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Capacity Mapping: R&D investment in SET-Plan technologies

Reference year 2011

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Abstract

SETIS (Strategic Energy Technologies Information System) is the European Commission's information system for the SET-Plan. It makes the case for technology options and priorities, monitors and reviews progress regarding implementation, assesses the impact on policy and identifies corrective measures if needed. Therefore, part of the broad scope of the SET-Plan focuses on capacities mapping, which aims to provide an assessment of public and corporate R&D investment in low-carbon energy technologies in the EU. The ultimate objective is to offer a benchmark, based on the observed R&D investments, that will serve as the basis for planning the future investments needed to address the key R&D technology challenges identified by the SET-Plan.The The primary focus of the Capacities Map is on technologies addressed by the SET-Plan (bioenergy, CCS, electricity grids, nuclear fission, solar, wind, fuel cells and hydrogen technologies). In addition, the current edition contains assessments on energy storage and ocean energy technologies, priorities identified in the 2013 communication on Energy Technologies and Innovation, which brings the total number of technologies addressed to nine. The reference year for the R&D investment is 2011.

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LIST OF ACRONYMS

CCS Carbon Capture & Storage
CEF Connecting Europe Facility
CF Cohesion Funds
CIP The Competitiveness and Innovation Framework Programme
CORDIS Community Research and Development Information Service

Country acronyms:

- AT Austria,
- BE Belgium,
- BG Bulgaria,
- CH Switzerland,
- CY Cyprus,
- CZ Czech Republic,
- DE Germany,
- DK Denmark,
- EL Greece,
- ES Spain,
- EE Estonia,
- FI Finland,
- FR France,
- HR Croatia,
- HU Hungary,
- IE Ireland,
- IT Italy,
- LT Lithuania,
- LU Luxembourg,
- LV Latvia,
- MT Malta,
- NL Netherlands,
- NO Norway
- PL Poland,
- PT Portugal,
- RO Romania,
- SE Sweden,
- SI Slovenia,
- SK Slovakia,

CSP Concentrated Solar Power
DG RTD Directorate-General for Research and Innovation
DOE Department of Energy (USA)
EAFRD The European Agricultural Fund for Rural Development
EBRD European Bank for Reconstruction and Development
EC European Commission
EEEF European Energy Efficiency Fund
EEPR European Energy Programme for Recovery
EFF The European Fisheries Fund
EIB European Investment Bank
EIF European Investment Fund
EIP Entrepreneurship and Innovation Programme
ELENA European Local Energy Assistance
ERDF The European Regional Development Fund
EU European Union; EU27 (reference year 2011)
FCH Fuel Cells & Hydrogen
FP7 The 7th Framework Programme for Research, Technological Development and Demonstration
GBAORD Government Budget Appropriations or Outlays on R&D (Eurostat)
GDP Gross Domestic Product
ICT Information and Communication Technology
IEA International Energy Agency
IEE Intelligent Energy Europe
JRC Joint Research Centre
LGTT Guarantees for transport infrastructure cash-flow
MFF Multiannual Financial Framework
MS Member state(s)
NEDO New Energy and Industrial Technology Development Organization
PBI Project Bond Initiative
PV Photovoltaic
R&D Research & Development (including demonstration)
RSFF Risk Sharing Financing Facility
SEFF Sustainable Energy Financing Facilities
SEI Sustainable Energy Initiative
SET Plan Strategic Energy Technology Plan
SME Small and Medium Enterprise
SMEG SME Guarantee Facility
T&D Transmission & Distribution
TEN-(T/E) Trans-European Networks (Transport/ Energy)
TSO Transmission System Operator
USA United States of America

EXECUTIVE SUMMARY

The Capacities Map provides an assessment of public and corporate R&D investment in low-carbon energy technologies in the EU, in order to offer a benchmark that will serve as the basis for planning the future investments needed to address the key R&D technology challenges identified by the SET-Plan.

The primary focus is on technologies addressed by the SET-Plan (bioenergy, CCS, electricity grids, nuclear fission, solar, wind, fuel cells and hydrogen technologies). In addition, the current edition contains assessments on energy storage and ocean technologies, priorities identified in COM(2013) 253 on Energy Technologies and Innovation, which brings the total number of technologies addressed to nine.

Despite the persistent climate of uncertainty due to the weak recovery of advanced economies and the slowdown of growth in emerging economies, there has been a progressive rate of increase in R&D investment in the EU; however overall R&D intensity remains below the 3% target.

In total €8.8 billion was invested in the nine technologies examined in this report in the year 2011. The majority of the funding came from the corporate sector, which invested over €5.8 billion; national R&D programmes contributed another €2.5 billion, the rest coming from EU funding mechanisms (Table 1). The investment in the SET-Plan technologies included in this report, amounts to roughly 3% of the total R&D investment in the EU.

Table 1: Summary of funds available for R&D in SET-Plan technologies in 2011 from national, EU and corporate sources. Data source IEA [1], JRC [2, 3]

(EUR million)	***Bioenergy***	***CCS***	***Grids***	***Storage***	***FC & H2***	***Nuclear***	***Ocean***	***Solar***	***Wind***	**Total**
National	383	313	235	59	202	690	39	366	179	**2466**
EU	45	214	119	1	46	28	8	39	54	**554**
Corporate	888	349	249	1576	463	495	60	548	1146	**5774**
Total	**1316**	**876**	**603**	**1636**	**711**	**1213**	**107**	**953**	**1379**	**8794**

Figure 1 shows the share of the funding received by each of the technologies in question. Energy storage received the most investment, followed by wind, bioenergy and nuclear fission. These technologies, in the same order have also received the most investment from the business sector, closely followed by fuel cells and hydrogen. In this group, nuclear fission stands out for receiving matching support from the public sector. Ocean energy technologies received the least support within the group of technologies examined. Significant effort at EU level was directed towards carbon capture and storage and electricity grids.

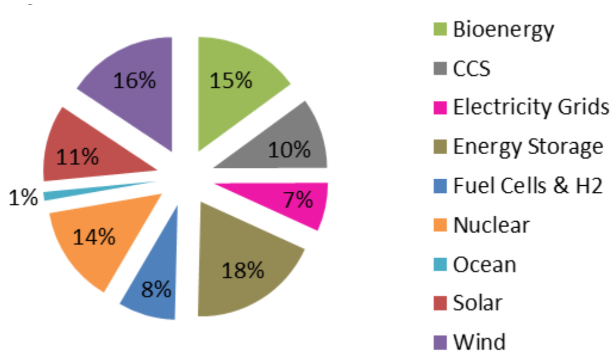

Figure: Split of the total investment between the technologies included in the analysis. Data: IEA [1], JRC [2, 3]

At the national level, the leading investors, Germany and France show interest across the board of technologies investing in eight and nine respectively each. On the other hand, smaller investors like Slovenia and Malta devote support to key technologies, like electricity grids and solar energy.

As shown in Figure 2, investment in electricity grids doubled with respect to 2010 and carbon capture and storage technologies had a similar – through smaller – increase in funding. Solar, bioenergy and nuclear also had moderate to small increases in R&D funding; for the rest of the technologies investment has decreased, most notably for ocean technologies, where support was lower by almost a third compared to 2010 levels. Due to the lack of data for a number of Member States for both years the numbers can only be considered indicative; however, data for the countries which have been known historically to lead in R&D investments are included, so the trend is representative of the momentum of investment for each technology at the given time.

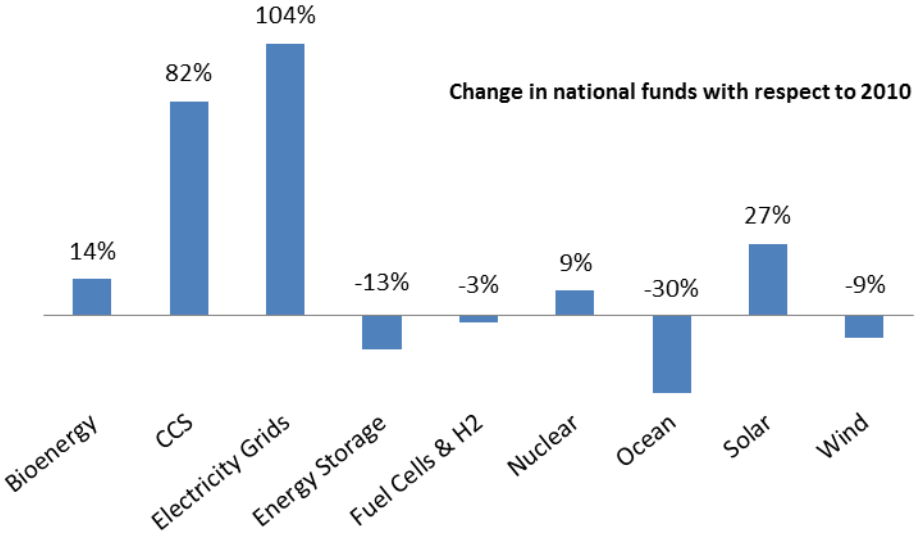

Figure 2: Indicative change in funding available through national funding programmes between the years 2010-2011. IEA data is used as reference for technologies not previously included in the Capacities Map. Data source IEA [1], JRC [2, 3].

In 2011:

- Bioenergy remained as the second largest global renewable R&D investment market despite a decrease in investment; the difference between corporate and public expenditure in the sector remained large.
- Despite some successes, CCS R&D projects for power generation and industrial applications have not been progressing as fast as their climate change mitigation capacity would warrant.
- As a key enabler for the efficient deployment of sustainable energy, electricity grids have become a priority in terms of R&D and infrastructure development.
- Several energy storage technologies are mature or near mature, thus the majority of the funding has come from the corporate sector. Much of the R&D effort focuses in reducing the costs of high-density storage.
- Commercially, this was one of the most prosperous years for fuel cells and hydrogen, following a gradual increase of successful demonstration and deployments projects in all areas of application.
- The events at Fukushima, which had a major impact on the nuclear sector in a number of countries. After the slow, gradual increase of the previous years, the global industrial investment experienced a sharp decline. In contrast EU public funding increased slightly; nuclear fission still attracts the highest level of public funding among the technologies examined.
- Following a tenfold increase of R&D investment in ocean energy technologies in the last 10 years, a correction to that trend was observed. Ocean energy remains the least developed, and commensurately, the less funded of the technologies included in this assessment.
- In solar energy, the dramatic decrease in production costs for photovoltaics resulted in a boom of installations and the policy response of rapid adjustment in feed-in tariff subsidies. Accordingly, global funds dedicated to solar R&D fell. Despite this decrease, the sector kept the global lead in renewable energy R&D. The drop in investment was not reflected in European public funding, which saw a slight increase.
- Wind energy is the most mature of the technologies examined in this report. As such, it has attracted less R&D funding from public sources, and more investment from the corporate sector, which is concurrent with a commercial technology. After energy storage, wind receives the second highest level of support from the technologies examined in both corporate and total investments.

1 INTRODUCTION

1.1 SCOPE

Since 2008, the EU implements the Strategic Energy Technology Plan (SET-Plan) with the aim to: accelerate energy technology development, technology transfer and up-take; maintain EU industrial leadership on low-carbon energy technologies; foster science for transforming energy technologies to achieve the 2020 energy and climate change goals; and contribute to the worldwide transition to a low-carbon economy [4, 5].

SETIS (Strategic Energy Technologies Information System) is the European Commission's information system for the SET-Plan. It makes the case for technology options and priorities, monitors and reviews progress regarding implementation, assesses the impact on policy and identifies corrective measures if needed. Therefore, part of the broad scope of the SET-Plan focuses on capacities mapping, which aims to provide an assessment of public and corporate R&D investment in low-carbon energy technologies in the EU. The ultimate objective is to offer a benchmark, based on the observed R&D investments that will serve as the basis for planning the future investments needed to address the key R&D technology challenges identified by the SET-Plan.

This analysis has been prepared by the Institute for Energy and Transport of the JRC in support of SETIS. The main aim of the Capacities Map is to contribute to the understanding of the effectiveness of R&D investment and to identify the extent to which public and private efforts contribute to the financing of technology development in the SET-Plan. The present document builds on the analysis of the previous editions and provides an update of the figures contained therein. The assessment year of the present analysis is 2011. There is an inherent delay in the publication of R&D statistics and the update of patent application data, which has accumulated in a 3-year gap between the reference year and the publication of this analysis. At the time of writing the latest available complete set of national R&D investment data refers to the year 2012. It is the goal of subsequent publications to bridge the 1 year delay and streamline the methodology to reduce the time gap between data becoming available and analysed in the context of the Capacities Map. However, using the existing data sources the best that could be achieved would be a 2 year delay between the reference year and the production of the analysis.

The implementation of the SET-Plan has led to the establishment of large scale programs, called European Industrial Initiatives (EIIs), which bring together industry, the research community, the Member States and the European Commission in risk-sharing partnerships aiming at the rapid development of key energy technologies at the European level. Six technologies have already been identified as the focal points of the first EIIs [6], bioenergy, carbon capture and storage, electricity grids, nuclear fission, solar (photovoltaics and concentrated solar power) and wind. The Fuel Cells and Hydrogen Joint Undertaking is also considered as part of the SET-Plan. It has been one of the first Joint Technology Initiatives (JTI) of the European Commission, established before the formation of the SET-Plan and its EIIs.

Acknowledging the limitations of the present analysis in gathering investment data (EU R&D investment, Member States' national R&D investment and corporate R&D expenditure), this report seeks to provide an estimation of the total European R&D investment for the year 2011. The primary focus is on technologies addressed by the SET-Plan (bioenergy, CCS, electricity grids, nuclear fission[1], solar, wind, fuel cells and hydrogen technologies). In addition the current edition also contains assessments on energy storage and ocean technologies, which brings the total of technologies addressed to nine. While the main aim is to evaluate the intensity of investment in the EU, a comparison with the level of investment made by several other large economies, i.e., the USA, Japan, South Korea and China, is included to provide an indication of the comparative magnitude of investments for each technology.

[1] Nuclear energy as included in the SET-Plan priority technologies only concerns Generation IV reactors. Due to the difficulty in obtaining R&D investment data specific to Generation IV reactors, the total investment for nuclear fission is investigated in this study.

The report is structured as follows: the introduction continues with a presentation of the broad R&D landscape for the year 2011 in which investments in the technologies in question and energy technologies in general are to be considered. Section 2 provides a description of the methodology, and an overview of the investments in all technologies for the public and private sector is provided in section 3. The following 9 chapters provide technology specific information and analysis for the technologies in question.

1.2 ENERGY INVESTMENTS IN THE BROADER R&D LANDSCAPE

Despite the persistent climate of uncertainty due to the weak recovery of advanced economies and the slowdown of growth in emerging economies, there has been a progressive rate of increase in R&D investment in the EU. According to Eurostat figures, in 2011, total R&D expenditure in the EU reached EUR 259 billion, increasing 5.1% with respect to the previous year and 9.4% with respect to 2009 [7]. This increase has not been enough to bring the investment levels up to the target intensity of 3% of GDP [8]. Overall R&D intensity amounted to 2.1% of the GDP (Figure 1.1), lagging behind countries such as South Korea (3.7%), Japan (3.3%) and the US (2.7%), but performing better than China (1.8%) and Russia (1.1%).

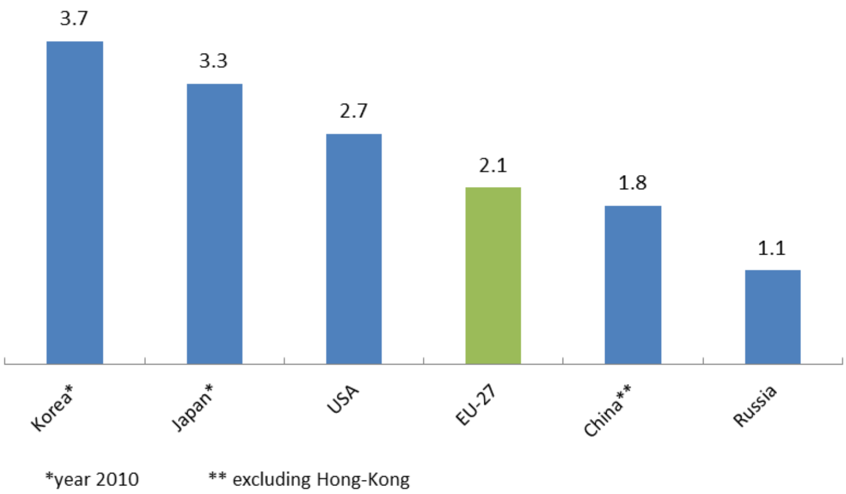

Figure 1.1: Total R&D expenditure in percentage points with respect to GDP. Data source: Eurostat [7]

As shown in Figure 1.2(a), during the period 2007-2011, R&D investment in the EU27 exhibited procyclical dynamics. The collapse of the annual variation, resulting from the economic crisis, culminated in the fall into negative territory in 2009. In general, there is evidence of a strong connection between the macro-economic environment and the consistency of R&D investment decisions. This is clear in the tight alignment displayed in Figure 1.2(b), where R&D expenditure is plotted against GDP for the EU.

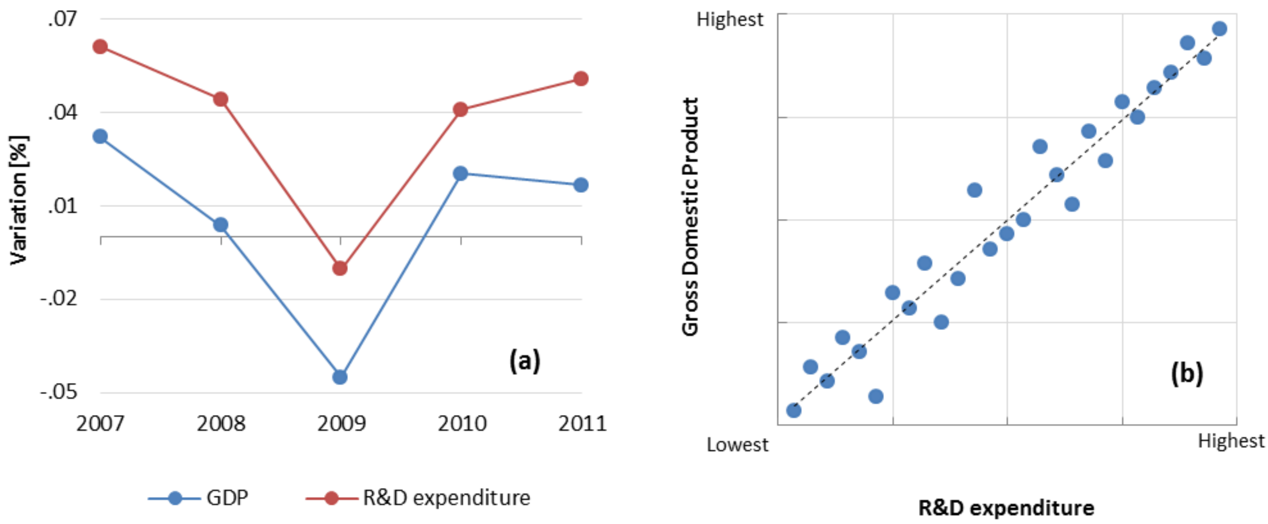

Figure 1.2: Annual rate of variation in percentage points (a) and R&D against GDP in standardised ranks for 2011 (b). Data source: Eurostat [7]

As reported in Table 1.1, in 2011, the three largest national economies have also been the largest contributors to the overall EU total R&D investment. Germany leads the ranking with a share of 29.1% of total EU R&D expenditure and 20.9% of the total GDP. France and United Kingdom follow, contributing 17.4% and 12.2% respectively to R&D investment, and accounting for 15.4% and 16.3% of the GDP. The intensity of the R&D effort of each Member State, measured by the ratio of the R&D investment against the aggregated output in terms of GDP, presents a different picture. Finland and Sweden are the only countries in 2011 with R&D intensity above 3% (Table 1.1/right column). Denmark (2.98%), Germany (2.89%) and Austria (2.77%) follow closely, with the remaining counties distributed as follows: 5 countries are placed in the range 2.0%-2.5%, 8 countries (including the UK) between 1%-2%, and 9 countries below 1%.

Table 1.1: R&D expenditure and GDP as a percentage of the respective EU figures and R&D intensity for the high- and low-ranking member states. Data source: Eurostat [7]

High ranking countries					
R&D expenditure (% of total EU-27 R&D expenditure)		GDP (% of total EU-27 GDP)		R&D expenditure/GDP (R&D intensity)	
DE	29.1	DE	20.9	FI	3.80
FR	17.4	UK	16.3	SE	3.39
UK	12.2	FR	15.4	DK	2.98
Low ranking countries					
LV	0.05	LV	0.11	BG	0.57
CY	0.03	EE	0.10	RO	0.50
MT	0.02	MT	0.05	CY	0.49

Figure 1.3 shows the R&D contribution by performance actor. In 2011, 62.5% of the overall EU R&D investment came from the business sector. The higher education sector was second in terms of relative contribution (23.6%), followed by the government sector (13%) and a small residual contribution derived from private non-profit organisations (0.9%). The same order is reflected by the R&D intensity, where the intensity displayed by the business sector (1.3%) is much higher than the higher education and government sectors (0.5% and 0.3% of the aggregate product respectively).

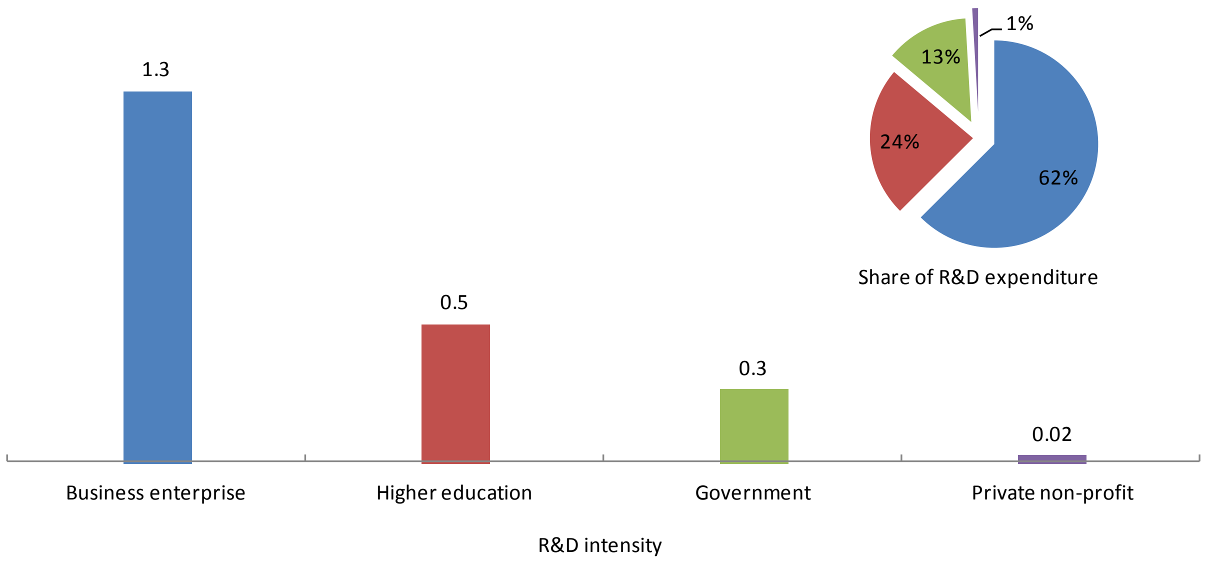

Figure 1.3: Figure: R&D expenditure breakdown per actor as a share of the total R&D expenditure and as R&D intensity (% of GDP). Data source: Eurostat [7]

According to the expenditure figures provided by the EU Industrial R&D Scoreboard [9], in 2011 the top 1000 companies invested EUR 153 billion in various R&D activities. As in the case of total R&D expenditure, companies situated in the largest EU-27 economies lead the ranking of main contributors. Almost one third of the financial effort, EUR 53 billion, has been invested by German companies, while EUR 26.8 and 24.4 billion was contributed by French and British companies, respectively. The UK average is, however, below the EU-27 average (EUR 101.7 million) in terms of R&D investment per company. Germany, Netherlands and France display high average investment per company, ranging between EUR 226.5 and EUR 212.5 million. Greece, Malta and Poland are under-represented in the sample of companies, with a compounded amount of R&D investment equal to EUR 78 million (Figure 1.4 (a)).

Considering R&D contributions by industry sub-sector, in 2011, Automobile and parts companies had the highest investment in R&D with a total of EUR 35.5 billion, followed by EUR 28.2 billion invested in industrial goods and services and EUR 25.6 billion invested in R&D by health care companies. This order is not maintained when looking at the average unit investment per company as displayed in Figure 1.4 (b). Automobiles and parts companies still top the list, but the gap between the average R&D of a company in this sector and the next highest average investor, telecommunications companies, is approximately EUR 580 million. The average R&D expenditure in the banking system (EUR 222 million) is also notable.

The relative R&D investment in SET-Plan technologies, as estimated in this report, with respect to the total R&D investment is shown in Figure 1.5 for a number of EU countries. France and Germany lead the EU, with 3.3% and 3.1% respectively of the total R&D investment channelled to the development of these energy technologies. Among the largest economies, United Kingdom exhibits the lowest share of R&D investment on low carbon technology (1.4%).

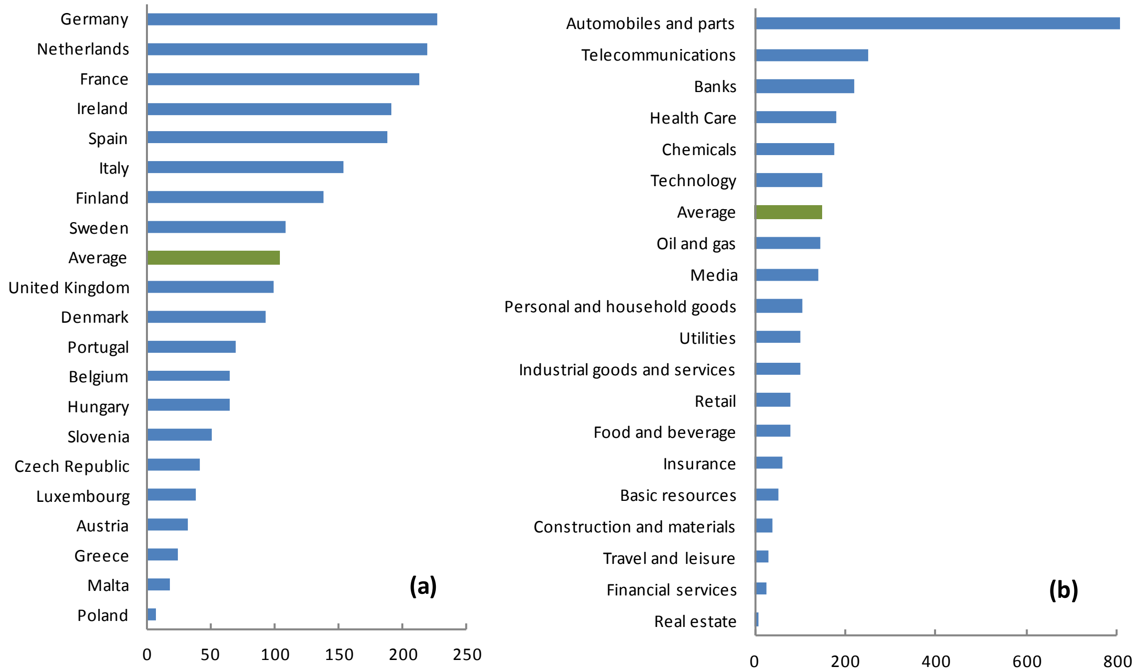

Figure 1.4: Average corporate R&D expenditure (EUR million) per company for 2011. Breakdown by country (a), and by industry sub-sector (b) Data source: JRC [9]

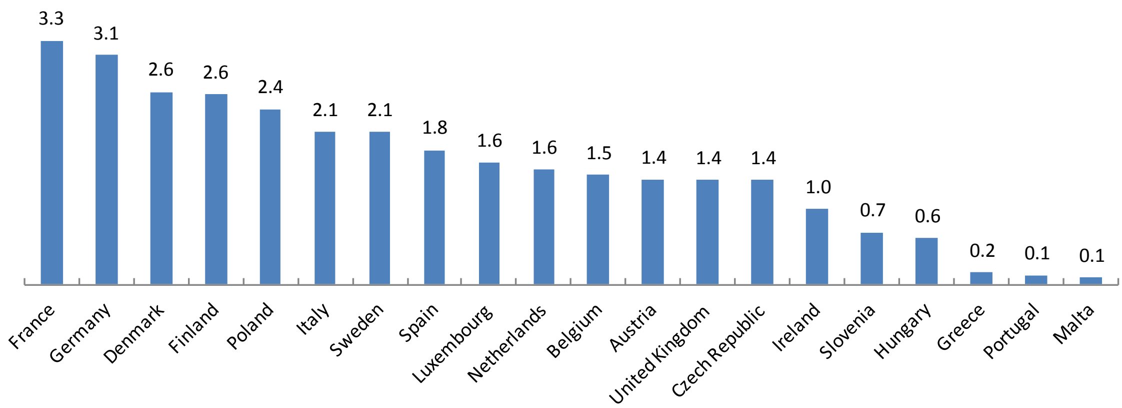

Figure 1.5: Figure: SET-Plan low carbon technology R&D expenditure as a percentage of the total R&D expenditure in 2011 for a number of European countries. Data source: Eurostat [7], IEA [1], JRC [2, 3]

2 METHODOLOGY

2.1 METHODOLOGY FOR THE ESTIMATION OF PUBLIC INVESTMENT

The present report contains data from several sources. This section provides a brief description of these sources and explains how data is combined and consolidated to provide the results and indicators for each of the technologies examined.

2.1.1 NATIONAL FUNDING

The IEA R&D is the main source of data at the level of detail necessary for the analysis of the member states' investment in the SET-Plan technologies. The drawback of the IEA R&D statistics is that it does not include complete datasets for all the countries in question. Moreover, as not all IEA members provide data regularly, there are data gaps present for certain countries. As a consequence, where data was not available, a basic "gap filling" method has been used, where data from 2010 has been attributed to the 2011 fiscal year[2]. The same approach was used to fill in data gaps for other past years: whenever technology entries were missing, the data from the latest available year were assumed[3]. For many member states[4] additional data sources have been used to adjust discrepancies or fill-in missing values:

- For carbon capture & storage investments, data provided by member states (FR, DE, EL, NL, PT, ES, NO, CH) in the context of this report has been used to correct IEA values.
- EE and LV investment values for certain technologies have been estimated based on reports available from Enterprise Estonia [10] and of the Latvian Ministry of Education and Science [11].
- Estimates of the investment in electricity transmission and distribution grids for BG, EL, LV, SI were carried out by consulting the JRC database of smart grids projects [12] and corresponding report [13] and the EC CORDIS database [14].
- Investment values for LT and PL were estimated using the Energy Research Knowledge Centre database [15] and the EC CORDIS database [14].

Not all EU Member States are IEA members. This has been a recurring limitation for the Capacities Map analysis. In this context, investment data for BG, HR, CY, EE, LV, LT, LU, MT, RO and SI have consistently been either missing[5], or approximated using alternative methods and data sources, as described above.

When using data sources that provided information at project level[6], with the investment not clearly broken down by participant, the contribution of the respective public partners was approximated by assuming an equal distribution of funds among the participants. Note that all the projects referenced in the above are multiannual projects. Therefore, in order to determine the national budget expenditure for the year in question, an equal disbursement of the projects' budgets across the projects' durations has been assumed.

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[2] The "gap filling" method has been used for the 2011 analysis for certain technologies for CZ, FI, HU, IE, IT, ES and for all the technologies for RO.

[3] The Capacities Map analysing the fiscal year 2010 has used the "gap filling" method for AT, BE, FR and NL.

[4] BE, BG, CZ, EST, FI, FR, DE, GR, HU, IE, IT, LV, LT, NL, PL, PT, RO, SK, SI, ES and NO.

[5] Data is currently still missing for HR, CY, LU and MT.

[6] The ERKC, JRC smart grids projects and EC CORDIS databases.

The indicators that are provided on energy R&D take into account "*research, development and demonstration related to the production, storage, transportation, distribution and rational use of all forms of energy*", covering "*basic research when is clearly oriented towards the development of energy-related technologies, applied research, experimental development and demonstration*" [16]. Deployment projects are excluded from R&D investments.

In order to verify the public R& D investment figures compiled for this report, questionnaires were distributed to relevant member states' services, as identified through the SET-Plan steering group, requesting validation of the respective datasets or complementary data if available. Several member states[7] have provided feedback on corresponding investments cited in the present report during this consultation and validation phase.

2.1.2 FUNDING THROUGH EU INSTRUMENTS AND EUROPEAN BANKS

At European level, the main bodies involved in the financing R&D activities relevant to the SET-Plan technologies are the European Commission (EC), the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD) (Figure 2.1).

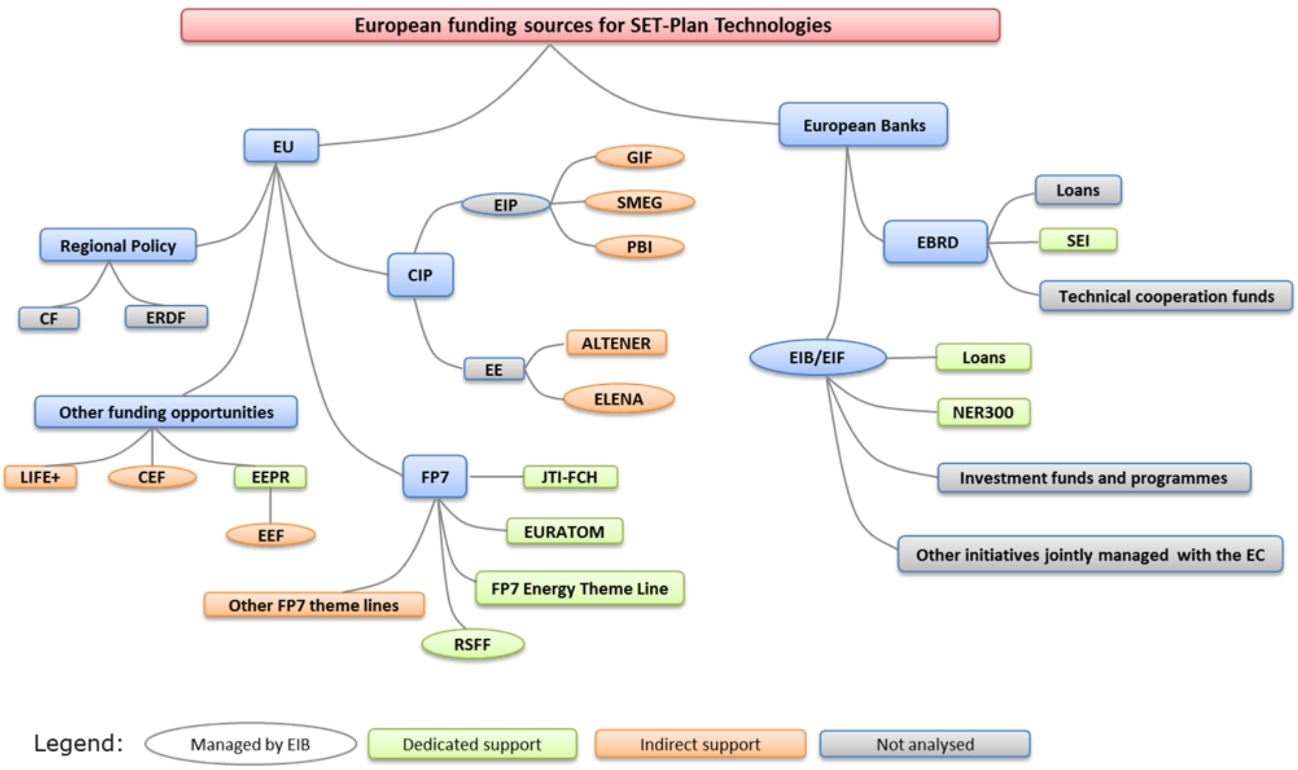


Figure 2.1. Sources of financing for R&D in SET-Plan technologies at European level

EU funding opportunities for research and innovation come from five main instruments:

[7] AT, BE, DK, DE, NL, NO, PL, PT, SE and CH.

- The 7th Framework Programme for Research, Technological Development and Demonstration activities which includes the Euratom Framework Programme for Nuclear Research and Training activities (FP7);
- The Competitiveness and Innovation Framework Programme (CIP);
- The regional policy with its Structural and Cohesion Funds (SF) and the European Regional Development Fund (ERDF);
- The European Agricultural Fund for Rural Development (EAFRD); and
- The European Fisheries Fund (EFF).

The EAFRD and the EFF offered limited support for research and innovation in the context of the SET-Plan technologies, and are not considered in the present analysis.

FP7 has been the main EU instrument for funding research between 2007-2013 and was structured in five Specific Programmes: Cooperation, Ideas, People, Capacities, Euratom and JRC activities. The total funds dedicated to energy research projects during this 7-year period were of the order of €2.35 billion. This value only refers to the FP7 Energy Theme budget lines that fall under the Cooperation Programme; other FP7 programmes have also supported clean energy technologies in this timeframe, so the overall investment would have been higher [17].

The aim of the **CIP** programme has been to encourage competitiveness, by targeting mainly Small and Medium Enterprises (SMEs) and supporting innovation activities (including eco-innovation) by providing better access to finance. For the defined period 2007-2013, the CIP programme had an overall budget of €3.6 billion [18]. Due to its structure and the specific nature of its sub-programmes, the main annual work sub-programmes relevant, in terms of investments in the SET-Plan technologies, have been the Entrepreneurship and Innovation Programme (EIP) and the Intelligent Energy Europe Programme (IEE). Financial support has been provided through the following funding schemes:

- The EIP financial instruments, managed by the European Investment Fund (EIF) bridging the gap between the financial needs of SMEs and the lack debt supply and equity finance. The SME Guarantee Facility (SMEG) has guaranteed loans through micro-credit and mezzanine financing, while the High Growth and Innovative SME Facility (GIF) has provided venture capital;
- The eco-innovation action launched in 2011 under the EIP supported first application and market replication projects, as well as projects proposing innovative measures that would help energy intensive manufacturing industries reduce their greenhouse gas emissions while maintaining their competitiveness and projects generating independent and credible information on new environmental technologies.
- Pilot and Market Replication Projects (MRP) and its executing instrument, the European Local Energy Assistance (ELENA) facility, are two of the options used within both the EIP and IEE programmes [19] with the aim to reproduce at large scale any "innovative techniques, processes, products or practices of Community relevance, which have already been technically demonstrated with success".

Two other financing instruments, relevant in the context of clean energy technology, are the European Regional Development Fund (**ERDF**) and the Cohesion Funds (**CF**). The two funds (ERDF and CF) mainly provided investments on the renewable energy technologies which are part of the SET-Plan. The ERDF focused investments on key priority areas aiming at strengthening the economic and social cohesion in the EU by correcting the imbalances between its regions. The priority areas known as 'thematic concentration' were: innovation and research; the digital agenda; support for SMEs; and the low-carbon economy [20]. For 2007-2013 programming period, the CF was dedicated to BG, HR, CY, CZ, EE, EL, HU, LV, LT, MT, PL, PT, RO, SK and SI.. These were member states whose gross national income per inhabitant is less than 90 % of the EU average, and where CF projects aimed to strengthen economic and social disparities and to promote sustainable development [21].

Additionally to EU funding, large scale investment was also assured through European banks via loans, structured financing options, equity and carbon funds, numerous initiatives and programmes managed jointly with other European or national/ regional institutions.

One of the most important financing institutions supporting R&D activities in the clean energy technology sector, is the European Investment Bank (**EIB**). In addition to an energy-dedicated lending line, the EIB finances the full range of RDI activities of the innovation cycle, including applied research within the energy sector [22]. The EIB also manages and participates in several other European and international initiatives and programmes that support clean energy projects.

Another important financial institution which supported R&D activities in the clean energy technology sector is the European Bank for Reconstruction and Development (**EBRD**). There have been several initiatives, programmes and funds through which projects have benefited from EBRD loans and equity: the Sustainable Energy Initiative (SEI) with its dedicated Sustainable Energy Financing Facilities (SEFF) and Western Balkans Sustainable Energy Direct Financing Facility (WeBSEDFF), technical cooperation and carbon funds.

Three other complementary European-wide funding instruments need to be mentioned here as their contribution to the R&D of the clean energy sector is significant.

LIFE, an EC programme dedicated mainly to environmental projects, with the objective of supporting the implementation and the development of EU environmental policy and legislation by co-financing large, transnational pilot or demonstration projects with clear added value. Launched in 1992, the programme has gone through several phases; the last one, **LIFE+**, running from 2007 to 2013, with a total budget of €2.1 billion covered three main areas: nature and biodiversity; environmental policy and governance; and information and communication. The environmental policy and governance component of LIFE+ has co-financing among others, innovative, pilot projects that contributed to the development of technologies, methods and instruments. In this sense, several of the SET-Plan technologies have received financial support through LIFE+ since 2007 [23].

The Risk Sharing Financing Facility (**RSFF**), a debt-based financial instrument implemented and managed by the EIB to support research and innovation across Europe, has provided significant financing in support to R&D in clean energy technologies. Established, in December 2005 by the EC and the EIB the RSFF has aimed to add value in areas where the market cannot provide the required funding and to catalyse private investment. The EU provided a contribution of up to €1 billion over the 2007-2013 period in order to increase EIB's capacity to assume and manage risk, and in so doing, to enable a larger volume of EIB lending and guarantee financing of higher risk projects. The €1 billion (released in two equal tranches over two periods: 2007-2010, and 2011-2013), was matched by a contribution of up to €1 billion from the EIB's own funds. With this combined volume of €2 billion for risk coverage via the RSFF, loan finance and/or guarantees of at least €10 billion were expected for eligible investments over the 2007-2013 period [24]. Of these investments, 15% are directed to research and innovation projects in the energy sector [25].

The European Energy Programme for Recovery (**EEPR**) was launched in 2009 as a funding instrument designed to make energy supply more reliable and help reduce greenhouse gas emissions, while simultaneously boosting Europe's economic recovery. The program has dedicated €4 billion to co-financing renewable energy projects in the fields of gas and electricity infrastructure, offshore wind and carbon capture & storage. Due to the availability of funds remaining unallocated by the end of 2010, a new financial facility, the European Energy Efficiency Fund (EEEF) has been launched out of the EEPR in 2011. Managed by the EIB, the EEEF was to support energy efficiency and decentralised renewable energy investments with an allocated budget of €146.3 million [26].

As a consequence of the credit crisis and the regulatory measures which followed in 2011, it became increasingly difficult for energy infrastructure projects to access long term financing. In response to these challenges, in October 2011, the Commission adopted the legislative proposal on the Connecting Europe Facility (CEF) and the Project Bond Initiative (PBI) [27].

The **CEF**, a cross-sector infrastructure fund, was designed to help projects put together financing by bringing in new classes of investors (pension and insurance funds) and mitigating risks. The financial instruments under CEF with a 2014-2020 earmarked value of €9.1 billion dedicated to energy infrastructure projects, aim at helping the promoters to access the necessary long-term financing [27][28]. These two instruments will act on a timeframe beyond the scope of this report (2012-2020), but are mentioned as having potential, through possible synergies with more dedicated mechanisms, to impact the financing landscape for R&D in the clean energy sector.

In terms of European funding, the main data sources for the present report were FP7 data at project-level provided by DG RTD [29], as well as EIB and RSFF committed investment data at project-level provided by the EIB, CIP/ EIP Annual Implementation Reports [30] and, other dedicated programme or technologies reports and analysis.

ALLOCATION OF EUROPEAN FUNDS BY YEAR & TECHNOLOGY

Where the data sources provided information at project level (FP7, LIFE+, EEPR and ELENA), the reporting methodology for the 2011 analysis has remained unchanged from previous publications of the Capacities Map [31]. In other words, the present document reports investments based on the disbursement year. As most of the projects have a duration of several years, each project budget was assumed as evenly distributed over the project duration; each project execution year sharing an equal amount of funds, irrespective of the starting and ending month of the project. Note that for projects that cover more than one technology, the funding has been assumed as equally distributed among the technologies addressed.

Due to the fact that each of the data sources used for the other European-wide financing instruments and programmes has its specific reporting methodology, there are certain limitations to our present assessment, discussed in section 2.1.4.

2.1.3 INTERNATIONAL DEVELOPMENTS

In the **USA**, R&D funding in energy technologies is mainly provided by the Department of Energy (DOE) and reported through the "DOE Budget Authority for Energy Research, Development, and Demonstration Database". However, to provide consistency throughout the analysis the IEA R&D statistics was the data source used for this report [32].

In **Japan**, management and evaluation of competitiveness in R&D within each of the targeted energy technologies is done at a centralised level with a dedicated support for commercialisation via the New Energy and Industrial Technology Development Organization (NEDO). For consistency reasons, and also due to the close collaboration between NEDO and the IEA, the IEA statistics was also considered the main data source in this case.

The strong governmental commitment to public investments in clean energy technology R&D and the recent technological developments in the domestic renewable sector, have been instrumental in the decision to include public spending in **South Korea** in the present report [33]. In order to ensure consistency throughout the analysis, data provided by the IEA R&D statistics are also here.

China's investment in the energy sector has a preference for the development and demonstration of general and key technologies, rather than basic research [34], and has been added as a reference point for the assessment of the overall public investment in the SET-Plan technologies. Since China is not a member of the IEA, we have included the national Chinese funding by referring to other resources, namely dedicated international and national reports and scientific papers as follows: Solar and wind data [35] [36]; Bioenergy data [37]; Ocean data [38]; Transmission & distribution technologies [39]; Fuel cells & hydrogen [40]; Carbon capture & storage [41]; Energy storage [42]; and Nuclear R&D with reference to China National Nuclear Corporation 's press release from 2012 [43].

2.1.4 DISCUSSION OF LIMITATIONS

Using the IEA R&D database has two main disadvantages, in that not all EU countries are members of the IEA, and for those who are, a constant level of investment has historically been assumed for years with incomplete datasets. This is partially addressed in this analysis through data validation by the EU member states and the use of additional sources.

For European-level public funding of the SET-Plan technologies, in order to ensure consistency with the national expenditure reporting, and due to the wide range of data sources and their different investment reporting methods, several of the instruments and programmes presented in section 2.1.2 have not been included in this assessment:

- Investment information on the CIP programme has been difficult to access, the only available data sources being the annual implementation reports. Reporting of investments in these official documents was based on the committed budget under the respective budgeted year. This was incompatible with the methodology adopted for estimating both national and corporate investments in this report.
- The investment provided at European level through the European banks could be determined, from the project-level data in the EIB and the EBRD annual reports. Due to confidentiality issues, reporting was based on the project signature year without further information on the project duration, start, or end dates. Thus, both EBRD annual report and CIP implementation report, information were also incompatible with the methodology followed in this report.

2.2 CORPORATE INVESTMENT METHODOLOGY

The analysis focuses on the assessment of corporate R&D expenditure in the year 2011. Corporate R&D expenditures incurred in 2011 account for the cost of materials and services consumed in research and development, the cost of wages and other related costs of personnel engaged in research and development activities. In the case of companies listed in stock markets, and other companies that have an obligation of publishing their annual statements, the amount spent on research activities in 2011 is retrieved from these publications. These statements include additional information on research activities that are not attributable to the period in question and therefore have not been included in the present analysis. Such information refers to technology and patent licenses, amortization of intangible assets, depreciation of equipment and facilities to the extent that they are used for research and development activities, copyrights, trademarks, trade names, franchise licenses, government licenses, goodwill, and other items that provide long-term benefits to a company. Although this information is not directly useful in identifying how much was spent in research in 2011, some of the enumerated indicators (i.e. the patent applications [44]) enabled the identification of key EU-based industrial companies performing research activities in SET-Plan technologies.

The level of corporate R&D expenditures was in some cases retrieved from the EU Industrial R&D Investment Scoreboard, which includes additional information related to companies' industrial classification, also allowing the identification of European companies by specific technology. Finally, industry associations report specific project information, revealing how much companies or public entities have spent on R&D for a particular SET-Plan technology.

Once the key industrial players for each energy technology are identified, a bottom-up approach is followed in order to distribute specific private R&D investment [31, 45]. First, the total R&D expenditures and their technology specific patents [44] were collected for the companies identified. Secondly, for companies that were engaged in the development of more than one technology, the total R&D investment was allocated between the relevant SET-Plan technologies, following the approach of previous studies [46, 47] in which the allocation of corporate research investment by technology was assumed to be a function of patents and corporate research:

$$Corporate\_R\&D_{mit} = \frac{Patents\_m_{i,t+1}}{Total\_Patents_{i,t+1}} * \mathrm{Re}search\_\exp enditures_{it}$$

Where m is the specific low carbon technology, i is the innovating entity and t is time (year). The formula accounts for the delay between the occurrence of the research and the filing of the patent application. Using this methodology, an additional indicator namely the research investment/patent is computed. Based on company's specific technology patent applications, an average value of the mentioned indicator enables accounting for additional companies to be included in the assessment. Additionally, in certain cases it is possible to retrieve information about companies' employees engaged in R&D for a particular technology, which complements information on corporate R&D, following the approach of previous JRC studies [45] Finally, industry associations and public organisations report the involvement of private companies in national/European projects and the amount with which they contributed to research activities for particular technologies. In the case of multi-annual projects an equal division by number of years (and, in some cases, by number of participants) is assumed, to allow the inclusion of an average amount spent in research activities in these technologies in the case of companies for which no other information related to patents/employees is available.

Figure 2.2 offers a schematic representation of the steps followed in the identification of the companies, the allocation of investments and calibration of results.

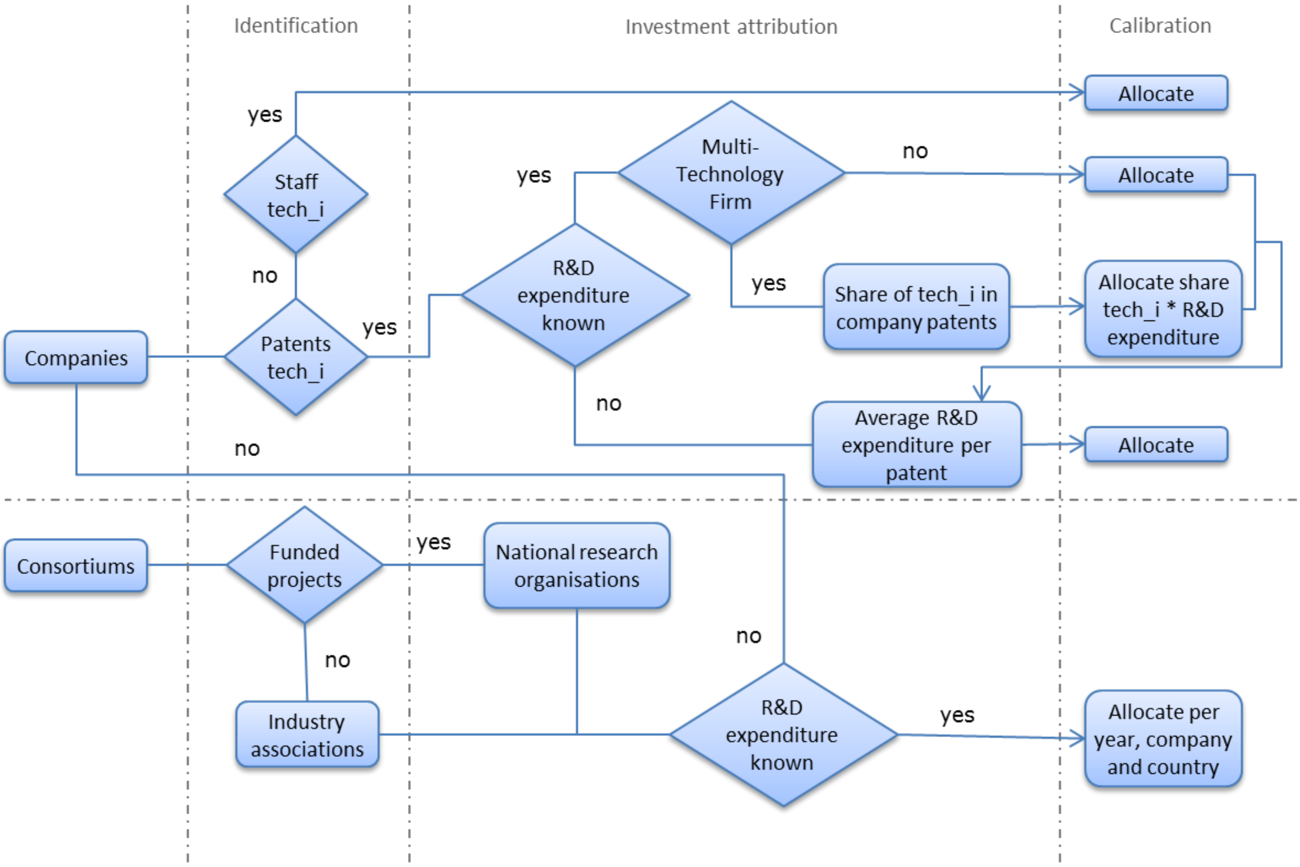


Figure 2.2: Schematic representation of the approach for the identification of relevant companies and estimation of R&D investment in 2011 for each of the technologies examined.

3 OVERVIEW

In the following, a brief overview of the R&D funding, as estimated for the year 2011, is provided for all technologies, funding sources and countries. Detailed analysis per technology follows in the respective dedicated chapters.

Figure 3.1 shows the absolute and relative level of funding contributed to each of the technologies considered through national, EU and corporate sources. Energy storage technologies received the most investment, followed by wind, bioenergy and nuclear fission. These technologies, in the same order have also received the most investment from the business sector, closely followed by fuel cells and hydrogen. In this group nuclear fission stands out for receiving matching support from the public sector. Ocean energy technologies, received the least support within the group of technologies examined. Significant effort at EU level seems to be directed towards carbon capture and storage and electricity grids.

The share each technology receives of the national, EU, corporate, public (comprising national & EU funding) and total estimated investment is displayed in Figure 3.2.

Figure 3.3 shows the absolute investment in each technology by country and the relative contribution to each technology out of the total investment estimated for the group of nine technologies for the reference year 2011. The leading investors, Germany and France show interest across the board of technologies investing in eight and nine respectively each. On the other hand, smaller investors like Slovenia and Malta devote support to key technologies, like electricity grids and solar energy.

Of the total €8.8 billion investment share between the nine technologies €0.34 billion of EU funding cannot be allocated as to the country (or countries) of implementation. Thus the total investment and the relative share displayed in Figure 3.3 are on a different basis than the one in Figure 3.2. The same breakdown of funds per technology and country, in both absolute and relative terms, for the national and corporate investments is provided in Figure 3.4 and Figure 3.5 respectively. Additionally, the figures provided by the national authorities on the investments made per technology through national R&D funding schemes are given in Table 3.1. For technologies presented in more detail in Table 3.1, the investment in the technology sectors will often add up to less than the total support for the technology; this has to do with the level of detail provided in statistical reports and the fact that often the distinction between subsectors is not provided but the funding is still included in the technology total.

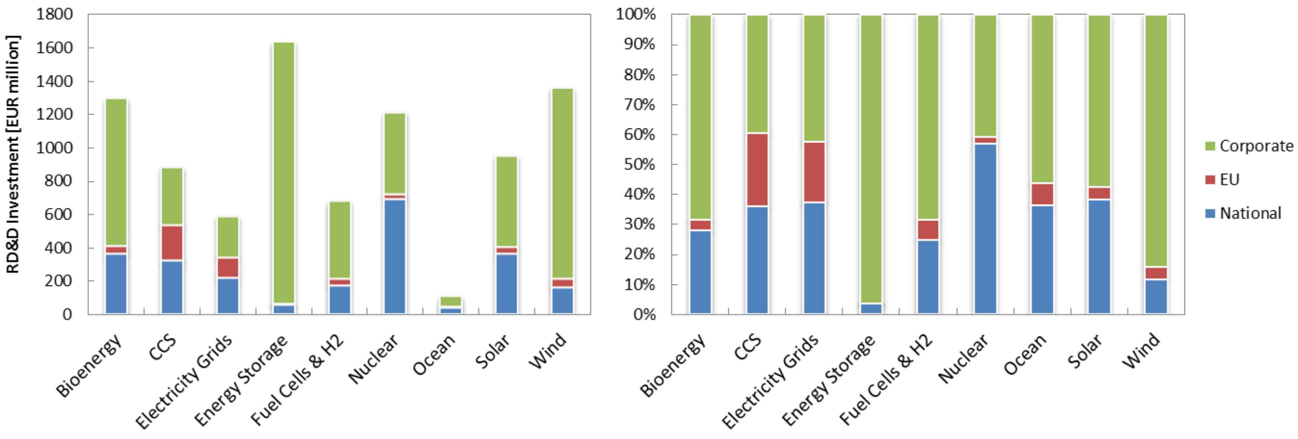


Figure 3.1: Absolute figures and relative contribution of national, EU and corporate funding to R&D for the nine technologies examined in the year 2011. Data source: IEA [1], JRC [2, 3], DG ENV[23], EC [26], EIB[48]

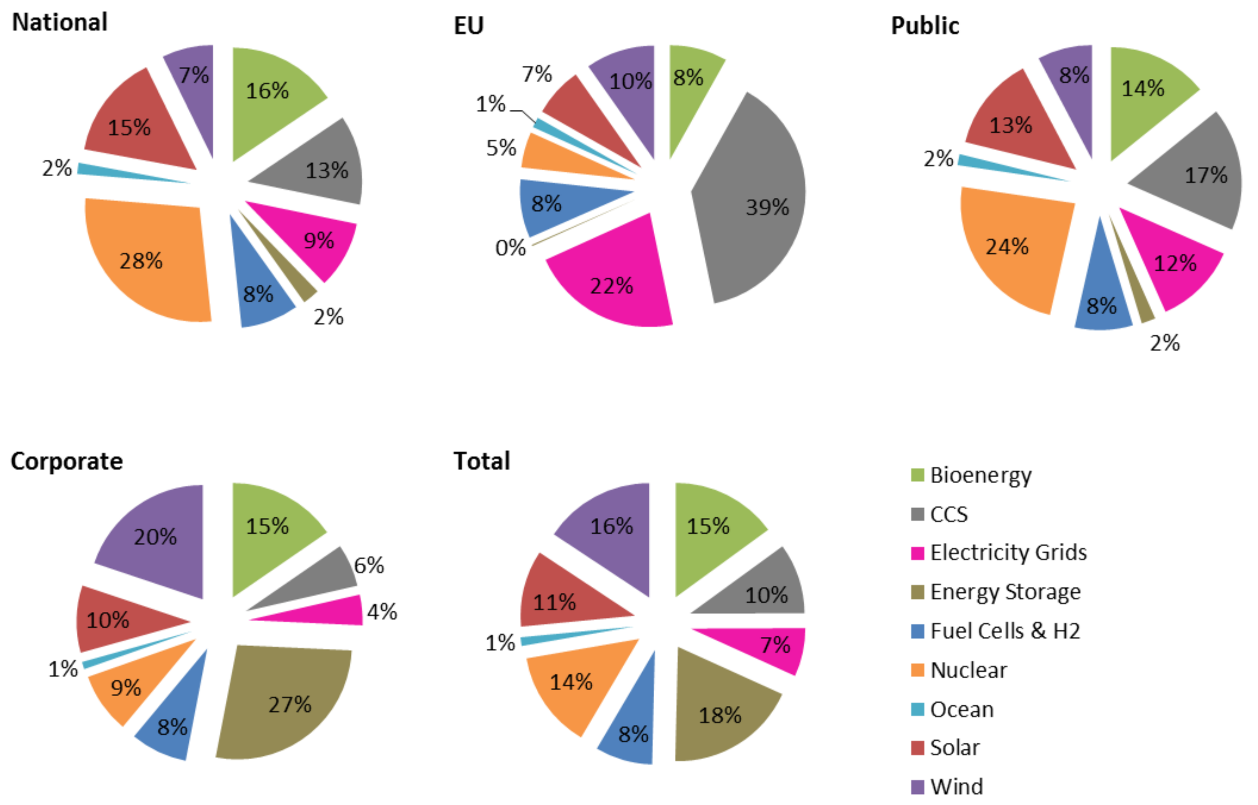


Figure 3.2: Share of R&D funding by source allocated to each technology as estimated for the year 2011. Data source: IEA [1], JRC [2, 3], DG ENV[23], EC [26], EIB[48]

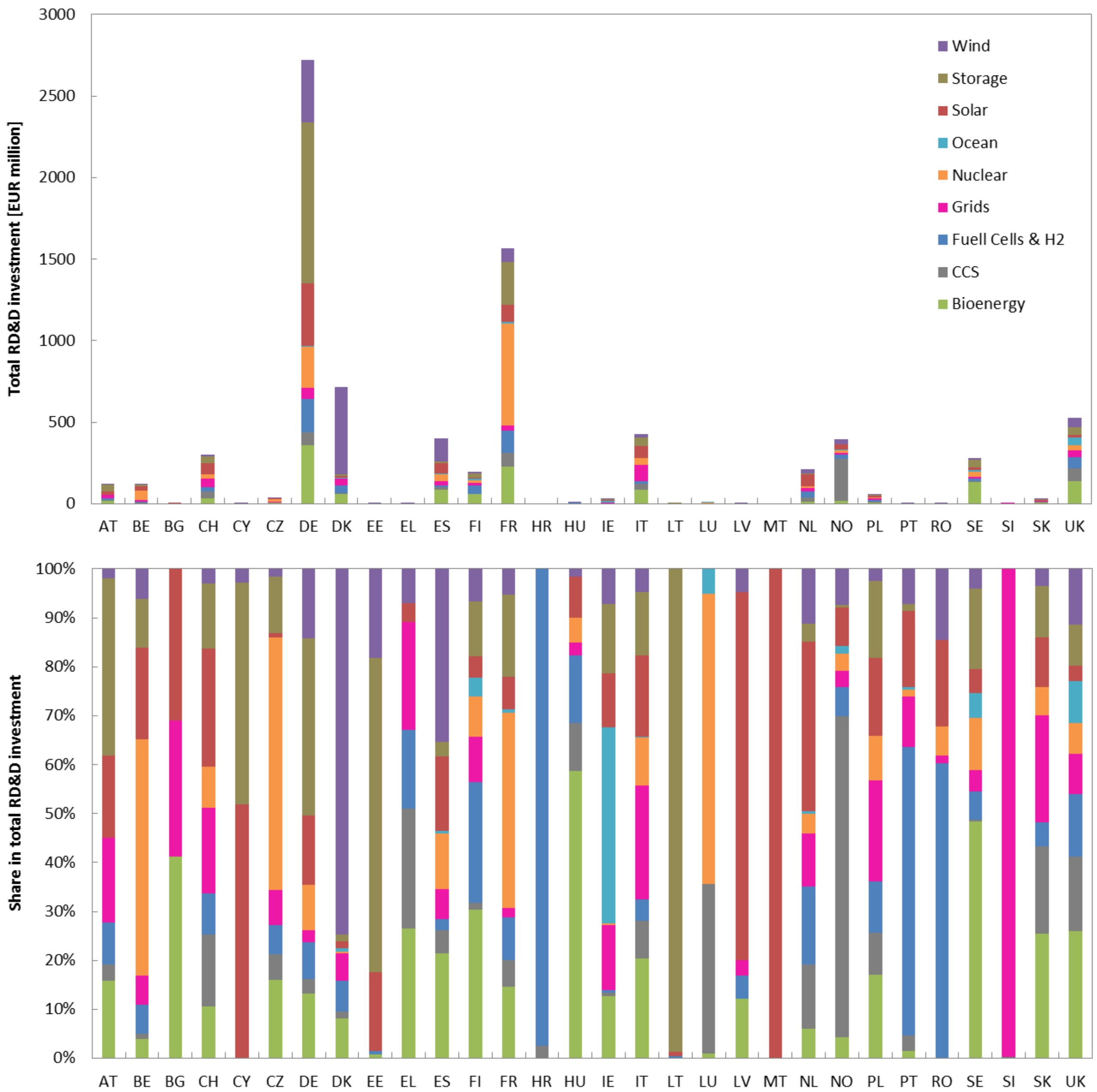


Figure 3.3: Absolute and relative investment in R&D per technology and country for 2011 from national and corporate sources for 2011. EU funding excluded. Data source: IEA [1], JRC [2, 3]

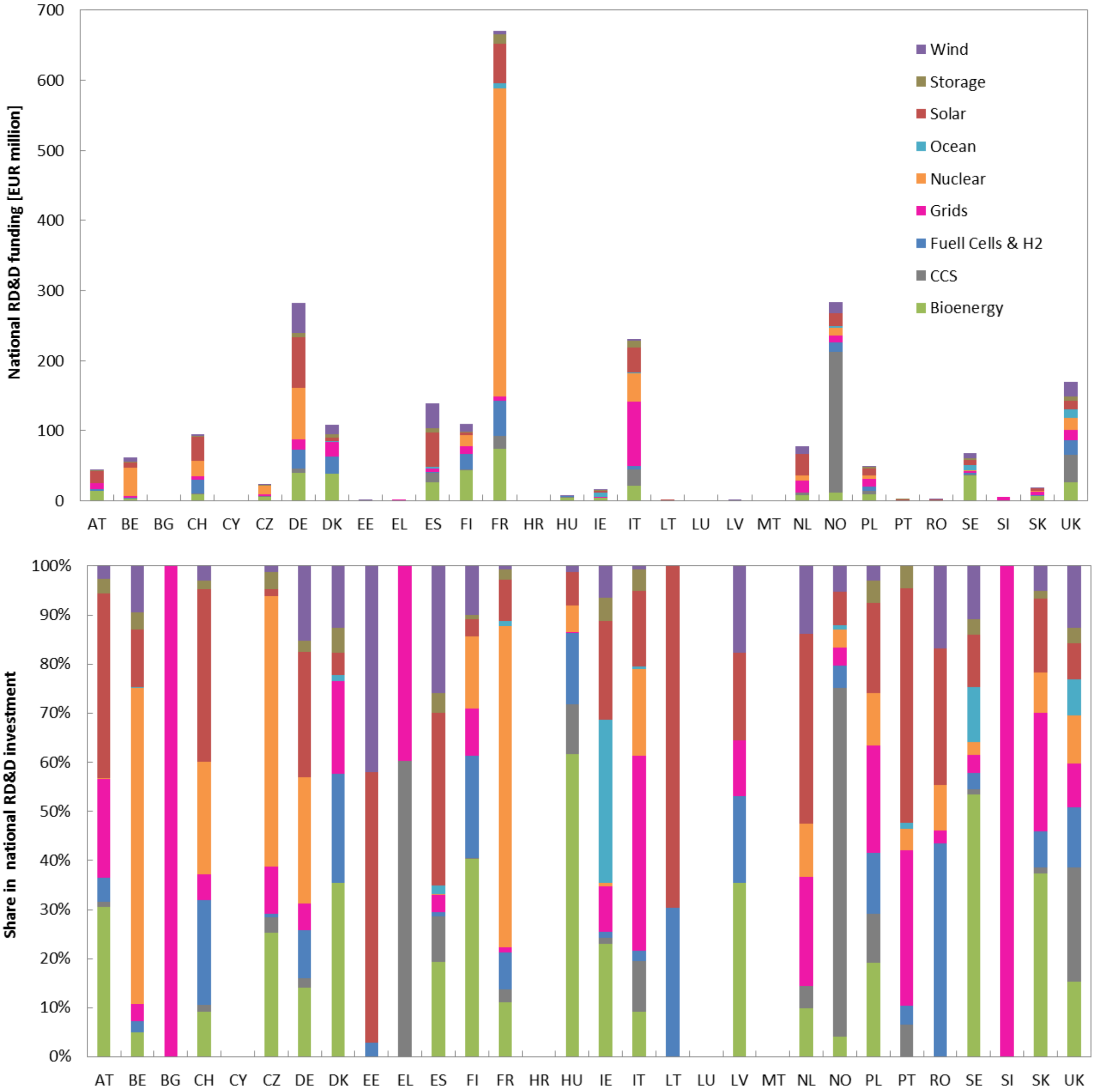


Figure 3.4: Absolute and relative investment from national programmes in R&D per technology and country for 2011. Data source: IEA [1], JRC [2, 3]

Table 3.1 : EUR million	Fossil fuels	RES												Nuclear	Hydrogen and fuel cells			Other power and storage technologies		TOTAL
		Solar				Wind			Ocean			Bioenergy							
	CCS	Heating/ Cooling	PV	CSP	Total	Onshore	Offshore	Total	Tidal	Wave	Total		Fission	Hydrogen	Fuel cells	Total	Transmission /Distribution	Energy storage	
Austria	0.527	5.384	9.321	0.849	16.819	0.552	0.009	1.155				13.647	0.123	0.407	1.742	2.149	9.011	1.351	44.782
Belgium		0.336	5.764	0.953	7.332	1.588	2.244	5.836			0.035	3.070	40.011	0.400	1.029	1.429	2.130	2.164	62.007
Bulgaria																	0.075		
Croatia																			
Cyprus																			
Czech Republic	0.754	0.134	0.198		0.303			0.279				5.832	12.741	0.103	0.042	0.145	2.220	0.825	23.099
Denmark					5.091			13.688		1.253	1.253	38.530				24.312	20.597	5.483	108.954
Estonia					0.750			0.570								0.040			1.360
Finland	0.201	1.205			3.815			10.966				44.087	16.175			22.852	10.441	0.923	109.459
France	17.833	1.943	32.837	3.885	56.090	1.010	1.388	4.713	1.414	1.012	6.978	74.215	439.718	26.640	24.169	50.810	6.395	13.949	670.701
Germany	5.500	8.000	56.200	8.000	72.200			43.000				40.000	73.021	3.000	24.600	27.600	15.100	6.500	282.921
Greece	0.410																0.271		0.681
Hungary	0.735				0.490			0.090				4.459	0.395			1.050	0.010		7.230
Ireland	0.201		2.999	0.025	3.239			1.040		5.392	5.392	3.724	0.125	0.148	0.050	0.198	1.512	0.787	16.218
Italy	23.394	5.086	15.257	15.257	35.600			1.526		1.017	1.017	21.360	40.685			5.000	91.542	10.171	230.293
Latvia					0.207			0.207				0.414				0.207	0.133		1.167
Lithuania					0.062											0.027			0.089
Luxembourg																			
Malta																			
Netherlands	3.500	0.400	28.900		29.800			10.700				7.647	8.400			0.000	17.200		77.247
Poland	4.952				9.052			1.436				9.499	5.274			6.174	10.829	2.321	49.537
Portugal	0.088	0.162	0.353	0.118	0.633				0.016		0.016		0.058	0.050		0.050	0.419	0.061	1.325
Romania					0.560			0.340					0.190			0.880	0.050		2.020
Slovakia	0.209	0.366	1.584	0.314	2.775			0.947				6.900	1.531			1.364	4.446	0.285	18.457
Slovenia																	5.385		5.385
Spain	12.860	0.241	4.539	15.990	48.974			35.845			2.274	26.725	0.380	0.522	0.758	1.280	4.844	5.580	138.761
Sweden	0.783	1.356	5.844		7.199			7.433		7.678	7.678	36.417	1.800	1.508	0.724	2.232	2.490	2.174	68.205
United Kingdom	39.276		1.694	0.043	12.474			21.361			12.450	26.083	16.635	4.832	16.129	20.961	15.153	5.254	169.647
TOTAL	**111.2**	**24.6**	**165.5**	**45.4**	**313.5**	**3.2**	**3.6**	**161.1**	**1.4**	**16.4**	**37.1**	**362.6**	**657.3**	**37.6**	**69.2**	**168.8**	**220.3**	**57.8**	**2089.5**
United States	229.78		202.097	111.674	313.772	38.048		61.250	11.334	8.905	19.945	273.959	669.822	50.722	155.084	205.807	103.522	37.815	1915.680
Japan	119.04	0.237	119.363		119.599	7.600		43.726				75.466	1560.46	36.503	62.049	98.552	39.305	72.395	2128.552
South Korea	23.564	1.978	13.646	1.023	61.131			26.757			5.143	8.495	85.567	1.902	33.923	35.825	32.519	19.014	298.014
Norway	200.96				19.300			14.975			2.175	11.875	10.813	4.988		12.875	9.963		282.939
Switzerland	1.310	3.530	17.470	11.400	33.620	1.070	0.160	2.790				8.770	21.800	7.950	7.710	20.420	4.920	1.640	95.270
China	5.609				666.746			204.728			24.896	112.032	217.840			28.340	116.700	93.360	1470.251

LEGEND

- (dark blue) National investments 2011 corrected by feedback provided via the JRC validation process [2]. Responding countries: BE, DK, DE, NL, PL, PT, SE, NO, CH
- (light blue) IEA 2011 figures [1] updated based on gap-filling and information from additional sources; CCS data update based on 2013 MS feedback,

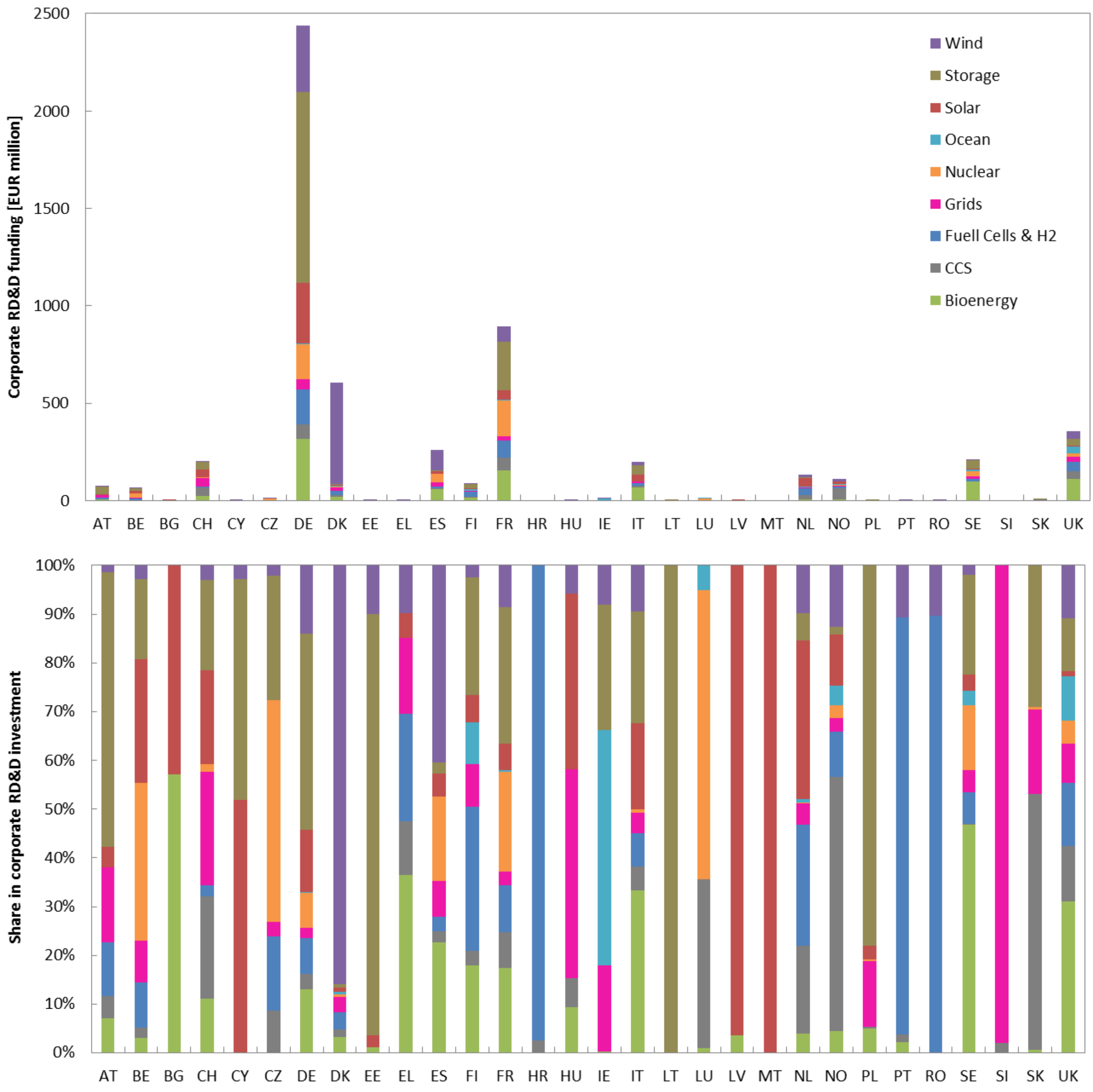


Figure 3.5: Absolute and relative investment from the corporate sector in R&D per technology and country for 2011. Data source: JRC [3].

4 BIOENERGY

For the year 2011, R&D investments in the bioenergy sector were characterized by the following:

- Bioenergy maintained its place as the second largest renewable R&D investment market despite a significant (11%) investment decrease, and falling just short of a total €2 billion in investment; and,

- the difference between corporate and public expenditure in the sector remained large, even though there were regional trends to bridge the gap between the two sources [35].

The table below summarises the main figures regarding R&D investments for bioenergy in Europe which will be further analysed in this section.

Summary table – Bioenergy R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 383 million
*Public funding available at EU level**	EUR 45 million
Corporate R&D Investment	EUR 888 million
Number of companies identified in the corporate investment sample	170
Number of countries represented in the corporate investment sample	25

*indicative; not all funding could be allocated by technology

4.1 PUBLIC INVESTMENT

In contrast to the global trend, research in bioenergy technologies in Europe has gained momentum in 2011 with an increase in both EU and national public support with respect to the previous year. Namely, EU funding was supplied through FP7 (€42 million, 6% increase), LIFE+ dedicated funds (€2.5 million, 48% increase) and the IEE which, through the ELENA facility financed projects in the bioenergy sector for the first time. The overall national support in the EU Member States for the sector amounted to €363 million (13% increase).

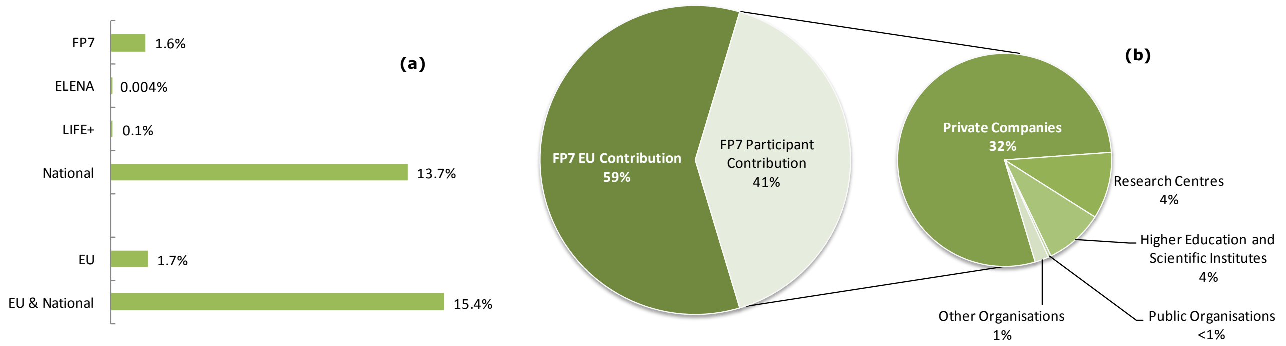


Figure 4.1: Indicative share of bioenergy in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: DG ENV[23], EIB[48], IEA [1], JRC [2, 3], Technopolis [29]

Figure 4.1(a) shows the share of the available funding that the technology captures in terms of EU, national (MS) and various European funding instruments. In total this amounts to 15% of the public funding for the energy technologies examined in this report for 2011. Note that values regarding European funding sources are tentative since not all projects can be assigned to a single technology; this is either because they support research in more than one fields, or because the project information is not sufficient to support assignment beyond a general area of activity. Nonetheless, they provide an indication of activity and the potential to raise additional funds from participant contributions. For example, an additional €28 million was contributed by FP7 Energy Theme participants on Bioenergy projects, the majority of which came from private investors (see Figure 4.1(b)).

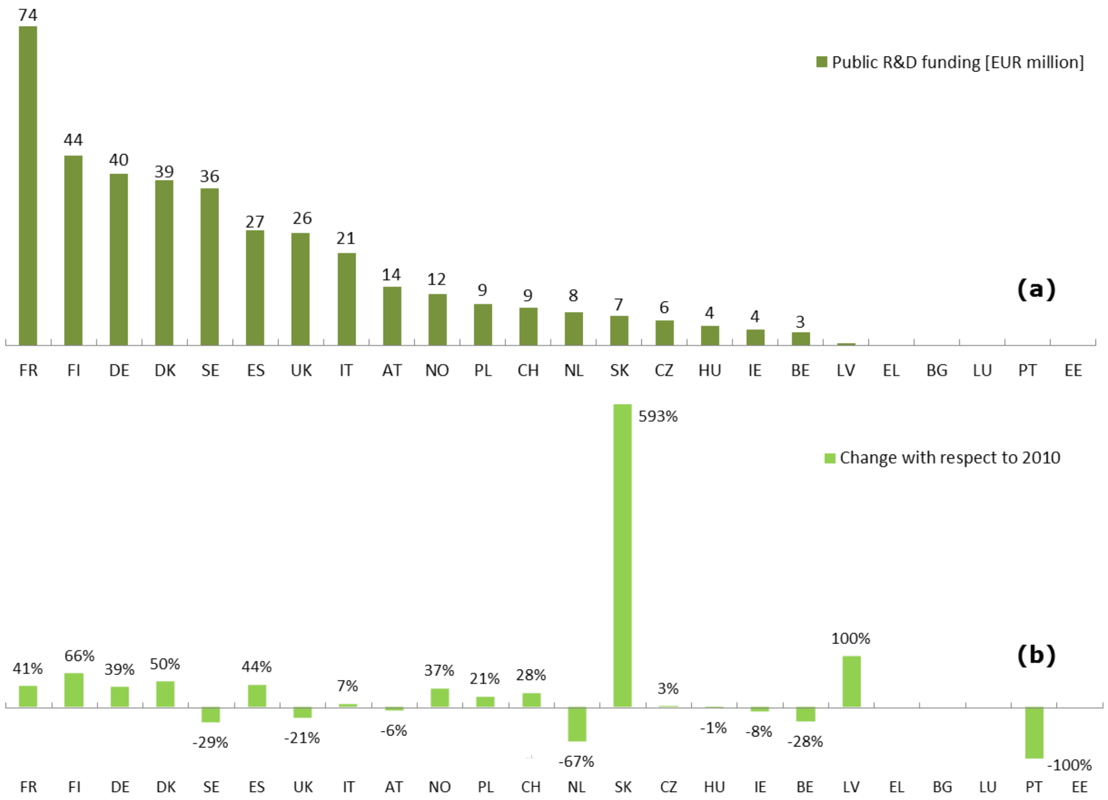


Figure 4.2: Public funding from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

Figure 4.2 shows the level of public funding available from sources at the national level for bioenergy technology in the year 2011. France is the clear leader, while North Europe and especially Scandinavian countries also invest in the technology. As also shown in Figure 4.2, the top five investing countries significantly increased their contributions – with the exception of Sweden, where funding dropped by about a third. Notable reductions were also observed for the UK, the Netherlands, Belgium and Portugal, while in Slovakia public funding contributions to the technology increased significantly compared to the previous year. Instances of a 100% change, such as in Latvia and Portugal are also due to the availability of records for the years in question, and not necessarily representative of the developments in public funding.

The relative contribution of national funding for the technology at European level for the leading investors in the field of bioenergy is displayed in Figure 4.3. Eight member states contribute around 80% of the public investment and - apart from France – have comparable contributions to bioenergy R&D.

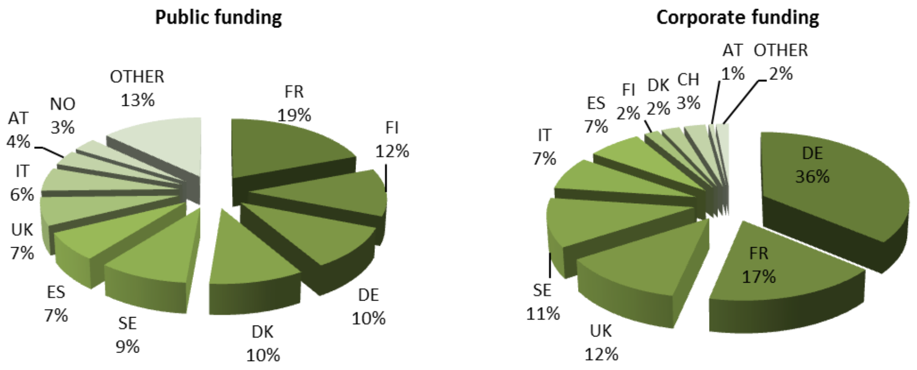


Figure 4.3: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in bioenergy technologies for the year 2011. Data source: IEA [1], JRC [2, 3] .

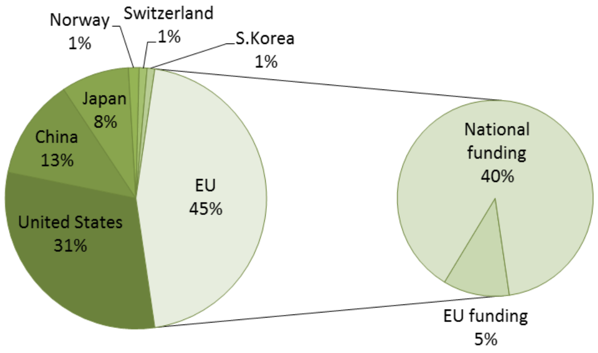


Figure 4.4: Distribution of global funding for bioenergy technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

In the international arena the EU maintained the lead, accounting for 45% of public investment in bioenergy technologies among the international actors included in this study. The bioenergy sector is one of the few sectors where the US has outperformed China in terms of national investments, dedicating more than double (€274 million) the Chinese funds, the equivalent of almost a third of the total global investments in R&D for this technology. Another important global player in 2011 was Japan, investing the equivalent of 8% of the global funds, an expenditure equalling that of France, the European member state that invested the most in bioenergy R&D in 2011. Figure 4.4 shows the distribution of national funds for a number of the major global investors for the year 2011.

4.2 CORPORATE INVESTMENT

The number of companies considered for the estimation of corporate investment and the relative clustering with regards to their geographical location is presented in Figure 4.5. Almost a quarter of the companies are located in Germany, while France, the Netherlands, the UK, Finland, Sweden and Belgium also show high corporate activity in this sector.

Corporate R&D investment in bioenergy technologies for 2011 was estimated at €888 million, distributed as shown in Figure 4.6. Unlike the case of public investment, where France tops the investment list, Germany is the clear leader when it comes to R&D spending in the corporate sector. Countries with high levels of public investment also display increased corporate R&D activity (Figure 4.2, Figure 4.6). Comparing the share of each country to the total R&D spending (Figure 4.3), the majority of corporate funding is concentrated in a smaller number of countries compared to public investments, with Germany (36% of investment) showing twice as much activity as France, which is the next major contributor.

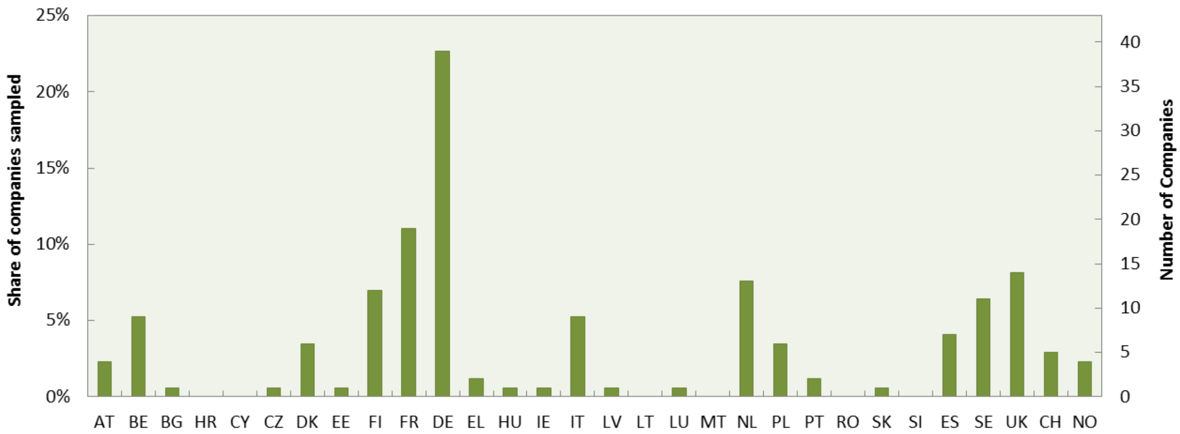


Figure 4.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

Looking at the intensity of corporate investment, in terms of the level of investment against sector turnover, Sweden stands out, as the equivalent of 21% of the bioenergy turnover seems to be reinvested into R&D. Denmark follows with 15%, while the Member States contributing the most in absolute terms - Germany and France - invest the equivalent of 9% and 6% in terms of the annual sector turnover respectively.

The corporate investment in the technology estimated for 2011 is higher by 18.4% compared to figures recorded in the 2010 exercise. However, this trend can only be perceived as indicative, due changes in the sample of companies used to produce the estimate.

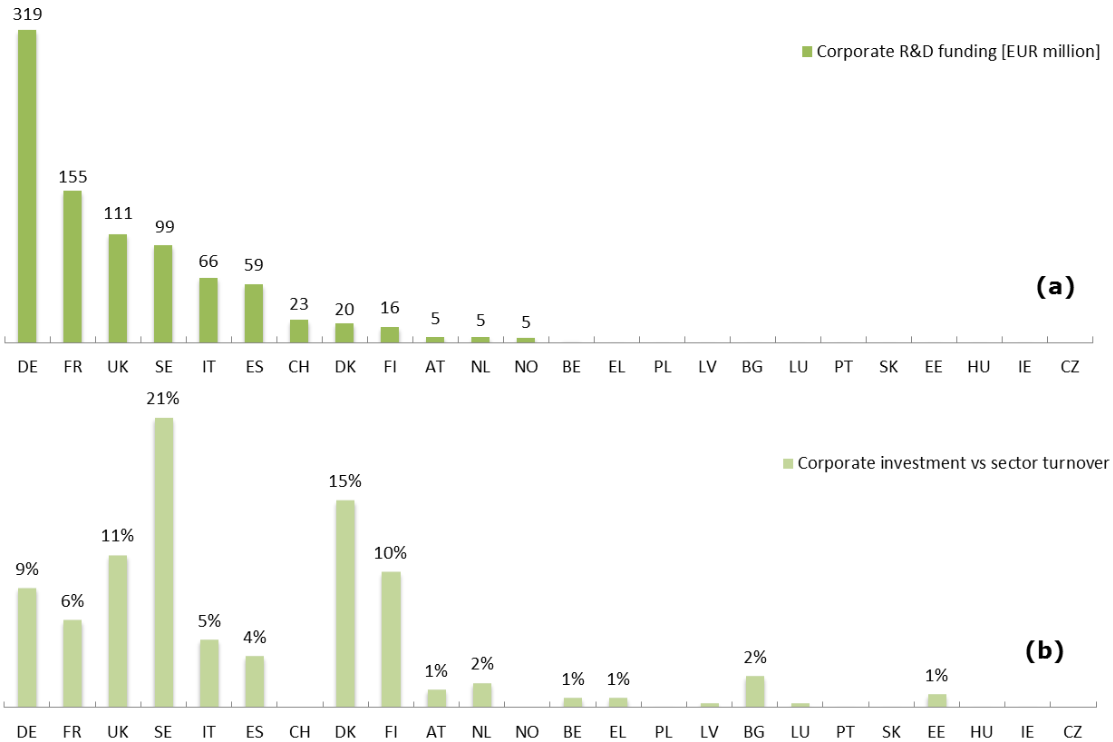


Figure 4.6: Leading countries for corporate R&D investment in Bioenergy technologies in Europe (a) and corresponding R&D intensity expressed against the sector turnover (b) for the year 2011. Data source: EURobserver [49-52], JRC [3].

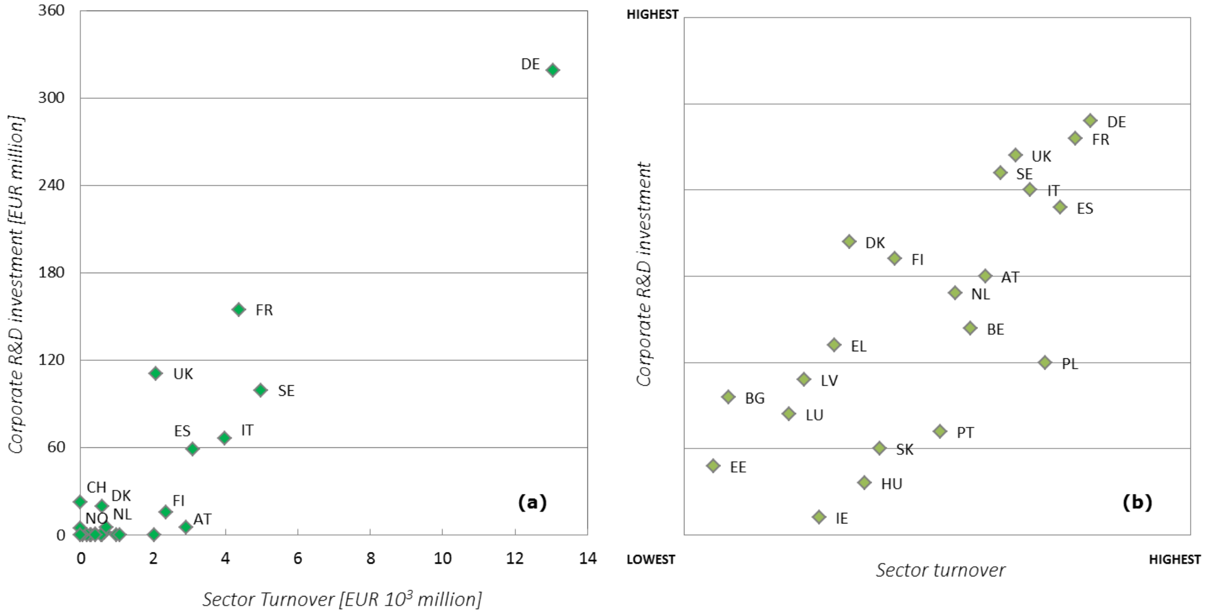


Figure 4.7: Absolute values (a) and relative ranking of countries (b) for the intensity of corporate R&D efforts against sector turnover in the field of Bioenergy technologies for the year 2011. Data source: EURobserver [49-52], JRC [3].

Figure 4.7 (a) shows corporate investment plotted against sector turnover in absolute terms, while the relative positioning of countries with regards to corporate investment intensity measured against the sector turnover is shown in Figure 4.7(b). The latter scatterplot is obtained by transforming each data point to its normalized rank, ordered from lowest to highest for each parameter. This representation aims to remove the distortion due to scale and measurement differences between the variables put in comparison. The resulting relative ordering allows a better visual representation, of the intrinsic shape of the association between the variables. It is evident that in Scandinavian countries, bioenergy R&D investments rank higher than expected based on the sector activity; in contrast countries like Poland ranked fourth in terms of turnover, holds a much lower position in terms of the availability of corporate R&D funding. Top investors (Germany, France and United Kingdom) show a tight degree of association between sector's turnover and R&D expenditure.

Bioenergy technological advancement is spurred by multi-sectorial synergies, established among companies belonging to distinct categories of economic activities in capital intensive industrial sectors. Examples are the investments from automotive (€188 million), petrochemical (€228 million) and alternative energy and green technology companies (€88 million). Most of these resources are channelled into the development of alternative biofuels for transportation, either for the implementation of specific technology portfolio strategies aimed at hedging oil fluctuations, or developed as the core (unique) business line. As shown in Figure 4.8, in 2011, petrochemical companies were the largest R&D investors in bio-energy related technologies, with an average estimated expenditure of €25.3 million per company, primarily dedicated to research on liquid biofuels by oil and gas production and refinery firms. Similarly, automotive companies invested €23.5 million on average for biofuels performance optimisation, as well as undertaking research on innovative engine concepts. Another significant contribution to the overall R&D investment in 2011 came from the utility and multi-utility companies (€ 9.8 million on average). For these categories of activity a high level of investment is contributed by a small number of large, established companies, while in areas such as industrial engineering and services a larger number of players invest smaller amounts in technology development.

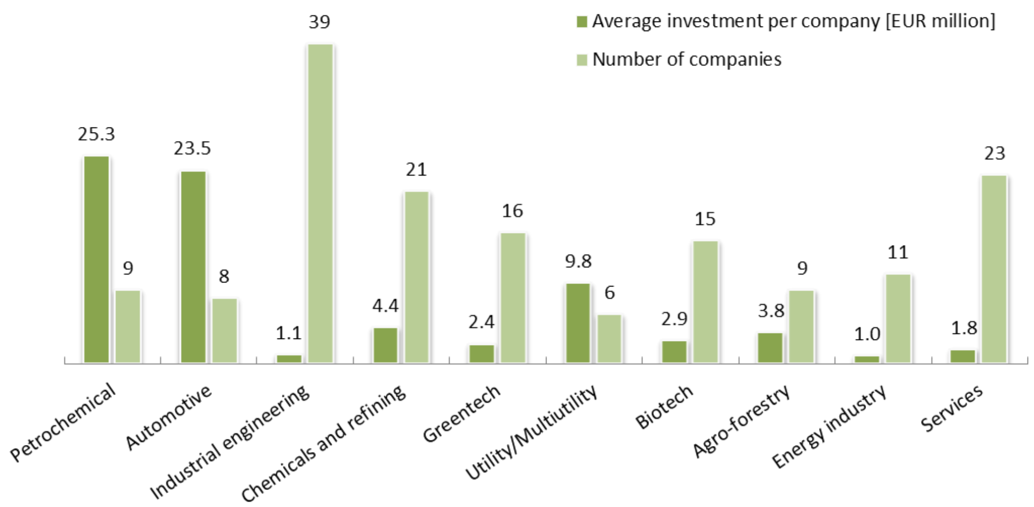


Figure 4.8: Number of companies identified and average investment per company for different bioenergy technology activity fields in 2011. Data source: EURobserver [49-52], JRC [3].

Estimating the distribution of corporate R&D investment over the various technological advancements in the bioenergy field is not straightforward. The main drawback is the limited information available from corporate data sources. Concerning advanced biofuels, according to the data collected, in 2011 €82 million financed R&D activities in advanced biodiesel deployment (eg. derived from algae biomass or hydro-treated vegetable oils). German and French companies were the main investors. Lesser resources were absorbed by research activities related with the production of bioethanol from lignocellulosic biomass (€29 million) with leading contributions from Denmark. In addition, advancement on enzyme chemical processes which represents a primary technology challenge in the field of advanced biofuels saw an investment of €43 million by the biotechnology sector.

R&D investment on bio-refining activities, and in general biomass resource management, encompassing the broad spectrum of R&D pursued by chemical companies engaged in the development of innovative bio-based materials (bio-plastics) received €84 million, while bioenergy research in the agro-forestry, food and health industry was supported by €34.2 million. Finally, it is interesting to stress the progressive integration of services firms among the bioenergy R&D investors (EUR 16 million). Their contribution takes the form of supporting technical and managerial services, development of processes and applications for innovative biorefinery concepts and consultation on project management, asset optimisation, or access to national funds and grants.

4.3 TOTAL INVESTMENT

Figure 4.9 shows the total investment in bioenergy technologies. It is obvious that, the majority of the R&D funding comes from the corporate sector, and it is the level of that investment which dictates the relative position of the countries in terms of absolute contributions to R&D activity. EU funding which would account for 3% of additional investment is excluded; however, part of the private investment raised as a contribution to these projects is captured in the corporate investment figures, with some uncertainty over the year and country of expenditure as well as potential overlaps in data collected through various sources.

In the following, the R&D investments are viewed normalised against figures such as the country GDP or the sector turnover to provide a measure of the effort with respect to the background of economic activity in each case. A relative ranking of the countries is also presented, which offers an overview of their positioning with regards to economic activity and whether the R&D investment performance is at a similar level.

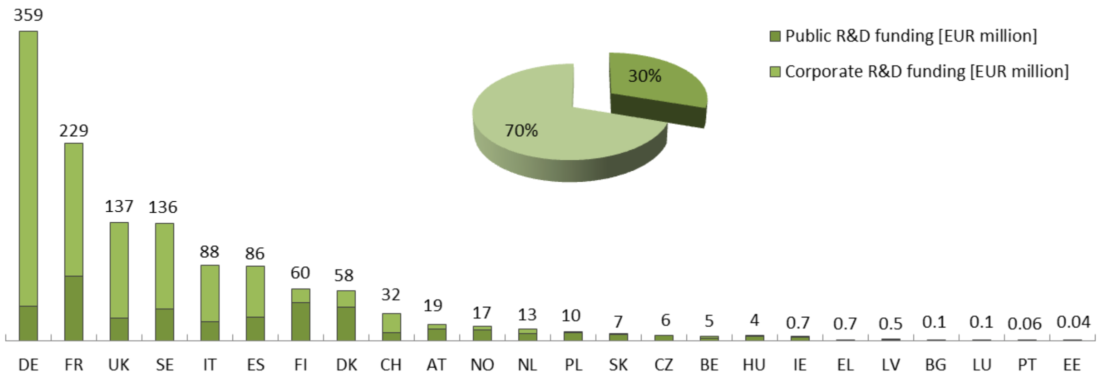


Figure 4.9: Leading European countries in terms of total R&D investment in Bioenergy technologies. EU funding is excluded. Data source: EURobserver [49-52], IEA [1], JRC [2, 3].

Figure 4.10(a) and Figure 4.10(b) show the relationship between the public and corporate investments in bioenergy in absolute figures and relative ranking, respectively. In France, Denmark and Finland there is relatively high support from public sources for bioenergy research; at the other end of the spectrum Belgium and Latvia rank much higher in corporate than public R&D funding.

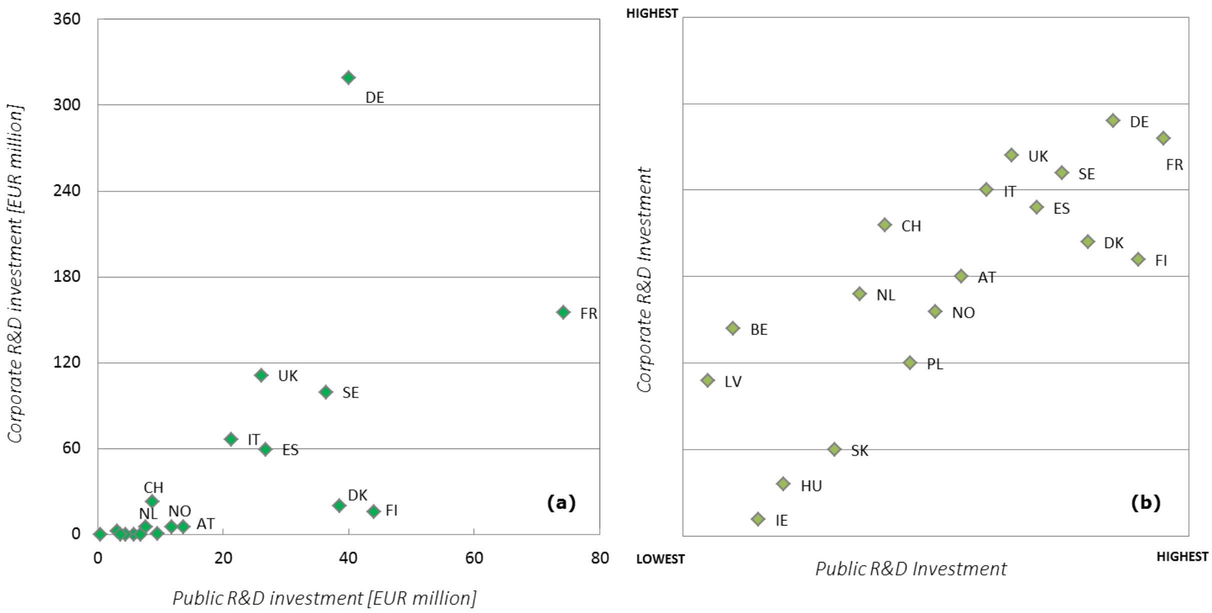


Figure 4.10: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in Bioenergy technologies for the year 2011. Data source: EURobserver [49-52], IEA [1], JRC [2, 3].

Figure 4.11(a) and Figure 4.11(b) show the absolute figures and relative ranking of R&D intensity in bioenergy research measured as total investment against the country's GDP. In general, the more prosperous the macroeconomic condition of a country is, the more companies are willing to divert resources to R&D purposes. In the case of low levels (rankings) of the GDP (lower/left quadrant), the more sparse clustering of countries can be interpreted as a more ambiguous relationship between investment decision making process and relative amount of the total output. In greater detail, note that the relative ranking of Scandinavian countries is higher in terms of total R&D investment, than what would be dictated in terms of GDP; on the other hand countries such as the Netherlands and Belgium seem to be investing less in the technology than counterparts with equivalent economic activity.

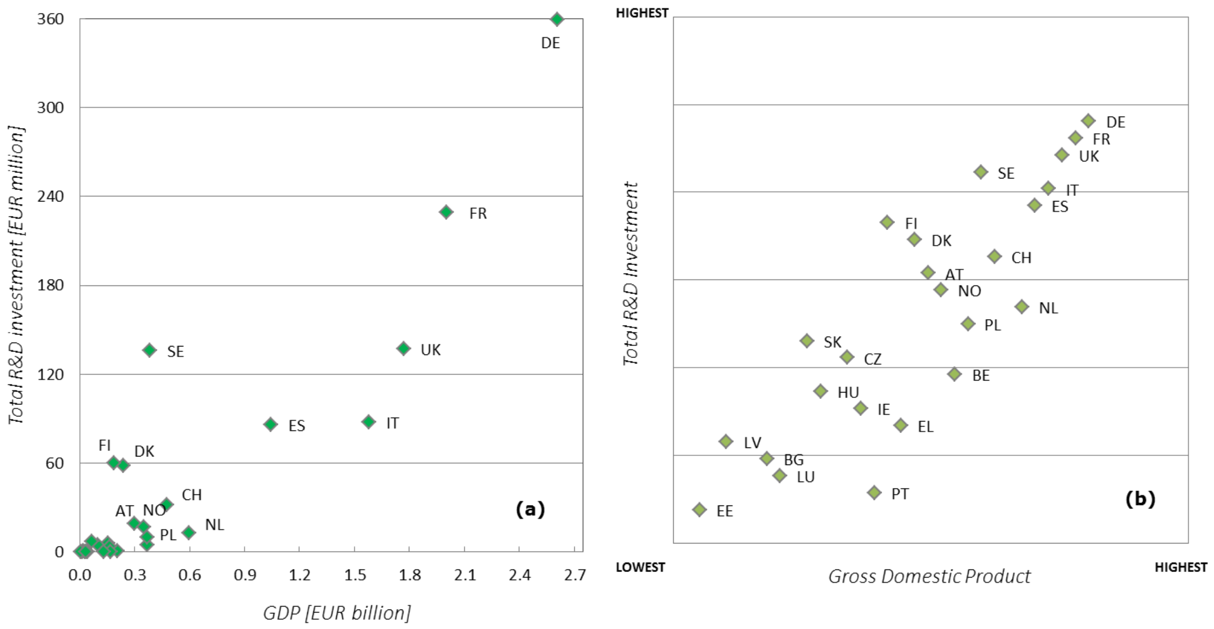


Figure 4.11: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in Bioenergy technologies with respect to GDP for the year 2011. Data source: EURobserver [49-52], IEA [1], JRC [2, 3].

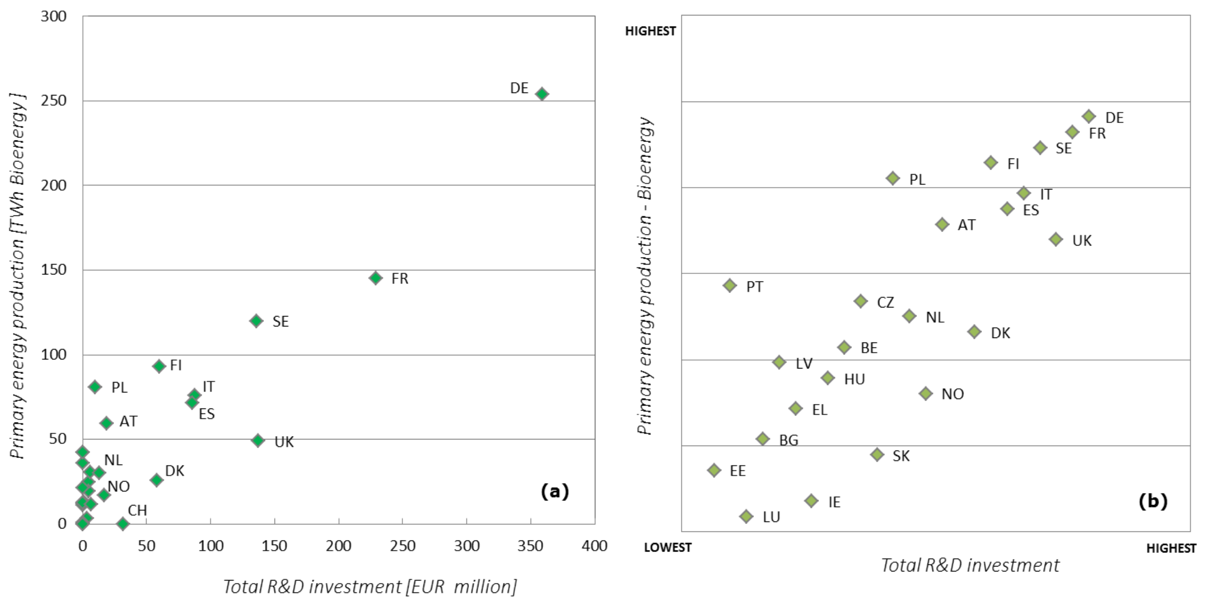


Figure 4.12: Absolute figures and relative ranking of European countries in terms of R&D investment against primary energy production from bioenergy. Data source: EURobserver [49-52], Eurostat [53], IEA [1], JRC [2, 3].

Finally Figure 4.12(a) shows the absolute R&D spending against the primary energy production from bioenergy sources; the relative ranking for this indicator is shown in figure Figure 4.12(b). The majority of European countries have a similar relative ranking in terms of R&D effort to the bioenergy resource used in the primary energy mix. In cases where there is high R&D investment compared to the respective energy production from the technology (e.g. the UK, Denmark) this can indicate an attempt to expand the use of the technology internally and exploit existing resources, or a continuing effort to retain a leading position in the bioenergy market by exporting technological innovation and know-how.

Maps of the public (Figure 4.13(a)), corporate (Figure 4.13(b)) and total investment in bioenergy technologies (Figure 4.14) are shown below.

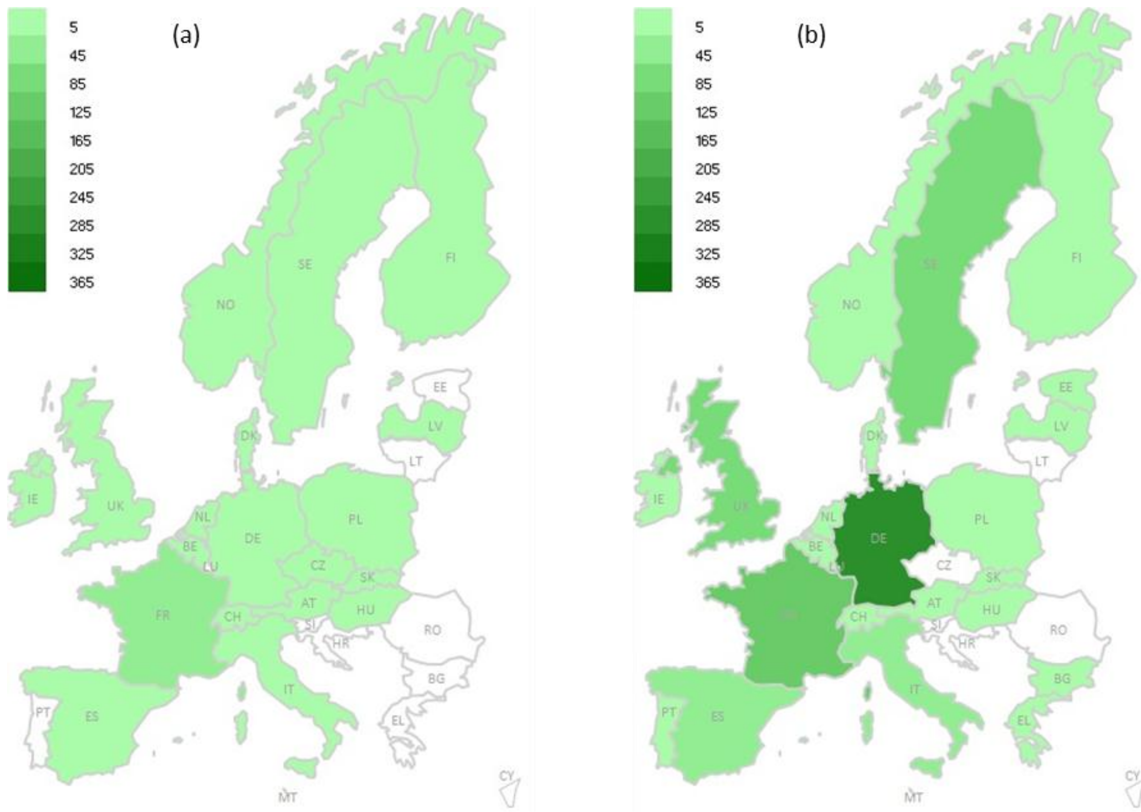


Figure 4.13: Maps of the public (a) and corporate (b) R&D investment in bioenergy for the year 2011. Legend in EUR million.

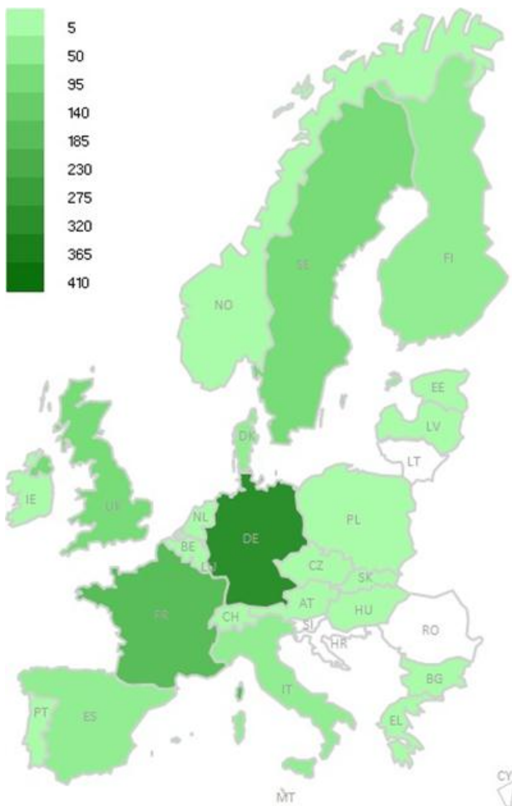


Figure 4.14: Map of the total R&D investment in bioenergy in Europe for the year 2011. Legend in EUR million.

5 CARBON CAPTURE AND STORAGE

Carbon Capture and Storage (CCS) technologies have reached different stages of the investment-risk curve, depending on the type and intended application. At the end of 2011 several large-scale projects around the world were capturing 23 MtCO_2 annually from natural gas processing or coal gasification plants, storing the gas in deep saline aquifers or in oil reservoirs as part of an enhanced oil recovery process. Despite these successes, integrated power generation and industrial projects have not been progressing as fast as their climate change mitigation capacity would warrant. By the end of 2011 no large project had been built in conjunction with power generation. However, 13 pilot-scale projects were ongoing, of which 4 in the EU, 5 in China and 2 in the US; 2 other projects were under development in 2011 in Australia and Norway [54].

Summary table – Carbon Capture and Storage R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 313 million
*Public funding available at EU level**	EUR 214 million
Corporate R&D Investment	EUR 349 million
Number of companies identified in the corporate investment sample	167
Number of countries represented in the corporate investment sample	21

*indicative; not all funding could be allocated by technology

5.1 PUBLIC INVESTMENT

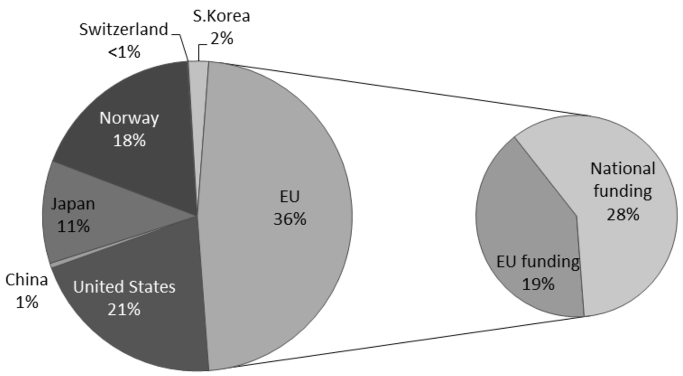


Figure 5.1: Distribution of global funding for CCS technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

In 2011 the EU accounted for over a third of the public funding available for the technology in the context of the countries included in this study (Figure 5.1). The US and Norway also provided significant funds to CCS R&D, contributing €229 million and €200 million respectively. Despite operating five integrated pilot CCS projects in power generation at the end of 2011, China has dedicated less than 1% of its clean energy R&D to the technology, as CCS is to a lesser degree compatible with the government's commitment to energy conservation and efficiency [54, 55]. Note that significant global investment for this technology is overlooked in the present report as Canada is not included in the analysis; in 2011 the SaskPower Boundary Dam Unit 3 power plant large-scale demonstration project received the bulk of the investment for power-generation, exceeding €900 million [54] .

European-level funding has kept pace with the global trend, providing €214 million, The main source of support for the technology was the EEPR, which dedicated 60% of its 2011 funds to the technology, also accounting for over 60% of the total investment across Europe. Figure 5.2(a) shows the share of the available funding that the technology captures in terms of EU, national (MS) and various European funding instruments. In total this amounts to 12% of the public funding for the energy technologies examined in this report for 2011. Note that values regarding European funding sources are tentative since not all projects can be assigned to a single technology. The significant difference between the funding opportunities offered by FP7 and EEPR are due to the technological stage CCS has reached, where large-scale demonstration/ pilot projects make the largest proportion of financing needs. Even though small in comparison to EEPR funds, the €22 million contributed by FP7 has attracted an additional €9.5 million in participant contributions split between investors as shown in Figure 5.2 (b).

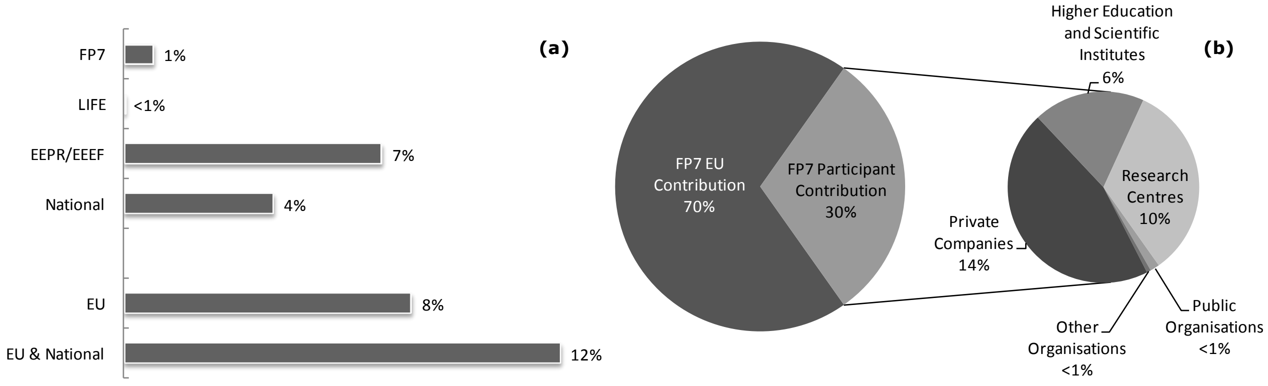


Figure 5.2: Indicative share of funds dedicated to CCS in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: EC [26], DG ENV[23], IEA [1], JRC [2, 3], Technopolis [29]

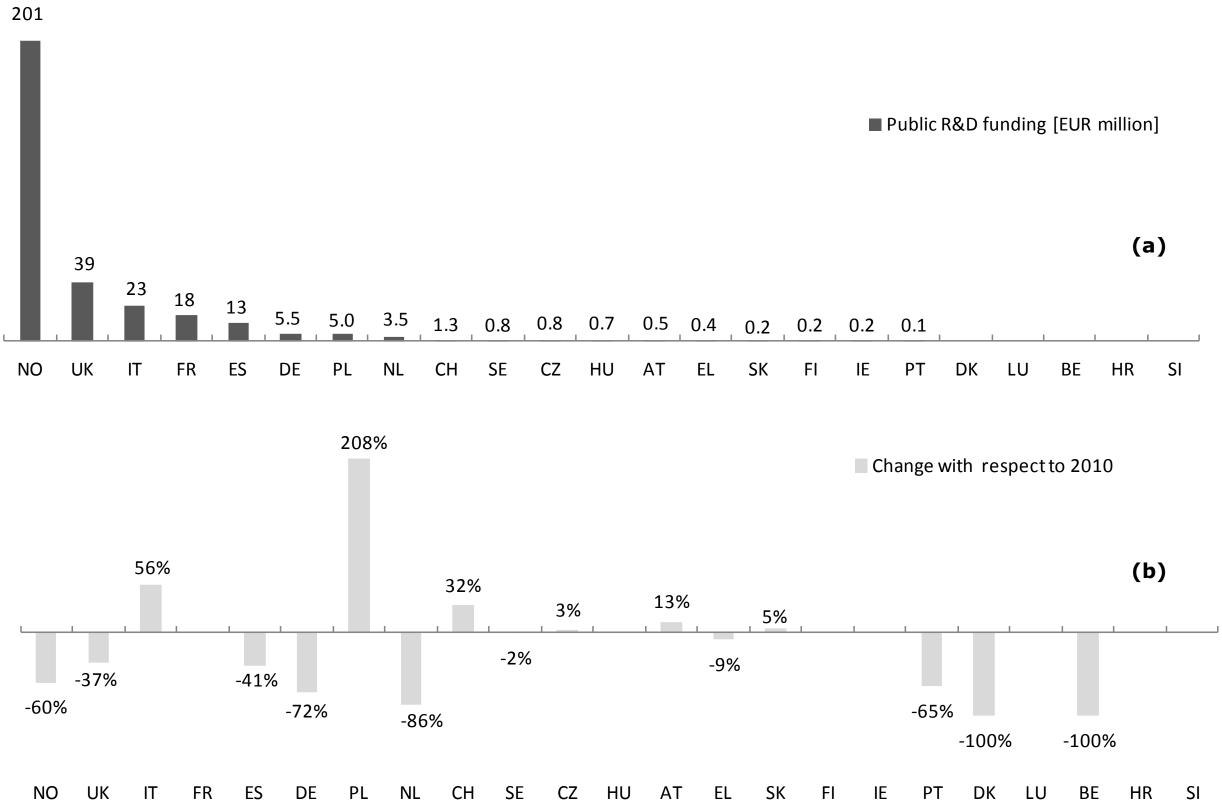
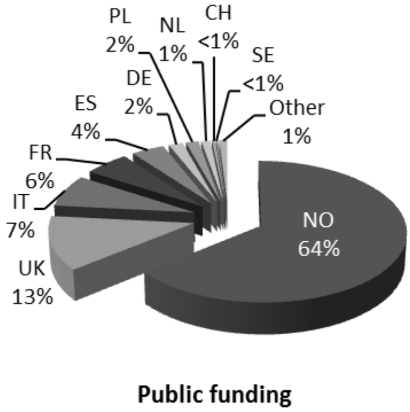


Figure 5.3: Public funding for CCS technologies from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

EEPR concentrated its CCS financing to projects in Germany, Netherlands, Poland, Spain, UK and Italy, which – apart from Norway – are also the major contributors of public funding for the technology in Europe as displayed in Figure 5.3. Despite the EU contribution to the technology, the above mentioned countries - except Poland and Italy - have shown a decrease in their annual spending in CCS R&D from the corresponding 2010 levels. Exceptions are: Poland, where a two-fold increase is observed; and Italy that also increased investment by 56%. Norway, which is the clear leader in public investment in Europe, has dedicated 71% of its 2011 clean energy R&D funding to CCS; this contribution however was 60% lower than funds received in the previous year.

The relative contribution of national funding for the technology at European level is displayed in Figure 5.4 As previously mentioned, Norway is a clear leader and there is a small number of countries contributing the majority of the funds available through national research funding programmes.



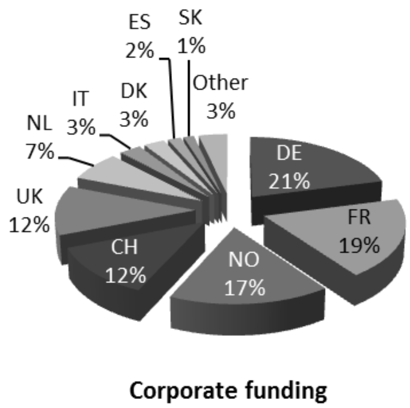


Figure 5.4: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in CCS technologies for the year 2011. Data source: IEA [1], JRC [2, 3]

5.2 CORPORATE INVESTMENT

European corporate research investments in CCS for the year 2011 were estimated at EUR 349 million split as shown in Figure 5.4. Although the majority of the investment still comes from a limited number of counties, unlike the case of public funding, contributions from the business sector are spread more equally among the leading contributors. The number of companies considered for the estimation of corporate investment and the relative clustering with regards to their geographical location is presented in Figure 5.5.

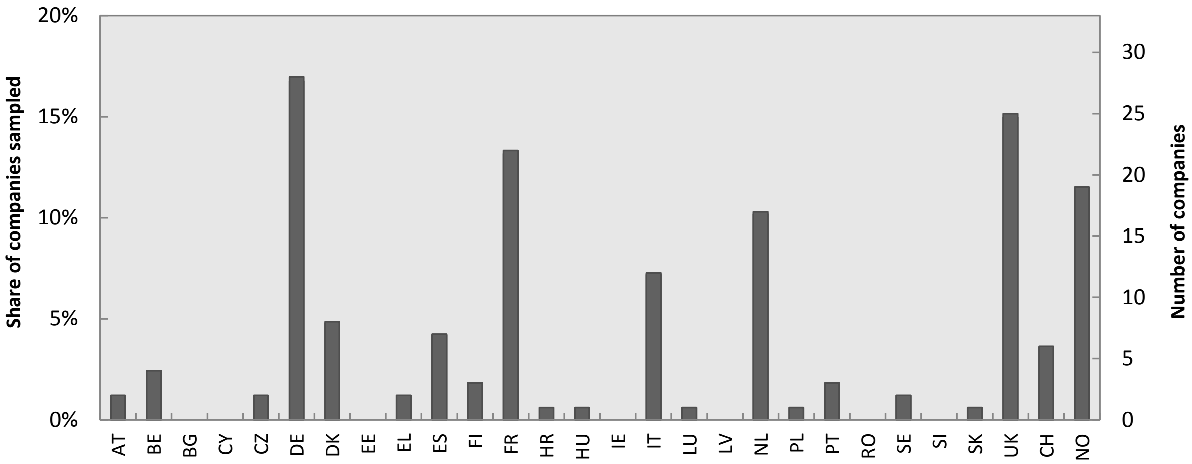


Figure 5.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

Companies investing in CCS research activities were mainly concentrated in France, Germany, UK, Norway and the Netherlands. Swiss companies, though not as many in number contribute a high proportion of the corporate investment at European level. The absolute investment of the business sector per country is shown in Figure 5.6.

The intensity of research efforts observed is not uniform across countries or economic sectors. In Norway oil and gas companies, which have long experience in large-scale carbon dioxide separation and injection into offshore geological formations, accounted for 86% of corporate investment in CCS technology. In the case of Switzerland, research activities aimed at testing the viability of technology implementation; research initiatives focusing on the potential of CCS deployment attracted investment from power and (petro) chemical companies. In France, utility companies accounted for a significant share of corporate investment in CCS technology, while in Germany significant efforts were made by both small domestic companies and large international investors from chemical, gas and engineering sectors.

Germany and France show significant research effort in CCS research, which has not translated to deployment of the technology, despite ongoing demonstration projects. This could be due to the fact that in these countries and in particular in Germany, technology development progressively made transitional steps from research in CO_2 storage to research in CO_2 utilisation, spurred by legal issues and lack of public acceptance. Thus research activities in CCS remained at the patent stage and did not receive further support for deployment. French investors on the on the other hand manifested activity in deploying the technology abroad, so there is a case of technology transfer related to their activities.

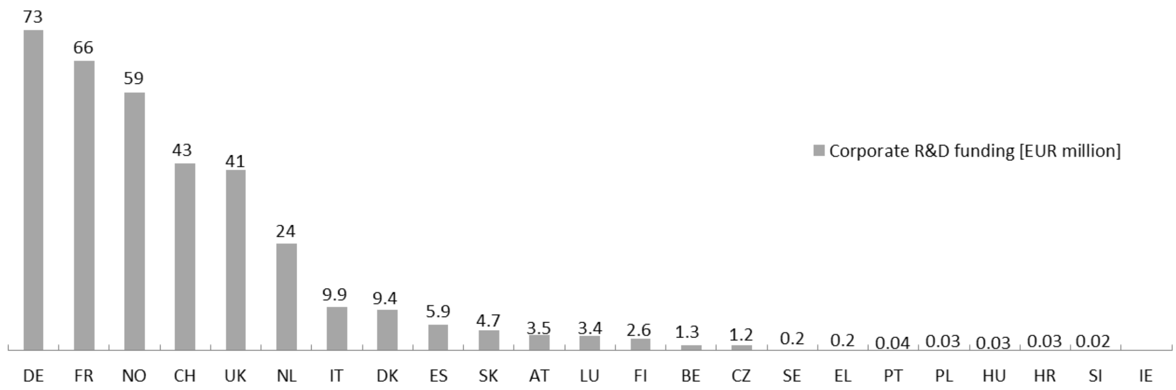


Figure 5.6: Leading countries for corporate R&D investment in CCS technologies in Europe. Data source: JRC [3].

5.3 TOTAL INVESTMENT

Figure 5.7 shows the total investment, public and corporate, in CCS for the year 2011. EU funding which would account for 32% of additional investment is excluded; however, part of the private investment raised as a contribution to EU funded projects is captured in the corporate investment figures. Excluding EU funds, the contributions from public and corporate sources are of a similar order. Norway is the clear leader considering overall investment in the technology, with an R&D budget over three times the size of the next significant investors. Note that the majority of this funding comes from publicly funded programmes. France, the UK and Germany follow, with comparable total investments, but varying share of contribution between the public and business sector.

Figure 5.8(a) and Figure 5.8(b) show the relationship between the public and corporate investments in CCS in absolute figures and relative ranking. Countries with similar ranking for investment from both public and corporate source would lie along an imaginary line at a 45 degree angle; there is a clear split in this case in countries were CCS research is driven by public funds e.g. Poland, and those where the corporate sector takes the lead e.g. Denmark.

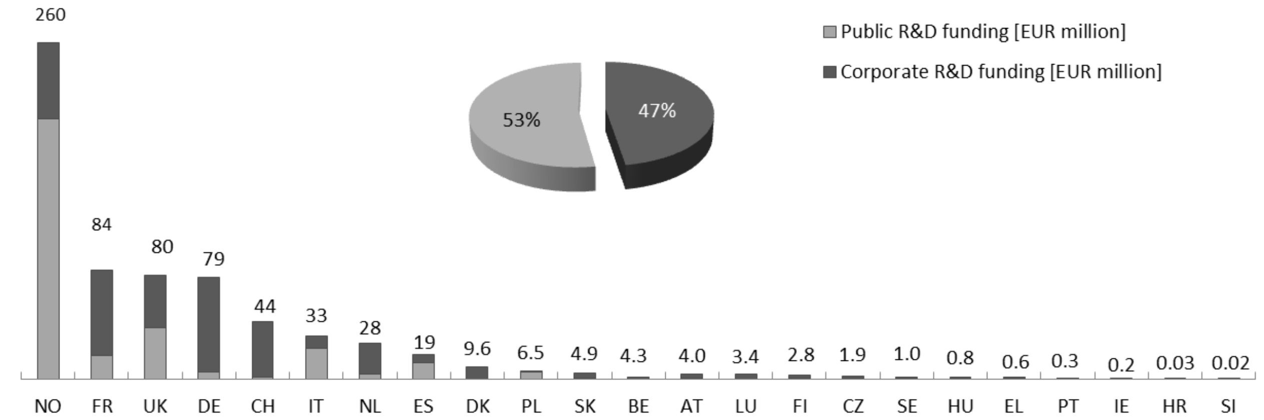


Figure 5.7: Leading European countries in terms of total R&D investment in CCS technologies. EU funding is excluded. Data source: IEA [1], JRC [2, 3].

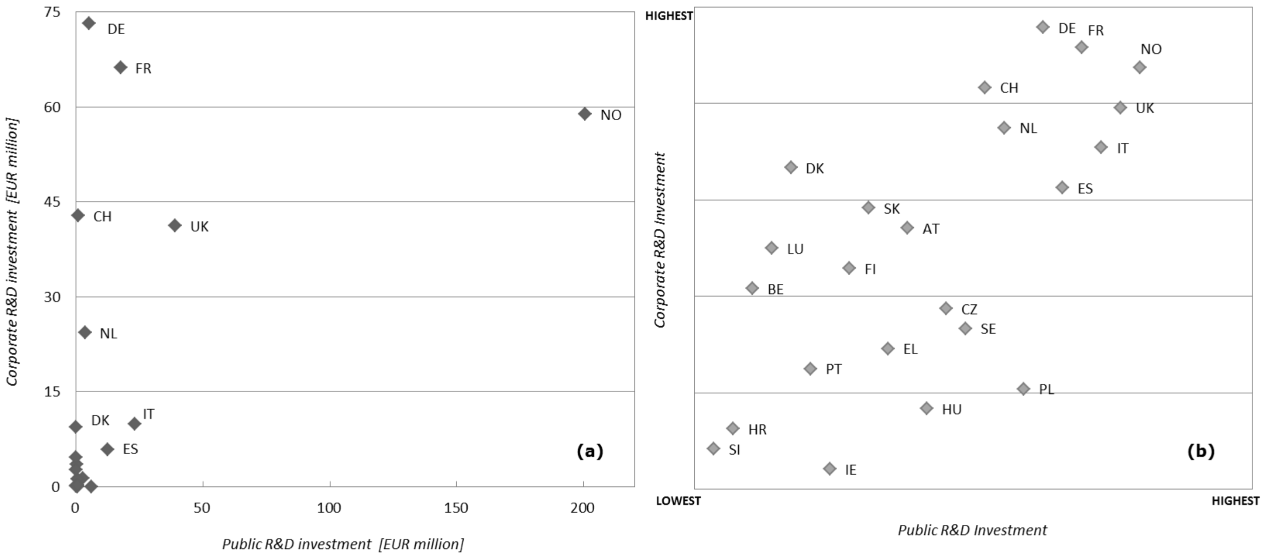


Figure 5.8: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in CCS technologies for the year 2011. Data source: IEA [1], JRC [2, 3].

Figure 5.9(a) and Figure 5.9(b) show R&D investments in CCS normalised against the countries' GDP to provide a measure of the effort with respect to the background of economic activity. A relative ranking of the countries is also presented, which offers an overview of their positioning with regards to economic activity and whether the R&D investment performance is at a similar level. Three groupings can be observed in Figure 5.9(b): one along the line of a diagonal at the lower part of the figure, indicating countries showing very little effort in the technology with respect to their position in terms of economic activity e.g. Sweden; the second group, along the diagonal in the centre of the graph depicts the instances where the level of R&D effort in this technology also reflects the ranking of the country in terms of economic activity; finally, above that line and towards the top left quadrant lie the countries investing in the technology to a greater extent than others with respect to their position in terms of GDP e.g. Norway.

The R&D funding available for CCS technology in Europe is mapped in Figure 5.10 and Figure 5.11.

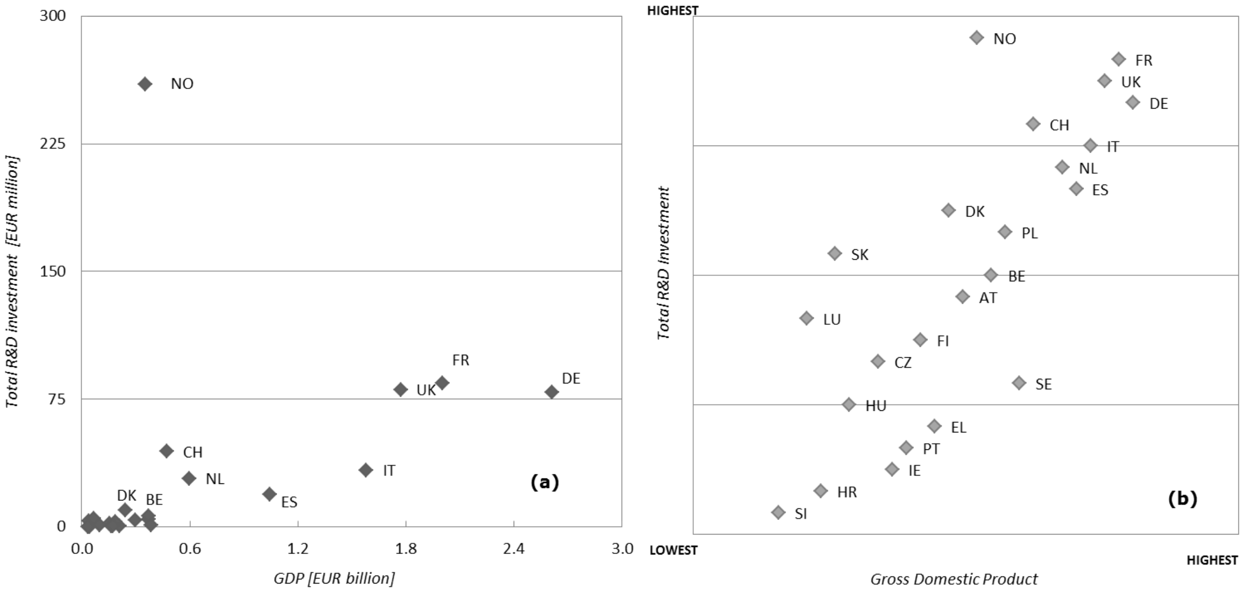


Figure 5.9: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in CCS technologies with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

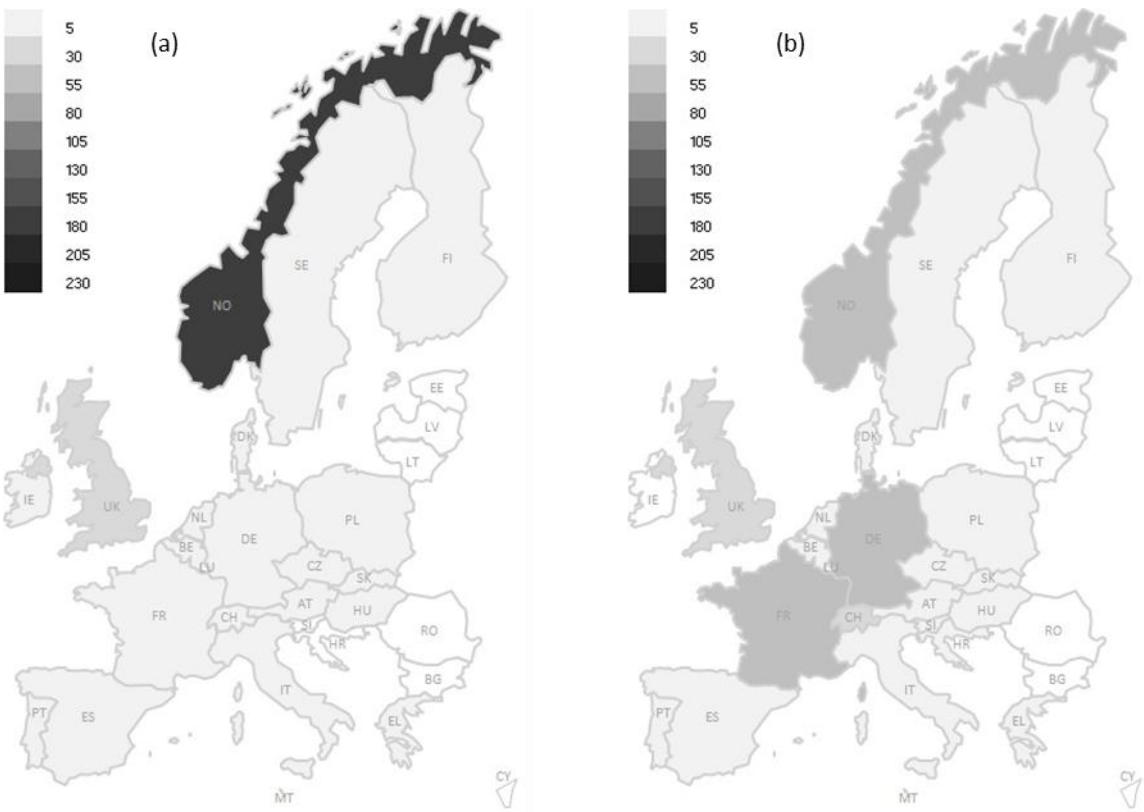


Figure 5.10: Maps of the public (a) and corporate (b) R&D investment in CCS for the year 2011. Legend in EUR million.

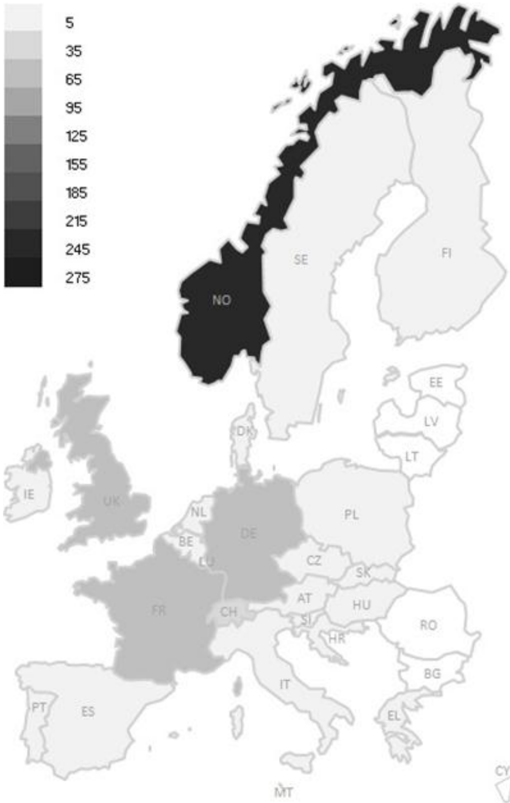


Figure 5.11: Map of the total R&D investment in CCS in Europe for the year 2011. Legend in EUR million.

6 ELECTRICITY GRIDS

As a key enabler for the efficient deployment of sustainable energy, electricity grids are a priority in terms of R&D and infrastructure development. In 2011, the European electricity grid has become the largest synchronous operating system in terms of installed capacity, while China and other powerful economies are also concentrating their effort in increasing their T&D capacity to keep up with ever increasing and diversifying power generating capacities [56] [39].

Summary table – Electricity Grids R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 235 million
*Public funding available at EU level**	EUR 119 million
Corporate R&D Investment	EUR 249 million
Number of companies identified in the corporate investment sample	150
Number of countries represented in the corporate investment sample	20

*indicative; not all funding could be allocated by technology

6.1 PUBLIC INVESTMENT

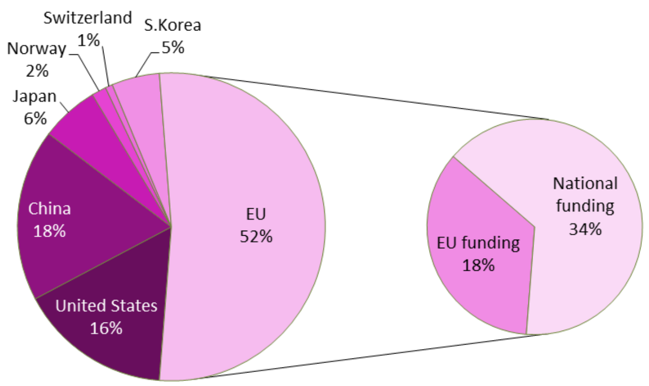


Figure 6.1: Distribution of global funding for electricity grids R&D based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

The EU leads the public investment in electricity grids, accounting for more than half the investment included in this study (see Figure 6.1). At country level, China is the largest investor (€116 million followed by the US, which despite a 27% reduction of its support for the technology has maintained a high level of investment (€104 million). Italy, which is the highest investor in the EU contributing €92million of public funding (see Figure 6.2(a)), is reaching levels of investment comparable to the global leaders. South Korea has been one of the few countries to decrease its support compared to 2010 investment levels, spending €32 million, the equivalent of a 13% decrease from the funds dedicated in the previous year.

In Europe, the vast majority of countries, not only continued but significantly increased their spending in electricity grids R&D compared to 2010 levels (see Figure 6.2(b)). Notable exceptions are Poland, Austria, Switzerland and Belgium, where a decrease in public funds was observed. The highest increase took place in Slovakia and Portugal which, from their 2010 investment levels of well below €100 thousand, reached in 2011 an expenditure of €4.5 million, and €0.42 million respectively. As mentioned previously, Italy is the clear leader with respect to public funding, dedicating over four times more resources than next prominent investors (Denmark, UK and Germany) and significantly more than a third of the overall European investments dedicated to this sector for 2011.

Over a third of the public funds in Europe dedicated to R&D in electricity grids in 2011 were supplied by European financing instruments, FP7 investing 13% of its total funding to the technology, while a quarter of the technology's investment came from EEPR which dedicated €89 million to the topic. Figure 6.3 shows the share of the funding for this technology with respect to the total R&D funding supplied from public sources to all technologies examined in this study as well as the share of each contributing partner in FP7 projects. The FP7 funding provided by the EU raised an additional €20 million from project participants, the majority of which was contributed by private companies.

Figure 6.2: Public funding from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

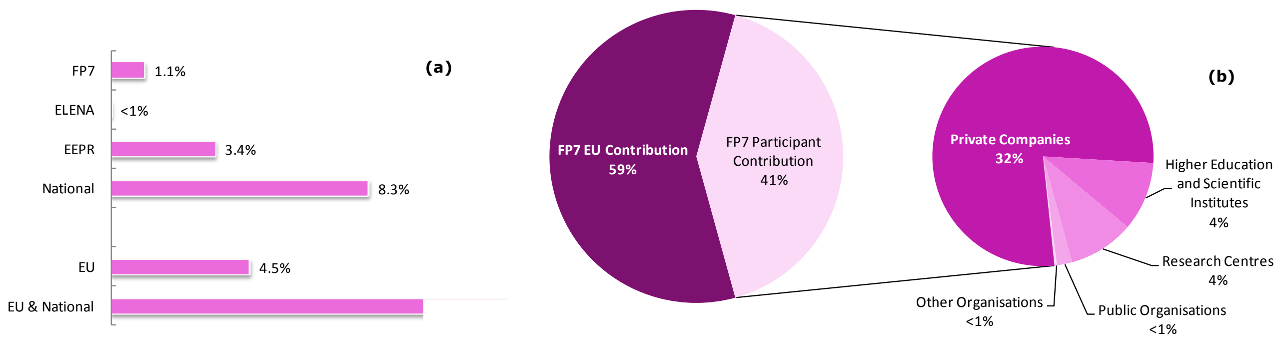


Figure 6.3: Indicative share of electricity ...al public funding available for energy technologies as calculated in this report (a) and contribution ...unding by FP7 Energy Theme participants (b) for 2011. Data source: EC [26], EIB[48], DG ENV[23], IEA ...Technopolis [29]

214%

Figure 6.4 presents the share of participation at a national level in the total investment for R&D in electricity grids in terms of public and private funding sources. As previously discussed, Italy provides by far the greater share of public funding, but has a comparative small resource of corporate funds. The next group of countries all show comparable contribution levels; Denmark and the UK also have a corresponding share in the corporate activity, while Germany has a much stronger contribution from the latter sector, as does Switzerland which does not feature strongly in terms of public funds.

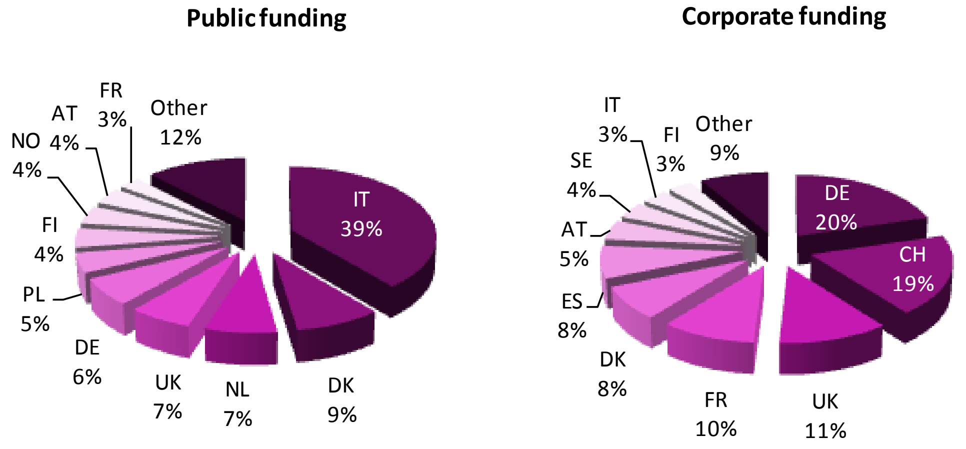


Figure 6.4: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in electricity grids for the year 2011. Data source: IEA [1], JRC [2], JRC [3, 57].

6.2 CORPORATE INVESTMENT

Figure 6.5 shows the number of companies considered for the estimation of corporate investment and the relative clustering with regards to their geographical location. As shown in Figure 6.4 and Figure 6.6 a considerable amount of corporate funding for electricity grid technologies originates from Germany and Switzerland, albeit with a markedly different distribution in terms of the number of investors in each country (Figure 6.5). This is due to the presence of two major international multiple-technology corporate investors in the case of the latter.

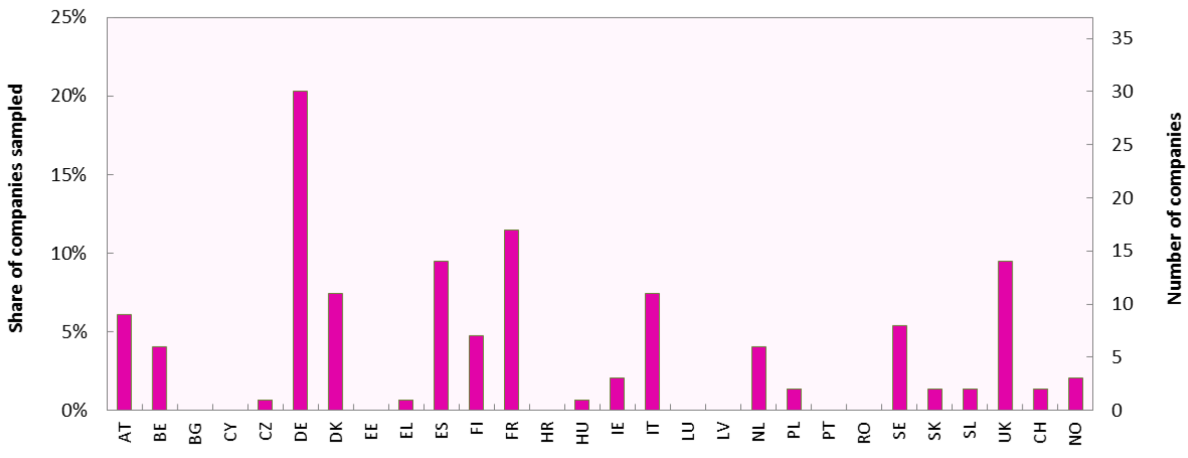


Figure 6.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

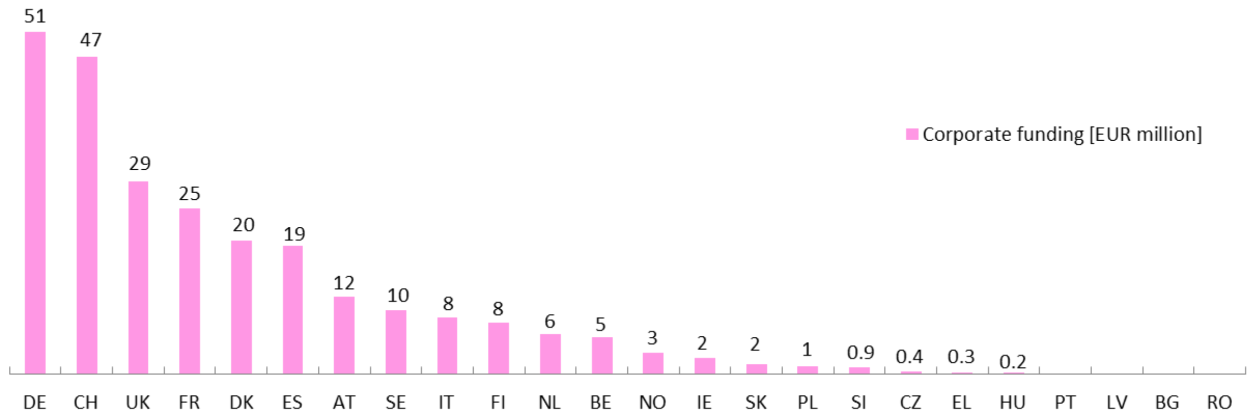


Figure 6.6: Leading countries for corporate R&D investment in electricity grids in Europe for the year 2011. Data source: JRC [3, 57].

Figure 6.7 shows a breakdown of the companies included in the study by subsector of activity, along with the average investment per company estimated in each case. Average investment is high in the case of wind and solar firms (Germany, UK, Denmark) seeking to accommodate short-term market demand for better integration of renewables in the energy system. Besides the renewables sector, other related engineering, electrical and power companies also showed a high average investment in electricity grids in 2011. The sampled TSOs account for just 1% of corporate research investment, comparable with sums invested by small electric car manufacturers. Utility companies invested four times more than the TSOs, but they lag far behind energy companies: wind companies invest nearly 10%, solar companies around 7%, oil, gas and nuclear together 3%; while other power companies invested around 6.5%. In total, energy companies accounted for 30 % of grid investments, which is twice as much as the research investment of Electronic & electrical equipment companies.

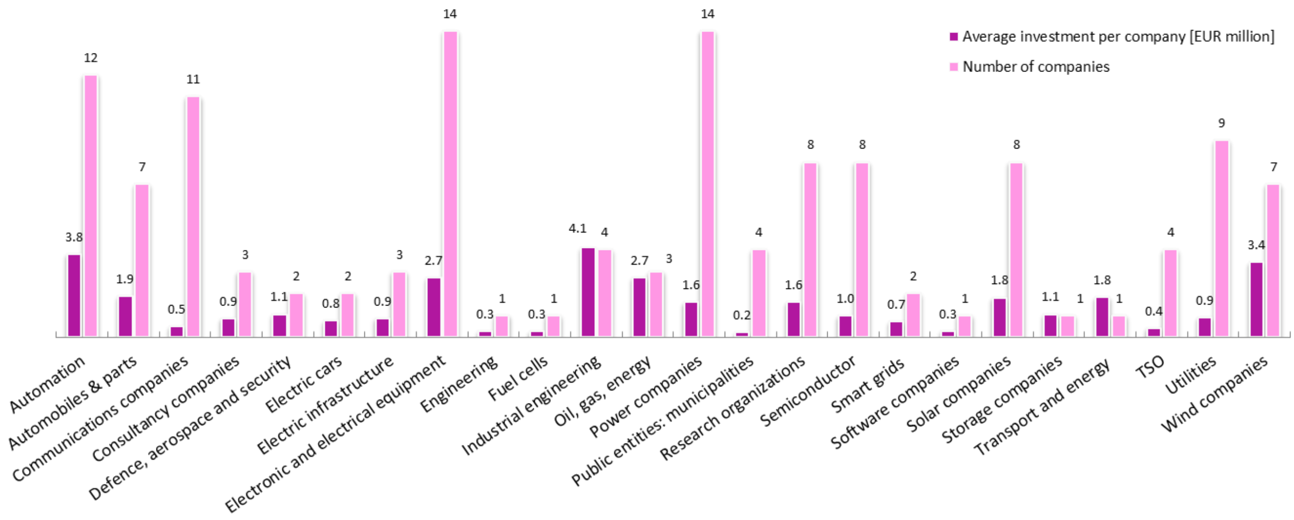


Figure 6.7: Number of companies investing in electricity grids R&D and average investment per company according to sector of main activity in 2011. Data source: JRC [3, 57].

6.3 TOTAL INVESTMENT

Figure 6.8 shows the total investment in R&D for electricity grids. The public and private contribution to research is balanced overall at the European level, although the respective contributions for individual countries are varied. EU funding which would account for 25% of additional investment is excluded; however, part of the private investment raised as a contribution to these projects is captured in the corporate investment figures, with some uncertainty over the year and country of expenditure as well as potential overlaps in data collected through various sources.

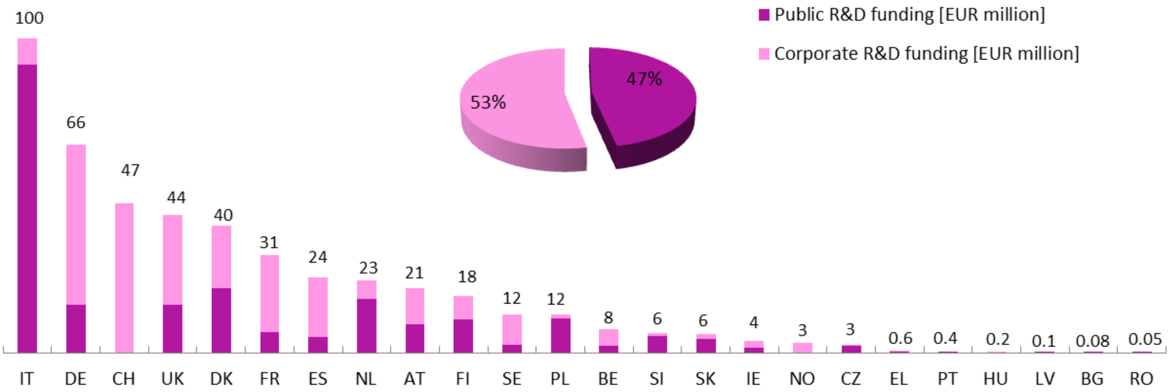


Figure 6.8: Leading European countries in terms of total R&D investment in electricity grids. EU funding is excluded. Data source: IEA [1], JRC [2, 3, 57].

In the following, the R&D investments are viewed normalised against the country GDP to provide a measure of the effort with respect to the background of economic activity in each case. A relative ranking of the countries is also presented, which offers an overview of their positioning with regards to economic activity and whether the R&D investment performance is at a similar level. The latter scatterplot is obtained by transforming each data point to its normalized rank, ordered from lowest to highest for each parameter. This representation aims to remove the distortion due to scale and measurement differences between the variables put in comparison. The resulting relative ordering allows a better visual representation, of the intrinsic shape of the association between the variables.

The relationship between the public and corporate funding for the technology at the national level is also shown in Figure 6.9 both in absolute figures and in terms of the relative ranking of each country in each case. In the case of electricity grids, more than the other technologies examined here, there is a clearer split between countries relying more heavily to one rather than the other source. In Italy, Poland and the Netherlands for example R&D is mainly publicly funded, unlike France, Spain, Sweden etc., where the initiative lies with the corporate sector.

Figure 6.10 shows the absolute figures and relative ranking of R&D intensity in electricity grids R&D measured as total investment against the country's GDP. In general most countries maintain their ranking in GDP when it comes to research funding, however it is clear that total investment effort in Italy, Switzerland, Denmark, Austria, Finland, Slovenia and Slovakia ranks much higher among European countries than would have been expected on the basis of GDP alone.

Figure 6.11(a) and Figure 6.11(b) display the public and corporate funding for R&D in electricity grids in 2011. Figure 6.12 provides the total funding for the same year.

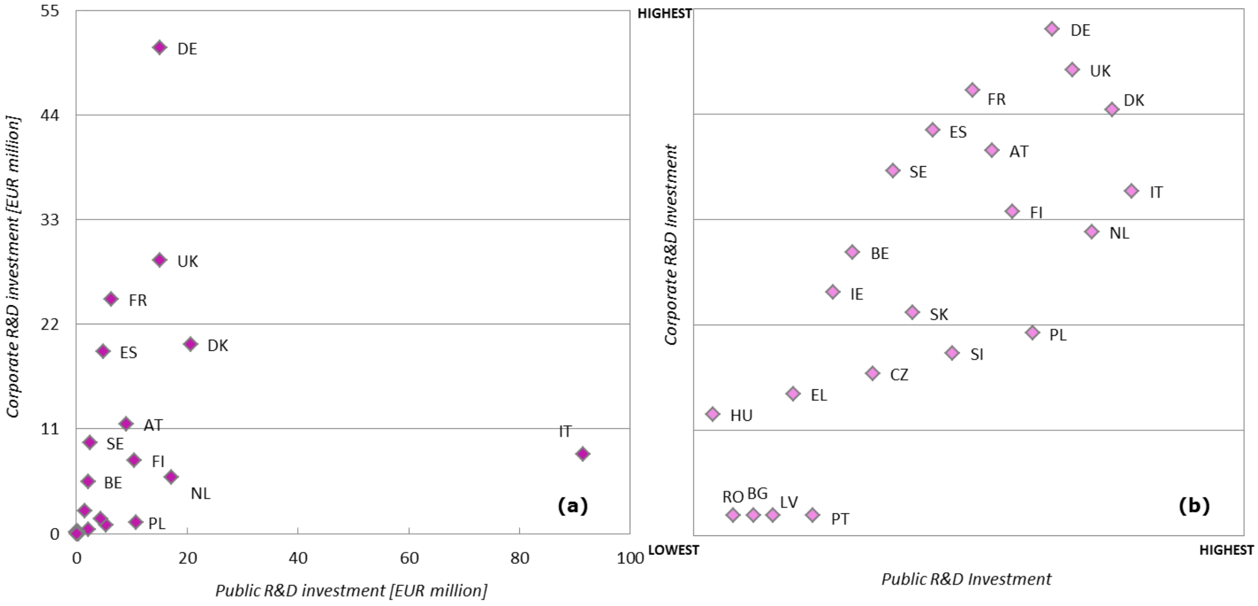


Figure 6.9: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in electricity grids for the year 2011. Data source: IEA [1], JRC [2, 3, 57].

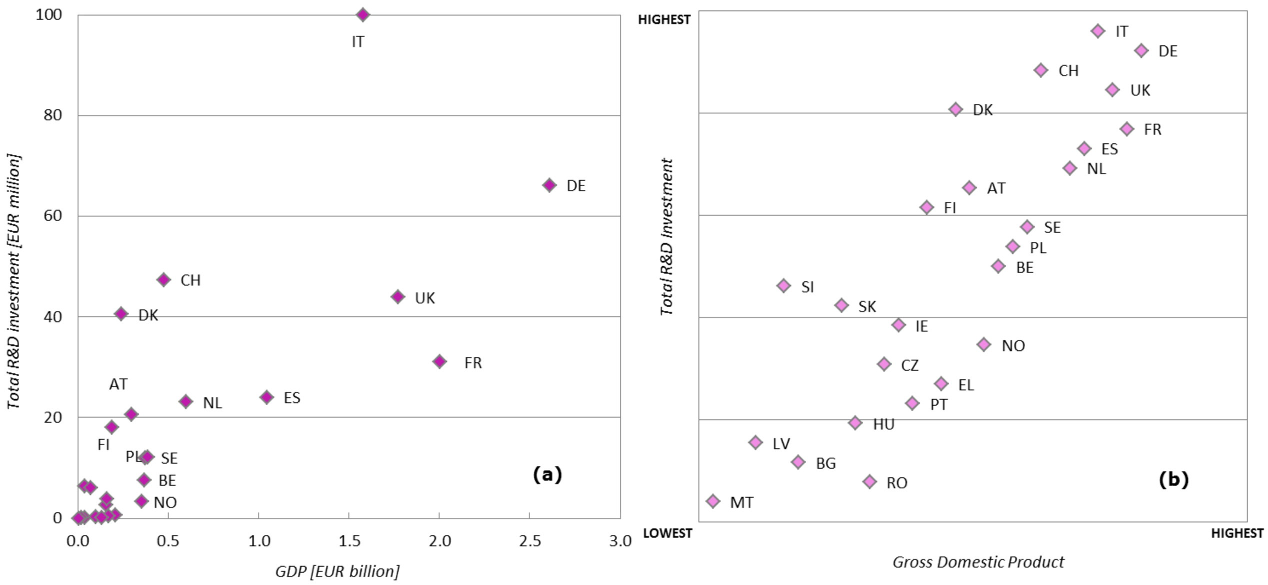


Figure 6.10: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in electricity grids with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3, 57].

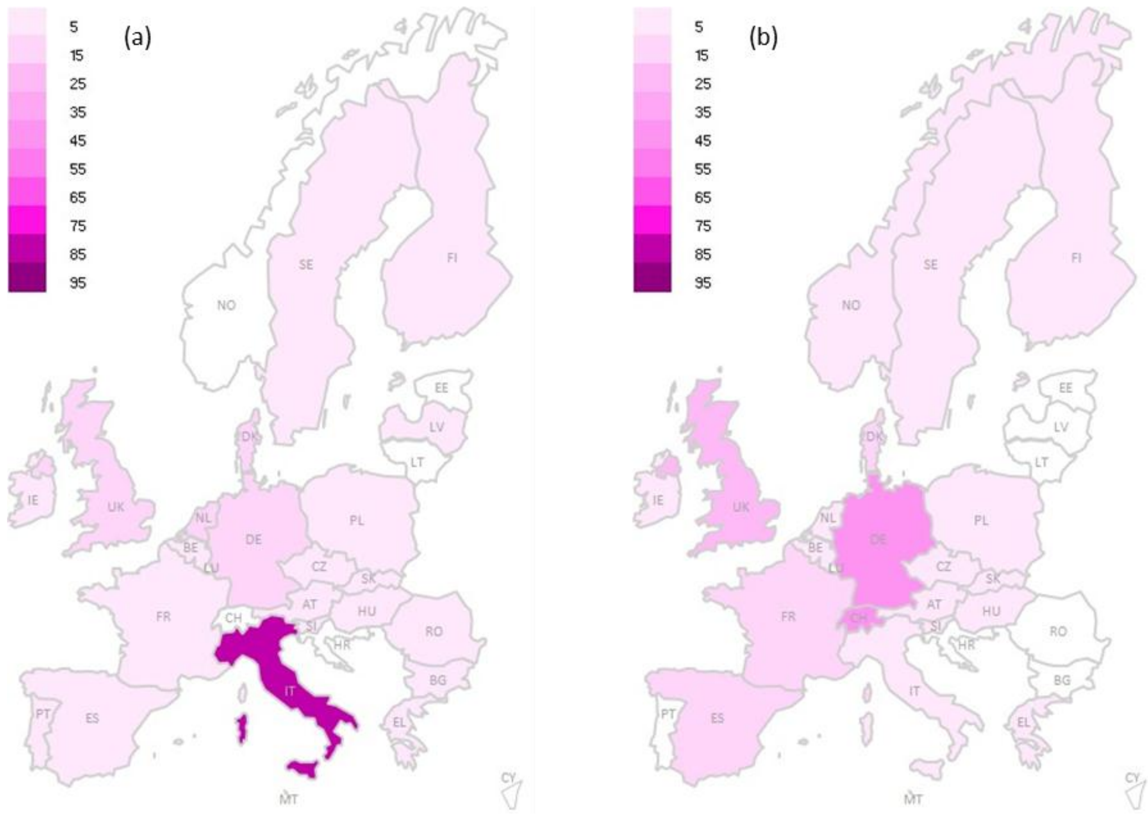


Figure 6.11: Maps of the public (a) and corporate (b) R&D investment in electricity grids in 2011. Legend in EUR million.

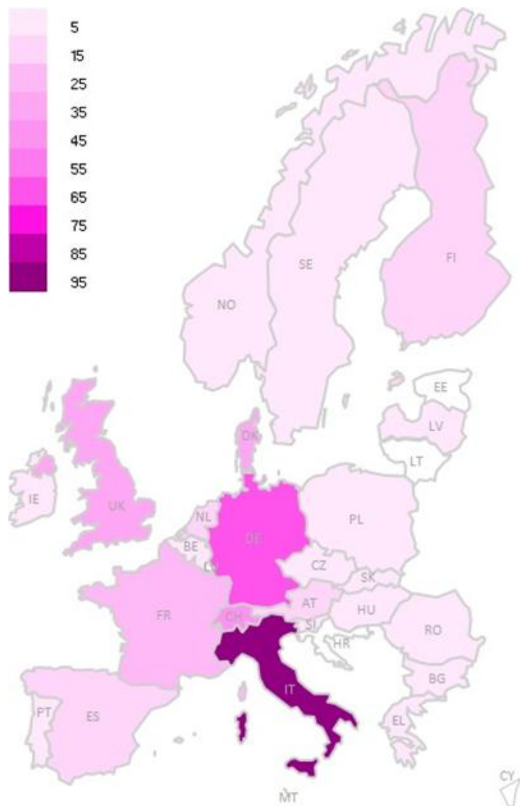


Figure 6.12: Map of the total R&D investment in electricity grids in Europe for the year 2011. Legend in EUR million.

7 ENERGY STORAGE

Energy storage technologies enable the "temporal and [...] geographical" decoupling of energy supply and demand, being at the same time versatile tools in our endeavour for a low-carbon economy [58].

While some technologies are mature or near maturity, others are still in the development stage, requiring both public and private support for R&D. With many thermal energy technologies already at the commercialisation stage, the sector focus now lies in reducing the costs of high-density storage and the development of the related thermo-chemical processes [58].

Summary table – Energy storage R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 59 million
*Public funding available at EU level**	EUR 1 million
Corporate R&D Investment	EUR 1516 million
Number of companies identified in the corporate investment sample	284
Number of countries represented in the corporate investment sample	20

*indicative; not all funding could be allocated by technology

7.1 PUBLIC INVESTMENT

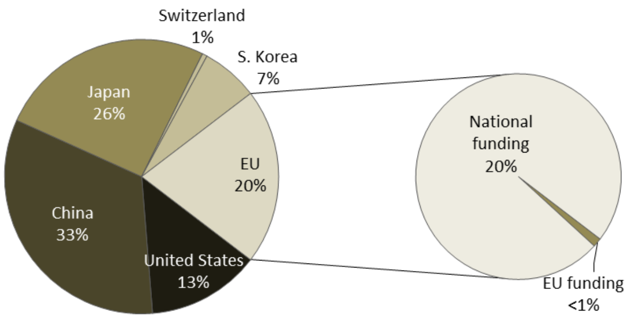


Figure 7.1: Distribution of global funding for energy storage technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

Many countries have shown policy support for the technology through "comprehensive market transformations, and mandates for energy storage projects". R&D activity concentrated primarily on cost reductions and on improving performance. Since 2009, China, Japan, South Korea, Germany and the US have supported targeted demonstration projects for electricity storage technologies, making 2011 a year of entry into either the construction or operational stage of several large projects [58]. In terms of absolute investment, China provided €93 million of public funding to energy storage R&D, more than any other country considered in this analysis. Despite a 30% reduction from 2010 levels, Japan has maintained its lead over both Europe and the US with a dedicated R&D expenditure of €73 million. The EU accounts for 20% of the public funding which, unlike other technologies is provided almost exclusively through national funding mechanisms (see Figure 7.1).

Within Europe (see Figure 7.2(a)), France leads in terms of public funding at the national level (€14 million), followed by Italy (€10 million). Germany, Spain, Denmark and the UK form a second distinct group in terms of the level of investment, contributing half as much as the leaders, and a difference of the same scale is observed for the next group of countries. Except France and Germany, most countries that provided a significant support to the sector increased R&D expenditure in comparison to 2010 levels. In the case of Spain the values reported show a sharp increase in 2011, with public support eight times higher than the year before (Figure 7.2(b)).

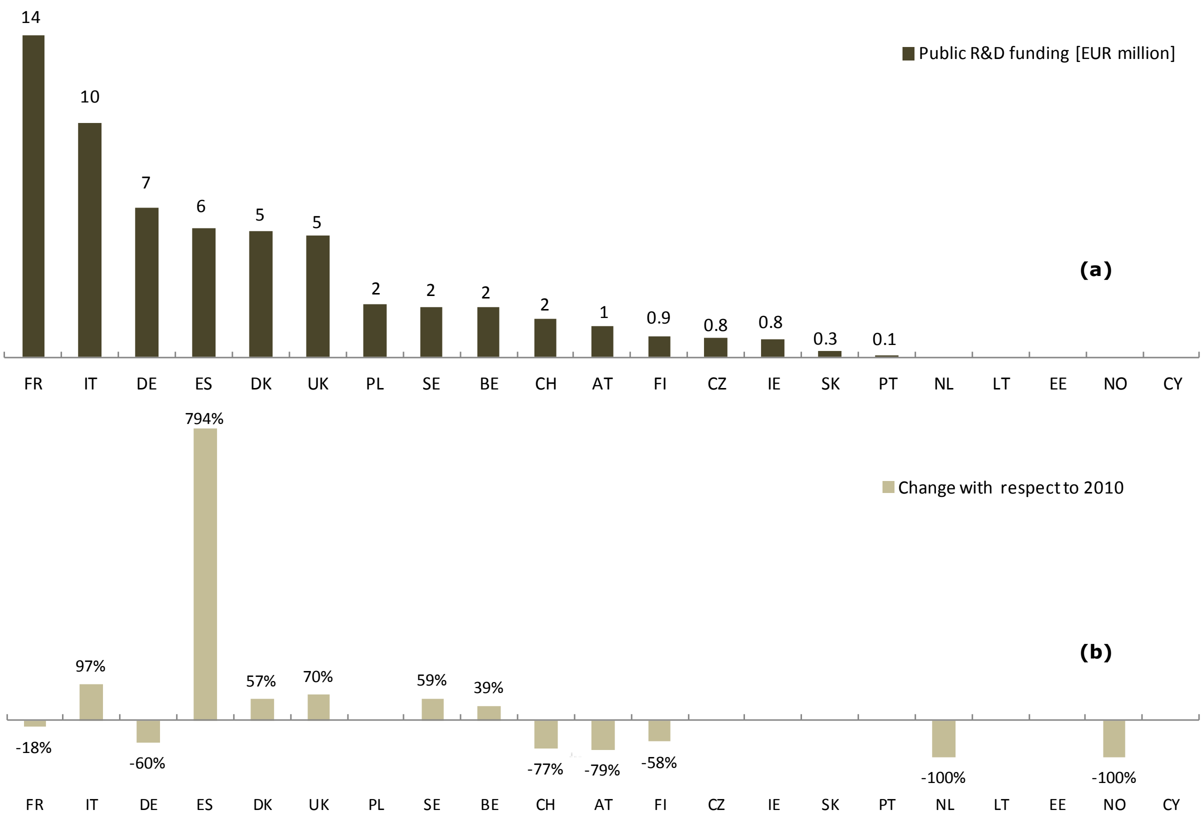


Figure 7.2: Public funding for energy storage technologies from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

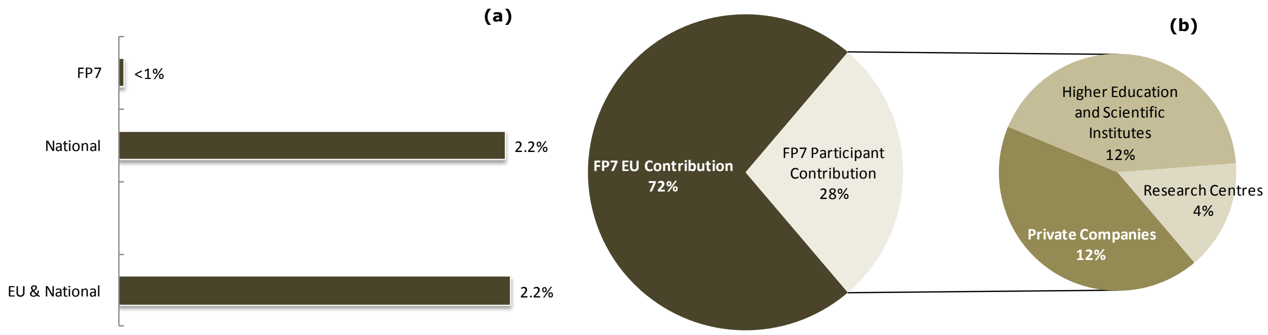


Figure 7.3: Indicative share of funds dedicated to storage in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: IEA [1], JRC [2, 3], Technopolis [29]

Increase was also observed in the funding available at EU-level. FP7 has disbursed €0.8 million to energy storage projects through its Energy Theme Line, which has attracted an additional €0.3 million from participating bodies, equally sourced through Higher Education, Scientific Institutes and, Private Companies as displayed in Figure 7.3(b). Part (a) of the same figure shows the relevant share of public investment in energy storage in the context of the total investment in the technologies considered in this report, which is low despite the increasing contributions both at EU and national level.

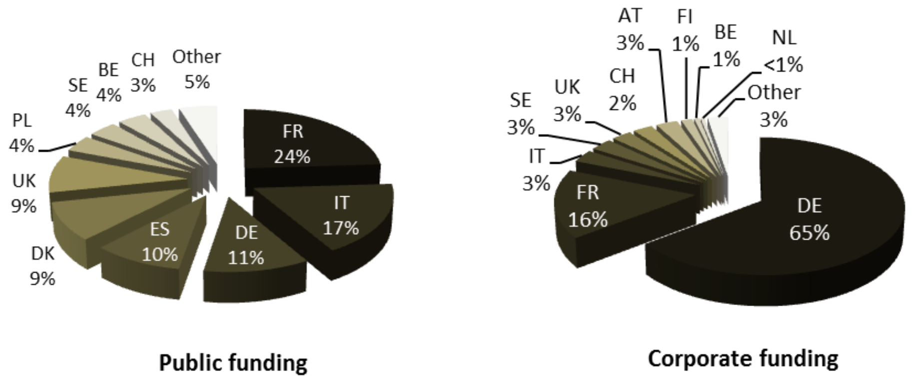


Figure 7.4: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in energy storage technologies for the year 2011. Data source: IEA [1], JRC [2, 3]

As discussed previously, France is the leading European investor at a national level, accounting for almost a quarter of the public investment in energy storage R&D, and also holds a significant position in terms of corporate investment, as the second highest contributor. Germany, Italy the UK, Sweden and Switzerland also figure in the top 10 for both public and corporate R&D investment. The relative contributions of the top ten investors for each sector are shown in Figure 7.4.

7.2 CORPORATE INVESTMENT

In the case of Germany, the corporate sector is much more active than public programmes in funding R&D in energy storage; as reflected in the sample of companies considered in the study (Figure 7.5). Investment form the business sector (a total of €1516 million) is much higher than public resources for the 10 top investors. Germany accounts for 65% of the corporate investment at European level, over three times as much as France which in the second highest contributor. The corporate investment for energy storage technologies estimated for 2011 is shown in Figure 7.6 according to the country where the respective companies where based.

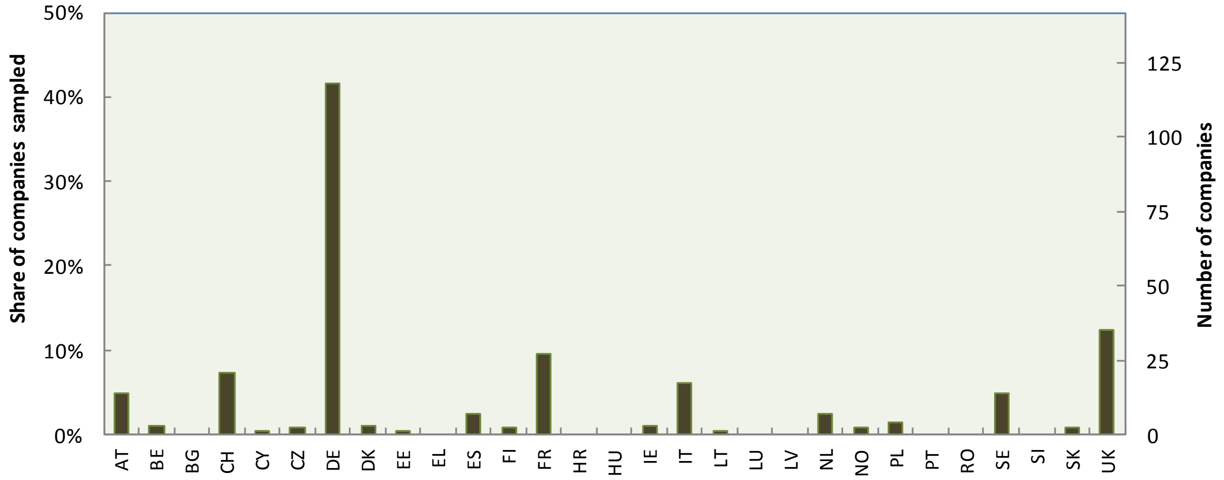


Figure 7.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

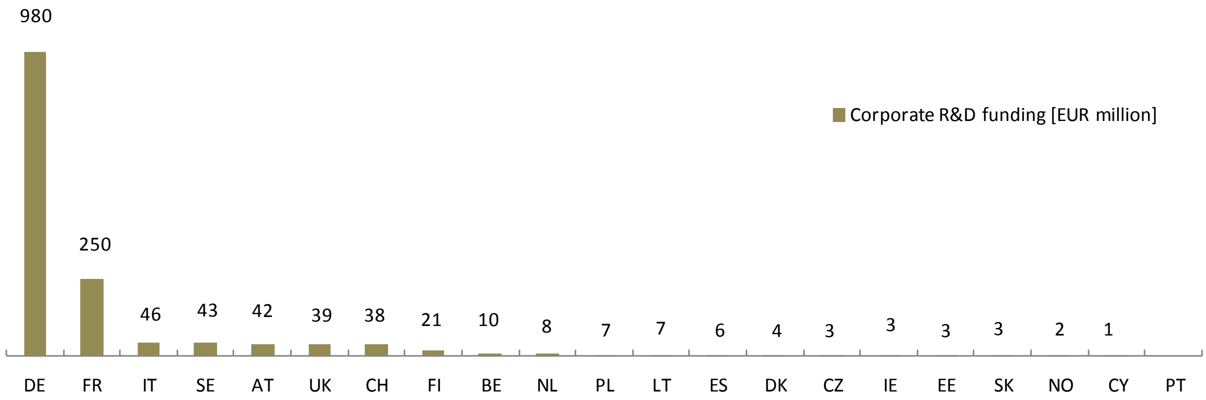


Figure 7.6: Leading countries for corporate R&D investment in CCS technologies in Europe. Data source: JRC [3].

The majority of companies included in the study were active in the area of battery R&D (90% of the total funds); this sub-sector also registers the highest average investment per company. German- and France- based firms dedicated 93% and 83% of their collective energy storage R&D budgets to battery research. Italy and Austria also had similar share of the corporate R&D budget directed at batteries, while almost the entire investment estimated for Sweden was aimed at the same topic. The remaining R&D topics as grouped in Figure 7.7 had much smaller representation in the sample and lower levels of average investment.

Over half of the corporate R&D funding for pressurised fluid storage (€45 million) originated from France; a quarter came from businesses based in Germany, with the UK, Switzerland, Italy and Denmark also participating in research in this field. In terms of the sector of activity of the investors, utility companies accounted for almost half the investment, the next notable sectors being energy firms and 'automobiles and parts' companies which contributed 10% and 9% of the funding in this topic respectively.

Research investment in capacitors (€80 million) had the major share of non-battery related energy storage investments. German and French investors were again prominent, along with Finland where the topic accounted for half the corporate energy storage R&D investment. Important investors in terms of sectors were companies active in automobile & parts (33%), industrial metals and mining (21%), and chemical companies (8%). Battery companies and pure (ultra) capacitors companies contributed a further 13% of the corporate R&D in this field.

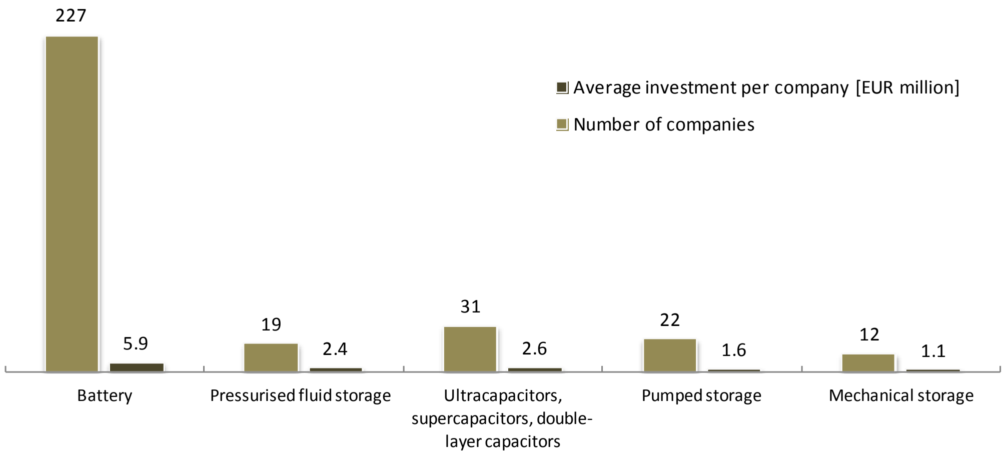


Figure 7.7: Number of companies investing in energy storage and average investment per company according to type of main activity in 2011. Data source: JRC [3].

Industrial engineering companies, in particular those involved in manufacturing hydraulic pumps, drilling and mining solutions, accounted for 50 % of research investments in pumped hydro storage (€25 million). Utility companies and energy companies had similar levels of research investments, on average approximately EUR 3.5-4 million each. Germany (€12 million) is by far the leader in corporate R&D in the field with the UK and Spain following at a third and a quarter of the level of investment respectively.

Mechanical storage only accounted for €14 million of the corporate investment, the majority of the funding for the development of flywheels originating in the automotive and transport sector, with contributions from energy and defence companies. Over 50% of the investment came from UK-based businesses, followed by German at less than half the level of investment.

7.3 TOTAL INVESTMENT

As discussed in the previous, corporate investment forms the main part of R&D funding for energy storage in Europe, the public contribution only accounting for 4% as shown in Figure 7.8. The EU level funding excluded is negligible.

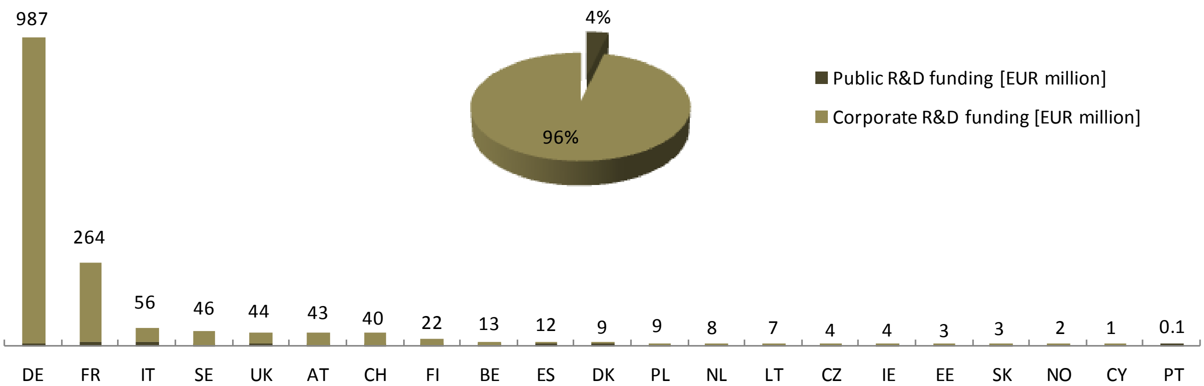


Figure 7.8: Leading European countries in terms of total R&D investment in energy storage. EU funding is excluded. Data source: IEA [1], JRC [2, 3].

Given the balance between public and private contributions in R&D funding it is to be expected that there would be very little association between the two as observed in Figure 7.9. In contrast, high association between total investment and GDP is shown in Figure 7.10 reflecting the impact of the macroeconomic environment on corporate R&D investment decisions.

Finally, the investment in R&D for storage technologies by the public and corporate sectors in Europe is mapped in Figure 7.11(a) and Figure 7.11(b) respectively, with the total displayed in Figure 7.12.

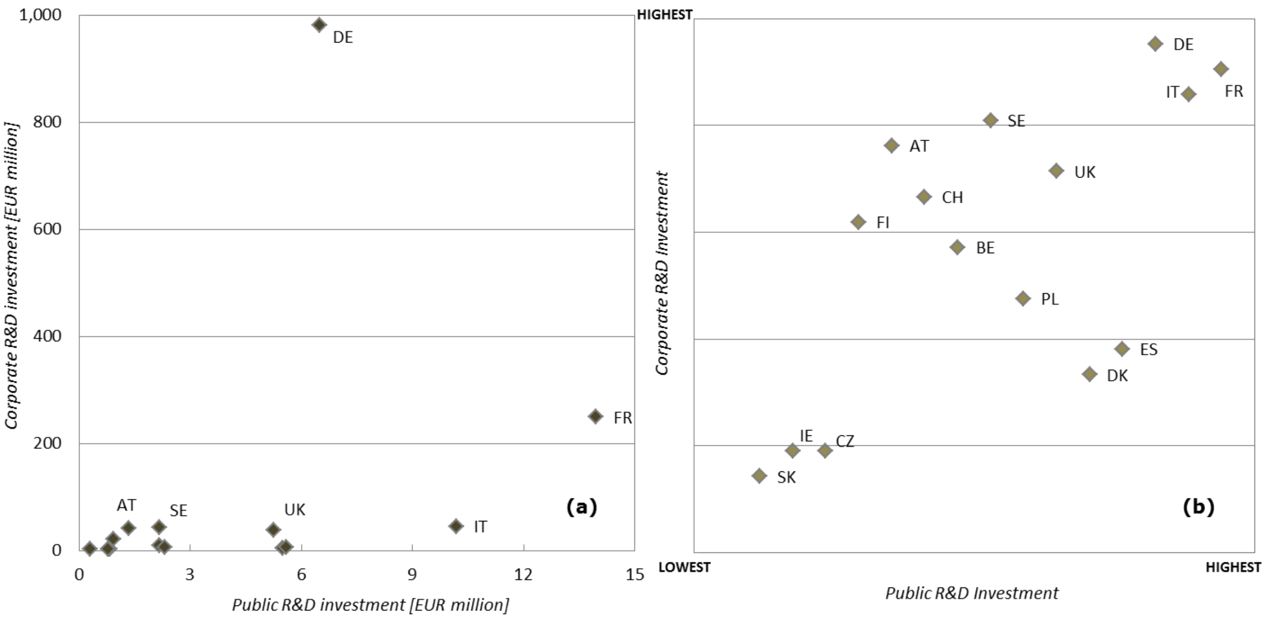


Figure 7.9: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in energy storage for the year 2011. Data source: IEA [1], JRC [2, 3].

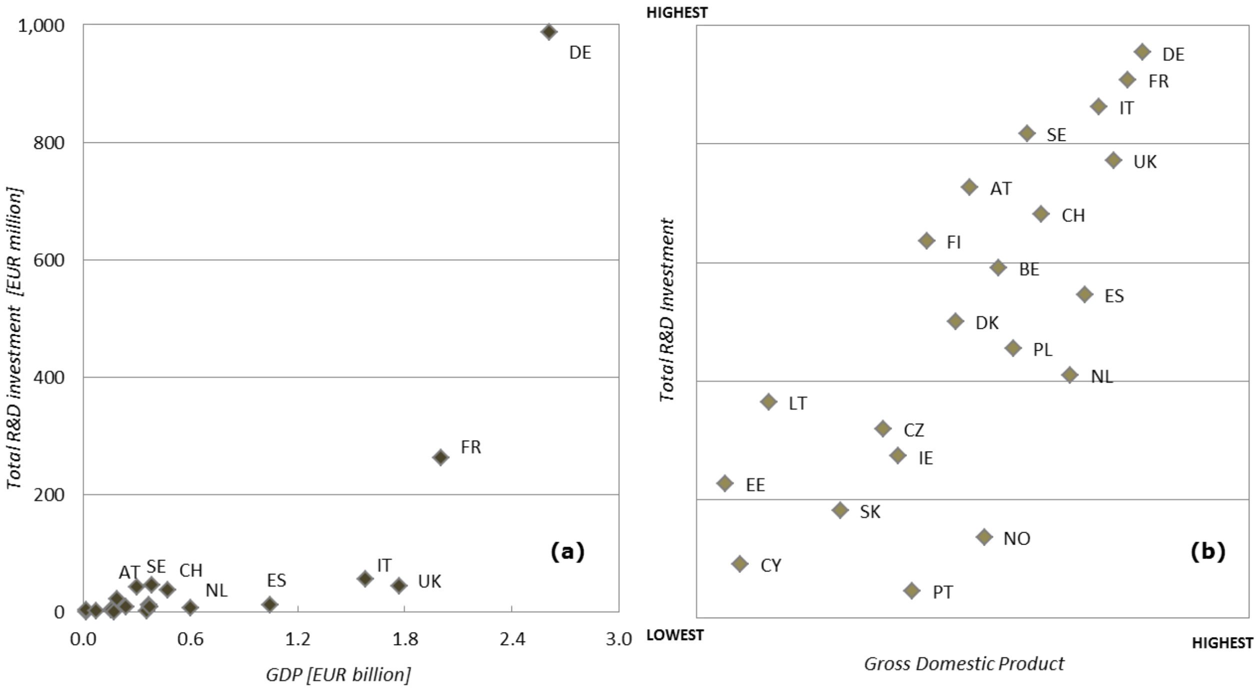


Figure 7.10: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in energy storage with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

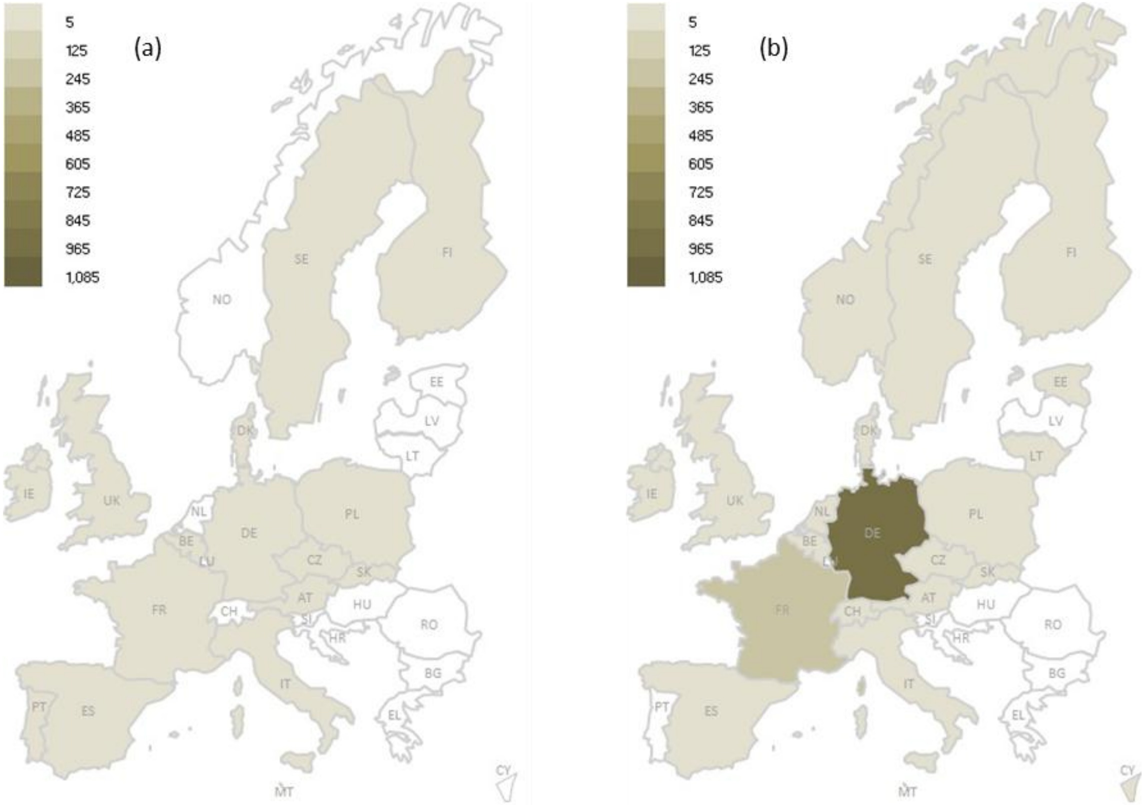


Figure 7.11: Maps of the public (a) and corporate (b) R&D investment in storage for the year 2011. Legend in EUR million.

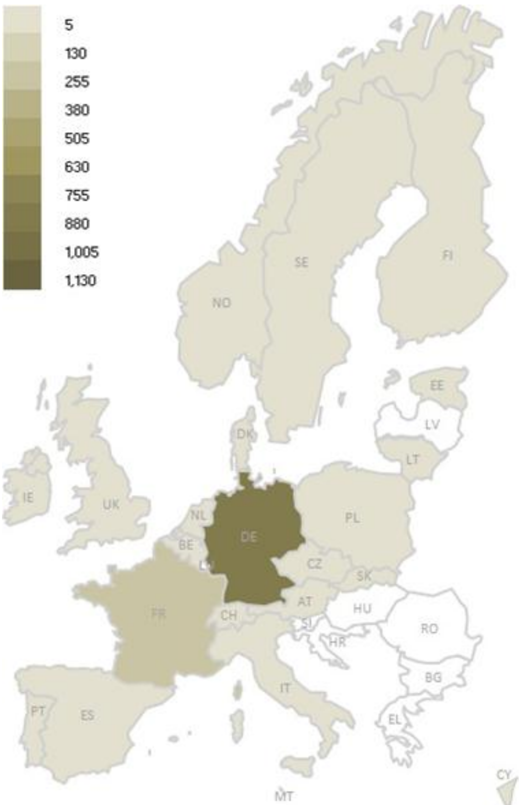


Figure 7.12: Map of the total R&D investment in storage in Europe for the year 2011. Legend in EUR million.

8 FUEL CELLS AND HYDROGEN

The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) has been one of the first Joint Technology Initiatives (JTI) of the European Union, established before the SET-Plan and its EIIs. It is a private-public partnership at European level, established in 2008 to develop and implement a targeted R&D and demonstration program with a total budget of EUR 940 million (up to 2013), 50% of which is contributed by the European Commission and 50% by the private sector. The FCH JU aims to accelerate the development and deployment of fuel cells and hydrogen technologies by executing an integrated European program of research and innovation activities.

Summary table – Energy storage R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 202 million
*Public funding available at EU level**	EUR 46 million
Corporate R&D Investment	EUR 463 million
Number of companies identified in the corporate investment sample	132
Number of countries represented in the corporate investment sample	18

*indicative; not all funding could be allocated by technology

8.1 PUBLIC INVESTMENT

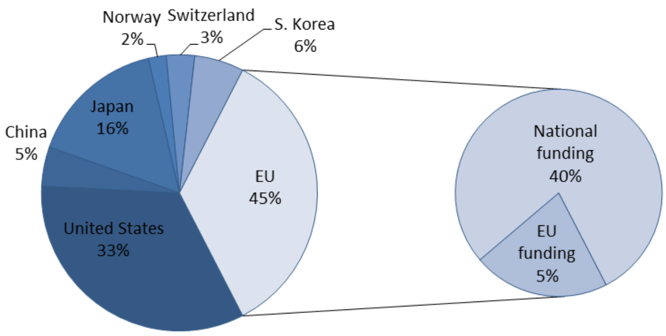
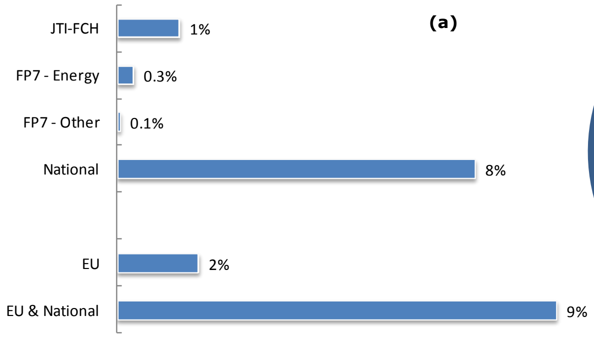


Figure 8.1: Distribution of global funding fuel cell & hydrogen technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

Commercially, 2011 was one of the most prosperous years in the history of FCH with a significant growth in shipments. Despite the gradual increase of successful demonstration and deployments projects in all areas of application, "continued R&D is still required to meet the long-term goals set" at global and national level [59]. In this sense, the priority has been to ensure that the sector makes a smooth transition from the research stage to the early market adoption stage. Financing has concentrated on four aspects: Hydrogen storage system cost reductions (US); fuel cell longevity/ durability advancements (EU); promoting infrastructure network expansion (US, EU, Japan and China); and on hydrogen generation from excess renewable energy (EU, South Korea) [40, 59-61].

EU has provided the highest share of support (45%) to the technology, equivalent to €215 million for the year 2011 (see Figure 8.1). The US is the second largest contributor, followed by Japan with just under half the level of investment. European funding came in its majority from national funding programmes, followed by the Joint Technology Initiative and the FP7. In addition to the Energy Theme Line of FP7, €1.6 million were granted by the EU to the "integration of the European R&D community around infrastructural elements that have the potential to facilitate and enhance the [...] outcome" of innovative activities in the fuel cell and hydrogen sector through the Capacities-Infrastructures theme line (see Figure 8.2). In contrast to other technologies, fuel cell and hydrogen research funding through FP7 attracted €3.7 million from the participants with an almost equal split between private companies, research centres and higher education / scientific institutes.

In terms of the 2011 European investment at a country level, as shown in Figure 8.3 the following are notable. Germany, a world leader in hydrogen station development, was surpassed in R&D investment by France, which, with near double the dedicated German funding, provided the largest European contribution to the technology (24% of the total). Scandinavian countries, which are leaders in the deployment of hydrogen fuelling stations, continue to contribute significantly to the sector, in line with their interest in storage and T&D grids.



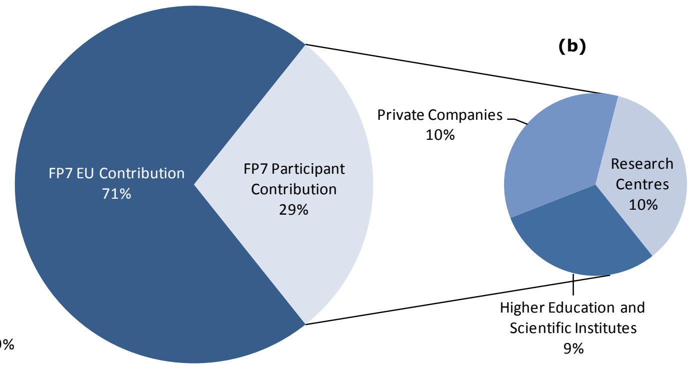
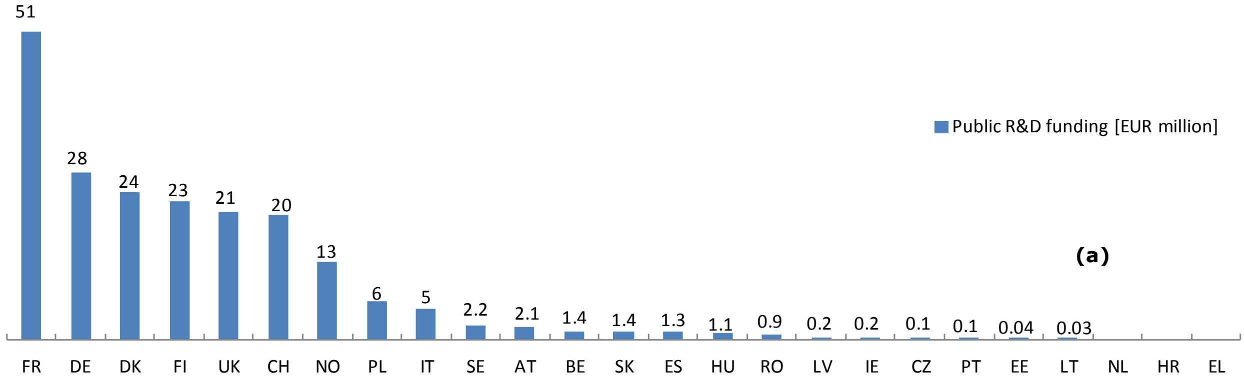


Figure 8.2: Indicative share of fuel cells & hydrogen in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: IEA [1], JRC [2, 3], Technopolis [29]



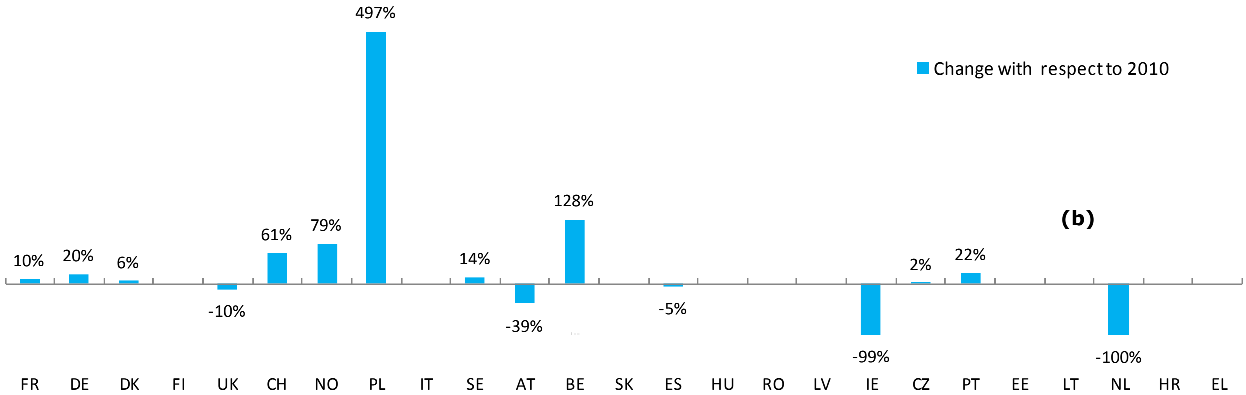


Figure 8.3: Public funding for fuel cell & hydrogen R&D from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

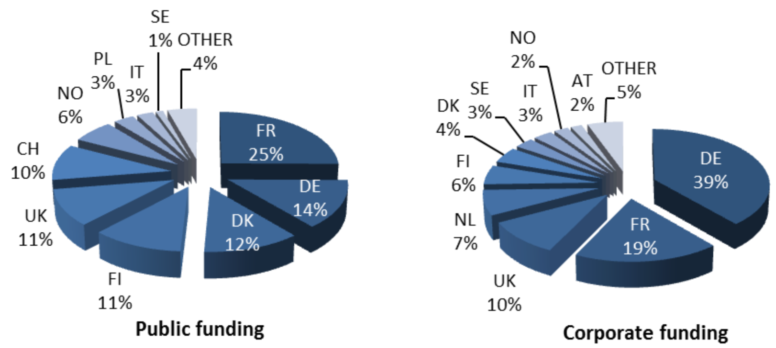


Figure 8.4: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in fuel cells and hydrogen technologies for the year 2011. Data source: IEA [1], JRC [2, 3].

National funding for fuel cell and hydrogen R&D is rather concentrated, with six countries accounting for 83% of the total as shown in Figure 8.4. The two major contributors remain the same in the case of corporate funding and command an even higher overall share of the expenditure than in the case of public funding; the remaining investors however are more equally distributed in terms of the country of origin.

8.2 CORPORATE INVESTMENT

Corporate research investments in fuel cells and hydrogen technologies (hydrogen production only) for the year 2011 were estimated to €463 million. The assessment took into account 132 companies across 18 countries as displayed in Figure 8.5. The majority of the companies identified are based in Germany, twice as many as France which has the second largest concentration. In the Northern Europe, important financial contributions to R&D come from suppliers of fuel cell components for automotive and stationary applications as well as companies dealing purely with fuel cells. In France, there is lesser representation of the automobile industry among large investors and higher commitment from chemical companies and utilities and oil & gas suppliers.

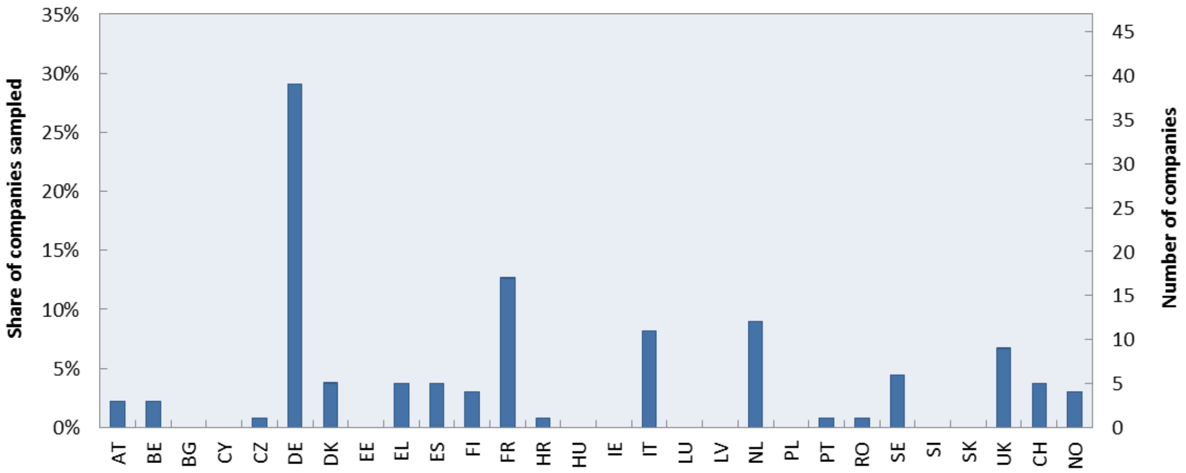


Figure 8.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

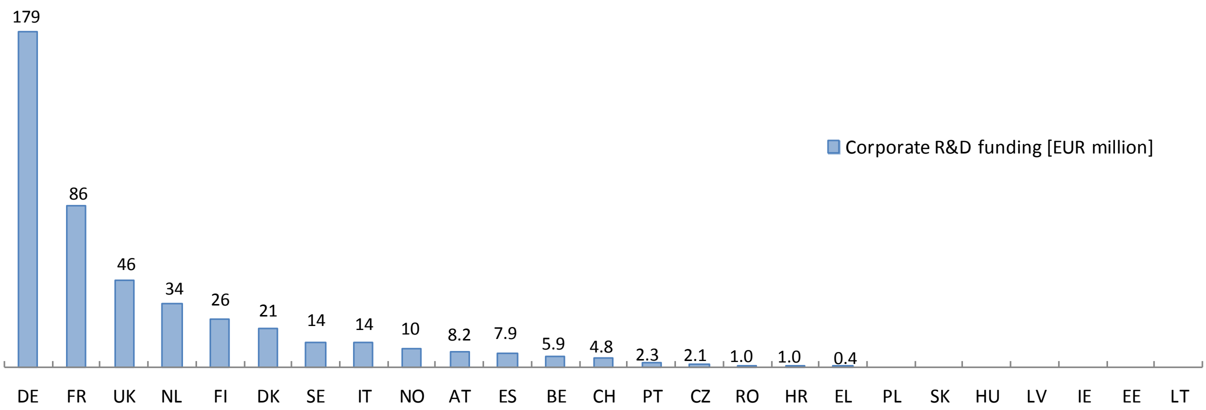


Figure 8.6: Leading countries for corporate R&D investment in fuel cells and hydrogen in Europe for the year 2011. Data source:, JRC [3].

Figure 8.7 shows a division of investments according to the area of activity of the R&D. Most corporate research focused exclusively on the development of fuel cell technology. A smaller number of companies invested in both hydrogen and fuel cell technologies (accounting for 18 % of the corporate investment in the field), while about one in six of the companies identified was only active in hydrogen production R&D. As previously mentioned, much of the corporate research effort for the development of fuel cell technology is concentrated in the German automotive industry. In France, companies have focused on the production of hydrogen and electricity from natural gas and Italian and Dutch companies active in gas production are also manifesting interest in the development of hydrogen production technology.

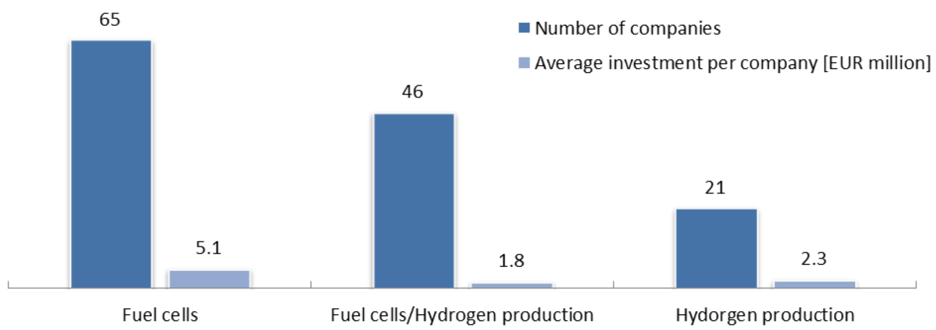


Figure 8.7: Split of corporate R&D activity between fuel cells, hydrogen or joint research in both. Number of companies active in each field, and average investment estimated per company for 2011. Data source: JRC [3].

8.3 TOTAL INVESTMENT

Corporate investment makes up 70% of the R&D funding available for these technologies as displayed in Figure 8.8. The balance of private to public funding differs across the leading investors; Denmark Finland and France have much higher contributions in public funding than the one stated above, while in the UK and in the Netherlands funding sources are exclusively from the business sector.

Nonetheless, for the countries where funding is contributed from both sources there seems to be a positive correlation between the two as shown in Figure 8.9. The implementation of public programs for hydrogen and fuel cell technologies, such as the ones in place in Germany and Finland have contributed to the mobilisation of private funding. In Germany, industry is estimated to have contributed €70 million annually in response to public initiatives, while in the case of Finland, the National program for fuel cells mobilised an additional €30 million of funding.

A relatively high association is also observed between total investment and GDP is shown in Figure 8.10. Given the important role of corporate investments in the overall funding for R&D in fuel cells and hydrogen this reflects the impact of the macroeconomic environment on corporate investment decisions. Notable exceptions here are Denmark and Finland; as discussed earlier the continuous interest in these technologies falls within a greater energy policy context for these countries, and as such also receives higher public support compared to the remaining investors. It is also apparent that countries with struggling economies are not able to follow the same investment trend as dictated by the GDP.

Figure 8.11(a), Figure 8.11(b) and Figure 8.12 show maps of public, corporate and total R&D investments respectively, with reference to fuel cell and hydrogen technologies for the year 2011.

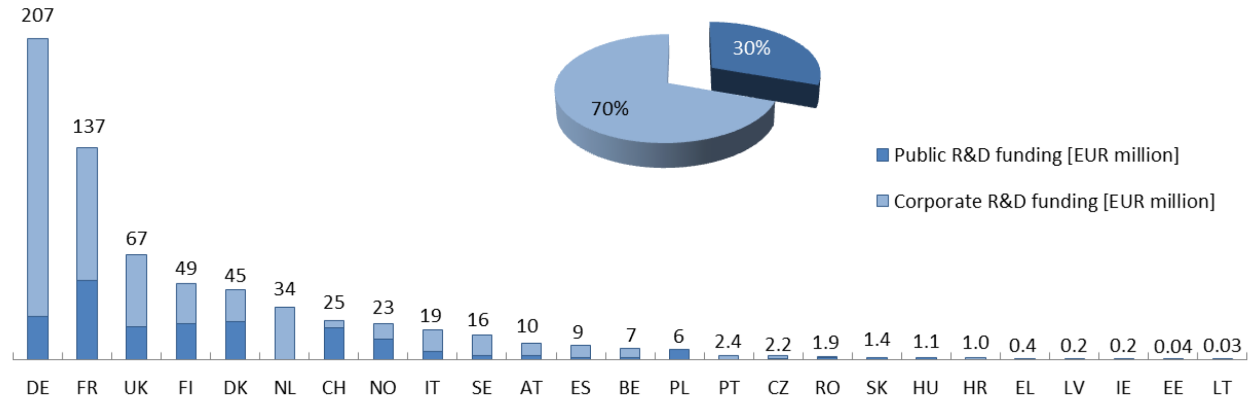


Figure 8.8: Leading European countries in terms of total R&D investment in fuel cells and hydrogen. EU funding is excluded. Data source: IEA [1], JRC [2, 3].

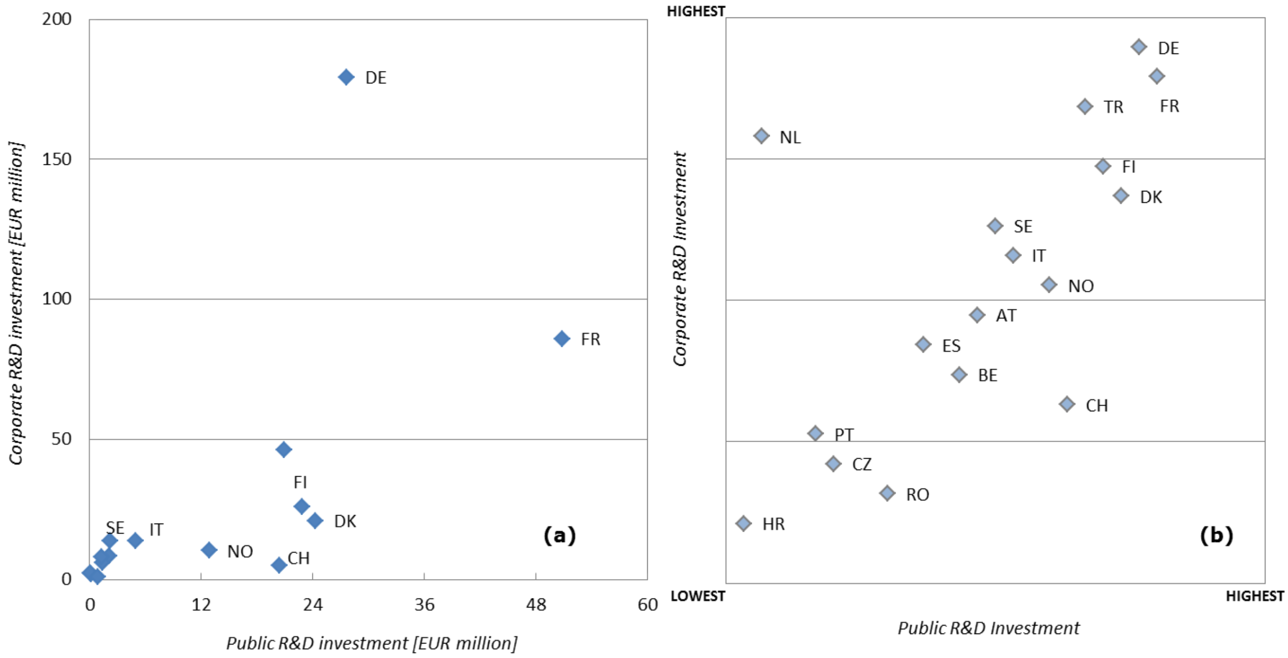


Figure 8.9: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in fuel cells and hydrogen for the year 2011. Data source: IEA [1], JRC [2, 3].

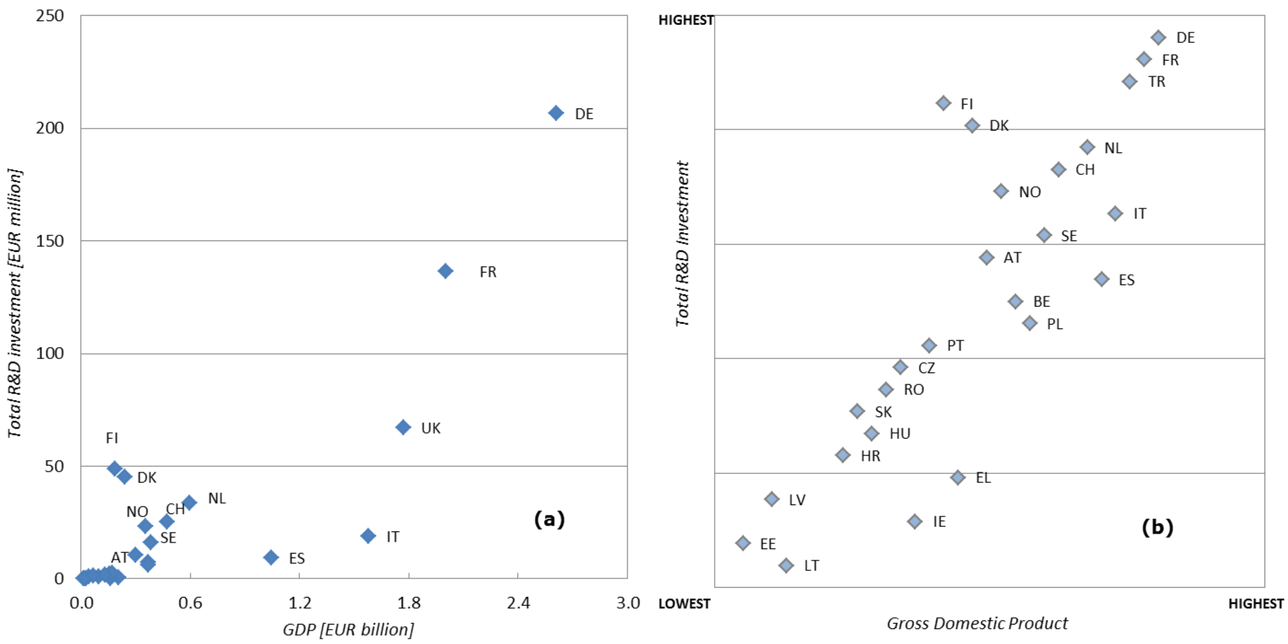


Figure 8.10: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in fuel cells and hydrogen with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

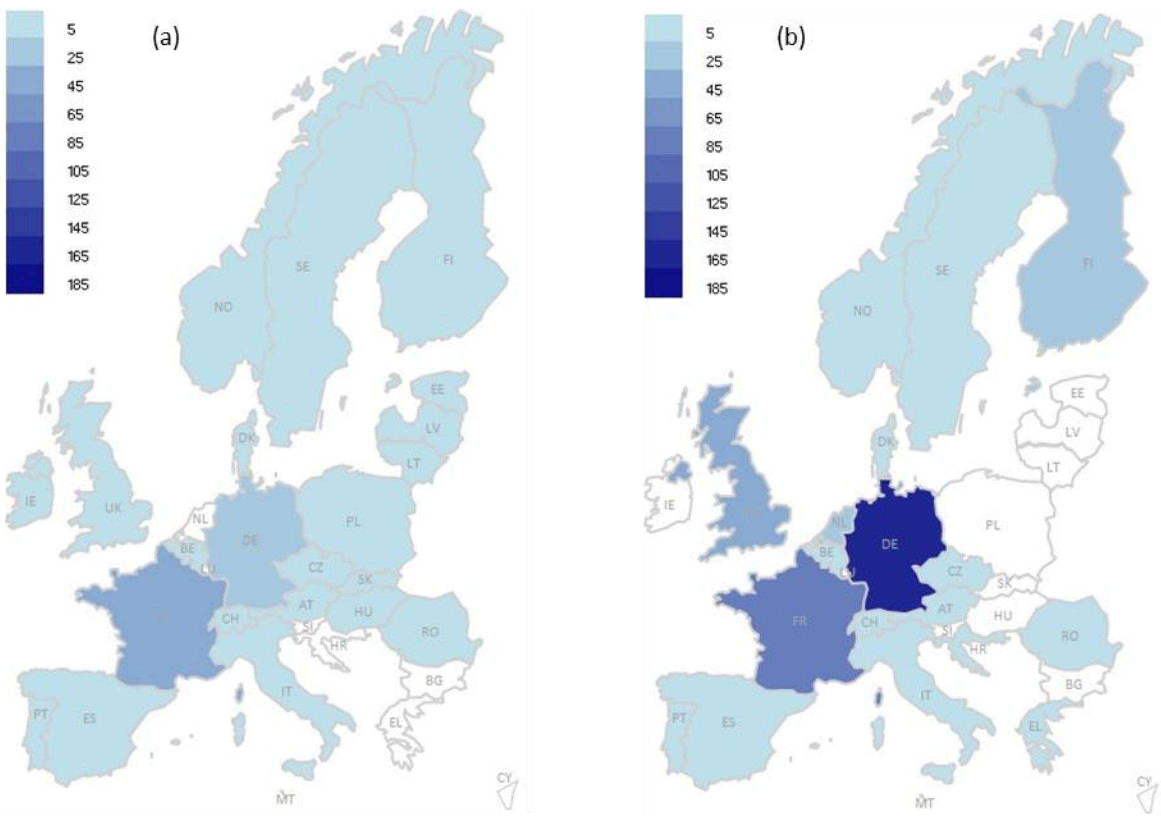


Figure 8.11: Maps of the public (a) and corporate (b) R&D investment in fuel cells & hydrogen in 2011. Legend in EUR million.

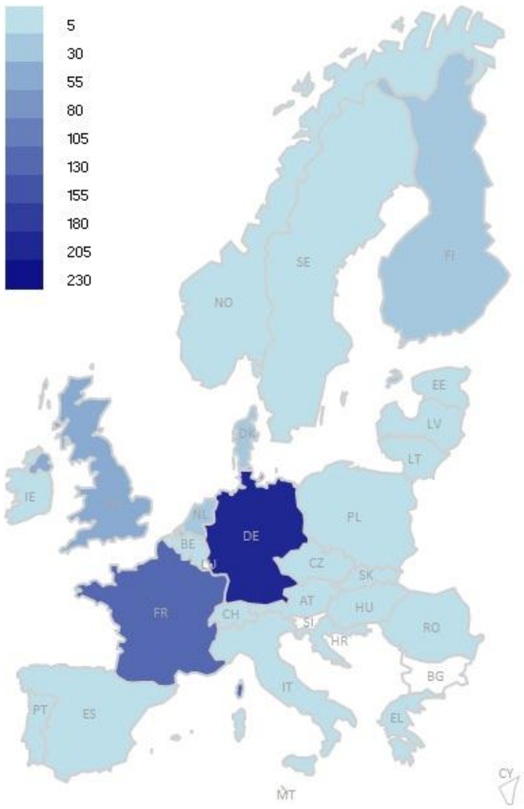


Figure 8.12: Map of the total R&D investment in fuel cells & hydrogen in Europe for the year 2011. Legend in EUR million.

9 NUCLEAR FISSION

The year 2011 was marked by the events at Fukushima, which had a major impact on the nuclear sector in a number of countries. However, even before Fukushima, it was remarked that "the long-awaited nuclear renaissance in the West seemed to be running out of steam" [62]. In 2011, only 7 reactors started up, while 19 were shut down. After the slow, gradual increase of the previous 5 years, in the period 2010-2011 the global industrial investment experienced a sharp decline of approx. 85%, mainly attributed to China which accounted for almost 40% of the reactors under-construction worldwide [63].

Summary table – Electricity Grids R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 690 million
*Public funding available at EU level**	EUR 28 million
Corporate R&D Investment	EUR 495 million
Number of companies identified in the corporate investment sample	96
Number of countries represented in the corporate investment sample	16

*indicative; not all funding could be allocated by technology

9.1 PUBLIC INVESTMENT

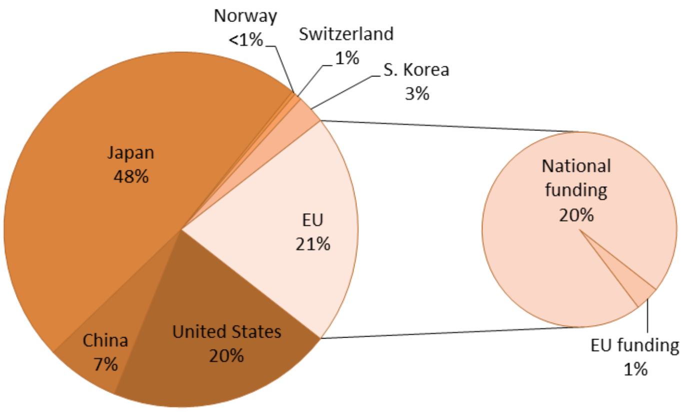


Figure 9.1: Distribution of global funding for nuclear fission based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

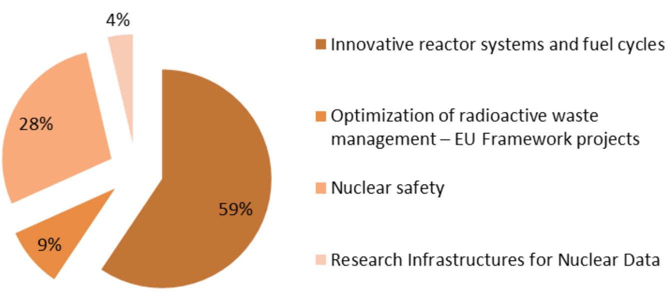


Figure 9.2: Priorities in EU funding for Generation IV reactor research. Data source: JRC [2, 3]

Since the global figures for public R&D investment in 2010 do not include China, it is not possible to judge if the drop in industrial investment was accompanied by a decrease in the public R&D funds. Japan, who is the major investor in the field, reduced the funds dedicated to the technology by 28%, but at near €1.6 billion, their R&D budget still accounts for almost half of the total investments as included in this report. EU public investment in nuclear fission R&D increased by 9% from 2010 values, making it the second largest investor slightly ahead of the US (see Figure 9.1). As shown in Figure 9.3(a), just over a quarter of the total R&D funding for the technologies examined in this report is dedicated to nuclear fission. The majority of the funding comes from national programmes. FP7/EURATOM contributed €28 million (4% of European funding), distributed to participants.as shown in Figure 9.3 (b). The priorities in EU funding for R&D are displayed in Figure 9.2. Innovative reactor systems and fuels are the dominant topic for Generation IV reactors, while a significant part of the budget is also dedicated to nuclear safety.

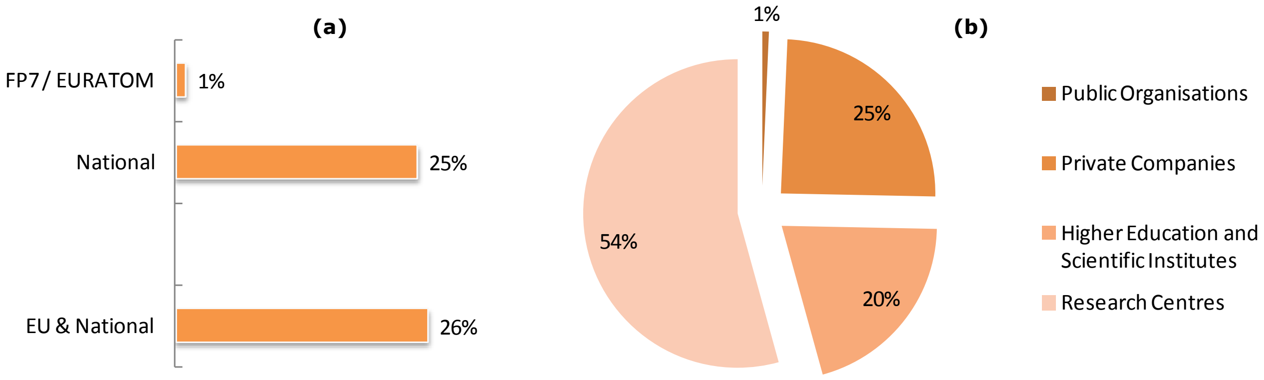


Figure 9.3: Indicative share of nuclear fission in the total public funding available for energy technologies as calculated in this report (a) and share of FP7/EURATOM funding by type of participant (b) for 2011. Data source: IEA [1], JRC [2, 3], Technopolis [29]

As displayed in Figure 9.4, France has maintained its leadership in supporting the technology, providing 64% (Figure 9.5) of the European funding; the second largest contributor (Germany) dedicated less than a sixth of the French budget to the technology. Variation of public R&D funding from 2010 to 2011 is small for the top 5 investors; however, a large increase is observed for Finland and considerable decreases for Sweden, Spain, Austria and Denmark. Sweden and Spain still maintained considerable R&D contributions through the corporate sector, where France is also matched by Germany in terms of the funding dedicated to nuclear fission technology (see Figure 9.5). Corporate investment is further analysed in the following section.

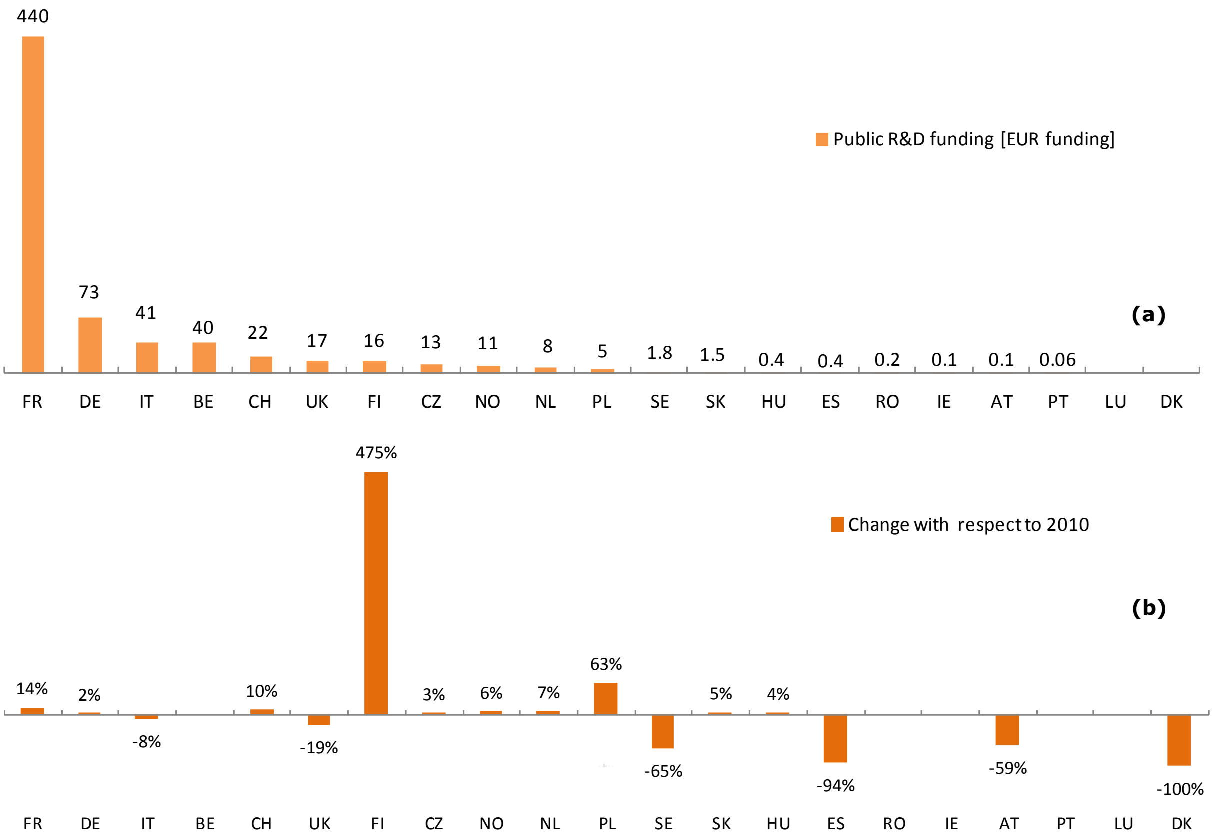


Figure 9.4: Public funding from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

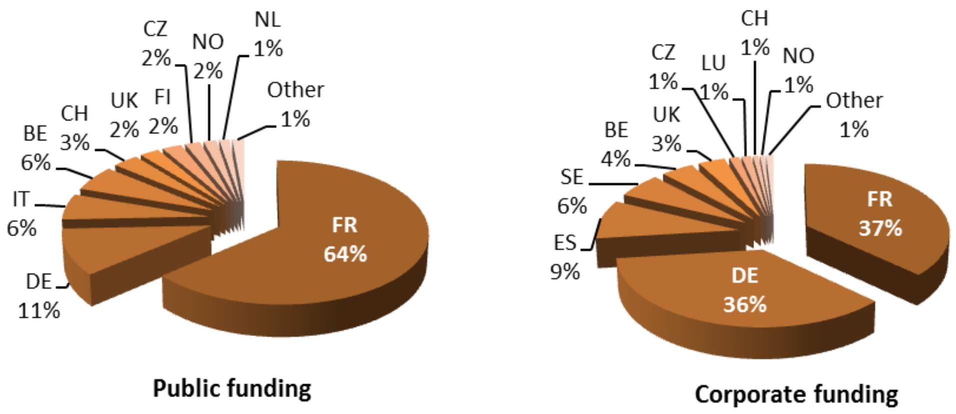


Figure 9.5: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in electricity grids for the year 2011. Data source: IEA [1], JRC [2, 3]

9.2 CORPORATE INVESTMENT

Corporate investment in nuclear technology was 31% lower in 2011 compared to 2010 levels. Most of the difference is due to the change in the investment levels of large energy companies. The long term investment decisions of large power companies with regards to nuclear energy are difficult to account for with the present methodology. It could be argued that for high capital cost technologies, such as nuclear, a longer timeframe of analysis might better reflect variations in corporate R&D investment. However, Fukushima and the related nuclear energy policy debates could equally have had an effect on R&D decisions for this particular year. While it is difficult to dissociate decommissioning decisions for the nuclear power plant fleet in Germany from the 26% drop in corporate R&D investment originating in the same country, it should be noted that many nuclear companies had initiated portfolio diversifications (including the development of renewable technologies) at a much earlier date.

Figure 9.6 shows the geographical distribution of companies included in the present study for the estimation of corporate investment in nuclear fission; the level of investment per country is shown in Figure 9.7. France and Germany lead, providing between them 73% of the corporate investment in Europe.

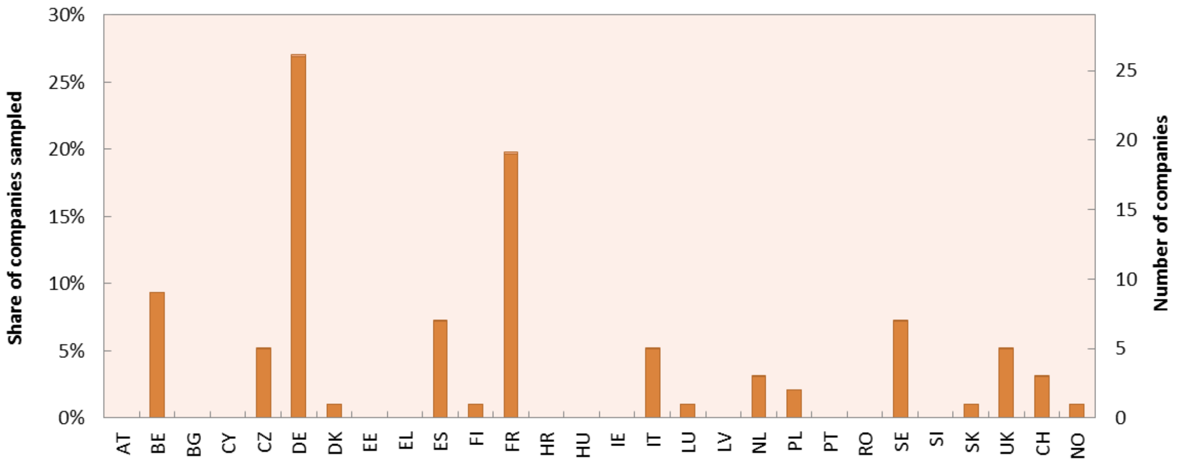


Figure 9.6: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

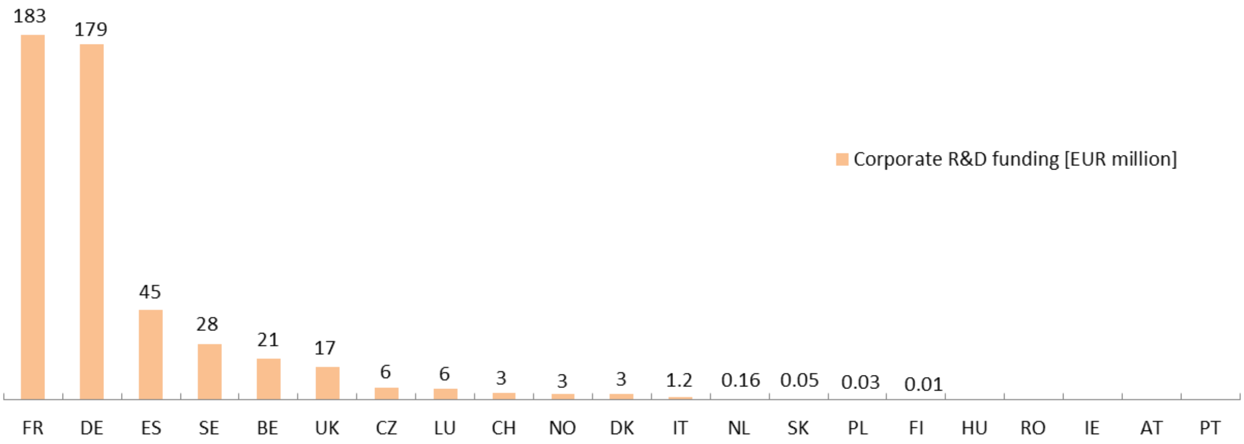


Figure 9.7: Leading countries for corporate R&D investment in nuclear fission in Europe for the year 2011. Data source:, JRC [3].

9.3 TOTAL INVESTMENT

Unlike other established technologies, in the case of nuclear the corporate sector has not taken over the majority of R&D effort, which is still shared with national programmes and relies on public funding more than half of the total R&D budget. The balance of public and private resources at country level and for the total funding at European level is shown in Figure 9.8. While there seems to be some association between the two for a number of countries, there are others that seem to maintain R&D activities in this technology based purely on one or the other funding source (see Figure 9.9). The association between R&D spending and GDP is also weak (see Figure 9.10). These results are to be expected to a certain extent, as this is a technology much dependent on policy decisions and a pre-existing tradition in the industry, as well as one that requires high capital expenditure and long term commitment. Countries that have entered the industry and have made this commitment – as expressed through the installed capacity for nuclear electricity generation – continue to support R&D in the field to a proportional level as show in Figure 9.11.

The public, corporate and total investments in nuclear fission in Europe for 2011 are mapped in Figure 9.12 and Figure 9.13.

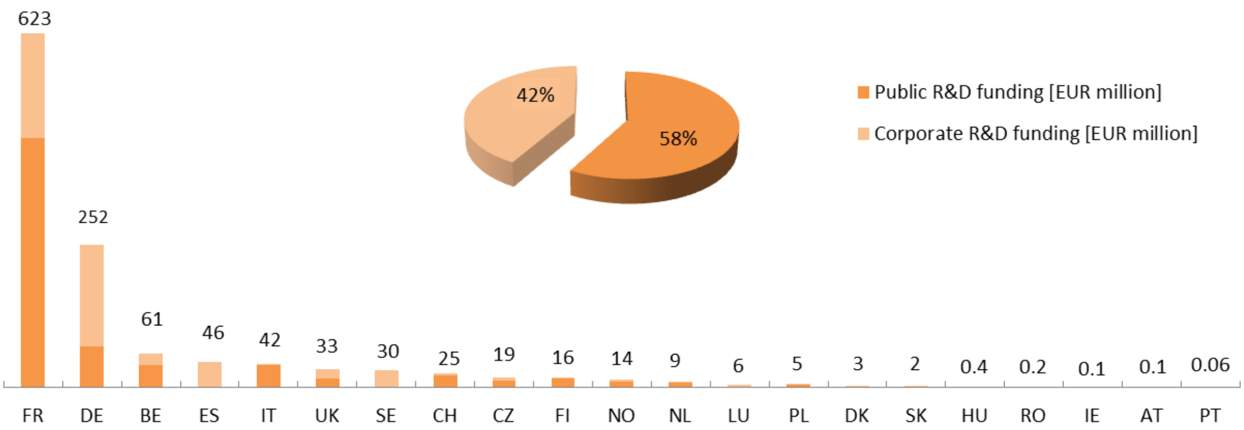


Figure 9.8: Leading European countries in terms of total R&D investment in nuclear fission. EU funding is excluded. Data source: IEA [1], JRC [2, 3].

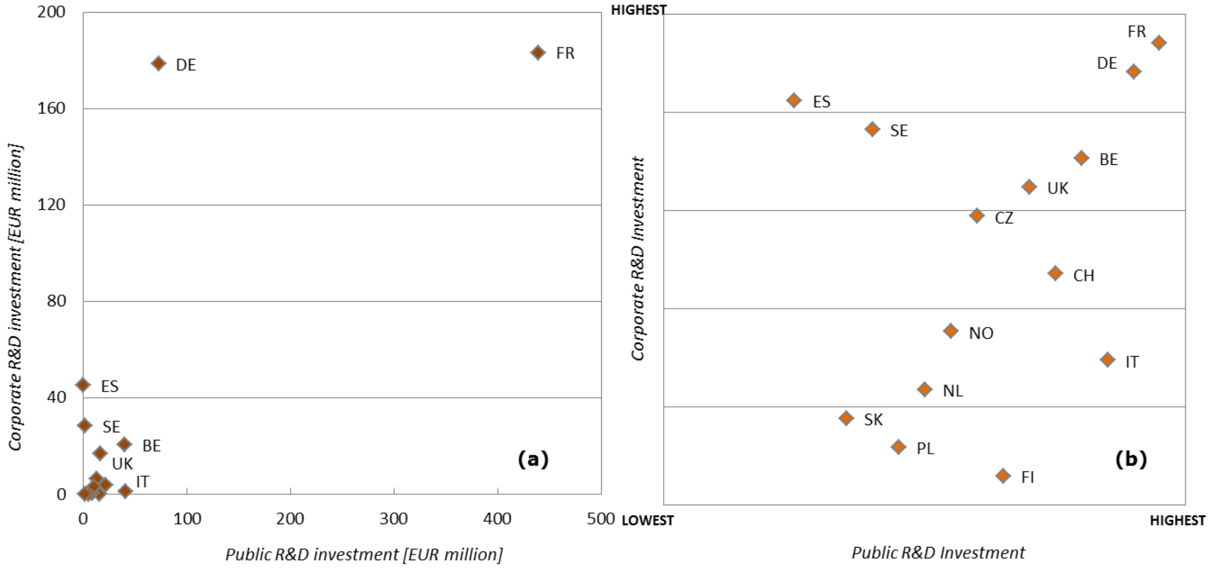


Figure 9.9: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in nuclear fission for the year 2011. Data source IEA [1], JRC [2, 3].

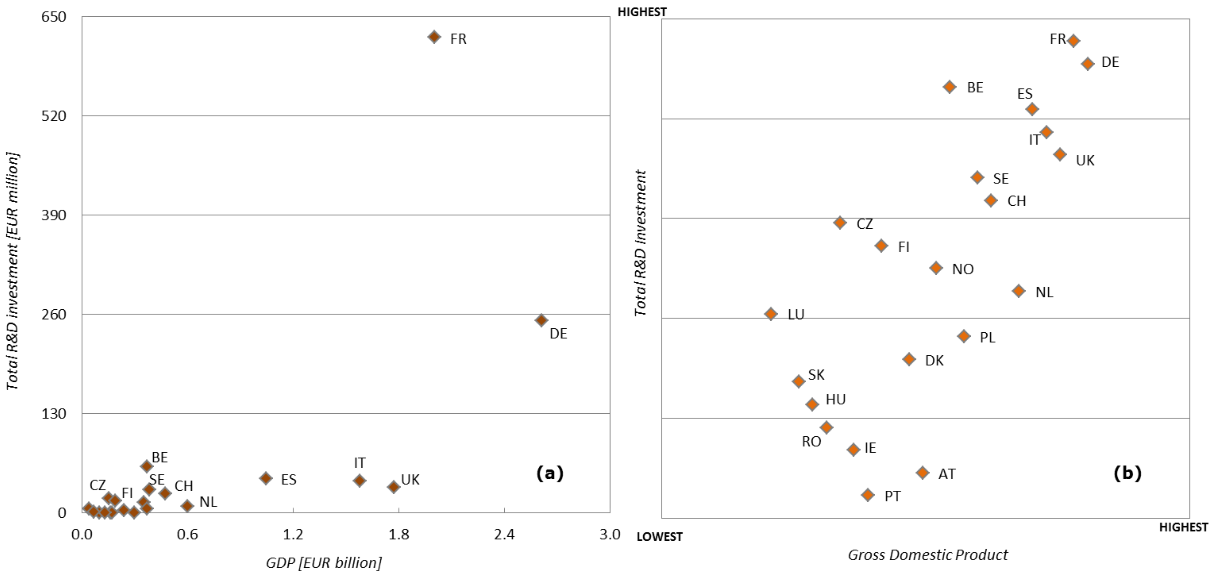


Figure 9.10: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in nuclear fission with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

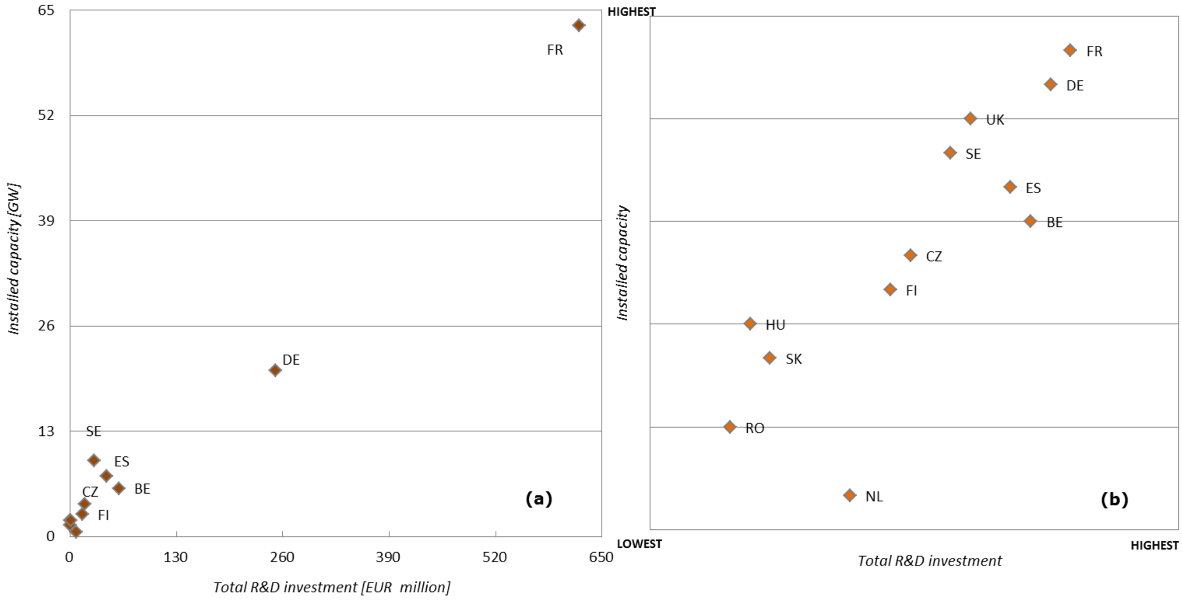


Figure 9.11: Absolute figures and relative ranking of European countries in terms of R&D investment against primary energy production from bioenergy. Data source: Eurostat [64], IEA [1], JRC [2, 3].

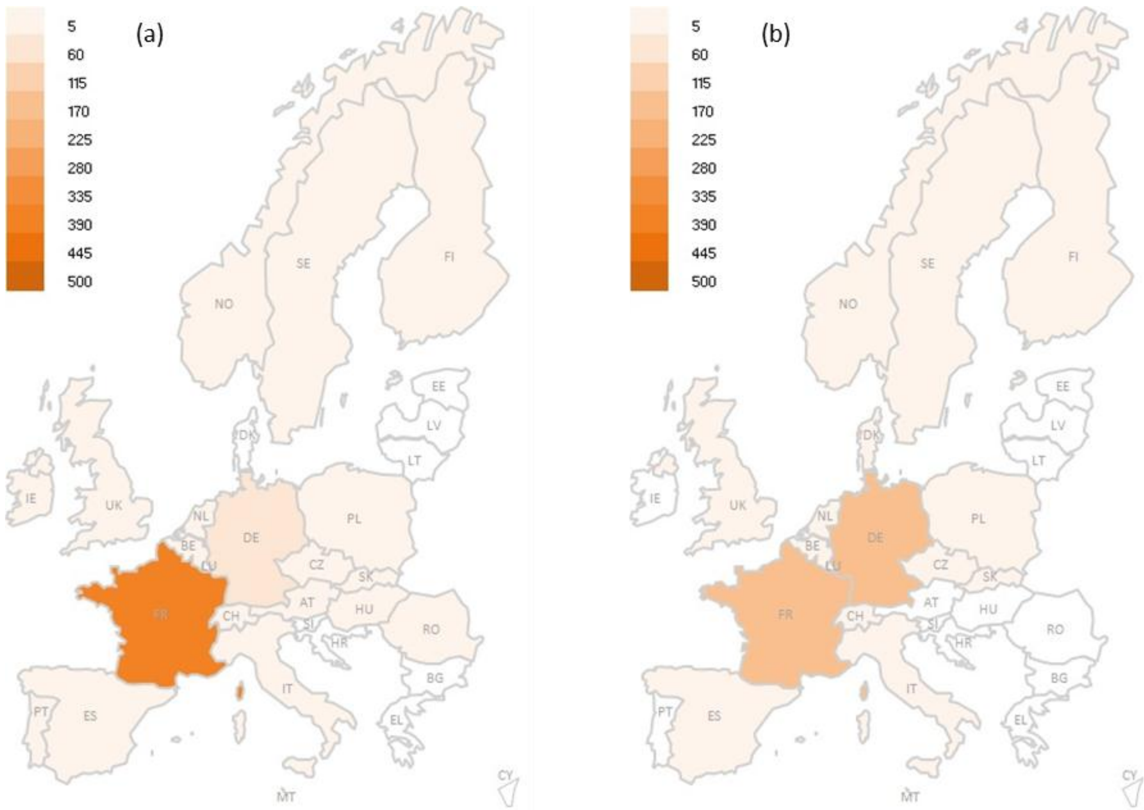


Figure 9.12: Maps of the public (a) and corporate (b) R&D investment in nuclear energy in 2011. Legend in EUR million.

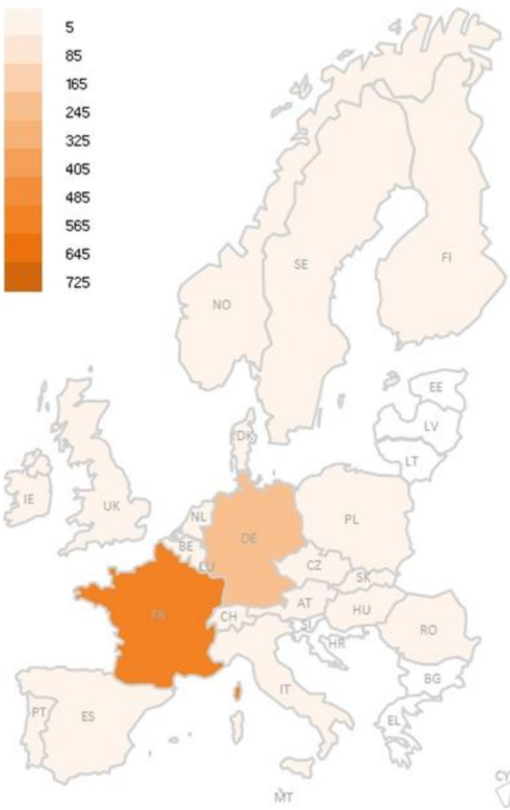


Figure 9.13: : Map of the total R&D investment in nuclear energy in Europe for the year 2011. Legend in EUR million

10 OCEAN ENERGY

Summary table – Ocean Energy R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 39 million
*Public funding available at EU level**	EUR 8 million
Corporate R&D Investment	EUR 60 million
Number of companies in the corporate investment sample	65
Number of countries represented in the corporate investment sample	10

*indicative; not all funding could be allocated by technology

10.1 PUBLIC INVESTMENT

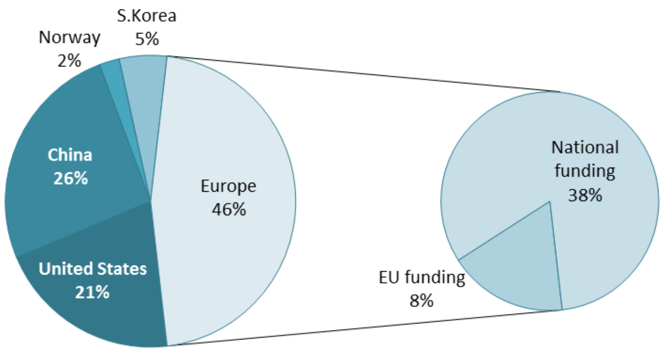


Figure 10.1: Distribution of global funding for ocean energy technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

Ocean energy, be it tidal, wave, thermal or salinity gradient technology-based, has had an accelerated development in the last years.

Reflecting an increased commitment to the development of the technology, the public investment in wave and tidal related projects had increased tenfold in the last 10 years. Most of this increase occurs in the last three years and mirrors a mix of prior involvements (taking place in the United Kingdom and Norway), as well as new entries in the industry such as projects developed in France and Sweden. The public sector and universities play an important role in this process through academic spin-offs and start-up companies.

With a public R&D spending of more than €45 million (46% of the global investments) in 2011, the EU leads the field in ocean energy technology research, other major public investors being China and the US. With highly favourable geographical conditions, South Korea is dedicating significant public funds to the R&D of ocean energy technologies with a strong focus on tidal range power (see Figure 10.1).

UK, Sweden, France and Ireland, countries with significant resources in marine energy, are the key European investors in the sector; together they account for 83% of European public R&D investment (see Figure 10.2, Figure 10.3). UK, the third global player in terms of public R&D investment (€12.4 million in 2011), launched in 2011 two large programmes through which it is dedicating substantial funds to accelerate "the development of multiple-unit wave and tidal farms" [65-67]. Sweden, the second largest European investor, has provided €7.6 million of funding for the development of ocean technologies in 2011, while all other significant investors like France (€7 million), Ireland (€5.4 million) and Norway (€2.2 million) in 2011 increased their investment in the sector compared to 2010 levels. The Irish government has supplemented its financial efforts by focusing attention on the simplification and acceleration of the foreshore licensing process, to enable a speedy development and deployment of the technology [65],[68].

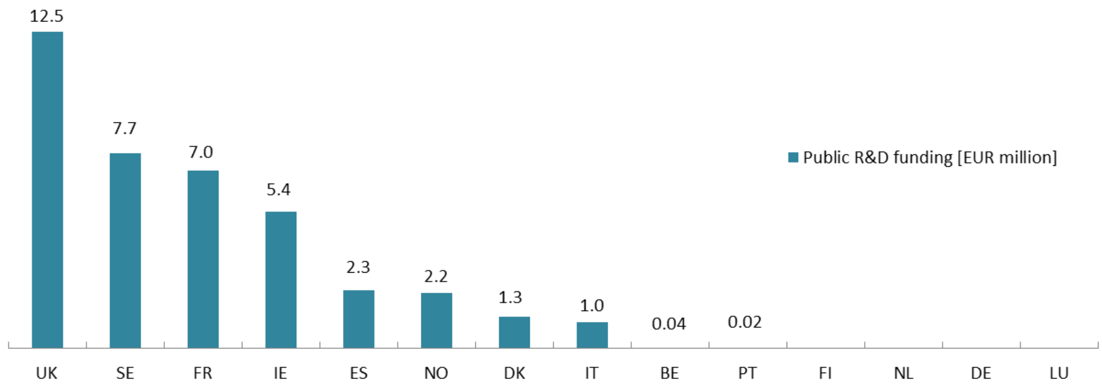


Figure 10.2: Public funding for ocean energy R&D from national sources in Europe for the year 2011. Data source: IEA [1], JRC [2]

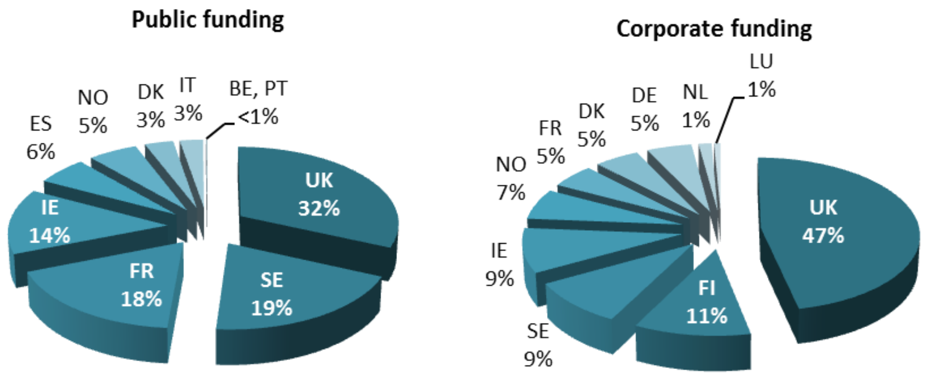


Figure 10.3: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in ocean energy technologies for the year 2011. Data source IEA [1], JRC [2, 3]

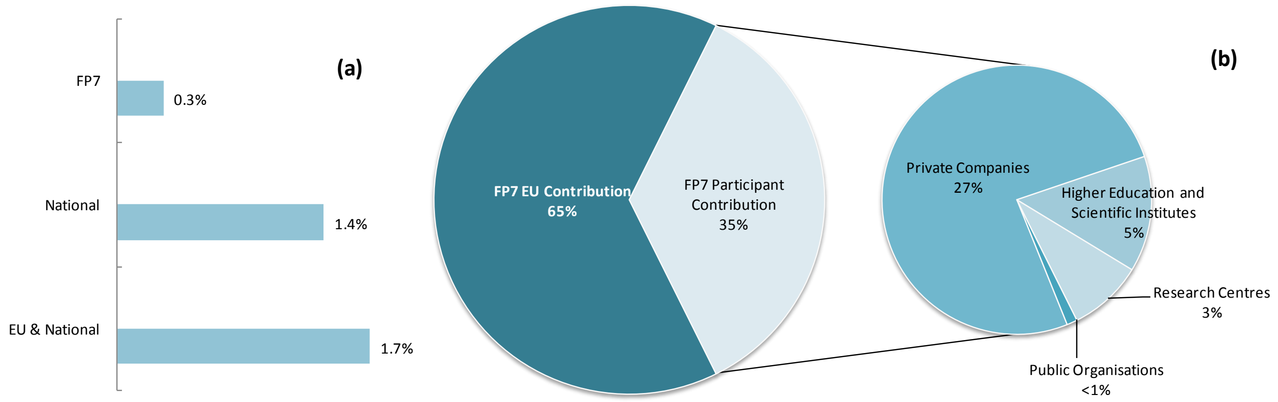


Figure 10.4: Indicative share of ocean energy in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: IEA [1], JRC [2], Technopolis [29]

Few other European countries have provided support to ocean energy R&D. Denmark, Italy, Belgium and Portugal are the remaining countries who made public investments in the technology in 2011, but their collective contribution came to less than 8% to public investment at European level. In 2011, the Danish government has initiated a new strategy for the development of wave energy [65, 66].

In terms of EU funding, in 2011 FP7 has contributed €8.2 million to ocean energy projects, raising an additional €4.5 million in participant contributions. Most of the additional funds were contributed by private companies, while higher education institutes and science and research centres also provided a significant share (see Figure 10.4). Participants based in the UK (€0.7 million), the Netherlands (€0.6 million) and Ireland (€0.5 million) provided more than a third of the additional funding, while Belgium and Portugal also provided a notable share.

10.2 CORPORATE INVESTMENT

The number of companies considered for the estimation of corporate investment and the relative clustering with regards to their geographical location is presented in Figure 10.5. The majority of the companies are UK based, with activity also noted in North-West Europe and Scandinavia. Corporate R&D investment in bioenergy technologies for 2011 was estimated at €60 million, distributed as shown in Figure 10.6. The estimate is mainly based on patent applications and, concurrent with the distribution of companies active in the field, is mainly located in the UK, which accounts for almost half of the corporate investment (see Figure 10.3). As ocean energy is an emerging, developing technology, with and abundance of start-ups and spin off companies there is no single dominant actor in corporate investment as seen in more established technologies.

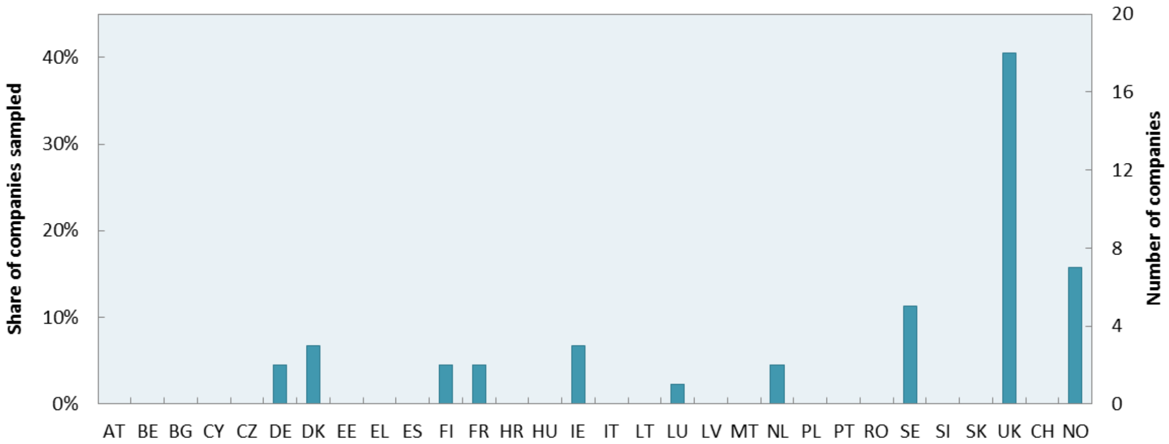


Figure 10.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

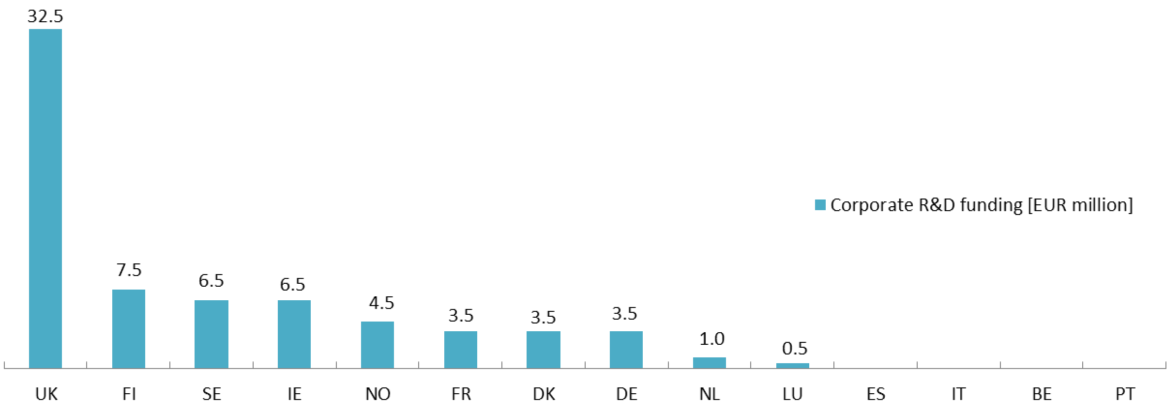


Figure 10.6: Leading countries for corporate R&D investment in ocean energy technologies in Europe for the year 2011. Data source: JRC [3]

10.3 TOTAL INVESTMENT

Figure 10.7 shows the total investment in ocean energy technologies, split into its public and private components; EU funding (€8 million) is included in the chart. As discussed previously, the UK leads in financial contributions to R&D both from the public and the corporate sector. With the exception of Finland, in all countries with significant investments in the technology public funding has a notable share of the total investment. For the top investors there seems to be an association between the ranking in terms of public and private funding, which could indicate that the public contributions are succeeding in energising private capital (see Figure 10.8(b)). On the contrary, there is no clear relationship observed between the total level of investment and the GDP of the respective countries, displayed in Figure 10.9. The latter is perhaps to be expected given the stage of development of these by and large pre-commercial technologies and the small amounts invested in comparison to the more mature fields of energy technology R&D.

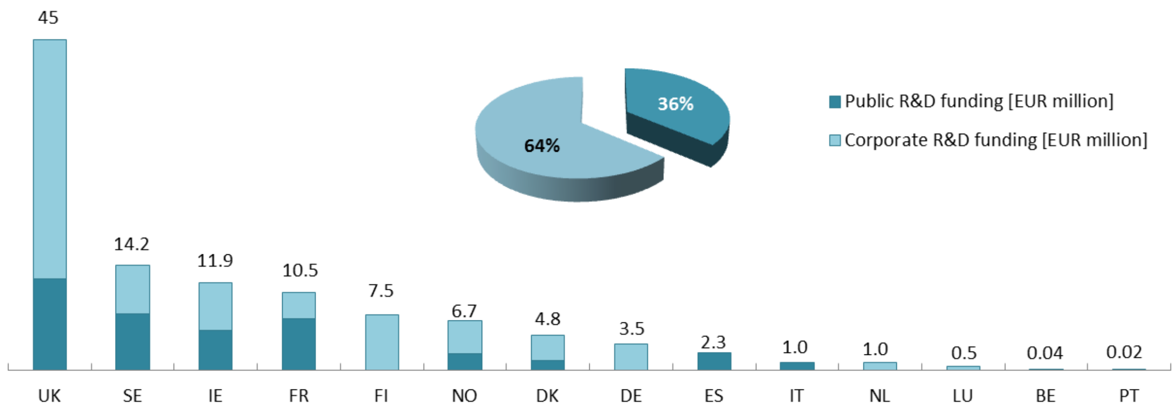


Figure 10.7: Leading European countries in terms of total R&D investment in Ocean energy technologies. EU funding is excluded. Data source: IEA [1], JRC [2, 3]

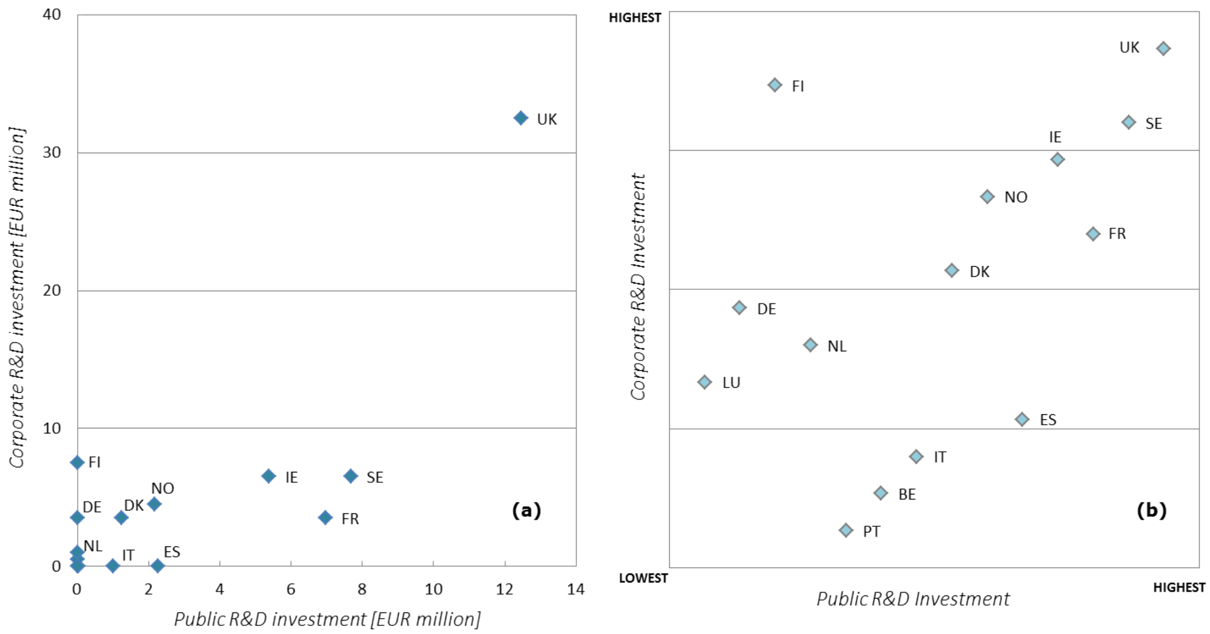


Figure 10.8: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in ocean energy technologies for the year 2011. Data: IEA [1], JRC [2, 3].

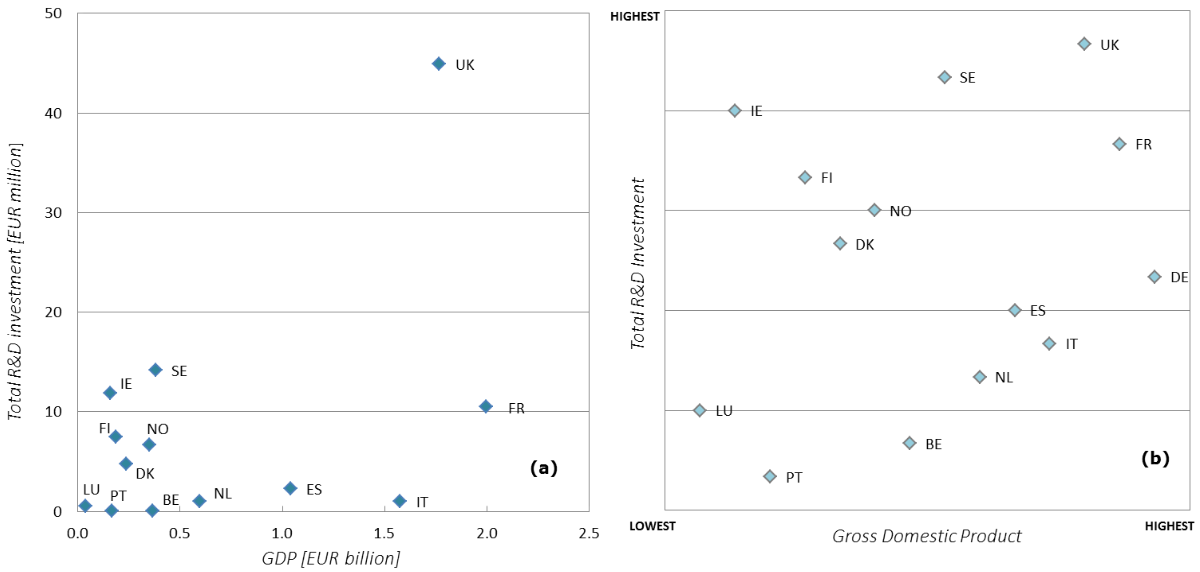


Figure 10.9: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in ocean energy technologies with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

Figure 10.10 shows the status and geographical distribution of ocean energy projects in various stages of development (announcement to completion) in 2011. The majority of activity, in terms of capacity in various stages of planning, construction and testing is centred in UK waters, which is partly to be expected due to the dedicated test facilities in operation. This is especially the case for tidal energy technologies, while Ireland and Portugal also had significant activity in terms of wave projects. Note however, that developments are rapid in this quickly evolving sector, and that over 20% of the above capacity belongs to projects that have since been abandoned.

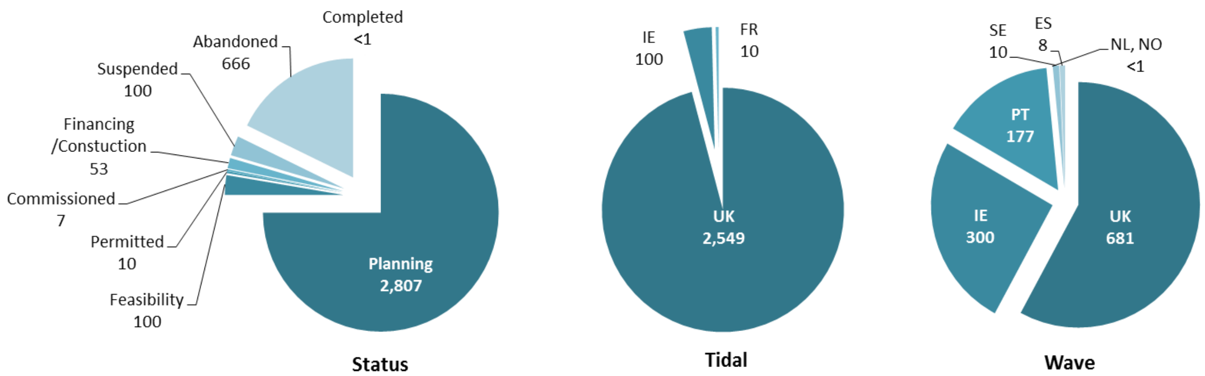


Figure 10.10: Status and geographical distribution of the cumulative capacity [MW] of ocean energy projects in various stages of development (announcement to completion). Data source: JRC [69].

The public, corporate and total investments in ocean energy in Europe for 2011 are mapped in Figure 10.11 and Figure 10.12.

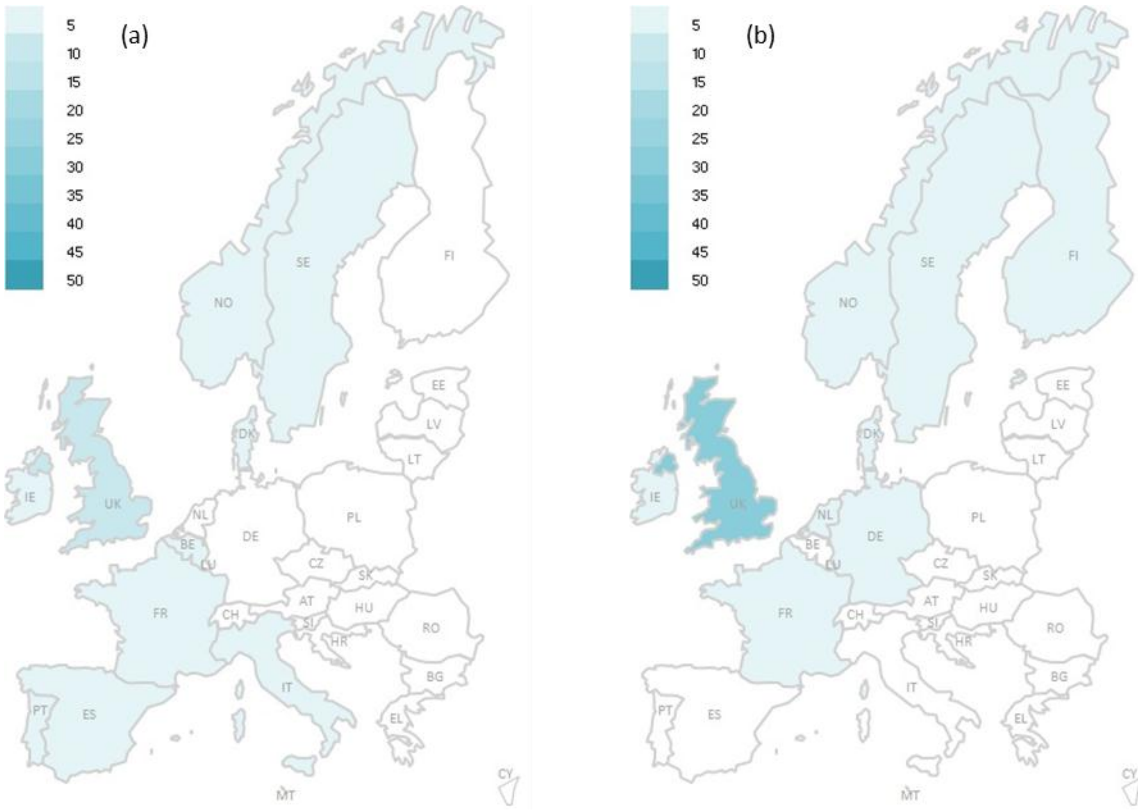


Figure 10.11: Maps of the public (a) and corporate (b) R&D investment in ocean energy in 2011. Legend in EUR million.

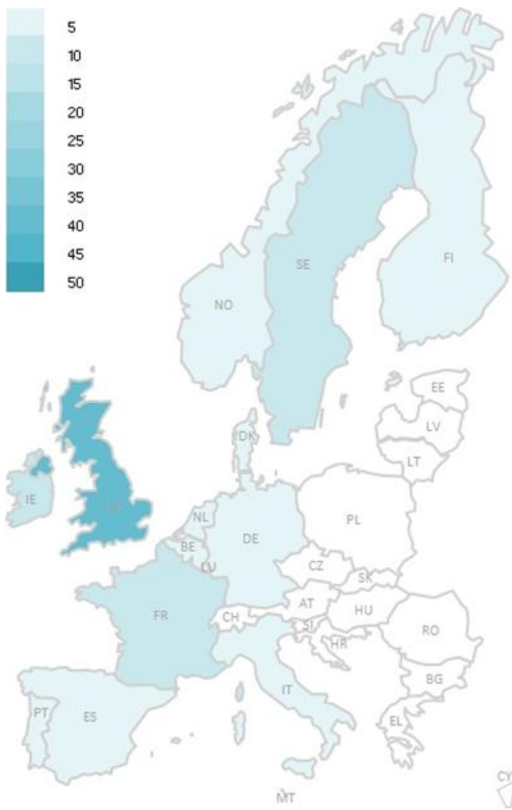


Figure 10.12: Map of the total R&D investment in ocean energy in Europe for the year 2011. Legend in EUR million.

11 SOLAR ENERGY

One of the main features of the renewable energy landscape in 2011 was the reduction of technology costs. A dramatic decrease (almost by half) in production costs for photovoltaics (PV) increased their competitiveness against other electricity generation technologies. These cost reductions resulted in a boom of rooftop PV installations (Germany and Italy each totalled installations over 7GW in 2011), the spread of small-scale PV (e.g. China, UK) and a surge in the financing of large-scale solar thermal electricity generation projects (e.g. Spain, US) [35, 70, 71]. The policy response to these developments and to the overall economic crisis was to rapidly adjust feed-in tariff subsidies for solar power. Accordingly, global funds dedicated to solar R&D in 2011 fell below €3 billion (16% reduction on 2010). Despite this decrease, the sector kept its leading position in the renewable energy R&D, receiving almost half of the overall investments.

Summary table – Solar Power R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 366 million
*Public funding available at EU level**	EUR 39 million
Corporate R&D Investment	EUR 548 million
Number of companies identified in the corporate investment sample	236
Number of countries represented in the corporate investment sample	19

*indicative; not all funding could be allocated by technology

11.1 PUBLIC INVESTMENT

In contrast to the global reduction, in Europe R&D investments in solar technologies increased both at the national and EU level. Compared to 2010 the public funding available increased by 24%. Figure 11.1(a) shows that the share of the funding that the technology captures in terms of EU, national (MS) and various European funding instruments amounts to 15.5% of the public funding for the energy technologies examined in this report for 2011. Significant funding was dedicated to the sector through FP7 via the Energy Theme Line and other themes which together disbursed €39 million in 2011. An additional €19 million was contributed by FP7 participants, the majority from private investors (Figure 11.1(b). However the majority of the investment came from national programmes as analysed in the following.

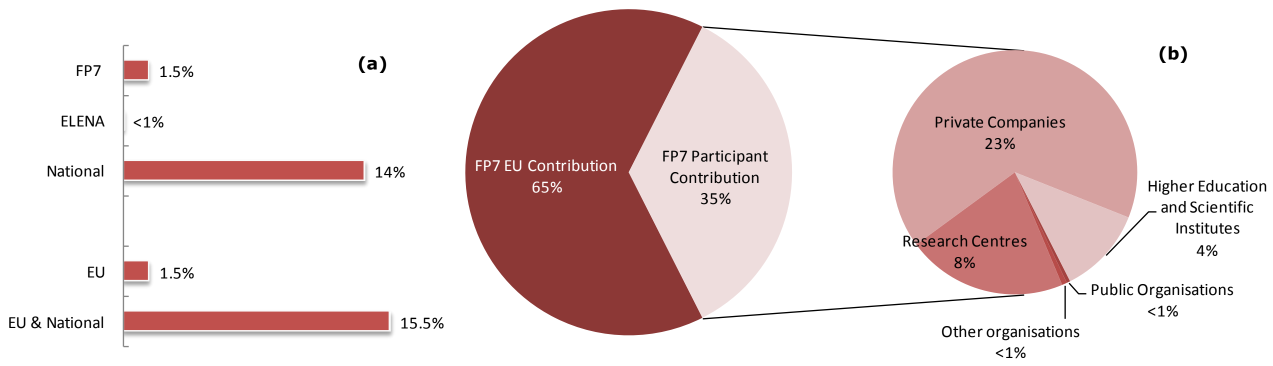


Figure 11.1: Indicative share of solar energy in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: EIB[48], IEA [1], JRC [2, 3], Technopolis [29]

Figure 11.2 shows the funding contributed to R&D of solar energy technologies through national programmes in Europe and the change in the level of investment compared to 2010. Countries with significant budgets dedicated to solar energy R&D, such as Germany, France, Spain and Italy, increased public funding support for the technology in 2011. As shown in Figure 11.3, while over 90% of the public funding for the technology comes from ten countries, there is a reasonable distribution of activities, unlike the corporate sector where Germany is dominant.

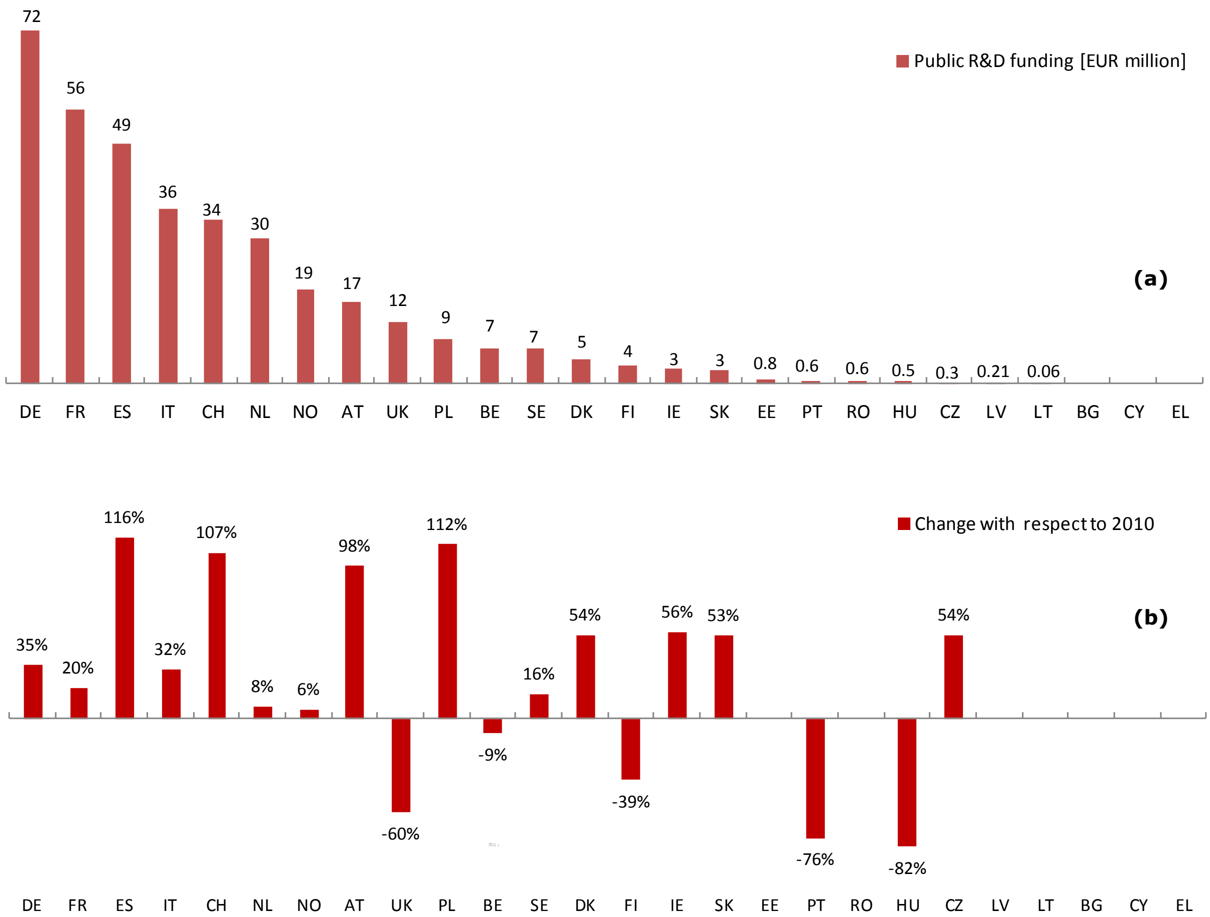


Figure 11.2: Public funding for solar energy technologies R&D from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

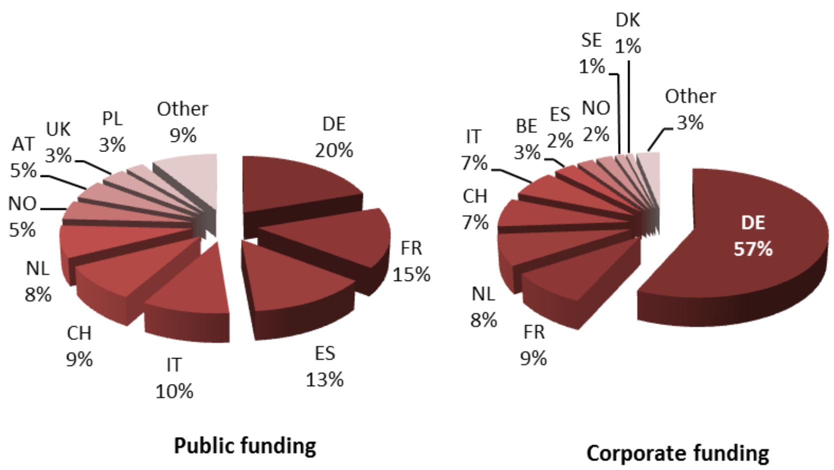


Figure 11.3: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in solar energy technologies for the year 2011. Data source IEA [1], JRC [2, 3]

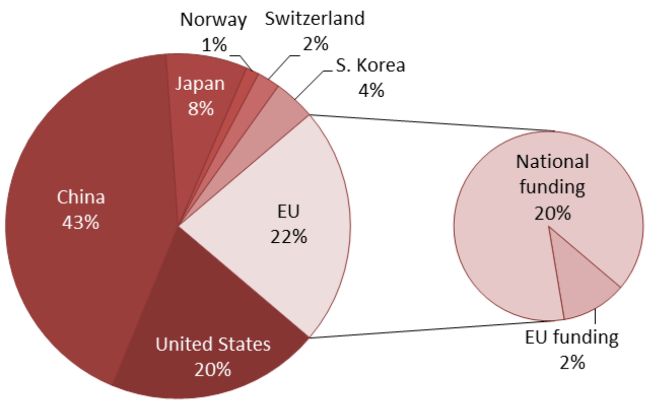


Figure 11.4: Distribution of global funding for solar energy technologies based on the countries included in this report for the year 2011. Data source: IEA [1], JRC [2, 3]

In 2011, investment in China accounted for more than the efforts in Europe and the US combined, (Figure 11.4). There is no information available in relation to Chinese investment with regard to the technologies prioritised apart from the share dedicated to PV [72]. Globally, the research priorities remained improving the energy output of PV and raising the cost efficiency of the production process [35]. Only few countries have broken with this rule and dedicated the majority of the financial support to CSP and connecting technologies: Spain, with large-scale CSP demonstration facilities, and Italy, invested more than €15 million in the technology, representing 33% and 43% of their total solar public funds respectively. By far though, the largest investment in CSP in absolute values came from the US, where 65% of the solar energy funds, were dedicated to this technology in 2011 (see Figure 11.5).

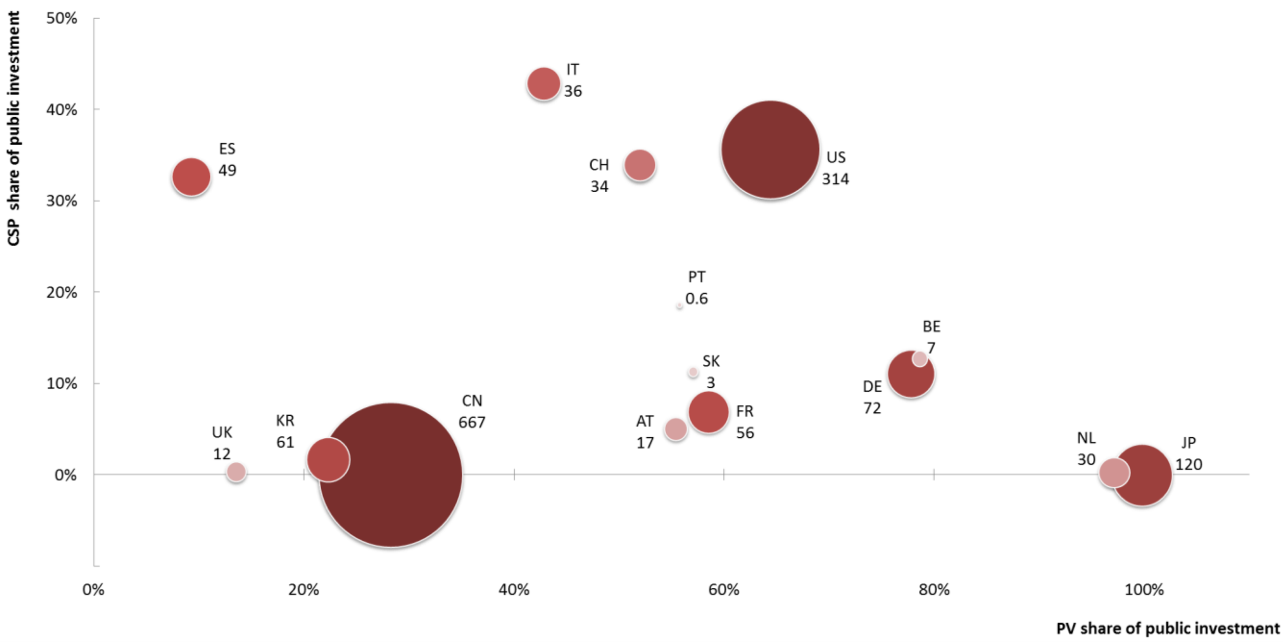


Figure 11.5: Research priorities in terms of the share of funding dedicated to PV and CSP technologies and total level of public investment (in EUR million) in 2011. Data source: IEA [1], JRC [2, 3]

11.2 CORPORATE INVESTMENT

Corporate research investment in solar technology in 2011 was estimated at €548 million. As previously shown in Figure 11.2 and Figure 11.3 Germany not only leads in terms of public investment, but also accounts for more than half the corporate investment in solar technologies in Europe. This is also reflected in the distribution of companies considered in this study; over a third of which are based in Germany (see Figure 11.6). France, the Netherlands, Switzerland and Italy each account for 7-9% of the investment from private companies, with the remaining countries following as shown in Figure 11.7.

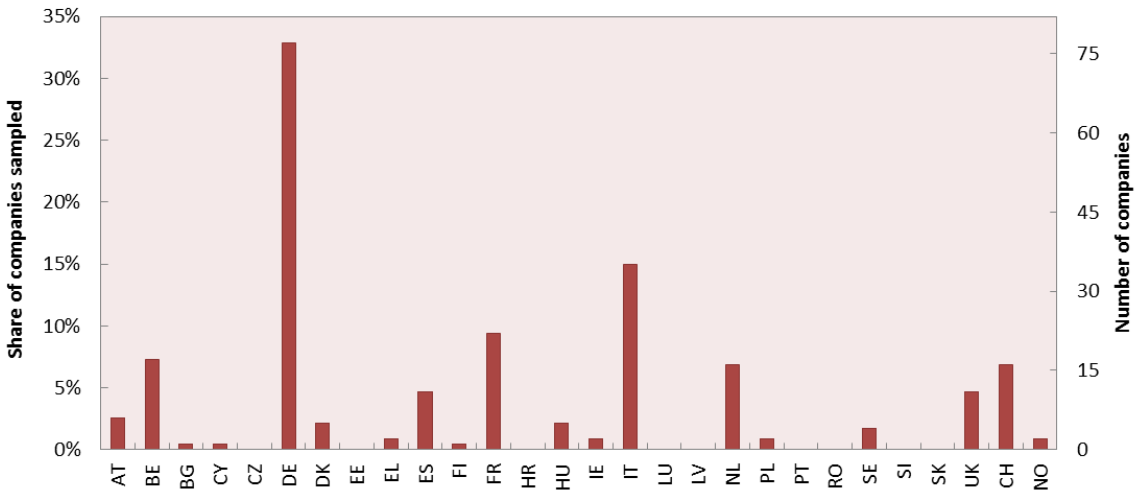


Figure 11.6: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

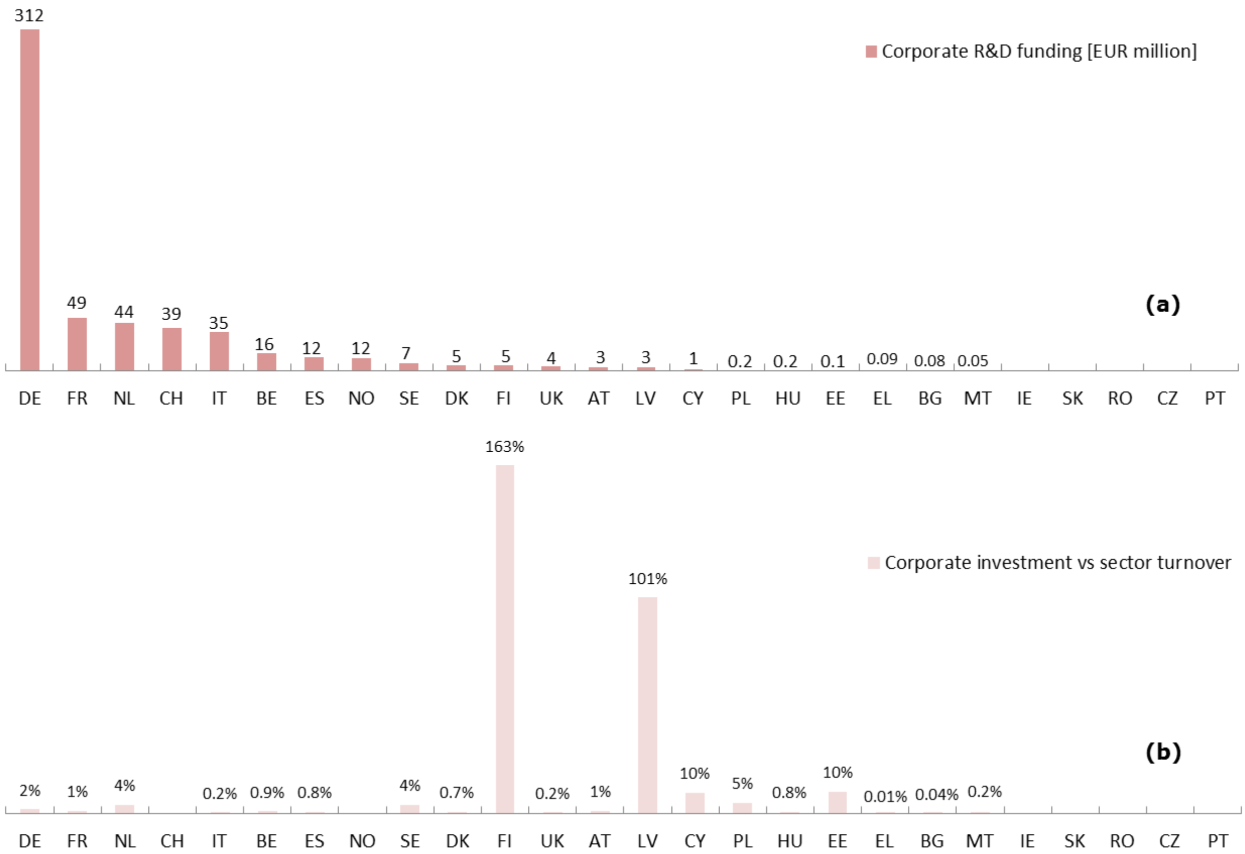


Figure 11.7: Leading countries for corporate R&D investment in solar energy technologies in Europe (a) and corresponding R&D intensity expressed against the sector turnover (b) for the year 2011. Data source: JRC [3].

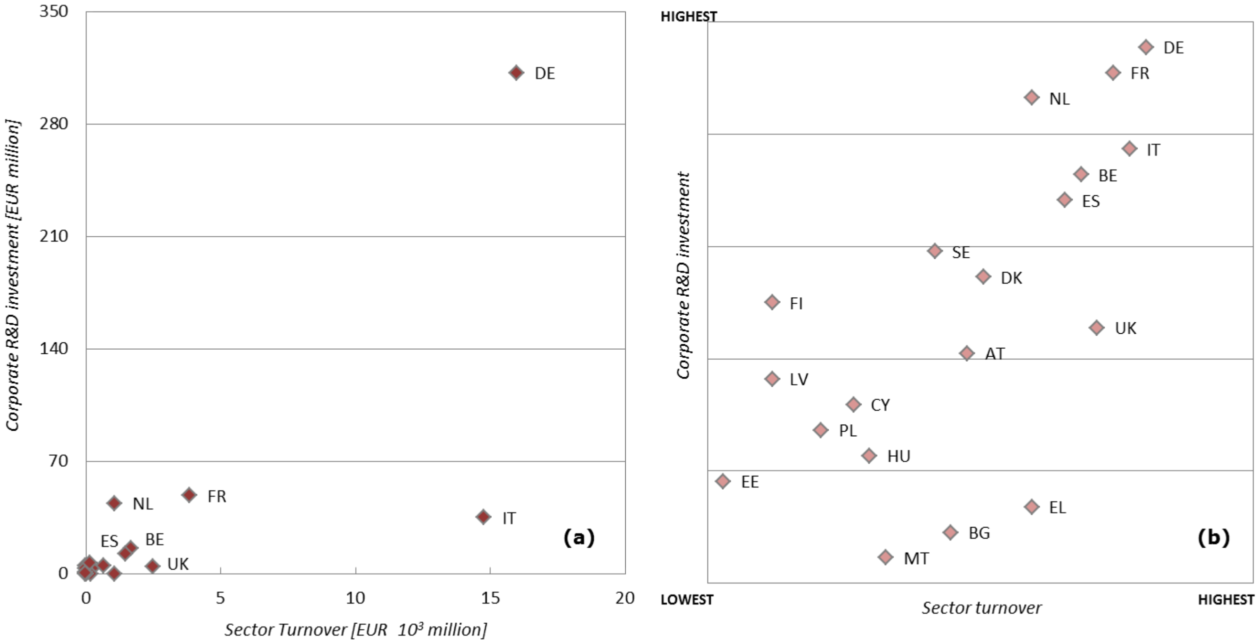


Figure 11.8: Absolute values (a) and relative ranking of countries (b) for the intensity of corporate R&D efforts against sector turnover in the field of solar energy for the year 2011. Data source: Data source: JRC [3].

Figure 11.7(b) also shows the level of corporate investment as a share of the sector turnover in each country. This indicator of research intensity for the companies in the sector can show distortions due to skewed/incomplete sample or the presence of subsidies not easily discerned in recording the corporate R&D expenditure. Corporate R&D expenditure and sector turnover are also plotted in Figure 11.8 both in absolute values and relevant ranking to reveal investment behaviour against market activity for each country. If we disregard Finland and Latvia as potential outliers, the graphs reveal both the countries where the sector is active in investing to create technology know-how like the Netherlands and Sweden and countries where an active market does not translate in equivalent R&D efforts e.g. Greece and the UK.

Figure 11.9 shows a rough distribution of corporate investment to major sub-sections of research. While detailed information on the R&D efforts of the business sector is not readily available, among the research topics in modules and solar cells are the improvement of the average efficiencies, thin-film technologies, dye-sensitized solar cells, organic photovoltaic cells and photovoltaic cover glass. Research investment in PV inverters continues to represent a considerable share of the private research investment.

In terms of the type of investor active in the sector, the present assessment finds that companies active in the later stages of technological life (i.e. utility companies) invest less in the development solar technology (approximately €20 million). On the contrary the role of smaller equipment companies, which invested approximately €30 million in solar research, is not a negligible one. Many of these small company investors originate from Germany and Italy which also have the strongest representation of companies in the sample (see Figure 11.6).

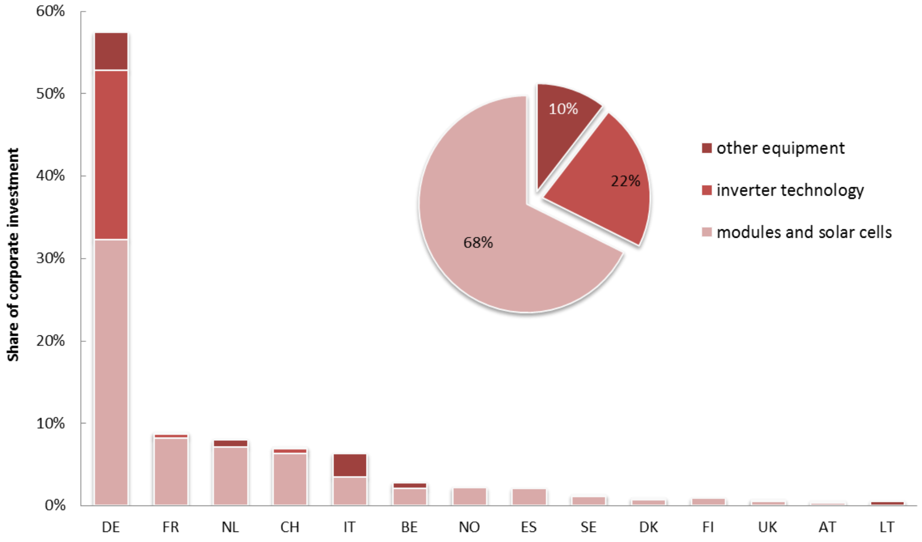


Figure 11.9: Corporate investment split between major research areas of solar energy technologies in total and by country for leading investors. Data source: Data source: JRC [3].

11.3 TOTAL INVESTMENT

The total investment in solar energy technology R&D is displayed in Figure 11.10. For the majority of the top investors the contribution of public investment is significant and, in terms of the country rankings, could be argued that it has a role in stimulating private funds (Figure 11.11). Germany is the exception to this rule. Although only slightly in front of the rest of Europe in terms of public investment, the intense activity in the corporate sector in Germany influences not only the country overview, but also the overall balance of the investment by the two sectors at the European level.

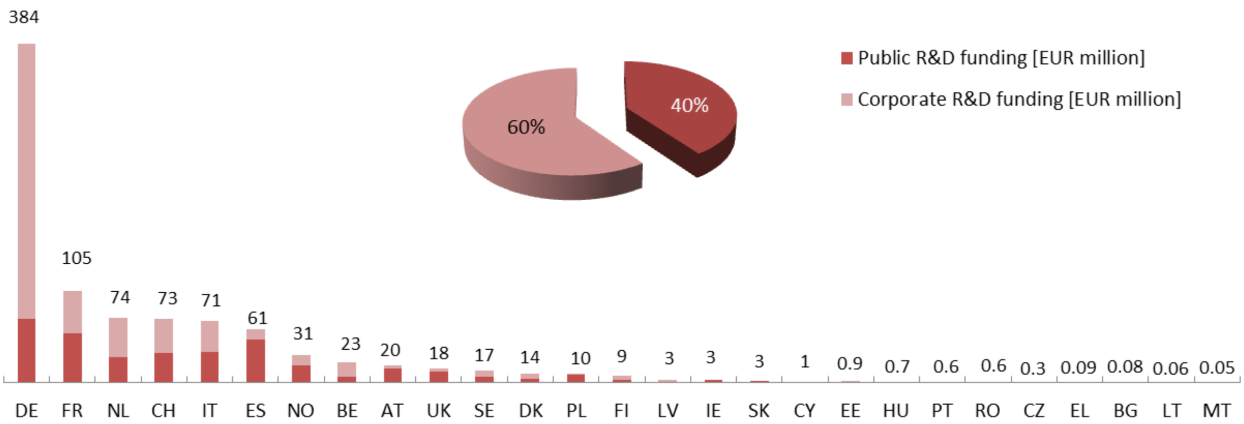


Figure 11.10: Leading European countries in terms of total R&D investment in solar technologies. EU funding is excluded. Data source: IEA [1], JRC [2, 3].

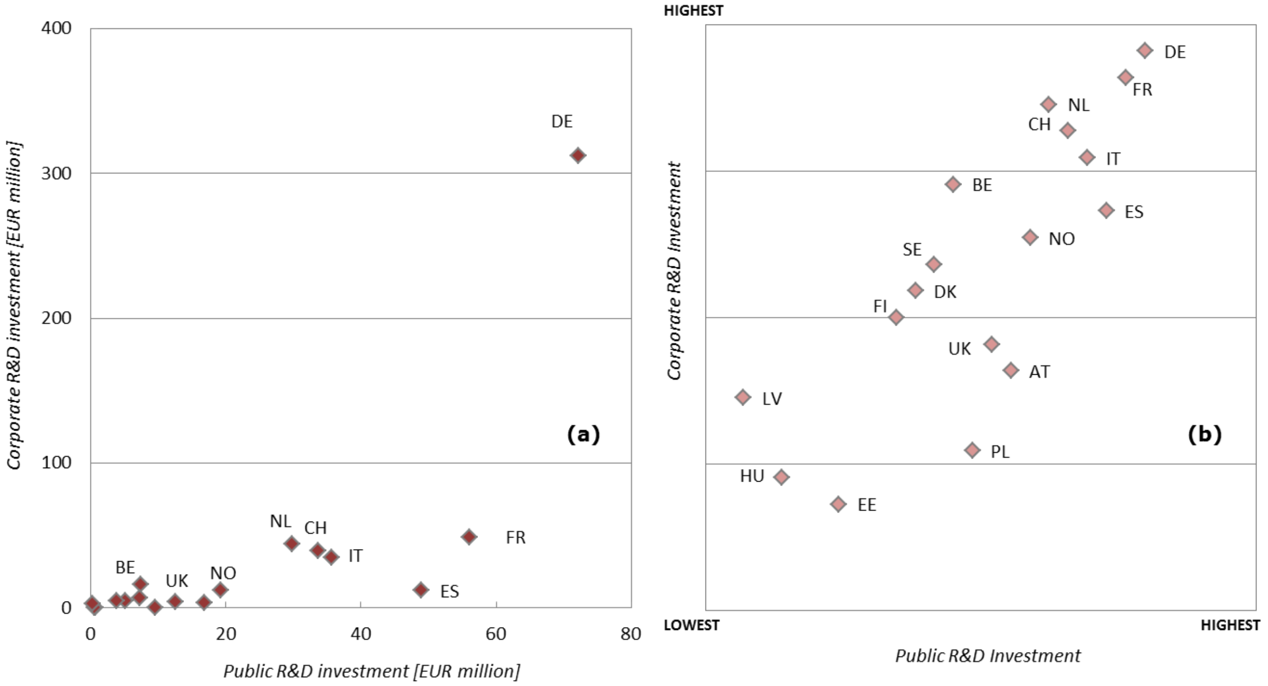


Figure 11.11: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in solar technologies for the year 2011. Data source: IEA [1], JRC [2, 3].

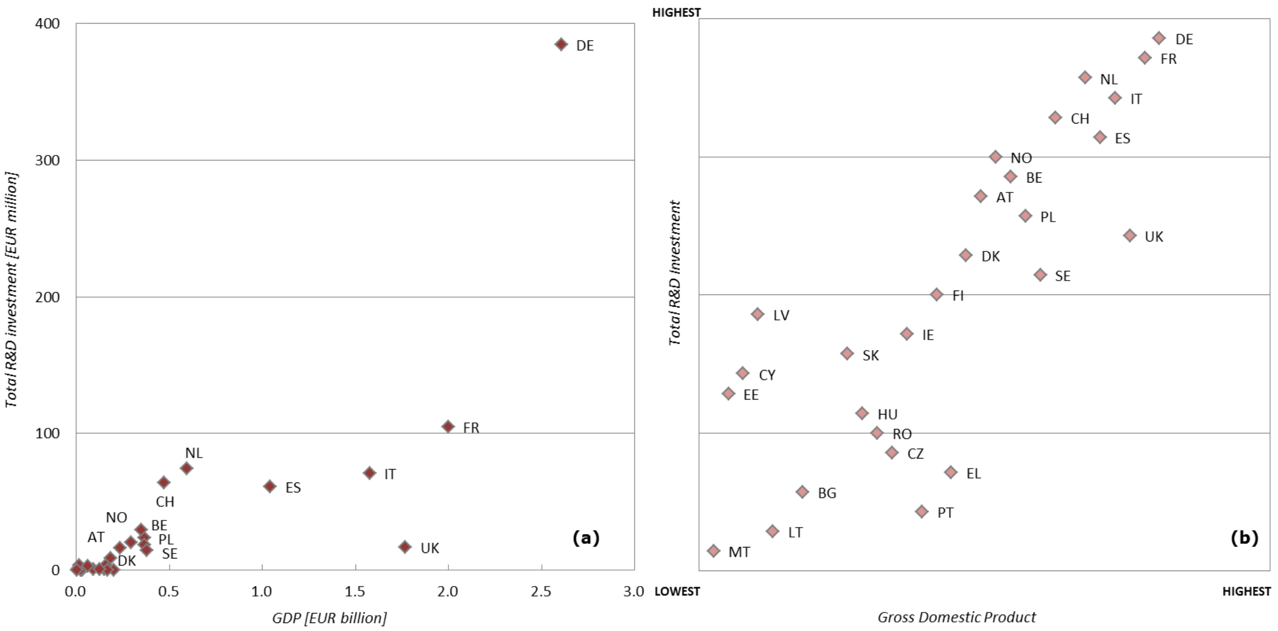


Figure 11.12: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in solar technologies with respect to GDP for the year 2011. Data source: IEA [1], JRC [2, 3].

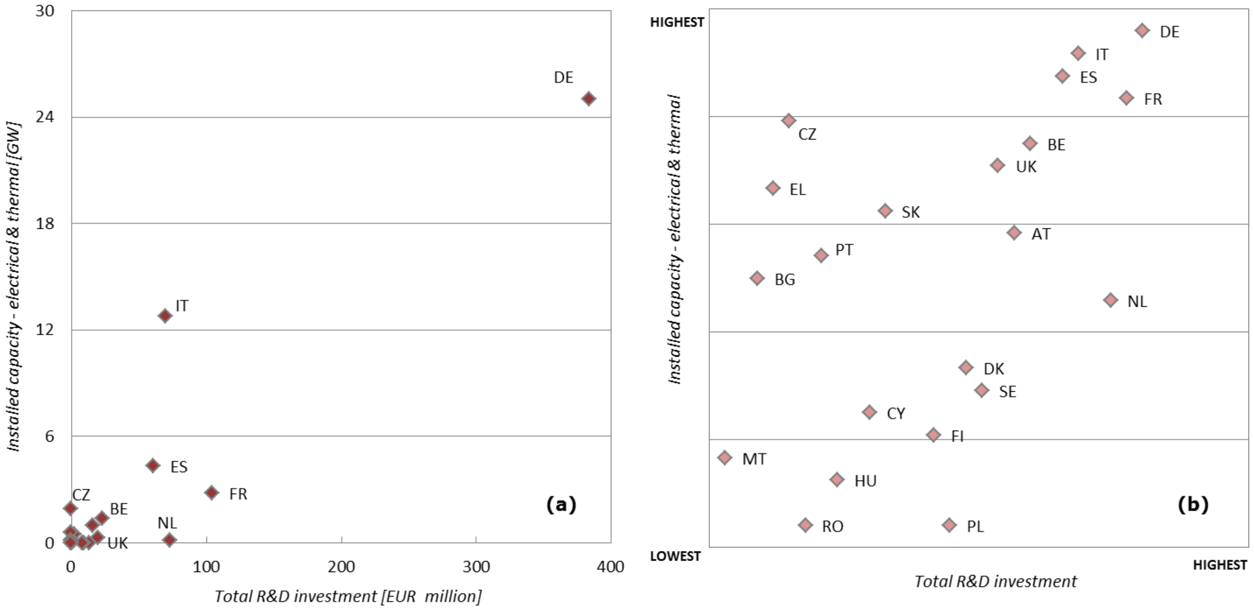


Figure 11.13: Absolute figures and relative ranking of European countries in terms of R&D investment against installed solar capacity (electrical & thermal). Data source: Eurostat [64], IEA [1], JRC [2, 3].

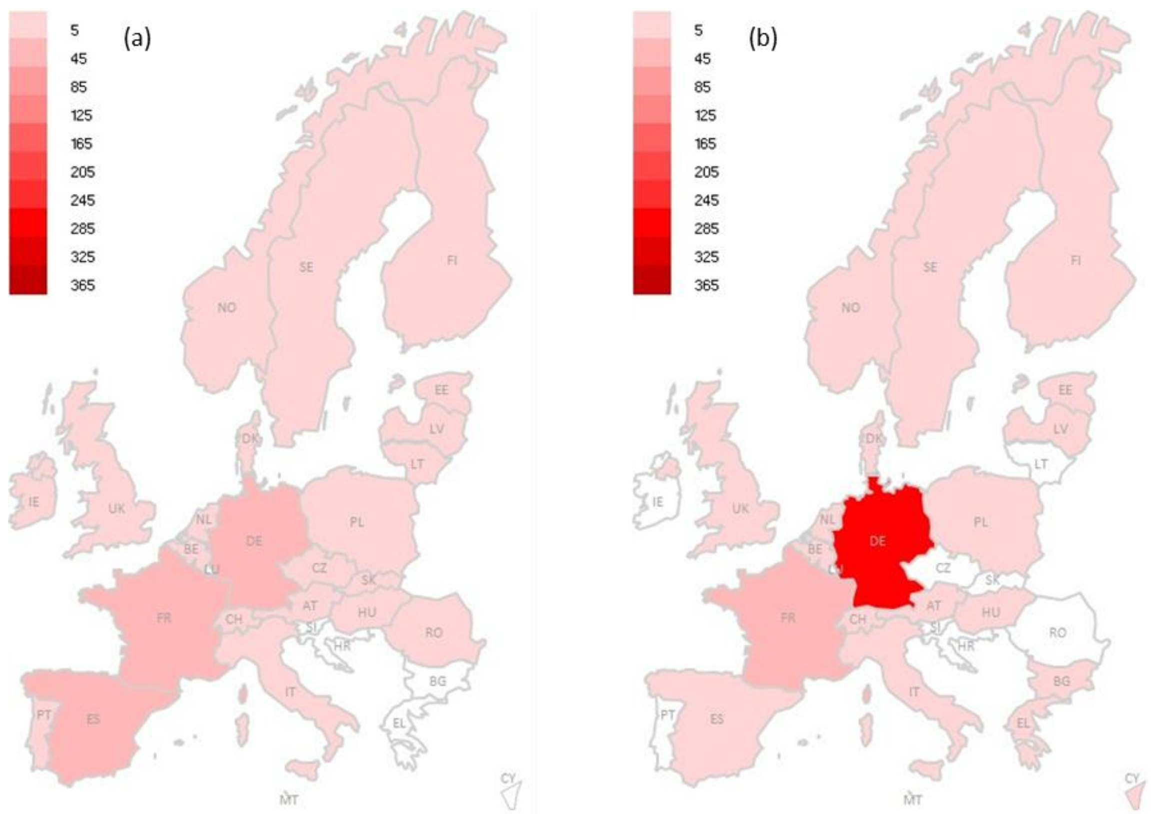


Figure 11.14: Maps of the public (a) and corporate (b) R&D investment in solar energy in 2011. Legend in EUR million.

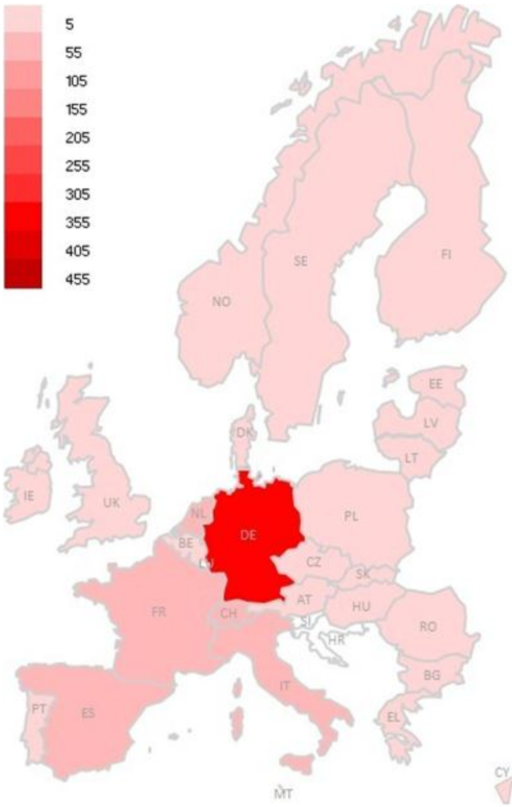


Figure 11.15: Map of the total R&D investment in solar energy in Europe for the year 2011. Legend in EUR million.

12 WIND ENERGY

Wind energy is the most mature of the technologies examined in this report. As such, and especially in the context of a difficult economic climate, it has attracted less R&D funding from public sources than some of the technologies examined previously. Most of the investment in R&D comes from the corporate sector, which is concurrent with a commercial technology; following energy storage, wind receives the second highest level of support from the technologies examined in both corporate and total investments.

Summary table – Wind energy R&D investment in Europe	
Public funding available through national mechanisms (EU, NO &CH)	EUR 179 million
*Public funding available at EU level**	EUR 54 million
Corporate R&D Investment	EUR 1146 million
Number of companies identified in the corporate investment sample	231
Number of countries represented in the corporate investment sample	20

*indicative; not all funding could be allocated by technology

12.1 PUBLIC INVESTMENT

In 2011, wind energy technology R&D accounted for almost 9% of the public funding for energy technologies in Europe as estimated in this report (Figure 12.1 (a)). Note that values regarding European funding sources are tentative since not all projects can be assigned to a single technology; this is either because they support research in more than one fields, or because the project information is not sufficient to support assignment beyond a general area of activity. Nonetheless, they provide an indication of activity and the potential to raise additional funds from participant contributions.

The majority of this funding was made available at country level, where €161 million were invested in wind technology through EU national research budgets, while an additional third of this value was brought-in by European institutions. Most of the latter support came from EEPR which dedicated over €41 million to offshore wind projects mainly in the UK, Germany and Denmark. Nonetheless the support offered by the programme shows a significant decrease from its 2010 levels which were 72% higher. FP7 funds invested in wind energy research increased by 39% to €13 million, attracting an additional €8.6 million from programme participants. The majority of the attracted funding came from private companies, which is consistent with corporate investment being the major R&D funding source for this technology (see Figure 12.1 (b)).

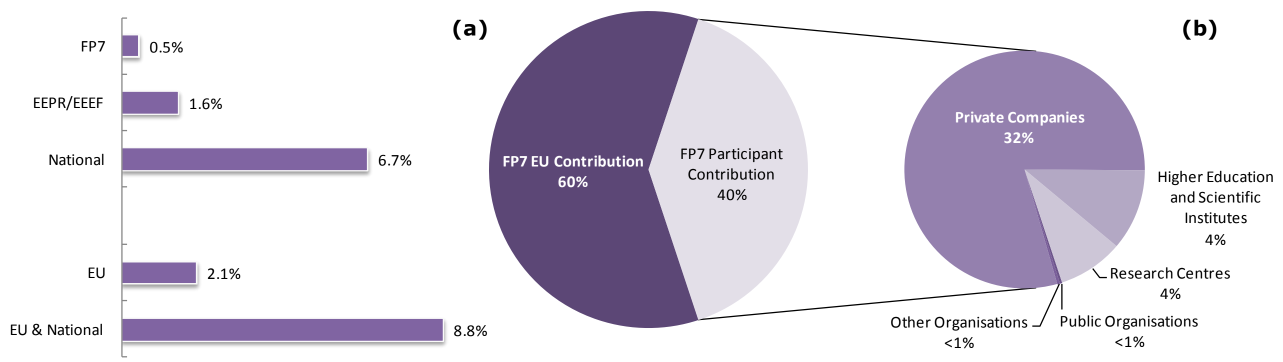


Figure 12.1: Indicative share of wind energy in the total public funding available for energy technologies as calculated in this report (a) and contribution of additional funding by FP7 Energy Theme participants (b) for 2011. Data source: EC [26], IEA [1], JRC [2, 3], Technopolis [29]

Overall, and despite the increase of funds offered through FP7, public investment in Europe has suffered a decrease compared with 2010. At the country level this reflects a 9% reduction in the total funding available through national research programmes. Figure 12.2 shows the level of funding for wind energy reported in Europe by country and the change with respect to the 2010 figures. With the exception of the UK, the other leading programmes increased their contributions to wind energy R&D. Large increases are observed for Finland, Belgium and Switzerland which are situated mid-table in terms of total investment, while the countries with smaller research budgets dedicated to this technology seem to have reduced them even further in 2011.

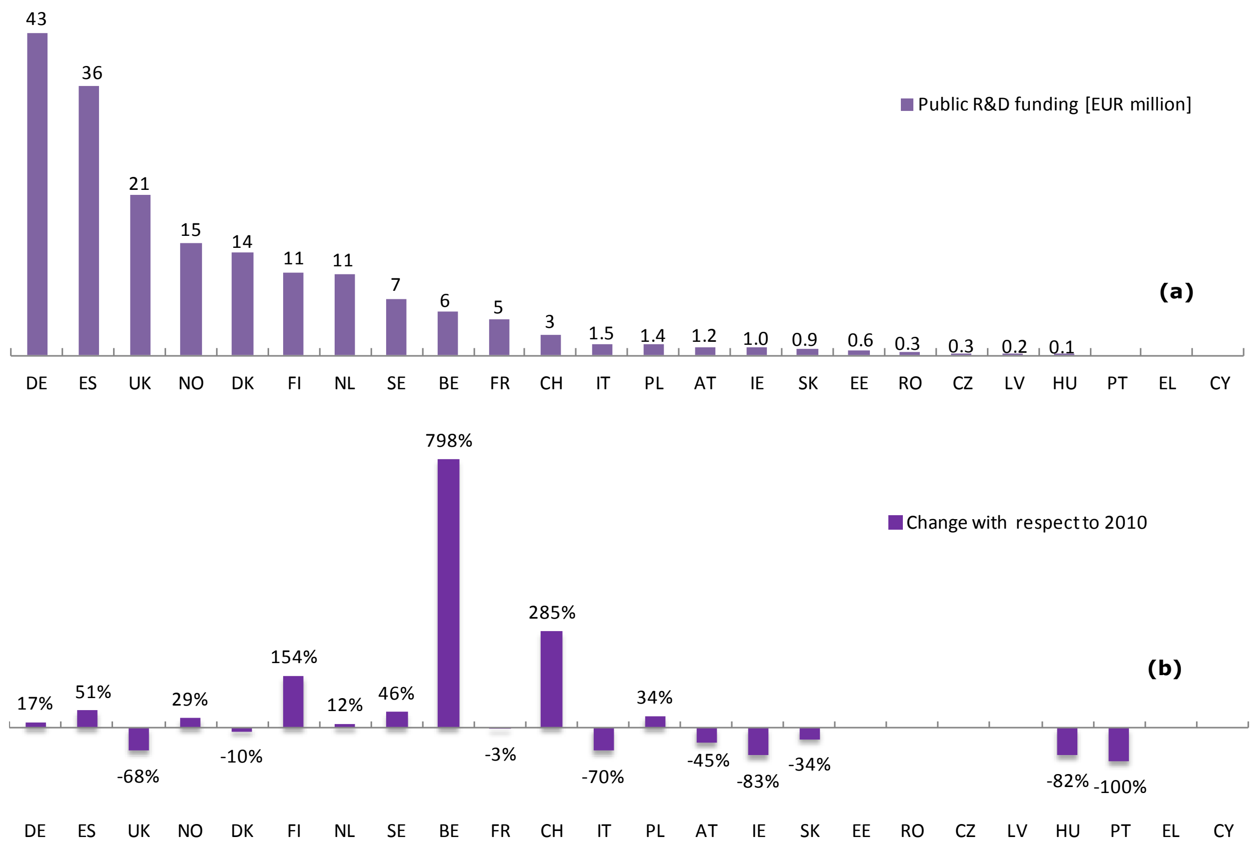


Figure 12.2: Public funding from national sources in Europe for the year 2011 (a); and change per country with respect to the previous year 2010 (b). Data source: IEA [1], JRC [2, 3]

The relative contribution of national funding for the technology at European level for the leading investors in wind energy technologies is displayed in Figure 12.3. There is a high concentration of R&D funding in both public and corporate R&D between a small number of countries, with over 94% of the total research budgets available distributed in the top ten presented here. Three member states contribute over 55% of the public investment, one of which – Germany – is also the source of almost a third of the corporate investment in the field. Another of the countries in the top five for public investment – Denmark – has the highest corporate contribution with 45% of the total, while the top five account for around 94% of all corporate R&D funding.

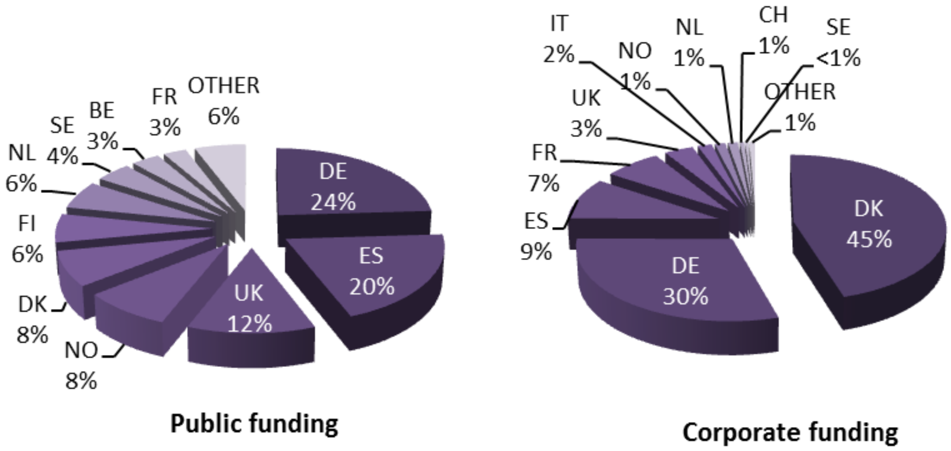


Figure 12.3: Share of the ten leading countries in Europe in terms of public and corporate R&D funding in wind energy technologies for the year 2011. Data source: IEA [1], JRC [2, 3]

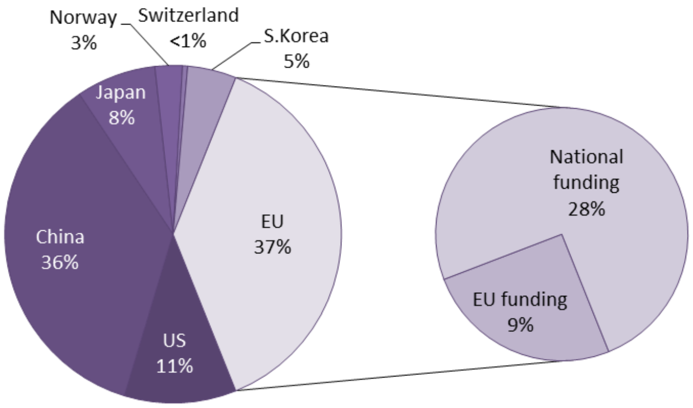


Figure 12.4: Distribution of global funding for wind energy technology based on the countries included in this report for the year 2011. Data source: BNEF [35, 36]. IEA [1], JRC [2, 3].

On a global scale, the EU still holds a significant position in terms of the availability of public R&D funding, as shown in Figure 12.4. This is almost matched by China which made notable investment in wind R&D of the order of €205 million in 2011 [35, 36]. This accounts for more than a third of the global public funds in the same year, and is almost twice the level of investment provided by the US and Japan put together. These two latter countries are the other significant investors at a global level; public funding for the technology in Japan increased by 78% compared to 2010, reaching €44 million in 2011.

12.2 CORPORATE INVESTMENT

The number of companies considered for the estimation of corporate investment and the relative clustering with regards to their geographical location is presented in Figure 12.5. As discussed in the previous section corporate funding is highly concentrated, with firms based in Denmark and Germany in particular being the major contributors (see Figure 12.3). It is worth noting that from the companies sampled for this study the contribution in Denmark is made by a small number of very large investors, while there seem to be a greater variety of actors in some of the other countries which feature strongly in terms of corporate wind energy R&D. The high numbers of companies with minor contributions may show a trend towards greater participation of smaller firms in R&D activities in this field or cross-over activities by companies expanding to this sector.

Corporate R&D investment in wind technologies for 2011 was estimated at €1146 million, distributed as shown in Figure 12.6(a). There is a big gap between the two leading contributors and the remaining investing countries. Beyond the top ten investors, R&D funding for wind energy is rather small and – with the exception of the Czech Republic also represents a very small percentage of the turnover of the sector. On the contrary, for the leading countries there appears to be some consistency in the level of investment against the sector turnover, if grouped by the magnitude of investment (see Figure 12.6(b). In Figure 12.7 the corporate investment is plotted against sector turnover in absolute terms and also in terms of the ranking of each European country (Figure 12.7(b)). This shows that in the majority of cases the level of corporate investment is consistent with the positioning of the respective country in terms of sector turnover, but with exceptions, such as Romania, Portugal, Greece and Austria.

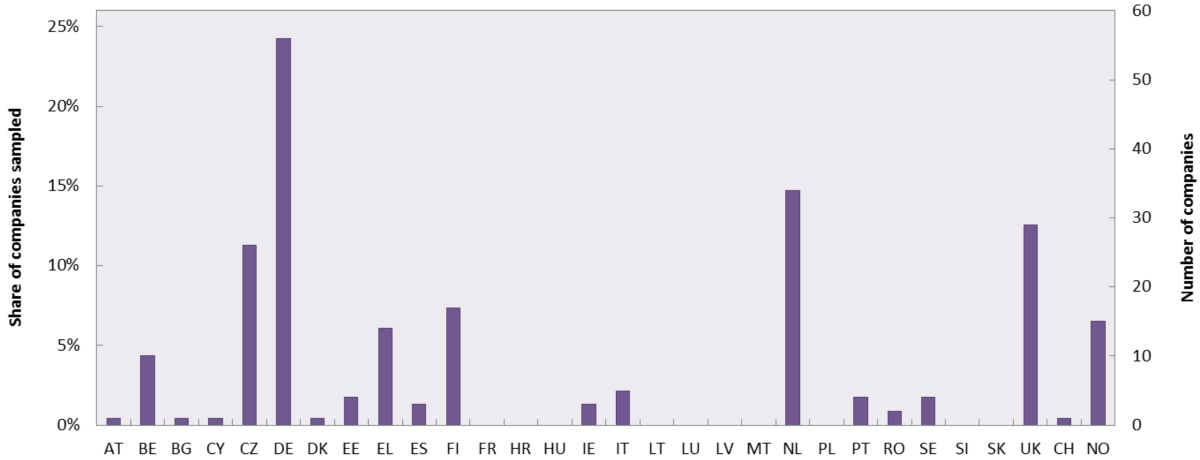


Figure 12.5: Geographical distribution of the companies identified to establish corporate investment levels for 2011.

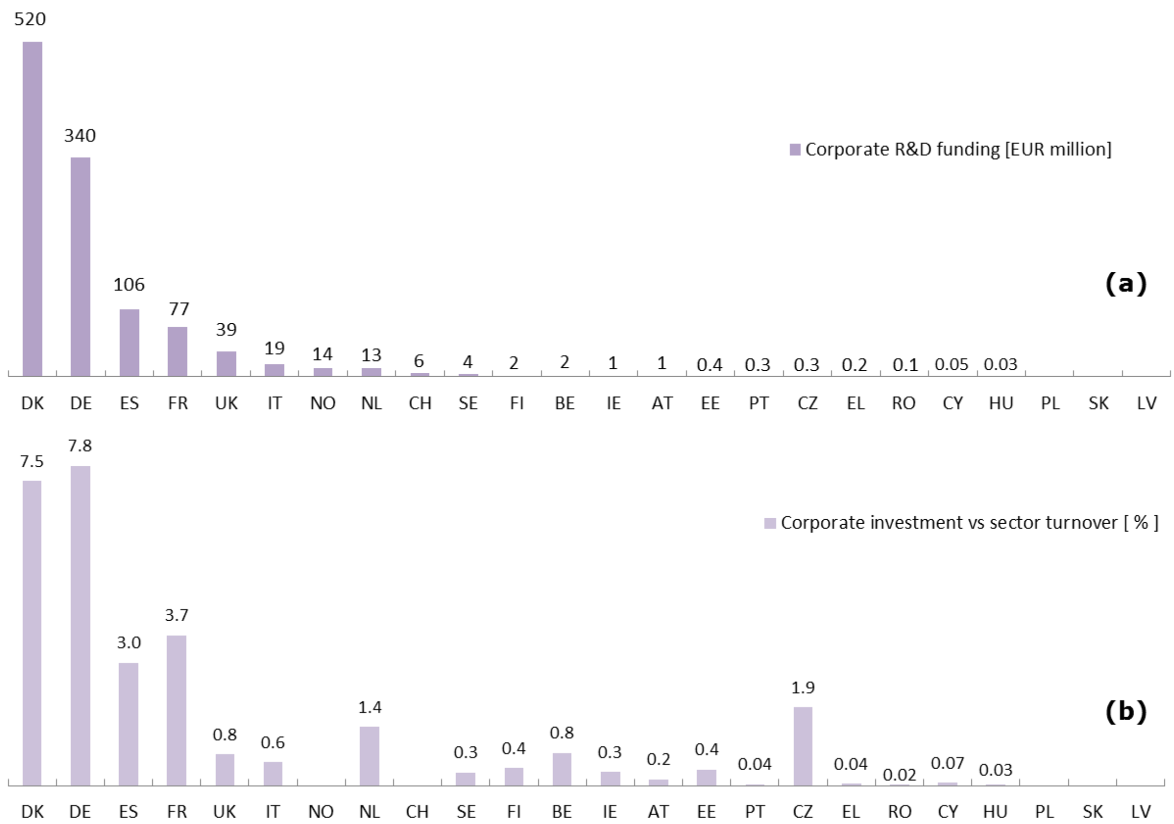


Figure 12.6: Leading countries for corporate R&D investment in wind energy in Europe (a) and corresponding R&D intensity expressed against the sector turnover (b) for the year 2011. Data source: : JRC [3], IEA Wind [73], EWEA [74]

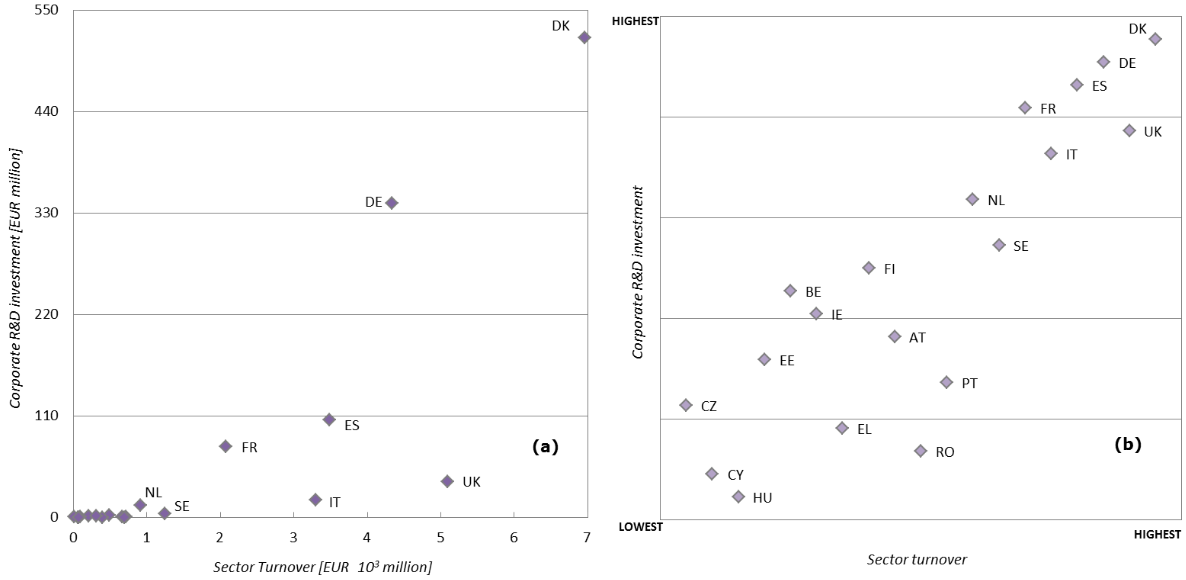


Figure 12.7: Absolute values (a) and relative ranking of countries (b) for the intensity of corporate R&D efforts against sector turnover in the field of wind energy for the year 2011. Data source: JRC [3], IEA Wind [73], EWEA [74]

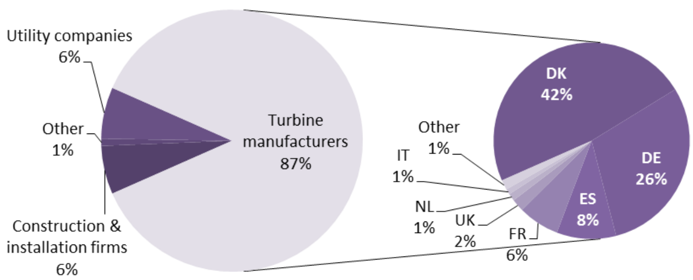


Figure 12.8: Participation of various industry sectors in wind energy R&D on the basis of investment, and distribution by country for the largest contributing sector (turbine manufacturers). Data source: JRC [3], IEA Wind [73], EWEA [74].

Figure 12.8 shows the participation of the different industry sectors in wind R&D research for 2011. Most of the investment comes from turbine manufacturers and is highly concentrated in a few countries. There is intense research activity in the early stages of the technology, with a growing participation of smaller companies. Information on construction and installation R&D is not as forthcoming, so it is difficult to assess whether the share of the sector reflects the interest and investment in the topic. Wind energy is a mature technology, and there is an increased participation of utility companies in wind energy R&D as part of the effort to diversify their portfolio of technologies. The average annual investment in wind technology of utility companies included in the sample was of the order of €4.5 million and it was mostly aimed at the later stages of the technology cycle.

12.3 TOTAL INVENSTMENT

Figure 12.9 shows the total investment in wind energy technologies for the year 2011. As the majority of the R&D funding comes from the corporate sector, it is the level of that investment which dictates the relative position of the countries in terms of absolute contributions to R&D activity. EU funding which would account for 4% of additional investment is excluded; however, part of the private investment raised as a contribution to these projects is captured in the corporate investment figures, with some uncertainty over the year and country of expenditure as well as potential overlaps in data collected through various sources.

In the following, the R&D investments are viewed normalised against figures such as the country GDP to provide a measure of the effort with respect to the background of economic activity in each case. A relative ranking of the countries is also presented, which offers an overview of their positioning with regards to economic activity and whether the R&D investment performance is at a similar level.

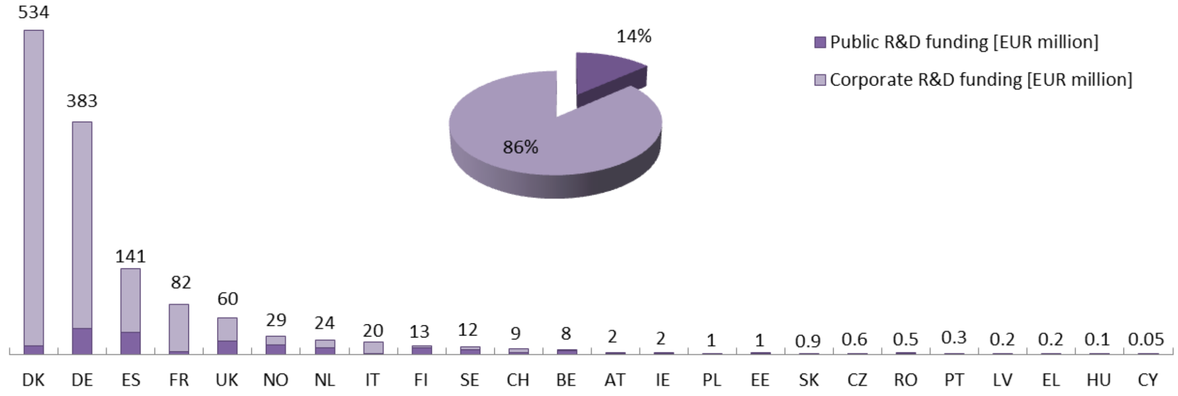


Figure 12.9: Leading European countries in terms of total R&D investment in wind energy. EU funding is excluded. Data source: EWEA [74], IEA [1], IEA Wind [73], JRC [2, 3].

Figure 12.10(a) and Figure 12.10(b) show the relationship between the public and corporate investments in wind in absolute figures and relative ranking, respectively. Denmark which has the highest corporate contribution, ranks much lower in public funding; a sign perhaps that the industry is considered mature and stable enough to take care of R&D without much public support. Similarly, France is lower ranked in terms of public support than its corporate position. The other major to medium investors more or less maintain the same position for both funding sources.

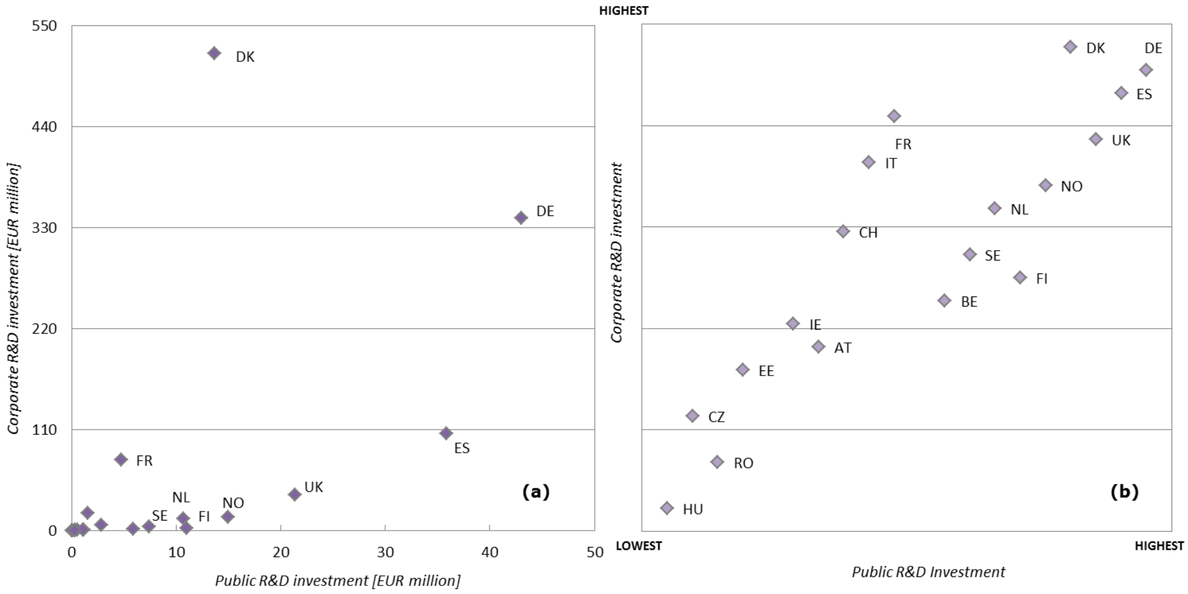


Figure 12.10: Absolute figures (a) and relative ranking of European countries in terms of the level of public versus corporate R&D investment in wind energy for the year 2011. Data source: EWEA [74], IEA [1], IEA Wind [73], JRC [2, 3].

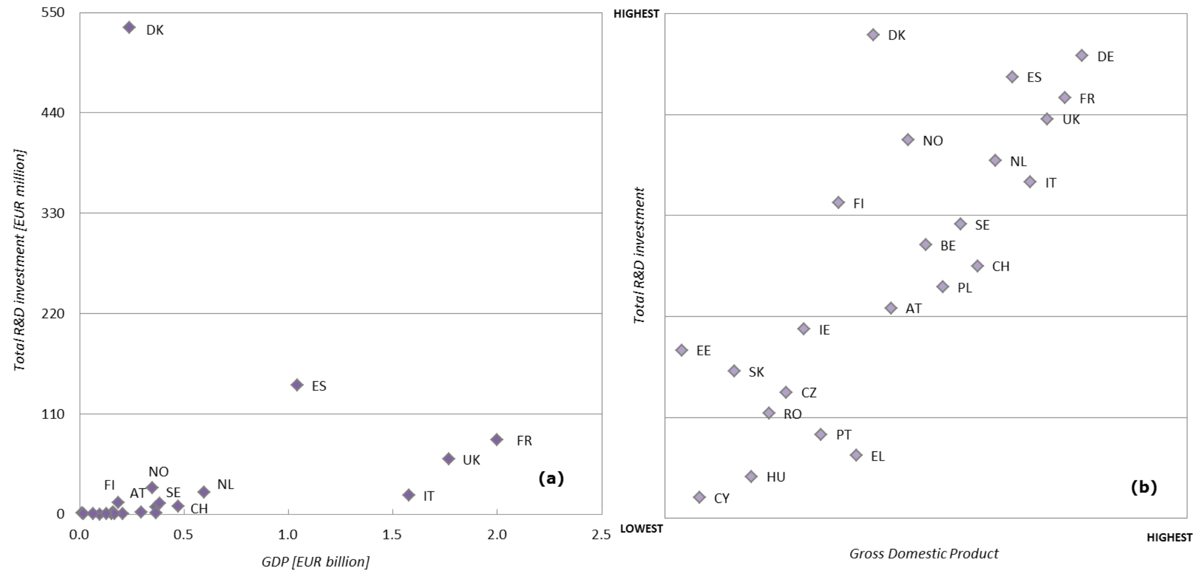


Figure 12.11: Absolute figures (a) and relative ranking of European countries in terms of the level of total R&D investment in wind energy with respect to GDP for the year 2011. Data source: EWEA [74], IEA [1], IEA Wind [73], JRC [2, 3].

Absolute and relative rankings in terms of total investment versus GDP and installed capacity are provided in Figure 12.11and Figure 12.12 respectively. In terms of investment against GDP, Denmark, Norway and Finland show high investment with regards to their position, as do Estonia and Slovakia in terms of smaller investors. The Scandinavian countries are ranking much higher in terms of investment than in terms of technology use; Denmark in particular, apart from the domestic support for wind energy is a significant technology exporter. Greece and Portugal can be mentioned among the countries where investments are not as forthcoming as the level of GDP or the level of technology deployment might suggest. In both cases wind energy deployment is high but the macroeconomic conditions coupled with the lack of relevant industries and know how account for the lack of R&D efforts.

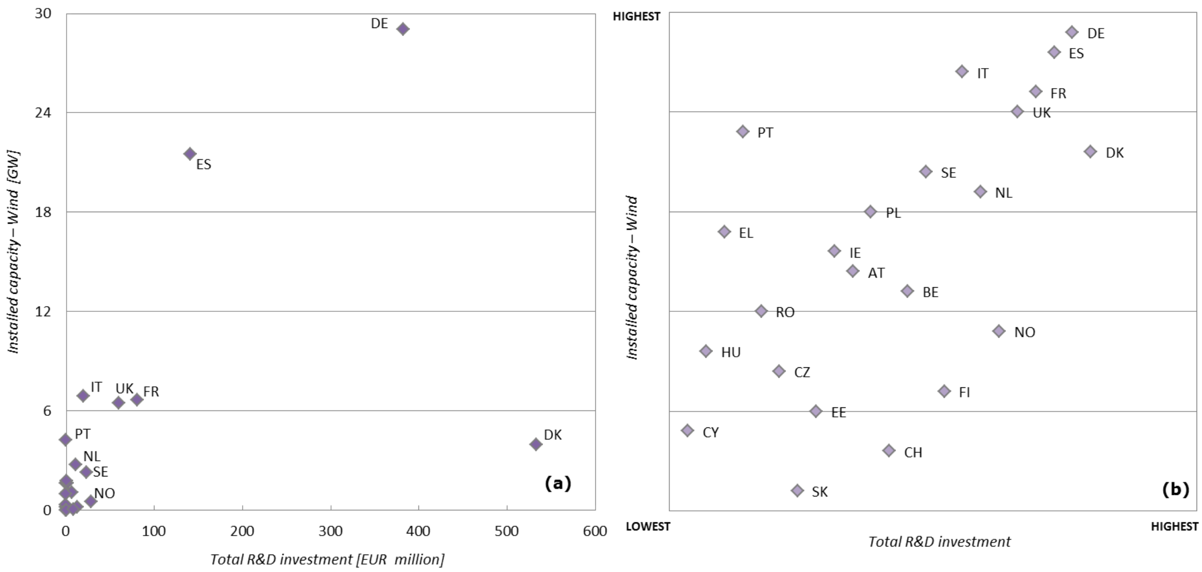


Figure 12.12: Absolute figures and relative ranking of European countries in terms of R&D investment against installed capacity for wind energy. Data source: Eurostat [64], EWEA [74], IEA [1], , IEA Wind [73], JRC [2, 3].

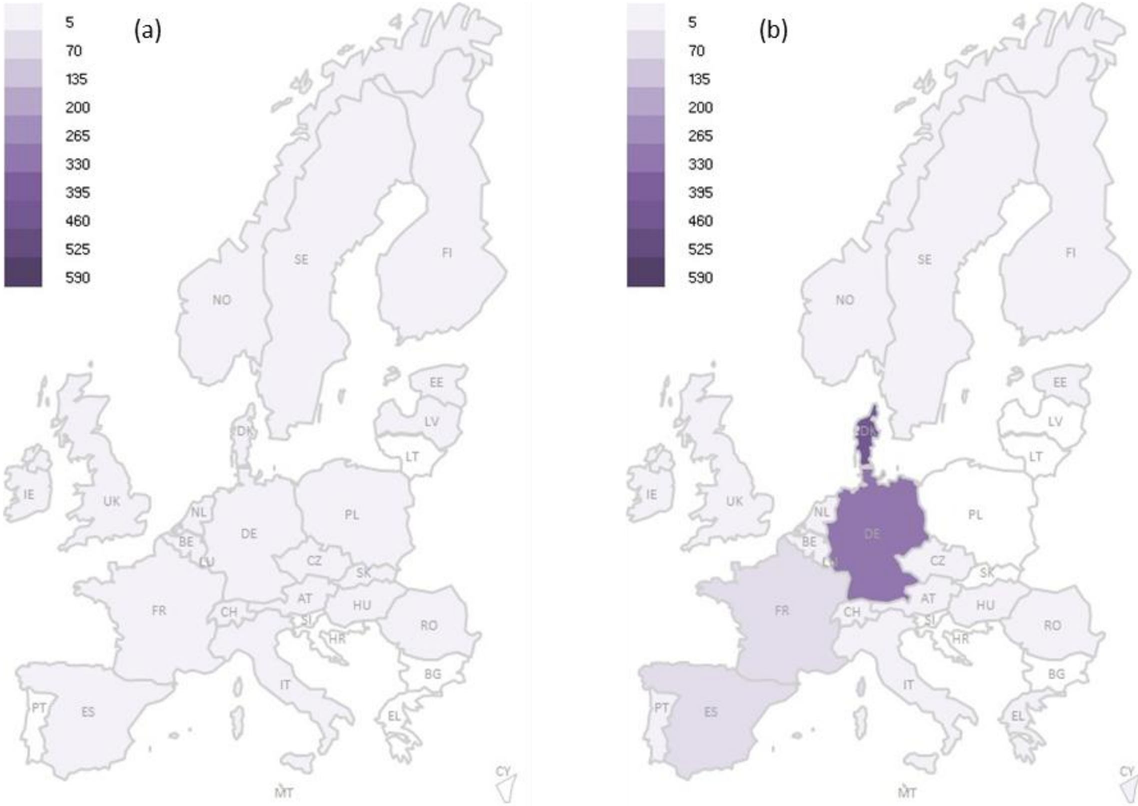


Figure 12.13: Maps of the public (a) and corporate (b) R&D investment in wind energy in 2011. Legend in EUR million.

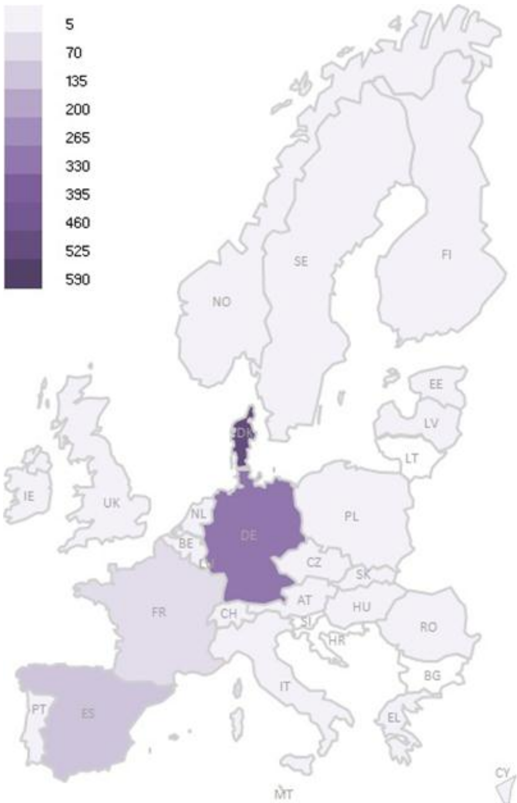


Figure 12.14 Map of the total R&D investment in wind energy in Europe for the year 2011. Legend in EUR million.

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Lucian Alexandrescu	Institutul National De Statistica, Romania

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Botond Dome,	European Investment Bank, Finance Directorate – Capital Markets, Funding Officer

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