Business Federation Luxembourg) or the FDA (Federation of Craftsmen). This extension will be an opportunity to appraise achievement of the objectives of the Law of 5 June 2009 and assess the need for any updates in order to meet these objectives more effectively.

4 Sectoral priorities

The Luxembourg economy remains relatively prosperous, due in particular to the health of the financial sector. However, this dependence on the financial sector remains a structural problem for the country. As part of its strategy to diversify the economy, the Government will be implementing an active policy to develop and diversify the economic fabric according to a "multi-specialisation" strategy to reduce dependence on the financial sector, which remains the predominant pillar of the economy. These diversification efforts will be focused on a number of specific sectors to increase visibility.

In line with the efforts of the European Commission to implement its strategy on Key Enabling Technologies (KETs), Luxembourg has specifically identified the following KETs as drivers of competitiveness:

- advanced materials and nanotechnologies;
- biotechnologies;

Developments in key enabling technologies will be applied in specific sectors where it is important to create and/or maintain employment within industrial companies, such as:

- Ecotechnologies
- Health sciences
- Information and communication technologies
- Logistics

It is important to acknowledge the growing importance of the social dimension in implementing R&DI strategy and projects. Therefore, work relating to the humanities and social sciences that applies to the above sectors will also be supported.

4.1 Presentation of action plans for priority areas

4.1.1 Innovative materials

The development of innovative materials will rely on the development of the so-called Key Enabling Technologies (KET), advanced nanomaterials and nanotechnology. The Materials department of the Luxembourg Institute of Science and Technology (LIST) will target two fields: (i) Nanomaterials & nanotechnology and (ii) Composite materials.

The development of innovative materials will rely on the development of Key Enabling Technologies (KET) in advanced nanomaterials and nanotechnology. The Materials department of the Luxembourg Institute of Science and Technology (LIST) will target two specialist fields: (i) Nanomaterials & nanotechnology and (ii) Composite materials.

The priority areas in the first specialist field include new-generation materials and technologies for consumer products, such as **energy collection and recovery**, transparent electronics, **sensors**, and nanocomposites with adjustable optical properties. Several of these technologies and materials open up possibilities for developments in oxide electronics. Innovative nanomaterial research and technology also provide an interdisciplinary basis for developing nanotechnologies used in medical diagnosis or **nano composites for biomaterials**. More specifically, these activities will be accompanied by **safety assessments** based on nanotoxicology practices and taking into account effects on human health and natural ecosystems.

Innovative composite materials are another field in which discussions will be finalised between private companies operating in the fibre materials sector (fibre producers, downstream **users** and companies with expertise in simulation and production technologies) and research stakeholders (PRCs and the University of Luxembourg) in order to build an integrated innovation chain in Luxembourg in the following key fields: **(i) Materials, Functionality and Durability, (ii) Predictive and Simulation Technologies, (iii) Engineering Technologies, Processes and Production.**

Naturally, the development of innovative materials and highly technical activities will rely heavily on top quality infrastructures and facilities. Firstly, the focus will be on advanced characterisation instruments and cutting-edge microscopy techniques. Secondly, significant resources will be mobilised for **synthesising samples and creating simple systems, including clean rooms.**

Innovative materials can be used in various economic sectors, including health and ecotechnology, and can help **anchor Luxembourg's industry in smart and sustainable innovation in medium and high-tech products.**

Luxembourg's small size does not allow it to cover all KET activities, which could damage its international standing. Consequently, rather than **limiting itself to just one specialisation**, the future LIST will work with other institutions in technology networks to cover all activities in the innovation chain and provide access to KETs, **with the exception of** advanced materials and nanotechnology. To do this, Luxembourg, through LIST, will propose **setting up strategic, productive partnerships**, which could be accelerated through financial support under the H2020 Programme Teaming initiative, Spreading Excellence and Widening Participation.

4.1.2 Biotechnologies applied to health sciences

In Luxembourg, the development of the red biotechnology (medical) sector has come from the proactive approach initiated by the governmental team in place in 2004 – and continued by successive governmental coalitions – driven by the fact that biotechnologies are key enabling technologies.

In the spirit of the RIS3 procedure, the country's existing skills and assets were first analysed to identify synergies that could be used to develop a skills niche in the vast life sciences sector.

The two pillars on which the current strategy is based are: (a) information and communication technologies (ICT) and (b) the logistics platform. The gradual switch to personalised or precision medicine – i.e. medicine that targets therapeutic practices according to expected patient response – requires robust computer infrastructure and innovative solutions for the storage, protection and analysis of data produced by '-omic' technologies (genomics, proteomics, transcriptomics, metabolomics, epigenomics and microbiomics), and to facilitate its integration, via ICT, with data relating to environment, lifestyle, toxic substances, social and economic factors, and the determining factors within health systems. These same requirements apply downstream when research findings lead to the development of molecular diagnosis tools and tests. Logistical infrastructure is also required for the transportation and distribution of samples.

The second stage involved increasing the volume and quality of national research in a targeted manner to develop skills and expertise capable of attracting industrial partnerships. This led to the setting up in mid-2008 (in partnership with North-American institutions) of the Luxembourg Centre for Systems Biomedicine (LCSB), which adopts an holistic and interdisciplinary scientific approach, with research focused on neurodegenerative diseases, and the Integrated Biobank of Luxembourg (IBBL), a dedicated research infrastructure for collecting, storing, preparing and analysing samples. The IBBL specialises in biospecimen research and standardisation (SOP) to provide a fertile environment for marker validation procedures. Finally, a clinical proteomic laboratory has been opened at the Public Research Centre for Health (PRC Health) under this initiative.

In September 2011, the three above-mentioned stakeholders, IBBL, LCSB and PRC Health, outlined a dual-purpose strategic plan: to maximise synergies between institutions and to focus research topics on the country's medical needs in order to ensure a link between the healthcare system and long-term returns in terms of public health. The pathologies principally targeted were

type-2 diabetes, lung, colon and breast cancer and Parkinson's disease. Discussions are under way to set up a cohort of about 10 000 individuals.

As regards commercialising research, it has been decided to invest in a risk capital fund to set up a scouting mechanism within research institutions, to fund early stage start-ups and more generally to allow stakeholders to familiarise themselves with, and create links with, the world of investors. In the first quarter of 2012, the Government invested €25 million in ALSF1, a life sciences fund managed by Advent (London) through the *Société Nationale de Crédit et d'Investissement* (SNCI).

Finally, an incubator dedicated to life science activities will be operational by the end of 2014 that will provide support and monitoring for innovative start-ups in the field.

4.1.3 Information and communication technologies:

Thanks to the prospecting and setting up of tailored connectivity and data centre infrastructures, Luxembourg is now the location of choice for many companies active in the ICT sector, particularly in the fields of electronic content distribution and data storage in a highly secure environment. The information and communications sector is an integral part of the development and diversification policy.

It is also a point of commonality between the various diversification sectors, because it is highly interconnected with eco-technology (e.g. smart grid and IT management), logistics (e.g. e-commerce), biotechnology (e.g. data archiving and management) and the industrial and financial sector (e.g. high-performance cloud computing).

4.1.4 Ecotechnologies:

As regards the development of ecotechnologies, the Ministry is focusing on the convergence of energy policies and economic and environmental diversification. Luxembourg has the potential to identify niches in the wider domain of clean/green technologies, by focusing on specific domains and stages in the value chain and by actively supporting the greening of Luxembourg's economic structure while improving sustainable development at local and global level.

4.1.4.1 Sustainable construction

To ensure that Luxembourg companies have a competitive advantage, the Government has stepped up pressure on stakeholders by introducing a compulsory energy passport for all residential buildings placed on the market and by requiring that all new residential buildings be A/A energy-rated by 2017. To help companies, particularly SMEs, to handle this regulatory pressure, a number of support measures will be needed.

Measures:

- Set up a skills centre for sustainable construction, tasked with developing a strategic research programme, facilitating the transfer of research findings to commercial applications, developing intra-disciplinary research and creating strong links with international partners.
- Create a *National Council for Sustainable Construction* , bringing together the various stakeholders and stakeholder representatives from the building sectors in order to establish a coordinated national approach.
- Support SMEs in the construction sector by facilitating their access to research and innovation. The innovation cluster *Neobuild*, which fosters innovative technologies, is an example of good practice in this area.

4.1.4.2 Sustainable mobility

Luxembourg is highly committed to developing sustainable mobility and will deploy some 850 electric charging points on national territory as part of its e-mobility strategy to reach the target of 40 000 electric car registrations by 2020.

Technological changes are pushing stakeholders to review their economic models and revealing brand-new activity niches. Luxembourg aims to make (soft) sustainable mobility one of its priorities as part of the development of ecotechnologies. The next three pillars seem very promising for Luxembourg:

- 1) Development of electromobility;
- 2) Use of ICT in soft mobility;
- 3) Development of technologies associated with autonomous driving.

Measures:

- Position Luxembourg more as a testing zone for new technologies.
- Set up a soft mobility data platform.
- Develop IT applications in the field of infomobility and collective mobility.

4.1.4.3 Circular economy

In a world with limited resources, where commodity prices are constantly increasing and where pollution is becoming an ever more urgent problem, a country with few natural resources such as Luxembourg will have to optimise the use of its own resources and move towards a circular economy with limited or even zero waste.

Measures:

- Raise awareness among companies of the principles of the circular economy.
- Carry out a study on the potential of a strategy based on the circular economy.
- Encourage a green procurement policy to make it easier for innovative technologies to enter the market.

4.1.5 Logistics sector:

The Government aims to position Luxembourg as an intercontinental multimodal logistics platform in Europe, mainly in high added-value logistics. As part of a multi-product policy, various categories have been identified which have possible synergies with other key sectors, particularly pharmaceutical products. The storage and transportation of works of art and valuables will be promoted by capitalising on the Luxembourg Freeport.

Work will be carried out on the Eurohub Sud logistics hub to offer high-performance infrastructures to serve the logistics sector.

The multimodal terminal and rolling highway platform in Bettembourg will be developed to serve an increasing number of destinations across Europe.

Promotional campaigns will be stepped up and the logistics action plan revised to take account of trends in the sector.

To facilitate import, export and transit procedures for goods, the Government will set up a single window for logistics in close collaboration with ministerial departments, administrations and the stakeholders concerned.

5 Action plan and instruments implemented

5.1 Encouraging private R&D initiatives:

5.1.1 Through mechanisms for State aid:

The Law of 5 June 2009, as amended, on the promotion of RDI extends intervention opportunities in terms of R&D projects and programmes to include initiatives for process and organisation innovation in services, the financing of innovative start-ups and cooperation through investment in and leadership of innovation clusters. New grant schemes will also be unveiled to encourage SMEs to avail themselves of innovation advisory services and temporary secondments of highly qualified staff. Finally, innovation grant schemes include a measure to encourage the protection of technical industrial property and a measure to support technical feasibility studies.

The use of these instruments has boosted investment, with the number of grant-aided RDI projects rising from 25 in 2009 to 142 in 2013. It should also be noted that SMEs are the major beneficiaries of State aid for RDI, as they accounted for over 63 % of the beneficiary companies in 2013.

| | 2009 | 2010 | 2011 | 2012 | 2013 |
|--------------------------------------------------------|------|------|------|------|------|
| Number of R&DI projects supported by Government grants | 25 | 45 | 69 | 87 | 142 |

The number of joint projects involving a company and a Luxembourg public research organisation has risen from 10 in 2011 to 16 in 2012 and stood at 28 in 2013.

The Government ordered a review of State aid for RDI in the summer of 2014 with a view to adjusting these grants based on effectiveness, efficiency and economic impact.

5.1.2 The Innovation Fund: a flexible instrument to support RDI policy

The Law of 5 June 2009 on the promotion of RDI authorised the government to set up a special financing fund to promote research, development and innovation in the private sector, known as the Innovation Fund. Its purpose is to finance various grant schemes, international cooperation projects and programmes and tasks specifically entrusted to Luxinnovation under the law.

This financing method enables:

- multi-annual commitments to be scheduled without having to take account of the constraints of annual State budgeting;
- adjustments to be made to this schedule as opportunities and political priorities arise, without having to go through budget transfer or overrun procedures;
- unspent budgetary allocations to be recovered at the end of the fiscal year;
- annual budgets to be defined for institutions promoting RDI according to RDI policy and documented requirements rather than according to a budgetary standard for all State administration running costs;
- extraordinary allowances to be allocated from extraordinary State revenues, in respect of the RDI promotion policy.

The Innovation Fund falls within the remit of ministers with economics and finance portfolios.

5.1.3 Clusters:

Clusters are a key element in Luxembourg's innovation policy as they bring together companies, research institutions and other stakeholders from specific sectors working on the development of joint projects with an economic and technological focus.

Luxinnovation heads six clusters, set up to actively encourage technological fields and key technologies of crucial importance to the Grand Duchy.

These are:

- biomedicine
- automotive equipment
- materials sciences
- environmental technologies
- information and communication technologies
- space technologies

A new cluster policy was unveiled by the Minister for Economic Affairs in October 2013. The cluster action plans have five priorities:

- developing key technology areas (listed above) and economic activities arising from them
- supporting flagship projects

- strengthening the brand image of key technological fields and economic activities arising from them
- enhancing prospecting for new members for these clusters at national and international level
- promoting clusters in the Luxembourg Cluster Initiative and the technological skills of their members, and supporting them in expanding their activities internationally

Concrete and measurable targets have been assigned to each cluster to facilitate in-depth monitoring of the results achieved. Cluster activities will be measured regularly against these targets, so that adjustments may be made to the strategy where appropriate.

The Ministry of Economic Affairs' Cluster Initiative, led by Luxinnovation, intends to adopt the following performance indicators for the period 2014-2020:

| Sectoral support service offered to members by the Cluster | Indicator |
|-------------------------------------------------------------------|------------------|
| Identifying cooperation opportunities | 1 000 |
| Setting up strategic partnerships between 2 or more stakeholders | 10 |
| Starting businesses | 300 |
| Creating new jobs | 3 000 |

5.2 Thematic targeting in public research:

National public R&D efforts have concentrated on a limited number of priority areas, particularly the CORE programme. CORE is a mechanism for financing competitive research which operates on the basis of calls for projects. Projects are appraised by international experts. The priority areas were defined taking into account the Foresight Exercise and selective specialisation fields. The CORE programme supported projects to the tune of €18.0m for the period 2008-2010 and €57.3m for the period 2011-2013. For the period 2014-2017, provision has been made for €22.54m per year on average for programmes promoting scientific quality and research excellence (CORE and INTER projects supporting joint projects, etc.).

| Priority area | Focus |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Innovation in services | Development and performance of financial systems Higher quality and more productive business services Information security and fiduciary management High-performance telecommunications networks |
| Sustainable resource management | Sustainable management of water resources Sustainable management and conversion of biomass Sustainable construction and bioenergy Urban and spatial development |
| Functional and smart materials and surfaces | Functional and smart materials and surfaces |
| Biomedicine and health sciences | Regenerative medicine in age-related diseases Biomedical research Public health |
| Societal challenges | Economic and social cohesion Education and training Identity, diversity and interaction |

5.3 Commercialising research findings and promoting public-private partnerships:

Increasing the number of public-private partnerships is a key objective in order to leverage public R&DI efforts to boost private sector investment. The National Research Fund performance contract thus includes a strategic objective to reinforce research with economic and societal impact (strategic objective 2). This objective is based on grant schemes for collaborative projects with industrial partners and other users as well as on commercialisation projects (patents, licences and spin-offs).

Existing grant schemes for public-private partnerships (AFR-PPP and CORE-PPP) will be reinforced and promoted more vigorously and will be allocated a dedicated budget every year.

Based on the pilot Proof-of-Concept programme, a regular programme for commercialising research findings will be rolled out. This programme will also provide support to personnel with both scientific and commercial skills to stimulate and underpin the commercialisation of research findings and technology transfer within research institutions.

The FNR will explore the possibility of setting up chairs of industry (or chairs of applied research) in research institutions, similar to the PEARL programme. The scientific fields covered by these chairs will be defined in collaboration with and co-funded by industrial partners and/or other research users (services, healthcare or education sectors). These chairs will be appointed by the FNR according to its usual criteria of scientific excellence. However, they must also have a proven track record in cooperation with the private sector and/or public services.

5.4 New instruments to attract entrepreneurial activity

The Luxembourg Future Fund, set up by the SNCI and the European Investment Fund (EIF) and launched in July 2014, is helping to attract entrepreneurial activity directly or indirectly to Luxembourg in the start-up, development or growth phase, as well as activities contributing to innovation and ecotechnologies.

6 Monitoring the national innovation system

6.1 Definition of performance indicators:

Performance contracts are multi-annual contracts concluded with three public research centres, namely the CEPS, the National Research Fund and Luxinnovation. The third generation of performance contracts has just been signed with all stakeholders for the period 2014-2017.

In line with the spirit of these contracts, the contracting party undertakes to achieve a certain number of objectives, demonstrated by indicators and output results, in exchange for State aid, thus linking R&D expenditure to expected results in scientific, economic and social terms.

These performance contracts are the main coordination and monitoring tool for the national research and innovation system. Each performance contract has ten or so indicators drawn up according to horizontal priorities:

- leveraging effect of public financing: in exchange for basic State aid, the institution undertakes to generate revenue from contracted research and competitive research;
- commercialisation of research findings: patents, licences and spin-offs;
- scientific findings measured through the institutions' publications and more generally their scientific activities (PhD dissertations, scientific exchanges, etc.). Regarding publications, particular emphasis is placed on publications listed in the Thomson/ISI and Scopus databases. The number of publications with an impact factor higher than 2 is also a target to be reached.

The new generation of performance contracts also sets out the vision, missions, strategy and priority topics for each public research organisation.

6.2 Monitoring:

Monitoring of performance contracts involves:

- annual monitoring based on annual reports
- appraisal by external independent experts

6.3 Review of the national innovation system:

Following an initial review of the National Innovation System by the OECD in 2006, Luxembourg engaged in a further appraisal of its national innovation system in the summer of 2014.

Conclusion:

The ERDF management authority has analysed the areas of specialisation and diversification outlined in this document with regard to its Operational Programme for the period 2014-2020. The priority fields thus identified are logistics, ecotechnologies, biotechnologies and any other field directly related to the specific needs of industry and potentially eligible for ERDF co-financing. These choices are in line with the priorities defined in the National Reform Plan. These priorities relate to both public and private research.

At a more cross-disciplinary level, the focus on building synergies between public and private research and stakeholders will continue. Skills centres and/or innovation clusters will be encouraged to increase the visibility of Luxembourg stakeholders in diversification and specialisation niches.