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Smart Grid Projects Outlook 2014

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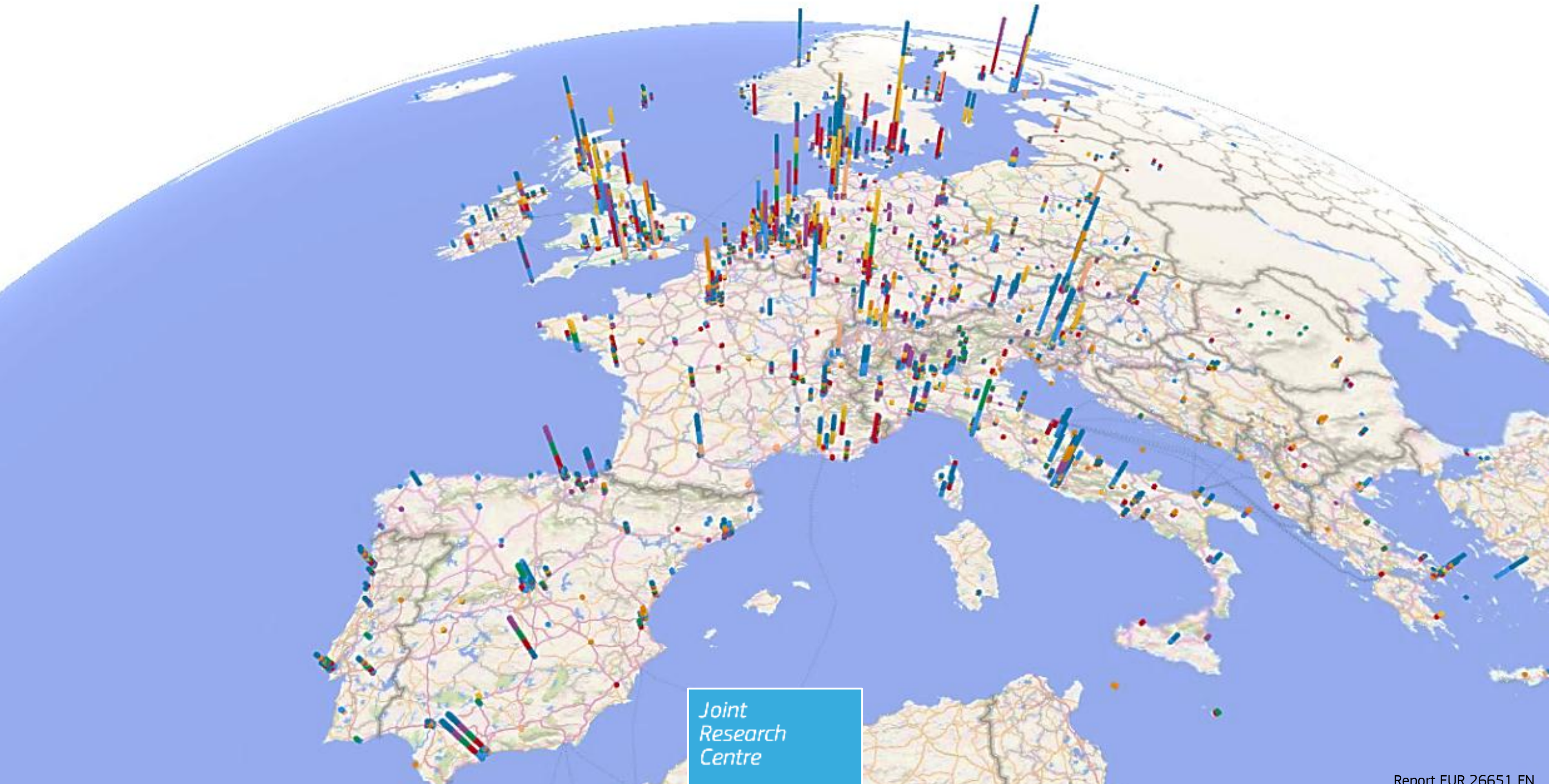

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ABBREVIATIONS AND ACRONYMS

CBA	Cost-benefit analysis
CHP	Combined Heat and Power
CO_2	Carbon Dioxide
D&D	Demonstration and Deployment
DEMS	Distributed Energy Management System
DER	Distributed Energy Resources
DG ENER	Directorate-General for Energy
DG	Distributed Generation
DMS	Data Management System
DR	Demand Response
DSO	Distribution System Operator
EC	European Commission
ENTSO-E	The European Network of Transmission System Operators for Electricity
EU	European Union
EV	Electric Vehicle
FP6	Sixth Framework Programme
FP7	Seventh Framework Programme
GPRS	General Packet Radio Service
ICT	Information and Communication Technologies
IEA	International Energy Agency
IT	Information Technologies
JRC	Joint Research Centre
KPI	Key Performance Indicator
kWh	Kilowatt-Hour
MSP	Multi-Sided Platform
OFGEM	Office of the Gas and Electricity Markets (UK)
PLC	Power Line Carrier
PV	Photovoltaic
R&D	Research and Development
RES	Renewable Energy Sources
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SMEs	Small and Medium Enterprises
TSO	Transmission System Operator
V2G	Vehicle to Grid
VPP	Virtual Power Plant

COUNTRY CODES

EUROPEAN UNION

EU 12	BE	Belgium
	DE	Germany
	DK	Denmark
	EL	Greece
	ES	Spain
	FR	France
	IE	Ireland
	IT	Italy
	LU	Luxemburg
	NL	Netherlands
	PT	Portugal
	UK	United Kingdom
EU15	AT	Austria
	FI	Finland
	SE	Sweden
EU25	CY	Cyprus
	CZ	Czech Republic
	EE	Estonia
	HU	Hungary
	LT	Lithuania
	LV	Latvia
	MT	Malta
	PL	Poland
	SI	Slovenia
	SK	Slovakia
EU27	BG	Bulgaria
	RO	Romania
EU 28	HR	Croatia

OTHER COUNTRIES

AL	Albania
AU	Australia
BA	Bosnia and Herzegovina
BY	Belarus
CH	Switzerland
IL	Israel
IN	India
IS	Iceland
KR	South Korea
LI	Liechtenstein
MC	Monaco
ME	Montenegro
MK	The former Yugoslav Republic of Macedonia
NO	Norway
RS	Serbia
RU	Russia
TR	Turkey
US	United States of America

EXECUTIVE SUMMARY

This report presents the latest analyses and insights from the most comprehensive database of smart grid projects for electricity across the European Union (EU) Member States. This rolling review, carried out on a periodical basis by the European Commission Joint Research Centre (JRC) in tight cooperation with the European Commission Directorate-General for Energy (ENER), builds upon the previous two smart grid project inventorying exercises published since 2011.[1]

The current edition of the survey includes a total of 459 smart grid projects, launched from 2002 up until today, which amount to €3.15 billion in investments. This study goes hand in hand with brand new interactive visualisation tools - available on the JRC's website: *ses.jrc.ec.europa.eu* - allowing the user to generate customisable maps, graphs and charts to track progress on smart grid projects realised in the 28 EU Member States (EU-28), plus Switzerland and Norway.[2]

This report and the underlying database cover the European smart grids projects – at transmission and/or distribution level – having inherent systemic, integration and interoperability connotations. In other words the reader can learn about all the European projects aimed at making the grid smarter through new technologies (e.g. storage devices, electric vehicles, distributed renewable generators) and

[1] This work cannot be directly paralleled with the preceding smart grid project reports for the following reasons: some older projects for which sufficient information was not available in the previous years have been now added (we noticed that some projects tend to be promoted later in their lifetime or even after their completion); some other projects faced modifications during their execution (in terms of budget, end dates etc.) and therefore have had to be duly updated.

[2] The discriminating criterion for including a smart grid project in the catalogue is the involvement of at least one partner from the EU28; this brought to the total number of 47 countries featured in this report.

new ICT capabilities. Projects focusing on individual energy technologies and resources have not been considered unless their integration in the grid was also in the project scope. A special case has been made for smart metering infrastructure deployment - one of the first smart grid enabling technologies having reached both maturity and viability for a full roll-out in many EU countries - which has been analysed in a dedicated section (the smart metering deployment and investment numbers however have not been added to the overall figures in the smart grid project inventory).

Smart grid project budgets have been growing steadily over the last decade: against the aforementioned €3.15 billion total investment, half of the projects are still ongoing, covering a budget exceeding €2 billion. After a first phase with some sporadic activity (2002-05), smart grid projects multiplied swiftly from 2006 onward, but the real boom was recorded after 2009. The smart grid projects are also getting larger: the share of projects with budgets over €20 million grew from 27 % in 2006 to 61 % in 2012.

In the period 2008-13, investment in smart grid projects was consistently above €200 million per year, reaching €500 million in 2011 and 2012. The number of Research and Development (R&D) projects is around the same as that of Demonstration and Deployment (D&D) projects, but the total investment in D&D is almost three times larger (the average D&D budget per project is usually two times larger than R&D). By far the largest investment comes from organisations in the EU15[3] Member States.

Denmark has the highest investment in smart grids per capita and per national electricity consumption followed by Slovenia. France and United Kingdom have the largest average budget per project (€5 million). There is a rather uniform geographical distribution of companies and budgets in several central-northern EU countries while East European countries together account for less than 1 % of the total budget and "insular patterns" in the geographical distribution of projects can be noted here. Czech Republic and Slovenia are the leading countries within the newer Member States in establishing a strategy for smart grids testing and implementation.

The smart grid projects are implemented in 578 different sites (532 within EU territory); half of their allocated budget goes to three countries: France, United Kingdom and Spain. In terms of regions/cities investing more on smart grid projects, there is a strong concentration of companies and budgets in Paris (France), Rome (Italy), Biscay (Spain) and London (United Kingdom), each of which retain more than €100 million in spending.

[3] EU Member States up to 2004.

As far as smart grids demonstration and deployment are concerned, key obstacles and challenges still appear to be at the social and regulatory levels (rather than technical constraints). The range of legal and regulatory arrangements in Europe might present significant barriers to the replicability of project results in different areas and to the scalability of projects to larger regions. Targeted analyses are necessary to understand the impact of the current wholesale and retail market schemes (and the related electricity prices and tariffs structures) on smart grid deployment opportunities. Uncertainty persists in several countries over: roles and responsibilities in new smart grid applications, sharing of costs and benefits and consequently new business models. Finally, a high degree of consumer resistance to participating in trials continues to be recorded throughout the EU.

In line with the JRC's mission to provide EU policies with evidence-based scientific and technical support and the JRC's objective to consolidate its position as independent observer and assessor of smart grid projects in Europe, the smart grid project database/inventory is intended to be updated on a regular basis. Project results are also being used to perform detailed cost-benefit analyses of smart grid applications and to assess scalability/replicability potentials and options.

This report and the related web-based visualisation platform offer comparative analyses and in-depth information - detailed per project or aggregated per clusters depending on the confidentiality level of the data collected - on several crucial aspects for smart grid project implementation and upscale: funding sources, organisation types, targeted applications, multinational collaborations, smart metering roll-out plans, the role of consumers. Concise information on these points is available in the following:

FUNDING SOURCES

- Funding still plays a crucial role in stimulating private investment in smart grid R&D and D&D projects. 90 % of the projects have received some form of public funding. In Eastern Europe the highest percentage of funding comes from the European Commission (EC);
- More than 50 % of the total smart grid budget originates from four countries: FR, UK, DE and ES;
- 49 % of the total budget for the smart grid projects surveyed comes from private capital and the remaining 49 % from various sources of funding (national, EC, regulatory) - 22 % of budgets come from EC funding, 18 % from national and 9 % from regulatory funding (e.g. Low Carbon Network Fund in the UK, OFGEM); 2 % is unclassified funding.

ORGANISATION TYPES

- There is a good level of diversity in the smart grid landscape: several types of organisation (universities, TSOs, DSOs, manufacturers, ICT companies, etc.) participate to significant degrees in the smart grid projects;
- 1670 organisations are involved; 22 % of them are participating in more than one project; 216 projects have only one participant; Germany is the country with the largest number of organisations; the most active organisation (DTU) is located in Denmark with participation in 45 projects;
- More than half of the budget is managed by universities and DSOs; DSOs manage 10 times more money in D&D than in R&D; The strongest cooperation is occurring between universities and manufacturing companies; TSOs, DSOs and Energy companies have the largest average private budget per project: above €5 million;
- The highest density of active companies (in terms of number and invested budget) is found in some of the largest European cities - Paris, Rome, London, Madrid, Copenhagen - as well as over a dispersed area in Belgium, Netherlands and Germany, northern Italy and northern Spain.

TARGETED APPLICATIONS

- A good degree of application diversity exists in smart grid projects and the level of diversity has remained steady over time. Smart Network Management and Smart Customer / Smart Home are the most targeted applications. New control/automation systems to improve the controllability and observability of the grid are quite consolidated and widespread and there is a large number of projects focusing on distributed ICT architectures for coordinating distributed resources and providing demand and supply flexibility;
- Electric Vehicles to Grid integration is the main targeted application in Germany and Austria; the current focus is still on ensuring that the charging and communication infrastructure works rather than on testing sophisticated applications with vehicle-to-grid (V2G) services;
- Focus on storage appears to be on the rise. Use of storage as additional source of grid flexibility is one of the key themes of the main projects that started in 2012 and 2013.

MULTINATIONAL COLLABORATIONS

- The catalogue contains 172 multinational projects (37% of the total) which together manage €1350 million (43% of the total). More than half of multinational projects are supported by EC funding. On average, 70% of the projects in a country (in terms of project number) are multinational collaborations;

- The majority of cooperation links are between organisations from older member states: lead organisations in multinational projects are almost exclusively from EU15 countries. There is a very limited level of cooperation between organisations from new member states. Organisations from Spain, France, Italy and Germany are the most active in setting up cooperation links in multinational projects. France is the top contributor while Switzerland is the top recipient in the multinational collaboration budget share ratio;
- 15 countries/half of the countries analysed (NO, CH, IE, PL, HU, SK, LT, RO, LV, HR, BG, LU, CY, EE, MT) receive 1 % or less from the total budget each and less than 5 % combined.

SMART METERING ROLL-OUT

- This section presents highlights from a targeted analysis, performed by the Commission services (DG ENER and JRC), regarding the smart metering deployment progress in the EU at national aggregated level, and reflecting the situation as of July 2013. Around 200 million smart meters in Europe (ca. 72 % of EU customers) are expected to be deployed by 2020 with an estimated investment of €35 billion. The most common smart metering communication technology intended to be used is revealed to be Power Line Carrier (PLC) in combination with General Packet Radio Service (GPRS). The results of this investigation and elaborated discussion are included in a Commission Report ("*Benchmarking smart metering deployment in the EU-27 with a focus on electricity*" and accompanying Staff Working Documents giving an overview of progress of smart metering roll-out in the EU along with detailed country-specific information) to be released later in 2014;
- The analysis demonstrates that where the roll-out of smart metering is positively assessed in a Member State, the expected penetration rate for electricity in many of these Member States may even exceed the Third Energy Package target of 80 % by 2020. 16 Member States (AT, DK, EE, FI, FR, GR, IE, IT, LU, MT, NL, PL, RO, ES, SE and UK) have either planned or already deployed nation-wide smart metering systems; 3 Member States (DE, LV and SK) are opting for selective smart metering roll-outs. 4 Member States (BE, CZ, LT and PT) decided currently not to proceed with nation-wide smart metering deployment; 4 Member States (BG, CY, HU and SI) had no CBA/data available at the moment of data collection (July 2013);

- Investment costs per smart metering point varies widely across EU Member States due to specific local conditions, communication technology and methodological differences in conducting the CBA, with an average cost of €252 (±€189) per metering point. Accounting only for those countries that have completed or will be proceeding with the roll-out, the average price is further reduced to €223 and the respective spread is narrowed (±€143); the expected average benefit per metering point across EU Member States that have completed or will be proceeding with electricity smart metering roll-out appears to be €309 (±€170) along with average energy savings of 3 % (±1.3 %);
- There is not yet an EU-wide consensus on the minimum set of smart metering system functionalities recommended by the Commission (Recommendation 2012/148/EU), which are in line with available standards. Only half of the Member States proceeding with nation-wide roll-out intend to deploy smart metering systems able to provide consumers (or a third party on their behalf) with frequent consumption data so that they can participate actively in the electricity supply market.

SMART CUSTOMER PROJECTS

- An increasing number of projects are focusing on the smart customer, however consumer participation in these projects is still limited in size (typically up to 2000 customers); consumers participation in trials is typically volunteer-based and cannot be considered representative of consumers in general;
- Organizations involved and investing in projects focusing on the smart customer are DSOs and university/research centres; Most of the smart customer projects are concentrated in a few countries: Denmark, France, UK and the Netherlands;
- 50 multinational projects focus specifically on smart customers. This number has been increasing since 2008.

1. INTRODUCTION

A smart electricity grid opens the door to new applications with far-reaching impacts: providing the capacity to safely integrate more renewable energy sources (RES), electric vehicles and distributed generators into the network; delivering power more efficiently and reliably through demand response and comprehensive control and monitoring capabilities; using automatic grid reconfiguration to prevent or restore outages (self-healing capabilities); enabling consumers to have greater control over their electricity consumption and to actively participate in the electricity market [1]-[14].

Main capabilities of the smart grid system include the integration and aggregation of: distributed energy resources (distributed generation – DG, electric vehicle – EV), demand response (DR) and large-scale renewable energy sources (RES) [15]-[17]. System integration is crucial to enable these capabilities [18], [19]. Making the smart grid system work requires the cooperation and integration of multidisciplinary players with different business interests, and the adoption of new compatible business models and regulations [9], [10], [12]-[14]. Moreover, it is imperative to make sure that consumers are on board, as the extent of the smart grid transformation should be tailored to consumers' needs and to their willingness to pay for its implementation [20]-[24].

At this stage, smart grid projects are playing a key role in shedding some light on how to move forward in this challenging transition. In 2011, therefore, the JRC launched the first inventory of smart grid projects in Europe to collect lessons learned and assess current developments [3], [4].

The participation of project coordinators and the reception of the report by the smart grid community were extremely positive. It was therefore decided that the project inventory would be carried out on a regular basis so as to constantly update the picture of smart grid developments [3], [4]. This study is the 2014 update of the inventory started out in 2011.

1.1 BOUNDARIES AND HYPOTHESES OF THE SMART GRID CATALOGUE

This publication includes and updates all the information from the previous reports on smart grid projects, and therefore it should not be paralleled with the preceding reports published by JRC. Since some projects are promoted later in their lifetime or even after their completion, the smart grid inventory had to be updated with older projects that were not found in the past. Also some projects may suffer modifications during their lifetime (in terms of budget, end dates etc.).

In line with the definition of smart grids, we adopted the following rules and hypotheses in compiling our database and this report.

General:

- We included projects focusing on individual new energy technologies and resources (e.g. new storage devices, electric vehicles, distributed renewable generators) only if their integration in the grid was also part of the project;
- We included projects aimed at making the grid smarter (through new technologies and new ICT capabilities);
- All the aggregations done for 2013 may be incomplete (this is applicable for all starting years, but in a lesser degree). Some projects are promoted later in their lifetime and insufficient or no information is available for them. This is why most of the aggregations for 2013 show a decrease in number or investment compared to 2012.
- We included projects starting in 2014 but we avoided presenting aggregated data for this year since this is just a partial aggregation (more projects will start later in the year or we couldn't find information on the ones that started).
- We did not include projects aimed at making the grid stronger (e.g. through new lines, substations and power plants) using conventional design approaches;
- We did not include projects where significant information gaps did not allow a reliable project assessment.

Project budget and funding sources:

- We included projects lacking budget information but they were not counted in any of the analysis involving investment.
- Most of the projects have more than one smart grid application (smart network management, smart customer and smart home etc.). The budget of a project was equally divided between the applications of that specific project, although in some cases this is not correct. This information proved difficult to find.
- If time was used as a factor for some of our studies, the following two cases can appear:
  - Budget division by starting year. For yearly aggregations, the entire project budget was allocated to the starting year (see sparkline).
  - Budget division considering the lifetime of the project. Even though this may not apply for some projects, the project budget was distributed equally over the lifetime of the project (division between the budget and the period, in years or months, see sparkline).

Participating organisations and implementation sites:

- The budget of projects was equally distributed between the participating partners. We know that this is not an ideal approach but the information regarding the share distribution between the partners was not available for most projects in our database. Additionally this is one of the simplest assumptions.

- The majority of projects have been classified against the funding source criterion (European Commission, private, national, regulatory). For a small minority of projects we couldn't find the exact funding source so we created an additional category named "Unclassified" (amounting to 2 % of the total budget).
- Some organisations may participate in more than one project. Because of these duplicates we had to coin for this report the term of "participation". The number of organisations is always lower than the number of participations, since some organisations are counted more than once.
- For the budget allocation to the implementation sites across different countries, a weighted method was used. For the projects with one site, the investments were assigned to the countries hosting the implementation sites. The budgets of the projects with several implementation sites (in one or more countries) were distributed evenly among the sites.

1.2 AN OPEN PLATFORM FOR DATA COLLECTION AND DISSEMINATION

The JRC inventory exercise highlights a number of important lessons about the dissemination and sharing of smart grid results and experiences:

✓ Caution in sharing quantitative data and lessons learned: As the majority of projects shared information on a voluntary basis, data confidentiality and reluctance to share negative results still represent a barrier to data-sharing;

✓ Lack of a common interest for data sharing and analysis: Carrying out a complete and detailed mapping of smart grid projects in Europe proved challenging since some have close to no information available to the general public. A great percentage of the projects in our inventory were found only after an active internet search for new data. Most of this information proved to be really fragmented, inconsistent or self-contradictory. For a multitude of motives, some project coordinators are not interested in sharing their project information either through a website or other means. Other projects are promoted when they are already in a completion stage. We found a considerable number of projects that we couldn't include in our inventory because of deficient information that did not allow a reliable project assessment;

✓ Fragmentation of initiatives for sharing project results: There is a need to keep track of and coordinate initiatives on smart grids and to exchange data and results. On the basis of the positive experiences of the 2011 and 2012 smart grid project-mapping exercises, the JRC sees merit in institutional actors acting as reference points for several stakeholders, thus avoiding a duplication and fragmentation of initiatives.

Against this background the JRC's broader objective was to establish an open platform for the collection and dissemination of project information involving all Member States, international organisations and energy operators. Therefore, an on-line questionnaire[4] is available which allows the standardised input of data by project coordinators, simplifying the data collection and processing phases.

The data collected have been checked for consistency and included in the JRC smart grid project database, which functions as the single repository of European smart grid projects. The JRC will regularly publish an updated version of the database (all financial/economic information will be treated confidentially and only aggregated data will be published) to be used by different users (institutional, industrial, etc). All users are encouraged to contribute to the mapping exercise.

An instrumental role is played by the visualisation platforms, linked to the JRC database, which map projects across Europe. Project data can be tracked on the JRC website[4]. Other interested parties are encouraged to use the database to create their own visualisation platform or perform their own tailored analysis.

1.3 THE JRC QUESTIONNAIRE

The main idea behind the survey was that any smart grid project, having one or more technical applications, is supported by one or more organizations that will need to provide funding or/and other resources. Figure 1.1 illustrates all the funding sources, organization types and the main smart grid applications. The on-line questionnaire (see Annex II) includes the following sections.

Project overview information

- Project name, acronym, brief description, contact details, website;
- Start and end dates;
- Stage of development (R&D, Demonstration and deployment);
- Participating organisations, participating countries (name, address, organisation type, role – leader or partner);
- Implementation sites (location);
- Project benefits, overview of project results and the main challenges and lessons learned.

Project financial information

- Total project investment;

[4] *ses.jrc.ec.europa.eu*

- Total investment division between the sources of funding (national funding, European Commission funding, regulatory funding, private investments); funding body or program.

Main project applications

This section includes information about which functional areas (applications) the project is contributing to and the main technical parameters (grid characteristics in terms of voltage or power level, number of users involved, number of EV and EV charging stations or of smart meters, etc.). Beside this the survey includes a small section enclosing specific technical and non-technical questions connected to the smart metering application.

Consumer involvement and social impact

This section includes qualitative and quantitative information about number of users, target sector, specific strategies and results achieved in the project on consumer involvement (e.g. main motivational factors used to involve consumers, main observed benefits for consumers, etc.) and social issues addressed by the project (e.g. social acceptance, job creation/loss, safety, vulnerable consumers, etc.).

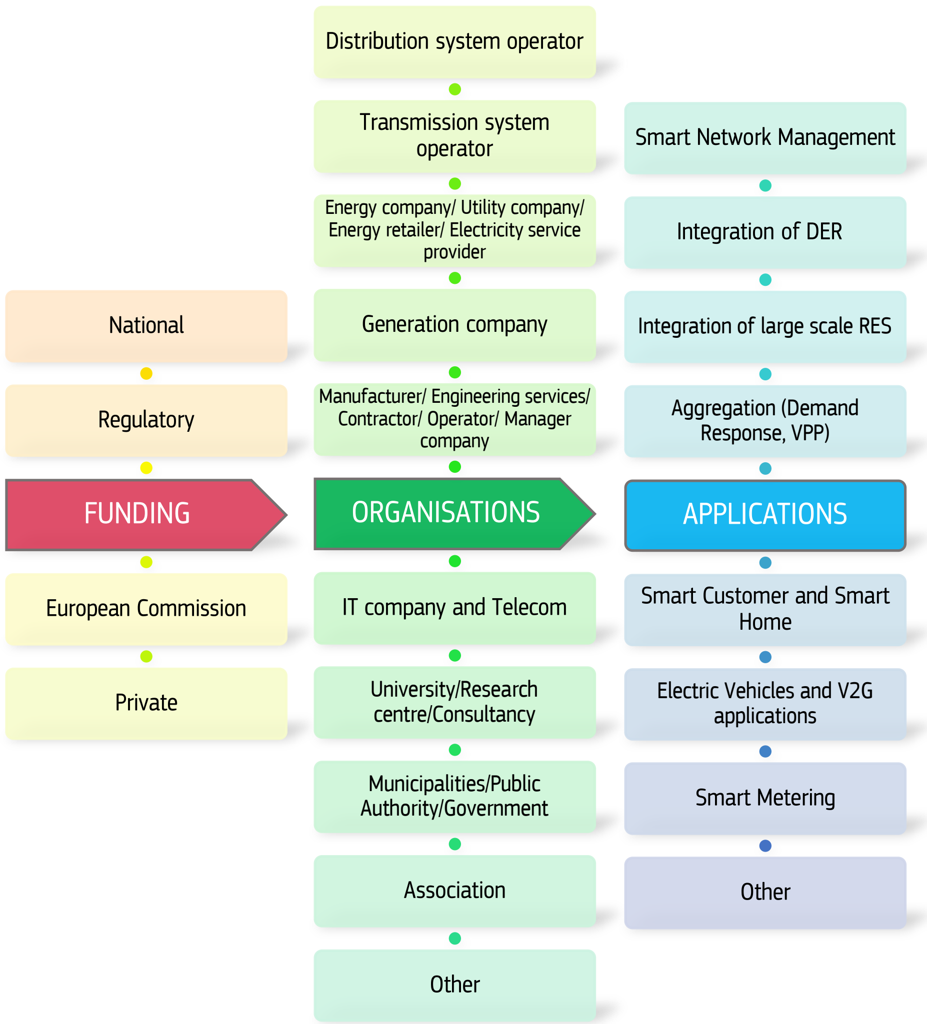

Figure 1.1 Smart grid project overview: funding source, participating organisations, applications

1.4 R&D, DEMONSTRATION AND DEPLOYMENT

The projects surveyed were classified in two categories: R&D and Demonstration / deployment categories. To identify R&D projects we used the definition in the Frascati Manual, according to which R&D projects comprise *creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications* [25]. The term R&D covers three activities: basic research, applied research and experimental development.

Demonstration projects can be regarded as a 'preview' phase before marketing. The concept includes projects designed to test the performance of a technology in different operational environments, through to full market trials in which the technology is used in customer installations [26]. The aim of these projects is to expose the technology to realistic user environments to test its suitability for more widespread use.

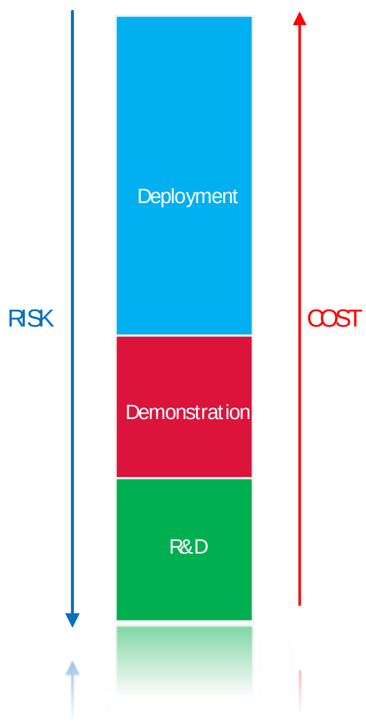

Figure 1.2 Risk and cost levels in R&D, demonstration and roll-out projects

Finally, deployment and roll-out projects refer to the implementation of a technology, application or system as a default solution within the project's geographical boundaries. Some deployment projects are nationwide; others are limited to a smaller geographical area.

As shown in Figure 1.2, there is an inverse relationship between risk and cost through the different stages of maturity of a technology or application, from R&D to demonstration up to final roll-out. Clearly the boundaries between the different phases are blurred. Projects might have both an R&D phase and a demonstration phase, for example. In these cases, for the sake of simplicity, we have assigned the project to the stage that seemed to best characterise the project and to which most project time and budget were allocated.

In characterising the level of maturity of a project, we have also considered other factors, like project size and budget, the number and type of partners involved and the level of maturity of a certain application in general and in the area where the project was implemented.

In our report the demonstration and deployment were merged in one category, named "D&D" or "Demo and Deployment", since in most cases there is a fine line between these two sets.

1.5 SMART METERING VS SMART GRID PROJECTS

As became clear from the 2011 and 2012 inventories, smart metering is the area where the most significant progress has been made throughout Europe. In fact, the large deployment projects in our catalogue are essentially smart metering roll-outs.

Smart metering roll-outs and large-scale pilots account for most of the total investment of the projects surveyed. In the present report the smart metering roll outs and large scale pilots were analysed independently (in the "Smart metering" chapter) from the rest of the smart grid projects.

More specifically, we can distinguish three types of smart metering projects: smart metering roll-outs (with regional or national coverage), smart metering pilots (typically for conducting the CBA of a full roll-out) and smart metering installations which are part of a wider smart grid project (it is noted that national smart metering roll-out programmes are analysed in the Commission's Benchmarking Report). Projects in this last category type 'straddle' the dividing line between smart grid projects and smart metering pilots and are covered in both sets of analysis in this report.

Figure 1.3 shows the links between the smart grid and smart metering project subsets analysed in following chapters. Projects in the area highlighted in red are common to both analyses.

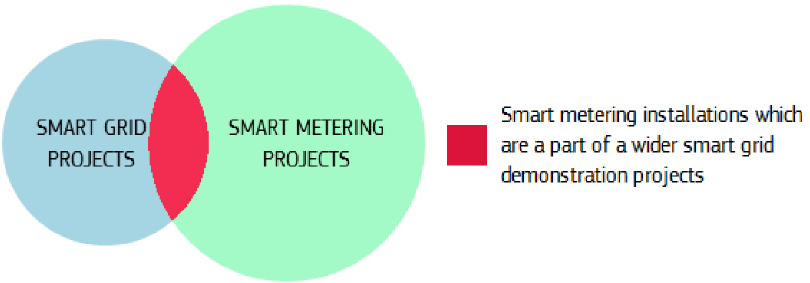

Figure 1.3 Smart grid and smart metering project subsets covered in the analysis (the green part is not included)

1.6 DATA COLLECTION PROCESS FOR THE 2014 INVENTORY

The on-line questionnaire was updated in August 2013. In this report only the projects submitted by January 2014 were considered. The on-line questionnaire remains open for the next edition of the inventory.

In parallel we conducted a thorough and extensive search of project information on-line and through participation in conferences and workshops. We then contacted project coordinators directly to ask for more information on the on-line form.

Data collected from respondents were double-checked in various ways to ensure consistency. For all projects we checked the website of the project (where applicable) and of the lead organisation to corroborate the information we received. Where discrepancies were found or the template was not clear enough, we also contacted the lead organisation by e-mail or phone.

Based on the data validation process, some projects have been omitted, as the data was considered not sufficiently reliable. These projects, along with projects not yet included/known/started, will be considered for inclusion in the next edition of the report, provided that reliable/complete information is delivered. As mentioned before, all the aggregations done for 2013 may be incomplete (this is applicable for all starting years, but in a lesser degree), since some projects are advertised later in their lifetime. This is why most of the aggregations for 2013 show a decline in number or investment compared to 2012. We also counted projects starting in 2014 but we did not show aggregated data for this year since this is just an incomplete aggregation (more projects will start later in the year or we couldn't find the ones that started).

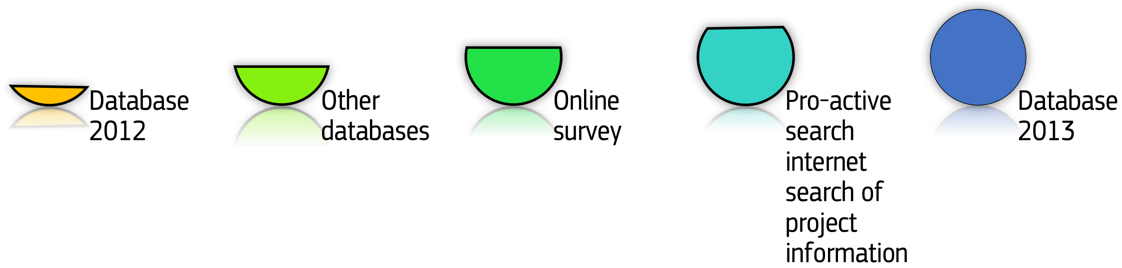

Figure 1.4 Data collection and validation process for the 2013 inventory update

Lastly, we established links with research institutions which had already produced some sort of smart grid project inventory and went through their databases, rigorously checking all relevant information before integrating it in our database (see Figure 1.4).

1.7 REPORT STRUCTURE

The analysis of the smart grid projects (Chapters 2 to 7) represents the main pillar of the report. These will be completed by a chapter dedicated to large smart metering projects and chapter studying the consumer involvement and the social implications of the smart grid projects.

Chapter 2 presents an overview of the European smart grid projects, aggregating project data and giving general information.

Chapter 3 analyses the smart grid projects considering their funding sources.

Chapter 4 presents an overview of the organisations involved in the smart grid sector.

Chapter 5 studies the main applications targeted by the projects.

Chapter 6 analyses the cooperation and the relationships between the European countries.

Chapter 7 presents a micro-perspective, focusing on individual smart grid projects.

Chapter 8 presents an overview of the activities on smart metering in Europe.

Chapter 9 gives an insight into the smart customer and smart home projects.

Finally the report ends with 3 annexes; the first one gives additional charts, maps and figures that bring further information to the ones existing in the main part of the report, the second one gives the format of the on-line survey and the third annex shows a list of the projects included in our inventory.

Chapters 2 to 7 follow the same structure, with minor differences. All of them will include (beside some other specific studies) the following analyses:

- a general overview (totals, averages);
- by stage of development (R&D and Demo & Deployment);
- by starting year (from 2004 to 2013);
- by geography (European countries).

2. SMART GRID PROJECTS IN EUROPE: OVERVIEW

In this chapter we use project data to support an analysis of macro trends and developments concerning smart grids in Europe from different perspectives. We will focus on smart grid projects only, considering R&D and Demo & Deployment stages of development. As mentioned, smart metering pilots and roll-outs will be analysed in Chapter 8 and are therefore excluded from the analysis that follows.

2.1 THE BIG PICTURE

Figure 2.1 Geographically more than half of the smart grid budget can be found inside the circle[5]

The JRC's 2013-14 Smart Grid database contains 459 smart grid R&D and Demo & Deployment projects from all 28 European Union countries. Switzerland and Norway were studied together with the EU28 countries since they are present in a substantial number of projects with EU countries. Other 17 non EU countries are represented in the inventory by their participating organisations. The total investment of the smart grid projects amounts to €3.15 billion[6]. Figure 2.2 gives a rough outline of the European smart grid scene.

Figure 2.2 Summary of smart grid projects in the 2014 JRC catalogue

[5] This is only an illustration. There are other additional significant isolated investment centres.
[6] 37 out of the 459 projects in the inventory have no budget information.

The database includes 211 R&D projects and 248 Demo and deployment projects (Figure 2.3). Considering the number of countries involved there are 172 multinational projects with an average of 6 countries per project. Circa 75 % of the 287 national projects have only one participant. The internet search that we performed provided evidence regarding the existence of other European smart grid projects. Because of insufficient data we couldn't include them in our inventory. These projects will be considered for inclusion in the next edition of the report, provided that reliable/complete information is obtained.

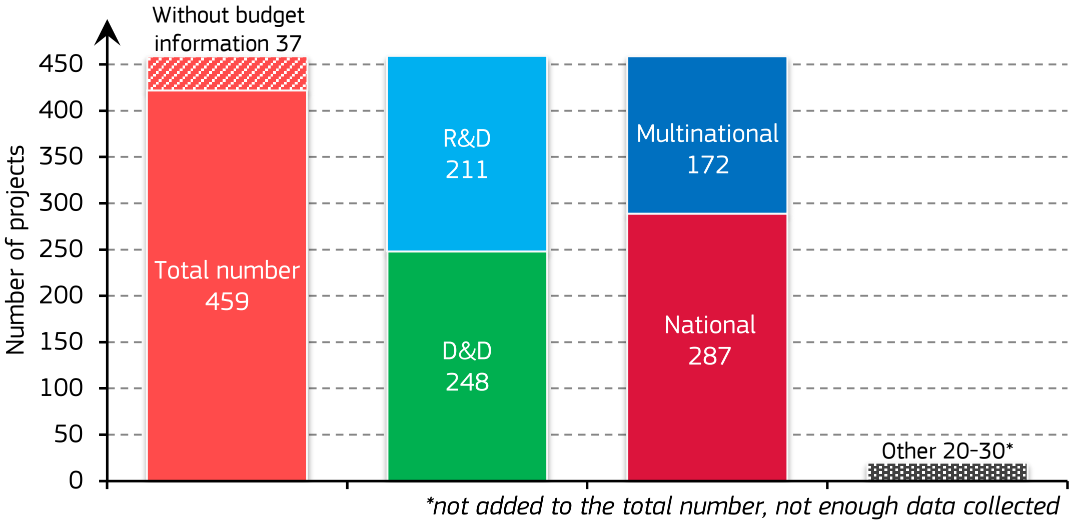

Figure 2.3 Total number of European smart grid projects (up to and including 2014)

The database includes R&D projects with a total budget of around €830 million and Demo and deployment projects with a total budget of around €2320 million (Figure 2.4). These figures apply only to 422 projects from our database since 37 projects have no budget information (we couldn't obtain the figures).

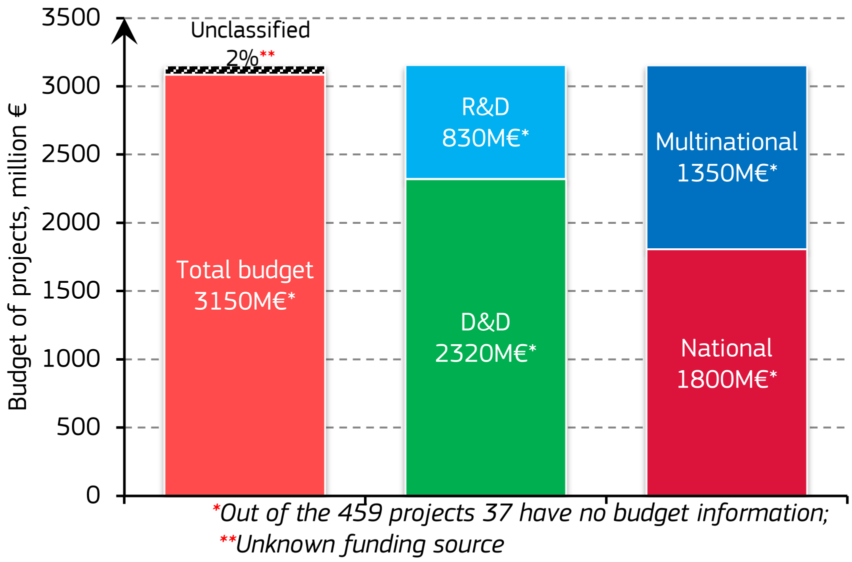

Figure 2.4 Total budget of European smart grid projects (up to and including 2014)

The multinational projects amount to €1350 million or 43 % of the total budget (compared to 37 % from the number of projects perspective). For 2 % of the total budget the funding source is not available. This will not influence the figures in this chapter.

The projects surveyed have an average budget of €7.5 million[7] and an average duration of 33 months. Demo and Development projects have a significantly higher average budget than the R&D projects and slightly higher than the general average (Figure 2.5).

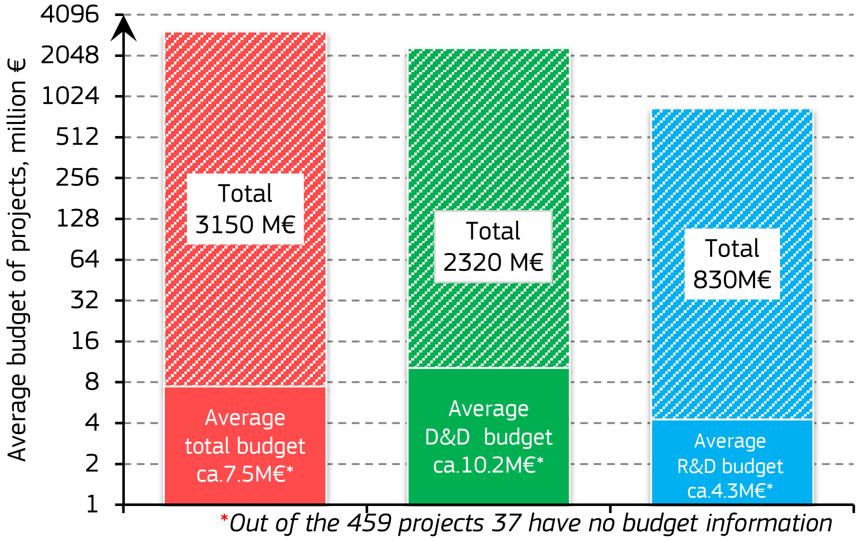

Figure 2.5 Average budget of smart grid projects by stage of development

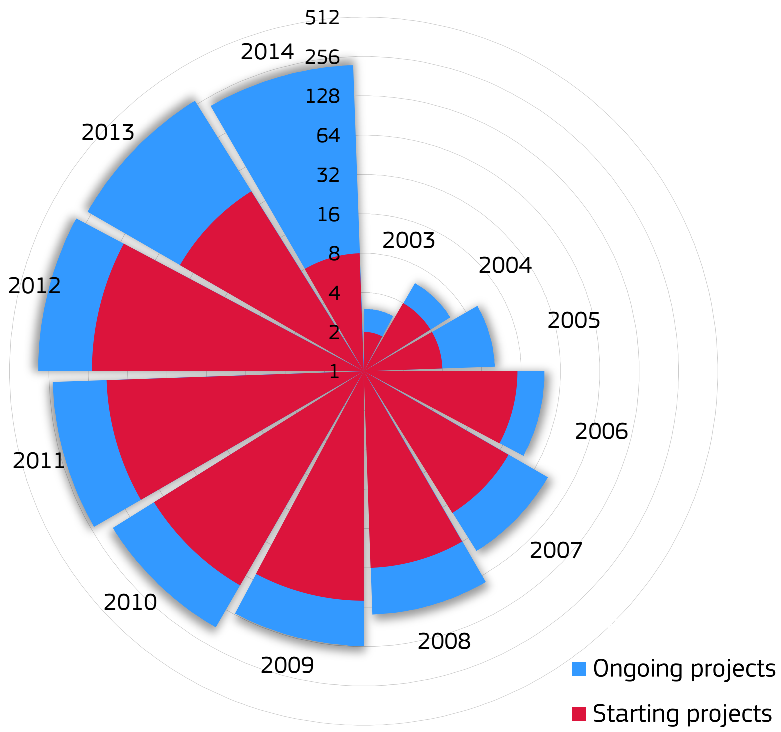

Figure 2.6 Starting and ongoing smart grids projects per year

[7] Not considering the 37 projects without budget information.

48 % of the projects surveyed are still ongoing (with a total budget of €2000 million), most of them ending by 2017. Figure 2.6 illustrates the starting projects and the active projects, both by year. To calculate the activity each project was counted-in for each year in its lifetime. The decrease in starting and active projects for 2013 and 2104 may be caused by the reasons mentioned in the introduction chapter[8]. A general increase in the number of smart grid projects is seen over the years, 2012 being one of the most active years.

2.2 PROJECT MATURITY

Figure 2.7 shows the number R&D and Demo & Deployment projects by year[9] and the yearly fluctuation in percentage (compared to the previous year). The data for 2013 may be incomplete. Starting with 2009 we can identify a phase where we observe a dramatic increase in the number of smart grid projects starting each year. Also in this phase we can observe that the increase in number of R&D projects isn't so intensive, compared to the steady growth of the Demo & Deployment projects, suggesting that some of the smart grid technologies have reached a mature stage, safe for deployment.

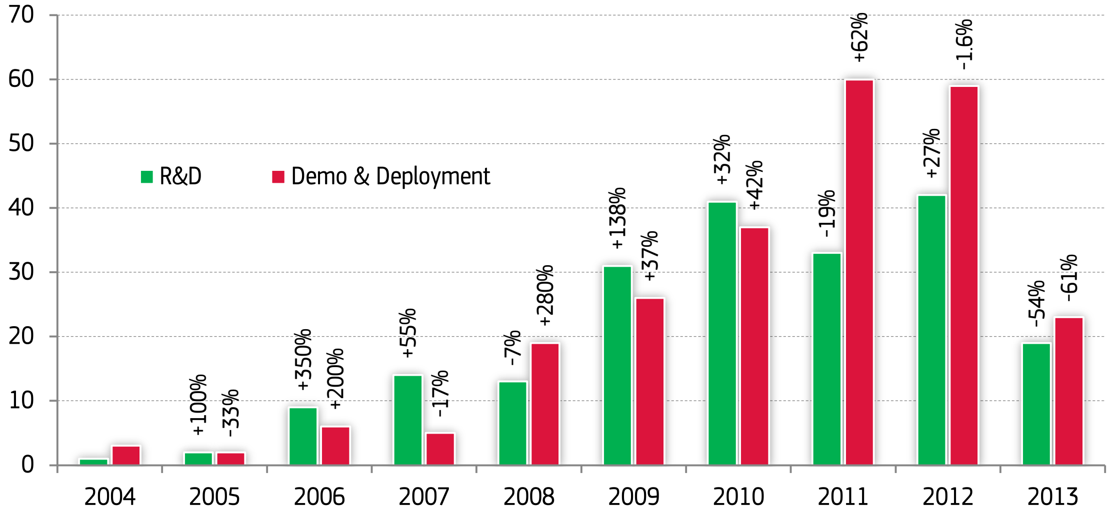

Figure 2.7 Smart grid projects number per year and stage of development
(and yearly fluctuation in percentage - compared to the previous year)

Concerning the financial side, Figure 2.8 illustrates the investment in R&D and Demo & Deployment projects by year. As said above the data for 2013 is partial. The investments in smart grid projects since 2008 have consistently exceeded €250 million a year. The level of funds committed in 2011 and 2012 is notable – more than €700 million a year. Based on the information in the catalogue, this can be attributed to some large publicly-funded projects, in particular the first batch of projects funded by the

[8] See subchapter 1.1 Boundaries and hypotheses of the smart grid catalogue;
[9] It is assumed that the whole project budget is allocated to the starting year of the project.

Low Carbon Network Fund (LCNF) in the UK, a significant number of large-scale demonstrators financed under FP7 or with European regional funding.

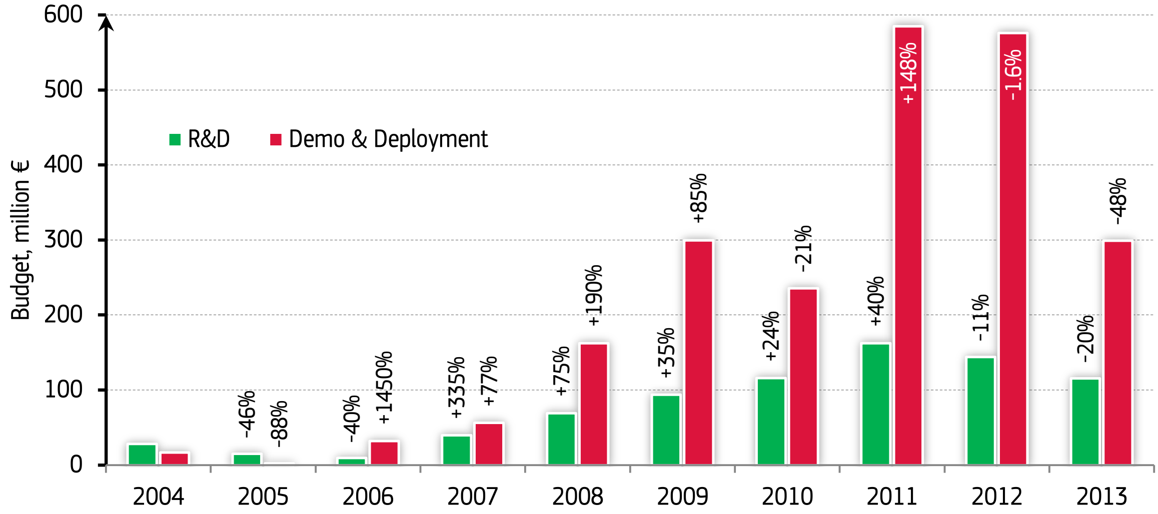

Figure 2.8 Smart grid projects budget per year and stage of development
(and yearly fluctuation in percentage - compared to the previous year)

Figure 2.9 shows the average project budget across the years. Between 2005 and 2013, the average budget for R&D projects varied from €1 to €7.5 million, with the highest values in 2004, 2005 and 2013 (fewer projects in the early years). Overall, R&D projects have an average budget of €4.3 million. For the Demo & Deployment projects, in the period between 2007 and 2013, the average budget is situated between €7 million and €14 million.

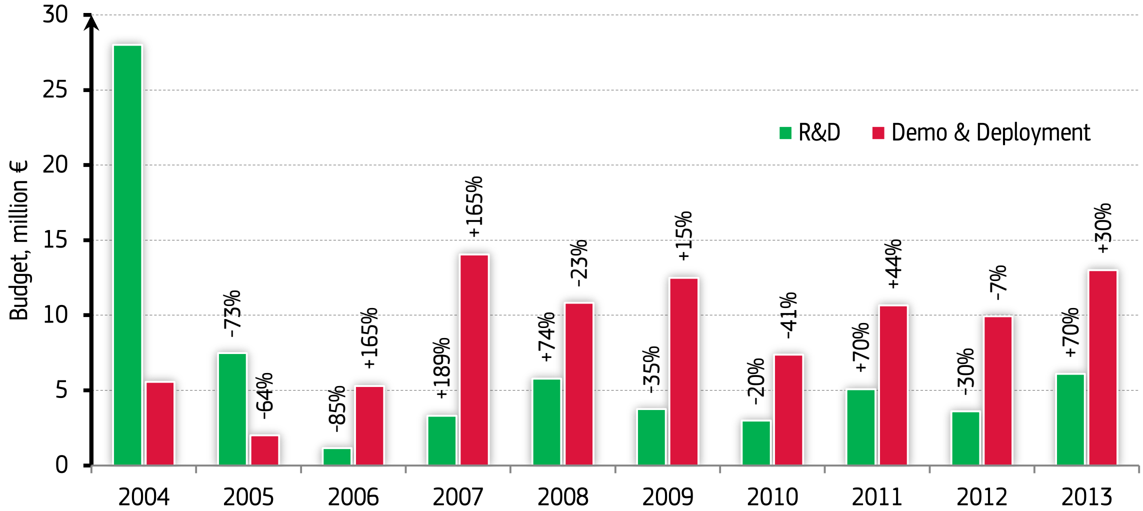

Figure 2.9 Smart grid projects average budget per year and stage of development
(and yearly fluctuation in percentage - compared to the previous year)

Overall between 2007 and 2013 the typical smart grid project budget started from €5 million and went up to €10 million, compared to €0.07 million and €77 million – the projects with the lowest, respectively highest budgets.

2.3 PROJECT SCALE AND BUDGET RANGE

The analysis in the previous section considers only the aggregated amount of investment over the years, without considering the individual size of the projects. An overall high level of investment (in a year or in a country) could be achieved through a few large-scale demonstrators or a high number of small-scale projects. The latter scenario might suggest a more exploratory approach in smart grid applications, whereas the former might imply that investment is being focused on more consolidated applications.

To give an impression on the budget size of the projects in our database, Figure 2.10 shows the budget of all the smart grid projects in the catalogue[10]. By clustering projects with similar budgets, we have identified five different project sizes:

- Very small-scale projects: between € 0 million and € 2.5 million;
- Small-scale projects: between € 2.5 million and € 7.5 million;
- Medium-scale projects: between € 7.5 million and € 20 million;
- Large-scale projects: between € 20 million and € 30 million;
- Very large-scale projects: above € 30 million.

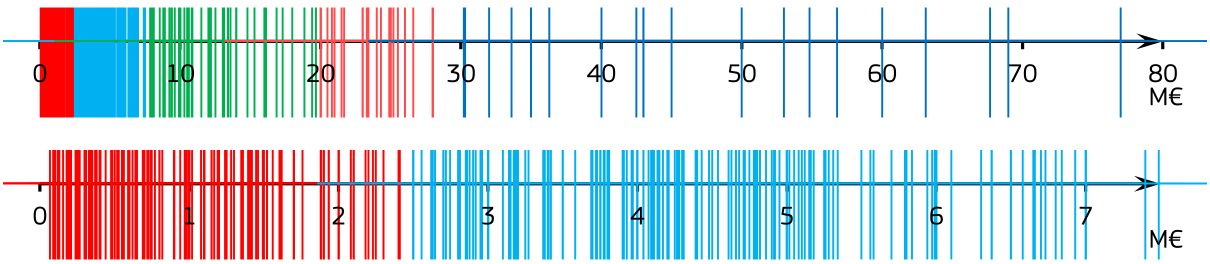

Figure 2.10 Budget categories distribution
(each line is a project; bottom chart is a zoom on the top chart)

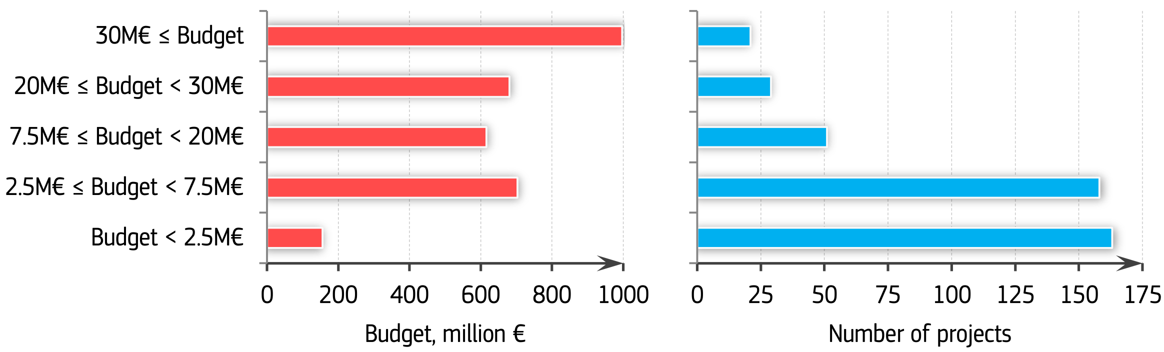

Figure 2.11 Project distribution by budget category
Left: investment; Right: numerical;

[10] The 37 projects missing budget information were not considered.

Figure 2.11 shows the total share of each cluster in terms of number (right) and budget (left). Most smart grid projects in the catalogue (around 75 %) have a budget smaller than €7.5 million and can thus be labelled 'very small-scale' and 'small-scale'. Incidentally the same percent of projects have a budget below the average of €7.5 million. Even though the majority of projects are small ones, more than 50 % of the total smart grid budget is found in large and very large scale projects and only 25 % in small and very small projects.

In terms of both number and budget, it is worth noting that the 'small-scale' cluster is increasing at the expense of the 'very small-scale' cluster and the 'medium-scale' cluster is shrinking in favour of the 'large' and 'very-large scale' ones. In other words, the size of projects is generally increasing, showing positive signs in terms of the scalability and maturity of related smart grid applications. Before 2006, projects with budgets below €20 million accounted for the majority of the total investment. In 2013, this share decreased considerably, in favour of large and very large-scale projects, which now represent the bulk of investments in SG projects.

2.4 GEOGRAPHICAL DISTRIBUTION

The total number of 459 smart grid projects is divided mainly between the European Union member states with some other participation, most notably from Europe but also from Asia, Australia and Americas. The average number of projects per European Union country is around 40 but this value hides large disparities.

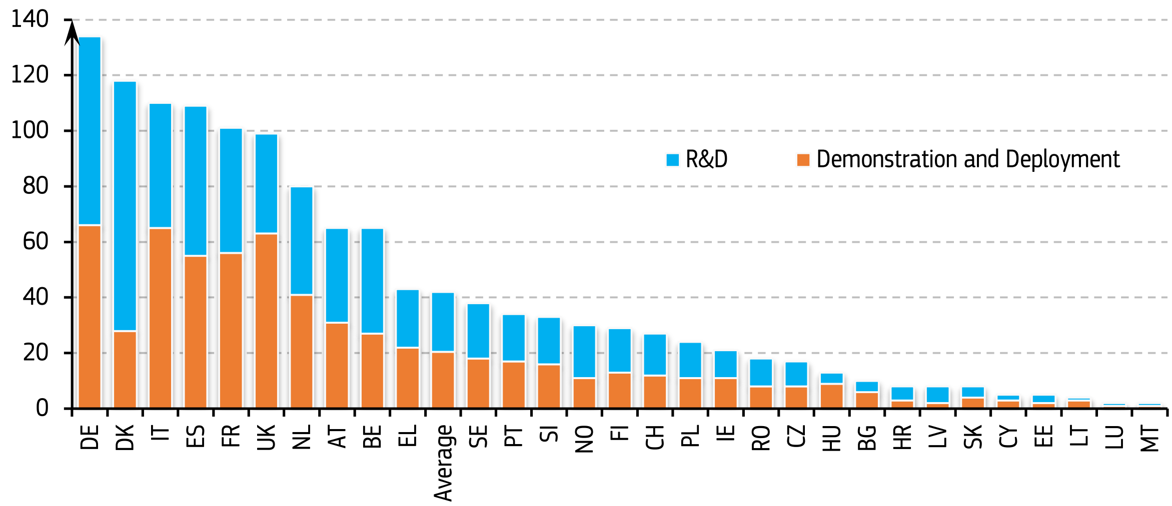

Figure 2.12 Number of projects per stage of development and country

Seven countries (Figure 2.12) are involved in a number of smart grid projects that is greater than the doubled average, with Germany being involved in the highest number of them. In the vast majority of countries there is a balanced ratio between the participation in the R&D and Demo & Deployment projects with the notable exception of Denmark where the number of R&D projects is almost three times larger than the number of Demo & Deployment projects. This case shows the position of Denmark as leader in research and innovation in the field of smart grids, particularly in the initial stages. In a similar situation is Finland although with not such a big difference between the types of projects. As we will see later, this is related to high percentage of budget absorption towards R&D by the universities and research entities in these countries. A slightly higher number of Demo & Deployment projects than R&D projects can be found in United Kingdom and Italy, probably connected to their large programs of smart-metering, some of them part of a wider smart grid project.

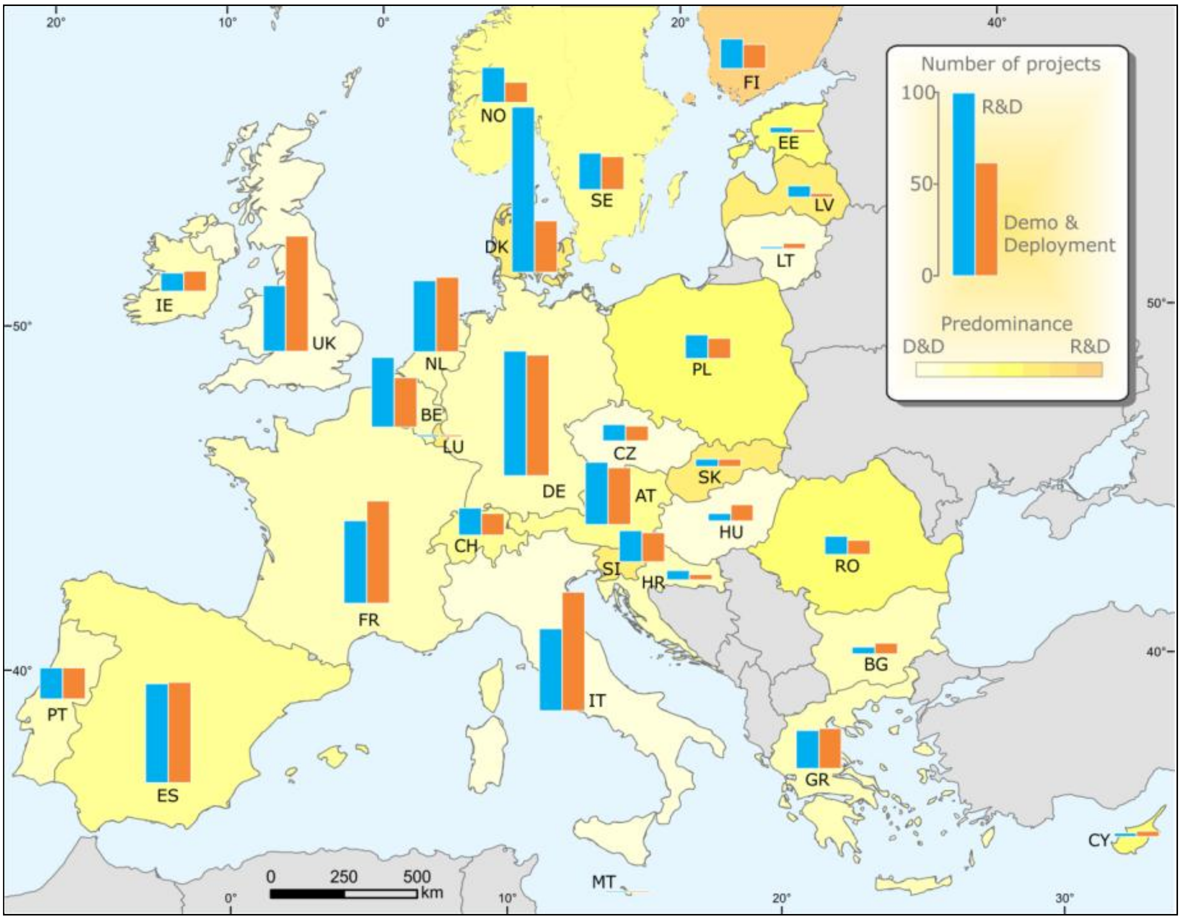

Figure 2.13 Number of projects per stage of development and country

The countries with a number of projects above the average are all situated in the western or southern part of the continent (Figure 2.13), the eastern part countries showing more modest figures, well below the average.

The total budget of approx. €3150 million follows closely the same pattern of distribution among countries, with a slightly different order (Figure 2.14). Most of the investment goes to France and United Kingdom each managing more than 15 % from the total budget (Figures 2.15 and 2.16). The distribution of budget according to the stage of development shows a net dominance of Demo & Deployment projects in all the countries with the exception of Finland, Denmark and Slovakia which attracted more money into R&D projects.

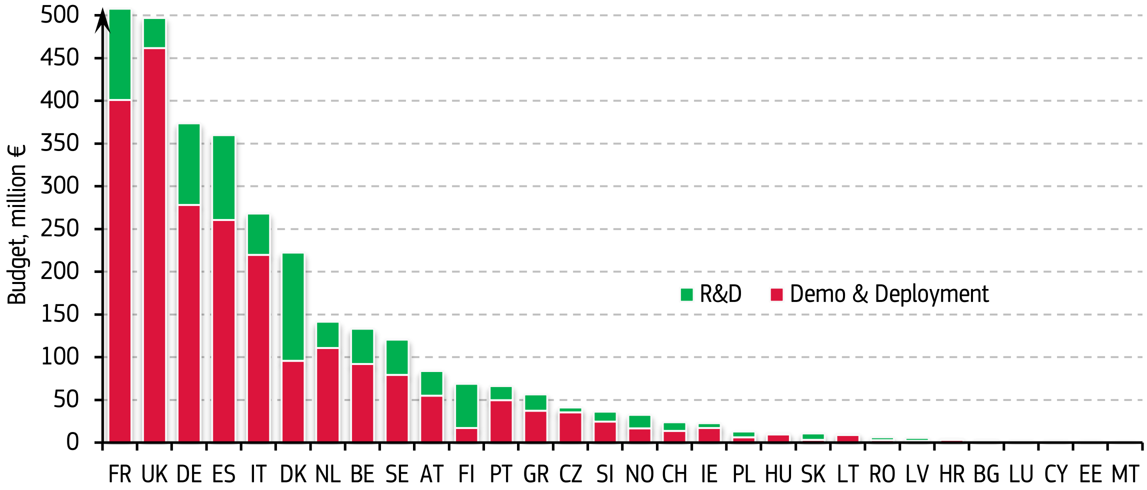

Figure 2.14 Distribution of total budget per stage of development and country[11,12]

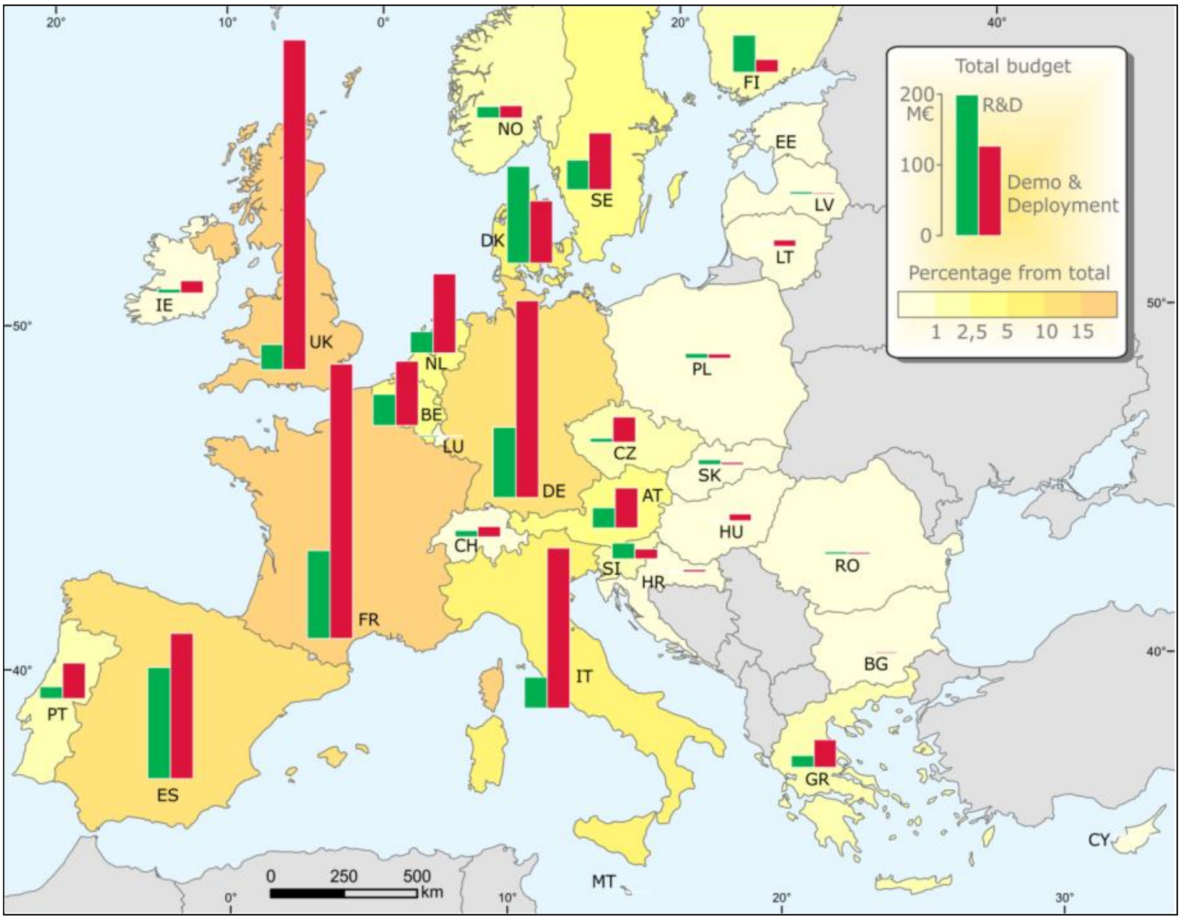

Figure 2.15 Distribution of total budget per stage of development and country

As in the case of the number of projects, mainly the countries in the western and southern part of the continent manage the largest shares of the budget. Together, the eastern countries hardly succeed in getting more than 1 % from the total budget.

[11] For a percentage distribution of total budget per stage of development and country see Figure A.1-Annex I

[12] For a normal and a percentage distribution of private and European Commission funding per stage of development and country see Figures A.2, A.3, A.4 and A.5-Annex I.

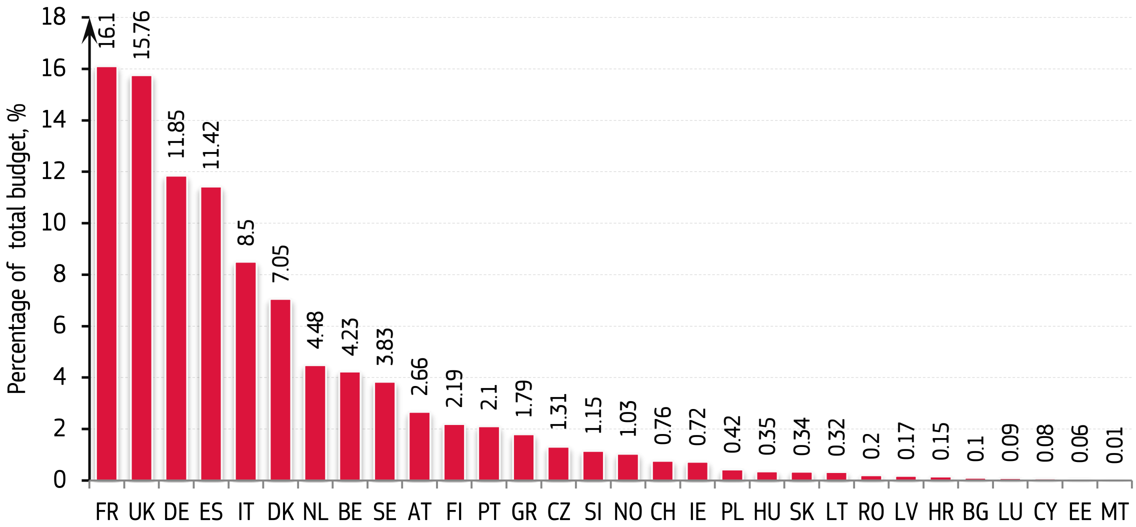

Figure 2.16 Percentage from total budget per country

By far the largest average budgets per project can be found in the two countries which also have the largest budgets: France and United Kingdom, with almost €5 million / project (Figure 2.17). As 80 % and more of the budget consists of Demo & Deployment, this high average figure can be associated with national financing programs.

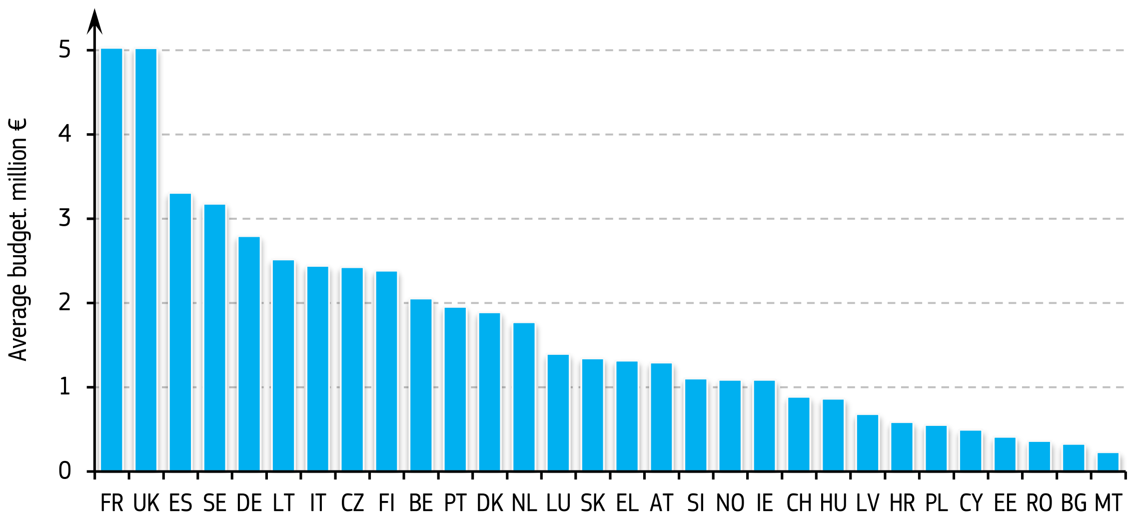

Figure 2.17 Average budget per project and country[15]

The countries with the largest budgets show a higher percentage of it allocated to the leaders of the projects, usually more than 50 % (Figure 2.18). Generally countries with higher percentages of budget administrated by project leaders have also a higher percentage of their budgets coming from national sources. This is the case for project leaders in United Kingdom and Denmark which manage to administer more than two thirds from their country's total budget. At the other end, the newer member states, in addition to having lower total budgets, administer their share mainly as partners. We mention

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[13] For the geographical distribution average budget per project, stage of development and country see Figure A.7-Annex I

the exception of the Czech Republic and Slovenia which have larger than the regional average budgets, half of them administered as project leaders.

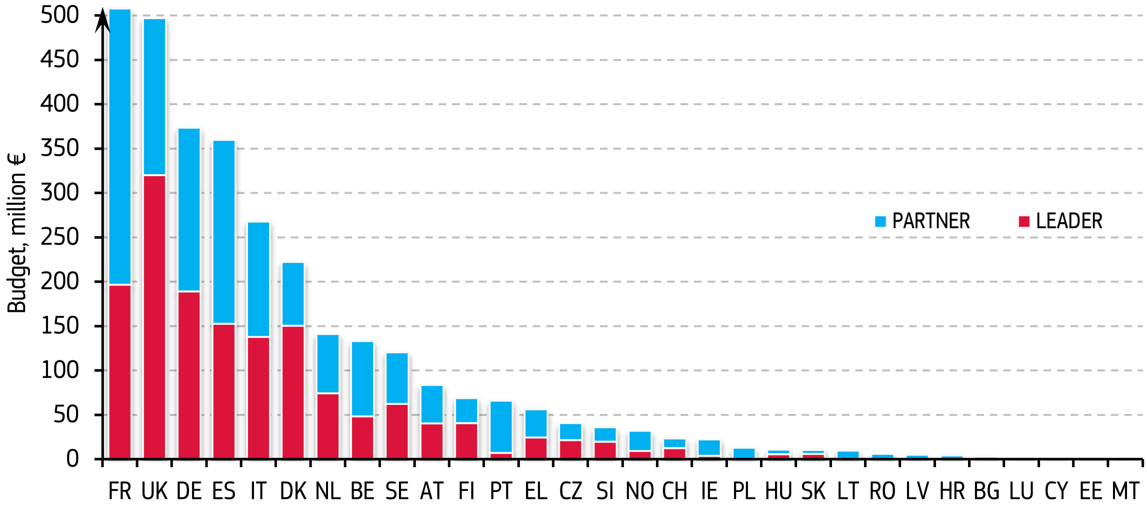


Figure 2.18 Distribution of total budget per country between leaders and participants[14]

When it comes to the private budget the top 4 countries remain the same, with a slightly different order but the differences between their values are larger (Figure 2.19). France is the top investor with a budget over €300 million. With the exception of the Czech Republic and Slovenia, countries from eastern and southeastern Europe administer small private budgets.

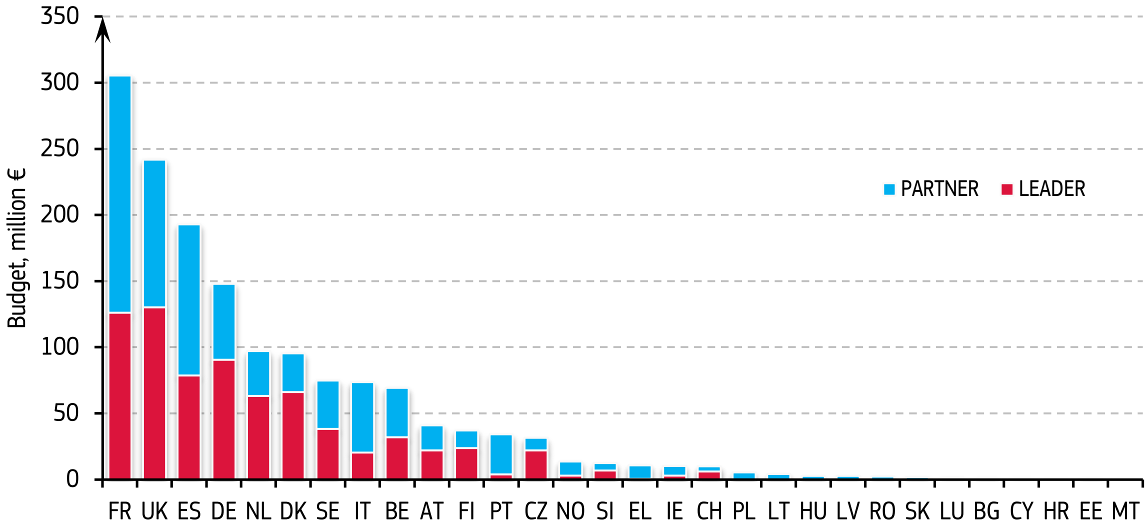


Figure 2.19 Distribution of private budget per country between leaders and partners

The highest percentage of the private budget administrated as project leaders can be found in the Czech Republic and Denmark at around 70 %, while countries in east and southeast Europe use more than 90 % of the private budget as project partners (Figure 2.20).

[14] For the percentage distribution of total budget per country between leaders and participants Figure A.6 in Annex I

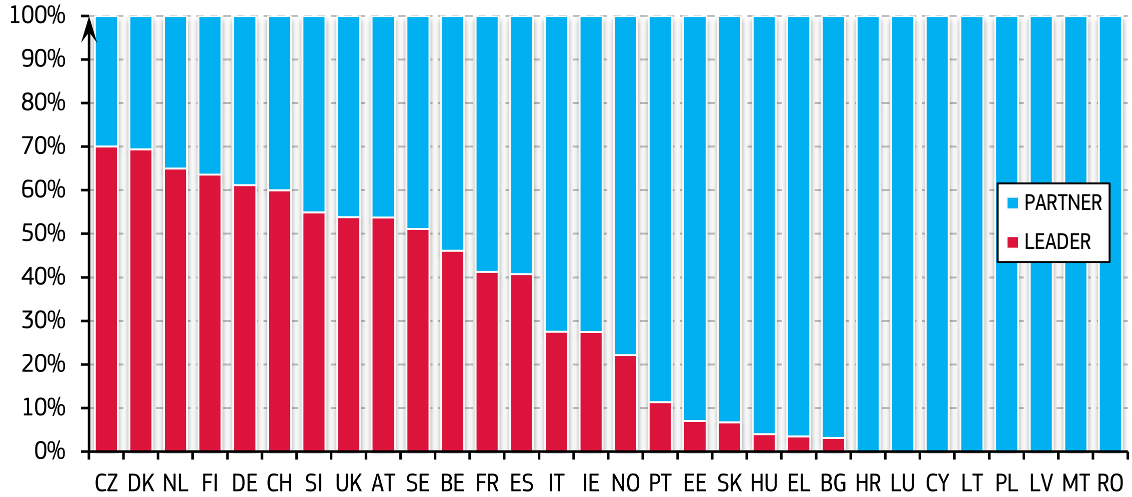


Figure 2.20 Percentage distribution of private budget per country between leaders and partners

The average budget for Demo & Deployment projects is roughly two times higher than that of R&D (€2.24 million compared to €1.08 million). Finland stands apart from this pattern (and at some extent Luxembourg) where the average budget for R&D projects is almost three times larger than that for Demo & Deployment. Besides Finland, two other countries have average budgets for R&D project higher than €2.5 million: Spain and France (Figure 2.21). On the Demo & Deployment side, United Kingdom and France stand apart with their very large average budgets in comparison with the other countries, with around €7 million per project each (Figure 2.22).

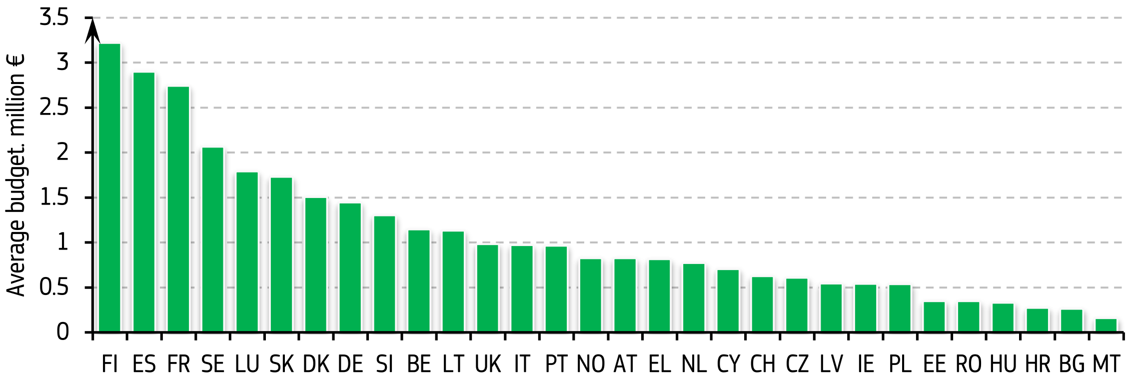


Figure 2.21 Average budget per project, stage of development and country: R&D

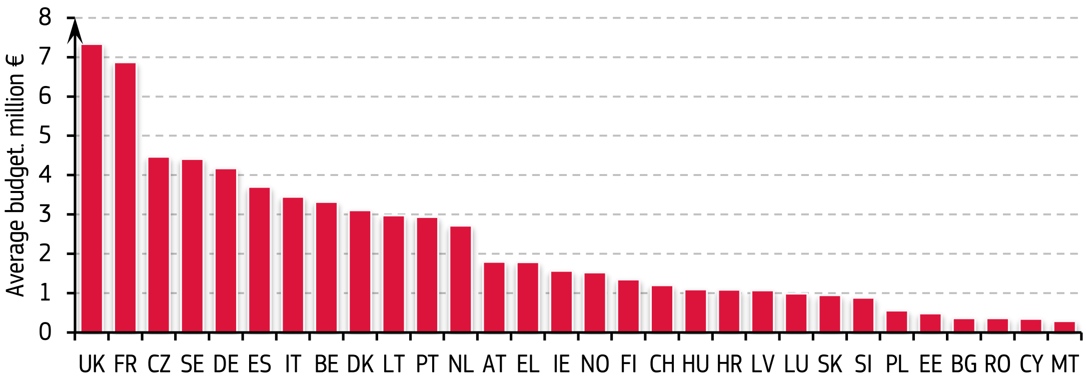


Figure 2.22 Average budget per project, stage of development and country: Demo and Deployment

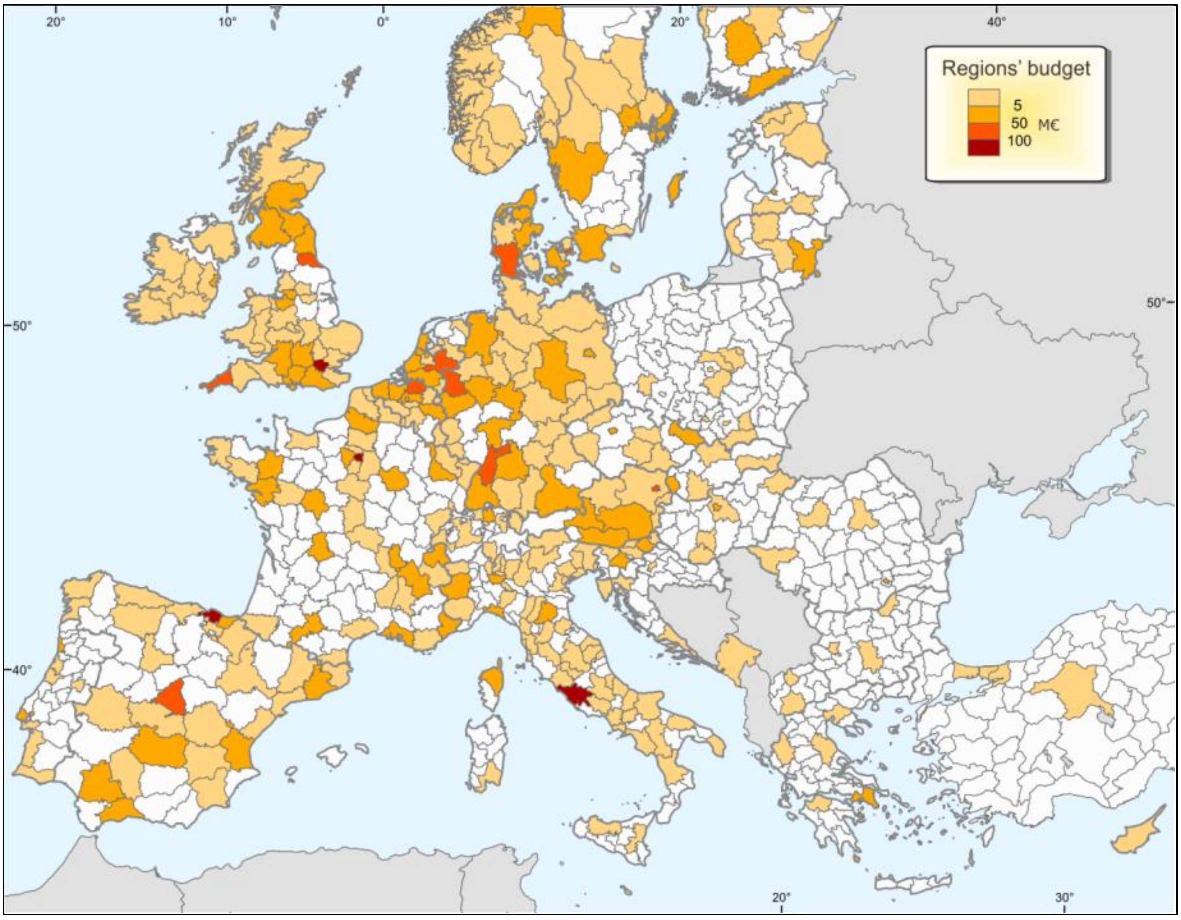


Figure 2.23 Source of funding per region (NUTS)

Taking a look at the distribution of budget allocated to organizations at the regional level, (NUTS 3, with exception of Netherlands, Germany and Austria where for an easier comparison NUTS 2 was used)[15], illustrated in Figure 2.23, one can notice a number of 'hot-spots' with a large amount of allocated budget.

Four such regions show outstanding concentration: Paris - FR, Rome - IT, Biscay – ES and London - UK, each gathering more than €100 million. Other 'hot-spots' with budgets above €50 million are regions from Germany (Karlsruhe and Düsseldorf), Belgium (Antwerpen), Netherlands (Gelderland - Arnhem), Denmark (Copenhagen and Sydjylland), Spain (Madrid), Austria (Vienna) and United Kingdom (Cornwall and Tees Valley). In these regions are present the most active universities and/or research centres in the smart grid field and/or the headquarters of some DSOs or TSOs.

[15] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU for the purpose of: the collection, development and harmonisation of EU regional statistics; framing of EU regional policies; socio-economic analyses of the regions.

- NUTS 1: major socio-economic regions;
- NUTS 2: basic regions for the application of regional policies;
- NUTS 3: small regions for specific diagnoses;

The current NUTS classification, valid from 1 January 2012 until 31 December 2014, lists 97 regions at NUTS 1, 270 regions at NUTS 2 and 1294 regions at NUTS 3 level.

Most of the regions in western, northern and central European countries benefit from shares of budget through the organizations and companies located within. In the eastern and at some extent in the southern Europe the regions receiving funds form an *insular* pattern containing the capital or a research center. In the western, southern and northern parts of the continent entities like municipalities, regional and local governments, manufacturing and IT/telecom companies show a stronger interest in participating in smart grid projects. In the eastern part, the universities, DSOs, TSOs and energy companies are more keen in taking part in smart grid projects.

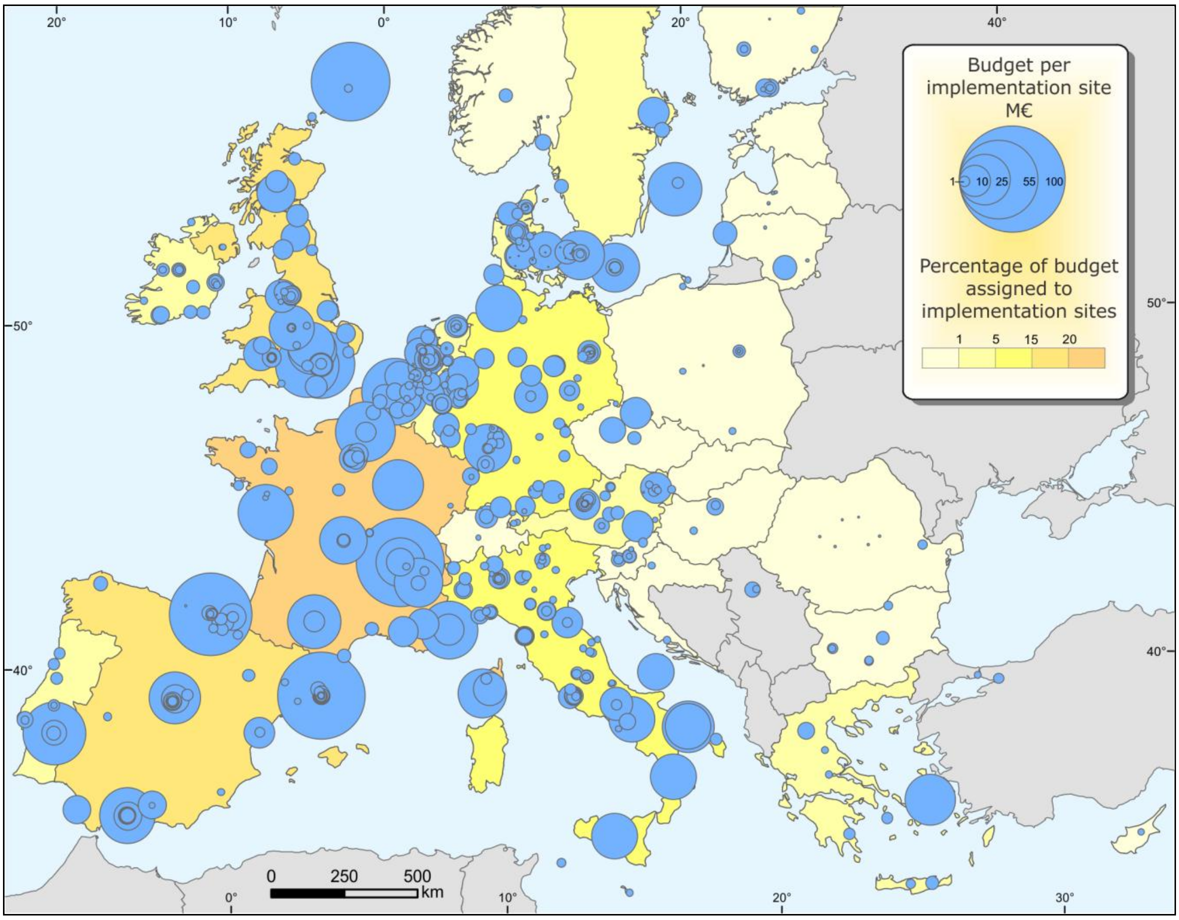


Figure 2.24 Investment per implementation site

A number of 201 projects have implementation sites. There are 578 such implementation sites worldwide, most of them (532) situated within the teritory of the European Union countries (Figure 2.24). The investments assigned to the implementation sites (through smart grid projects) target various locations:

- the vicinity of major organizations involved in research, inovation, or managing the national or regional transmission networks (major cities as London, Paris, Brussels, Barcelona, Roma or university centers as Bilbao, Grenoble, Arnhem, Karlsruhe, Copenhagen);
- areas with high integration of RES (south Spain and Italy, Corse Island - FR, Gotland Island – SE, Ikaria Island – EL, Bornholm Island – DK, Shetland Islands - UK).

Again, the largest investments tend to congregate on the western and southern side of Europe. The few implementation sites in the eastern part of Europe have budgets generaly below €1 million with few exceptions in Lithuania, Czech Republic, Hungary and Bulgaria.

Half of the budget allocated to implementation sites goes to three countries: France (20 %), United Kingdom and Spain (each with 15 %). All the new EU members from eastern and southern Europe as well as Finland, Luxembourg, Norway and Switzerland have less than 1 % each from the total budget allocated to the implementation sites.

The budget distribution over the years matches the consistence of interest and moments of investment injections in smart grid projects (Figure 2.25). Most of the countries have been involved and had managed investment in smart grid projects from 2002 onward (on the graph only from 2004 due to the low budgets before). Other countries have had only episodic presences in smart grid projects (Latvia, Luxembourg, Lithuania, Estonia, Cyprus, Malta). While countries like France and Denmark had a steady rise in budget amounts, others showed a more irregular pattern with ups and downs (Portugal, Italy, Spain, Germany).

The *boom* momentum in financing smart grid projects seems to be the years 2009-2010 when countries like United Kingdom, Sweden, Italy, France, Denmark, Belgium, Austria, Ireland, Greece and Czech Republic have seen a sharp rise in their budgets.

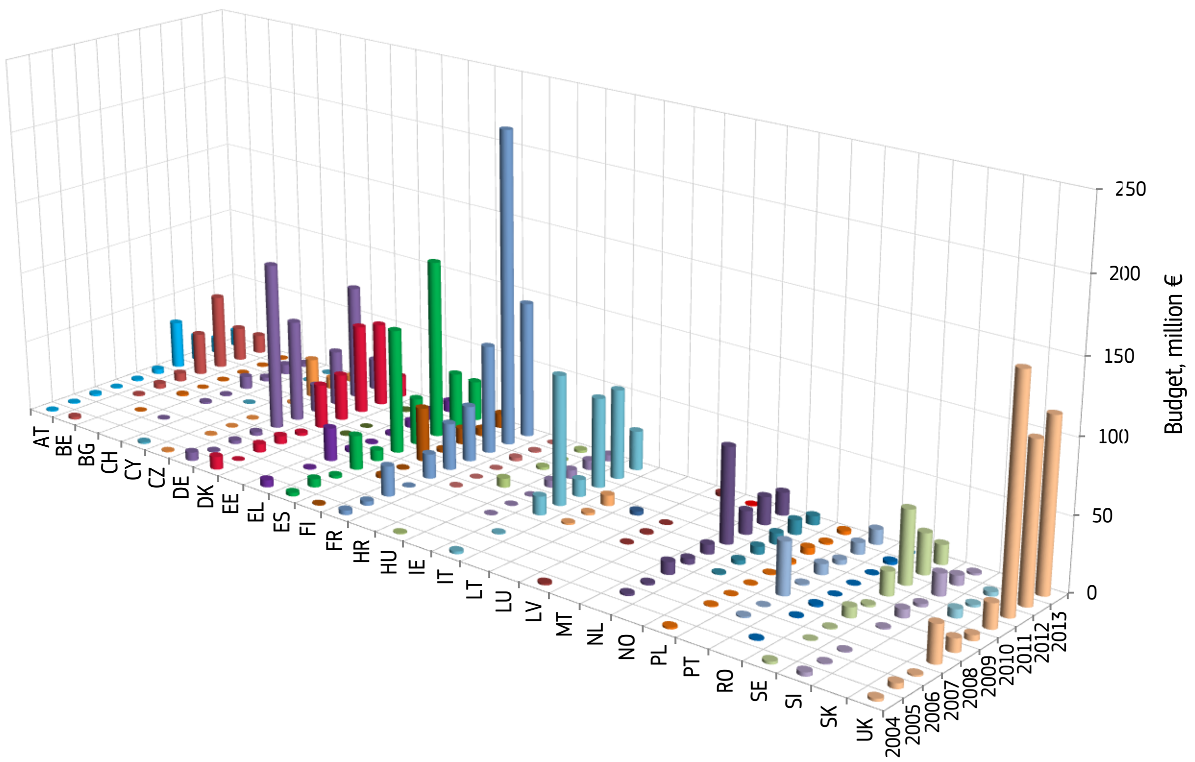


Figure 2.25 Distribution of total budget per starting year and country

2.5 DATA NORMALISATION

As seen in the previous chapter, the smart grid projects and investments are not uniformly distributed across Europe, from the geographical point of view, since just a few countries stand out in terms of spending. Nevertheless this can be contested in some cases by bringing additional factors in the equation such as: population, gross domestic product (GDP), area, electricity generation and consumption of the country etc. For instance a comparison between Germany and Malta wouldn't be appropriate if we ignore any of the factors mentioned before. Regardless, any aggregative analysis between these two countries would be in most of the cases highly imbalanced. In this subchapter we will adjust the previous investment aggregations taking into account the country population and electricity consumption[16].

Figure 2.26 shows a different perspective, dividing for each country the specific smart grid investments to the population (€/capita). The dispersion in euro per capita across the EU Member States is uneven. Denmark has by far the highest investment per capita (almost 40 €/capita) among all the 30 countries included in this comparison, having an index two times higher to the second country in the comparison (Slovenia, with 17.6 €/capita). Finland (12.7 €/capita), Sweden (12.6 €/capita), Belgium (11.9 €/capita) and Austria (10 €/capita) were the only other countries to record double-digit numbers (not the countries with the largest budgets have the highest values when compared with population or consumption.).

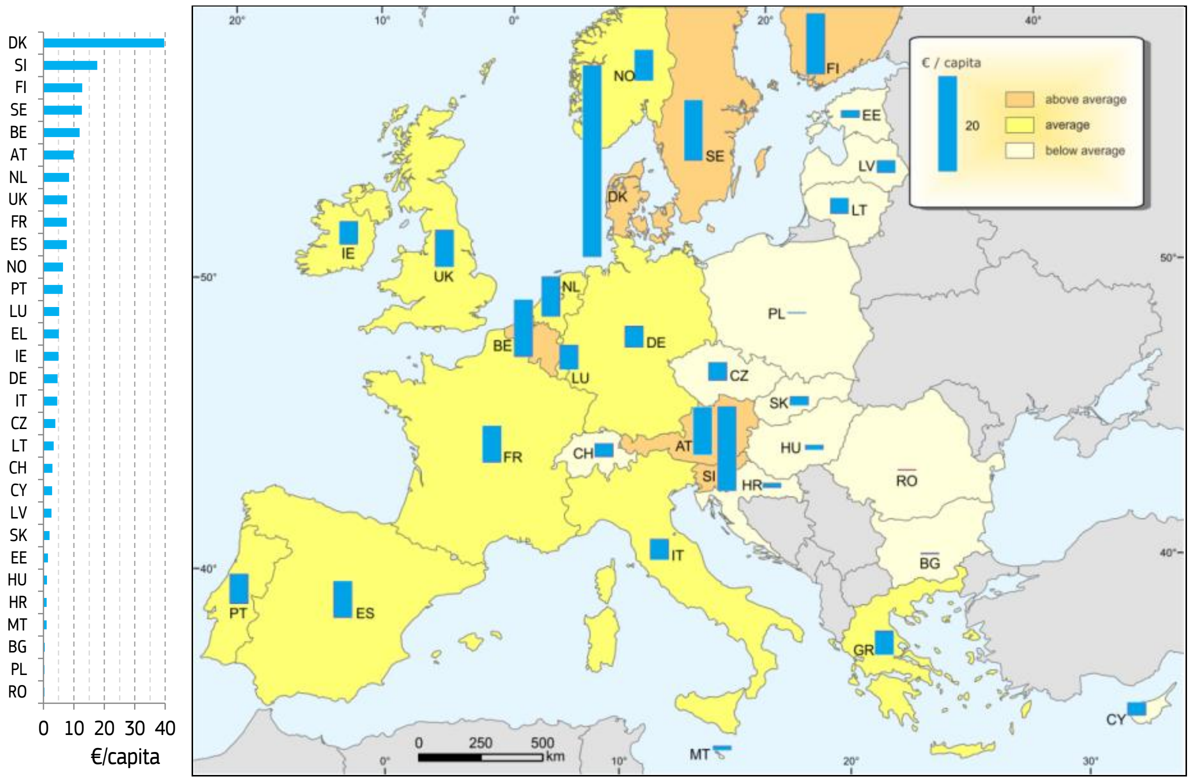


Figure 2.26 – Investments in smart grid projects across Europe per capita

[16] According to Eurostat (European Commission) and ENTSO-E.

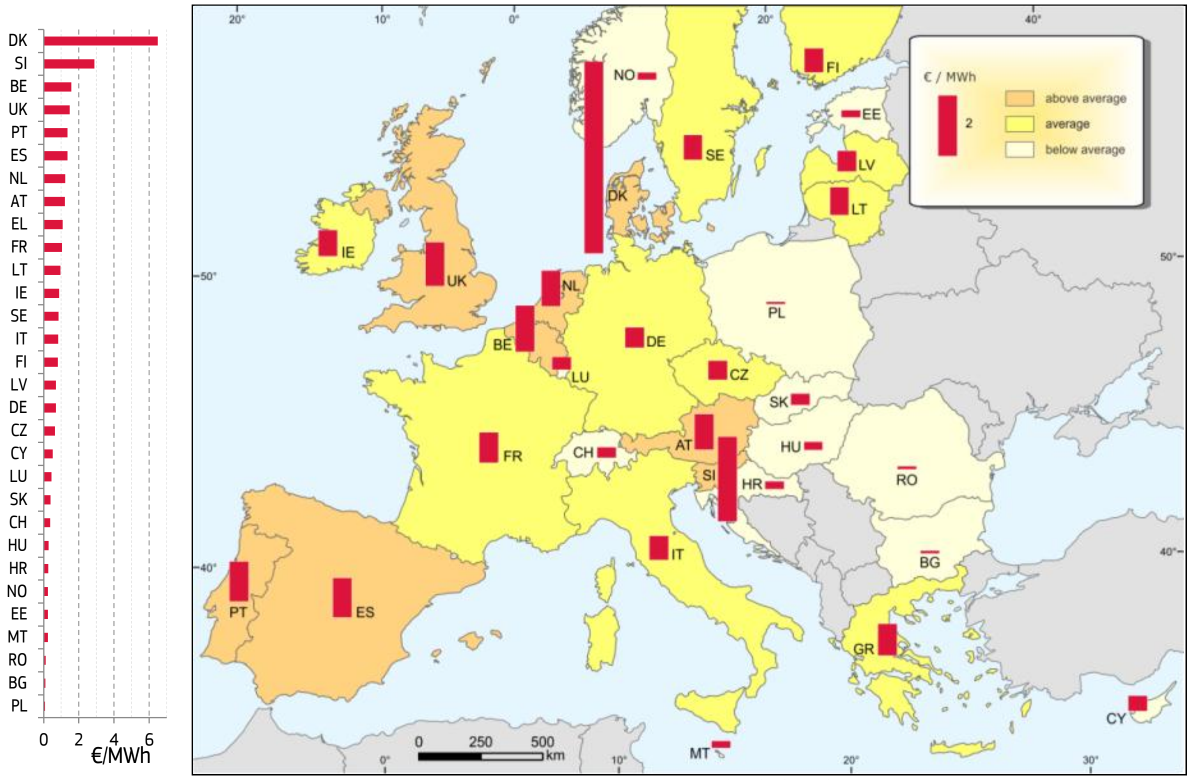


Figure 2.27 – Investments in smart grid projects across Europe divided to the electricity consumption

Figure 2.27 maps the value of the index obtained by dividing the country smart grid investments to its total annual electricity consumption[17] (€/MWh). The latter covers the electricity delivered to the final consumer's door (in the industry, transport, households and other sectors). Based on this index, Denmark has the highest level of investment per electricity consumed, accounting for a 6.5 €/MWh of the 30 countries in total. Slovenia (2.88 €/MWh), Belgium (1.57 €/MWh), UK (1.49 €/MWh) and Portugal (1.35 €/MWh) follow Denmark.

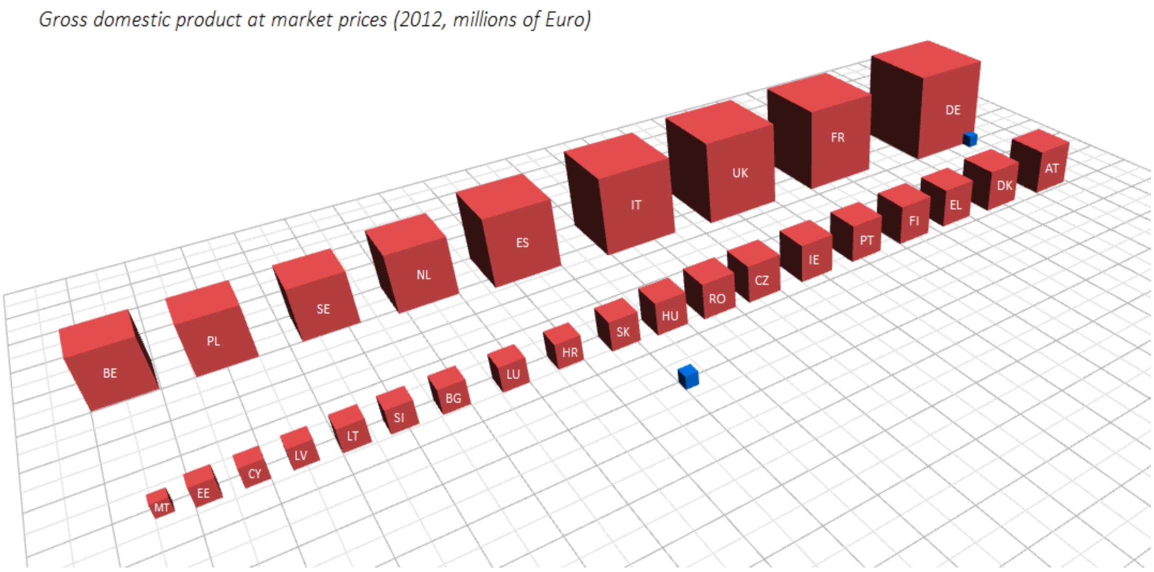


Figure 2.28 Investment in smart grid projects (blue) compared to the GDP (2012) of the EU states

[17] Total electricity consumption in 2012.

Figure 2.28 illustrates a visual comparison between the total smart grid projects budget and the annual gross domestic product[18] of the 28 member states. The total investment equals to 45 % of Malta's, 1 % of Austria's or 0.01 % of Germany's annual gross domestic products.

[18] GDP in 2012.

3. SOURCES OF FUNDING

3.1 THE BIG PICTURE

In science and engineering, besides having an innovative idea, the funding source is an essential component of the equation in order to carry out the work. The role of funding for smart grid projects is very important. The sources of funding were classified into five general types as follows:

- Private funding (own resources) — Private capital typically comes from particular companies, individual investors or private capital groups that fund smart grid projects. Many private companies provide grants and/or resources in support of R&D and Demo & Deployment projects.
- European funding (EC) — A number of EC funding and financing programmes are available at European level to support activities in the Research & Development, Demonstration and Deployment of smart grids projects, supplementary to direct investments in needed infrastructures. During the last years, smart grid initiatives have been receiving wide support through different channels such as the 6th and 7th Framework Programmes and the European Regional Development Plan.
- National funding — Many governmental agencies provide funding to individuals and/or organisations to work on diverse projects. In several European countries, smart grid investments are receiving increasing levels of national support funded by innovation or energy ministries (e.g. the E-ENERGY Programme in Germany). These funding initiatives are targeting projects across different countries and technological applications. We are aware that in some cases there may be a close link between the national funding and the EC funding (national funding may come from an EC programme), but this fine line is difficult to identify.
- Regulatory funding — In this category we consider specific smart grid programmes managed by regulators to support innovative smart grid projects. For example, a rather big percentage of the Danish projects are supported by the Forskel programme, which is financed from tariffs. Furthermore, since 2010, the UK regulator OFGEM has set-up the low carbon network fund (LCNF) to provide regulatory funding for particularly innovative smart grid projects. In other countries, regulators are supporting the development of smart grids with specific tariff schemes securing an additional rate of return on smart grid investments. In some cases there is close link between the national and the regulatory funding.
- Unclassified funding — In this category we included the budget of a minor number of projects missing information on the funding source (amounting to 2 % of the total budget).

Figure 3.1 illustrates the distribution of investment based on the source funding. As seen in the previous chapter, the total amount of investment is ca. 3150 million euros. Of the overall budget of the projects

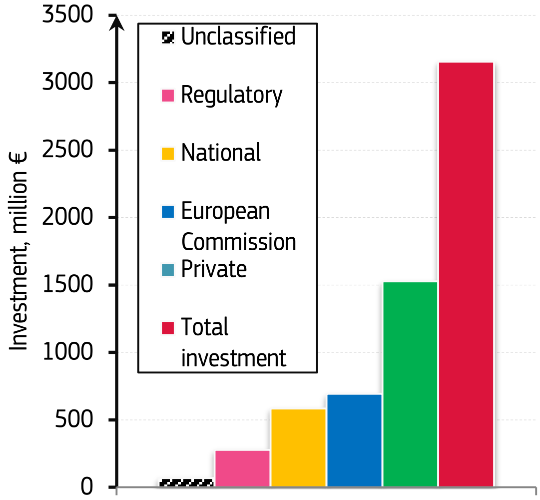


Figure 3.1 Distribution of investment by source for all projects[19]

in the JRC catalogue, 49 % comes from private capital, 22 % from the European Commission, 18 % from national funding sources and 9 % from regulators (2 % is unclassified funding). Around 90 % of the projects have received some form of public funding. These figures indicate that decisions to invest in smart grids are not taken autonomously and project coordinators still rely on funding institutions to invest in smart grid projects.

3.2 MATURITY

Research and development (R&D) activities advance smart grid functionality by developing innovative, next-generation technologies and tools in the areas of transmission, distribution, energy storage, power electronics and the advancement of precise time-synchronized measures of certain parameters of the electric grid. Besides others, Figure 3.2 shows that the national and regulatory funding is invested mainly on demonstration and deployment projects. It is important to mention that D&D activity area is larger than R&D area due to the fact that it develops a framework for analyzing smart grid metrics and benefits, which is necessary to help build the business case for cost-effective smart grid technologies.

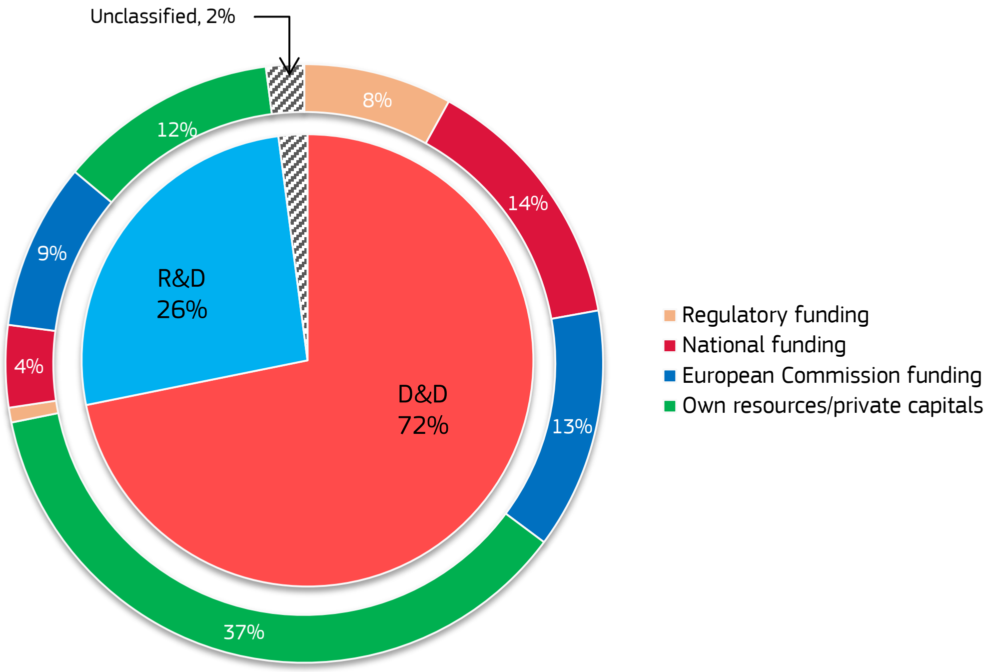
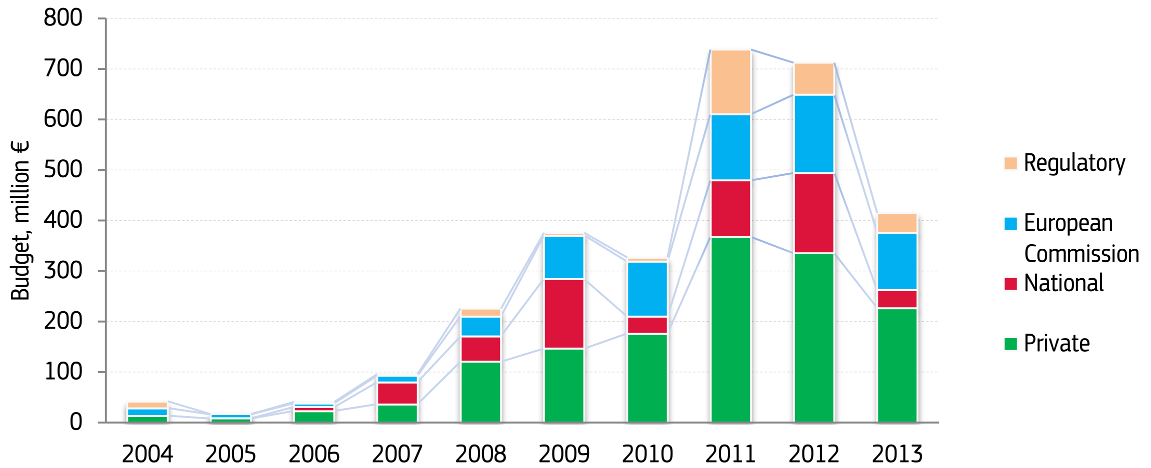


Figure 3.2 Investment distribution by stage of development

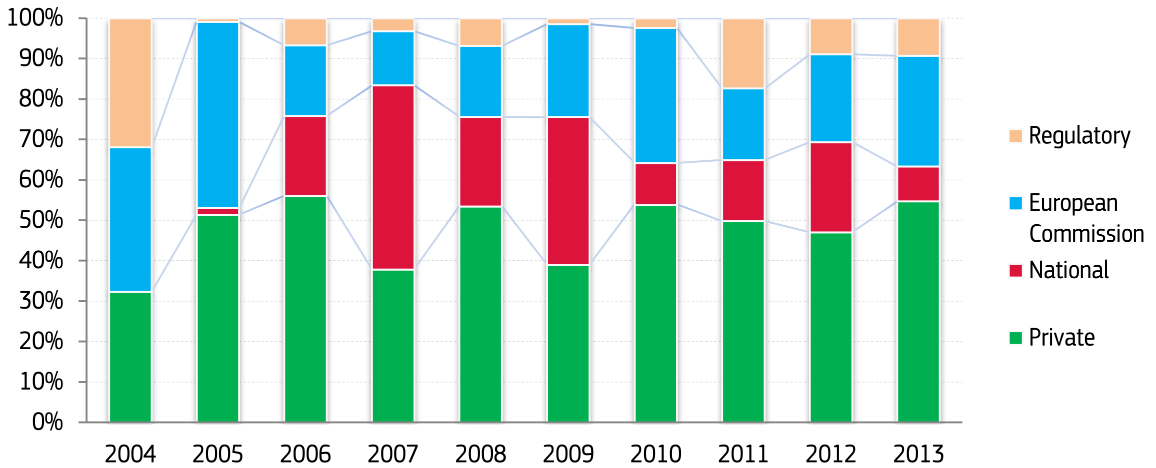
[19] For a distribution of investment by source and stage of development see Figure A.8-Annex I



*For 2% of the total budget the funding source is unknown

Figure 3.3 Distribution of total investment by source and year
(each project may have more than one source)[20,21]

From 2004 to 2013, Figure 3.3 shows that a lot of investments in smart-grid technologies have been placed, with over €700 million euros in 2011 and 2012. However, starting with 2012 a drop in investment across all categories is observed. One of the reason could be, beside the fact that the data may be incomplete, the financial crisis which affects energy-supply industries, individual firms, investors in smart grid technologies in different ways (e.g. according to how dependent they are on external finance, the sensitivity of demand and final prices to economic trends).



*For 2% of the total budget the funding source is unknown

Figure 3.4 Percentage distribution of total investment by source and year
(each project may have more than one source)

Considering an annual percentage distribution by funding type we can observe in Figure 3.4 a constant noteworthy presence of the private and EC funding. The national investment started to gain momentum later, in 2006.

[20] For a different view (3D) of the distribution of total investment by source and year see Figure A.9-Annex I

[21] For a normal and a percentage distribution of the funding by stage of development and starting year see Figures A.10, A.11, A.12 and A.13-Annex I.

3.3 INVESTMENTS CONSIDERING THE LIFETIME OF THE PROJECT

Figure 3.5 shows the cumulative value of the total budget and of the different funding sources over the years. During the diagram development, it has been assumed, for the sake of simplicity, that the total budget of a project is distributed evenly over the duration of the project (division between the budget and the period, in years or months). The area under each curve of the graph represents the corresponding budget allocated by funding type for smart grid projects over the years, as it is clearly depicted in the figure's example of the total budget (curve in black). Out of the 459 projects in our inventory the first projects started in 2002 and the last ones will end in 2020.

Based on this figure, all five curves increase with different slopes. In particular, a relative steady increase over the years can be observed in the cumulative total and in the funding source budgets. It is clear that the total active budget till the year of 2011 was about 20 million euros, whereas in the next 2 years the total active budget became more than two times higher (black curve), i.e. about 47 million euros, showing an increased interest on smart grids.

From 2013-14 to 2018, all curves show an artificial diminution rate representing only the ongoing projects (till 2013-14) without considering the future smart grid projects. Based on this observation, two different trend lines were calculated (drawn with dashed lines): high increase (in green) and low increase (in red). Overall, it is expected that the total smart grid investment will increase. The most significant back-up to private investment comes from national and EC funding. A sharp increase in regulatory funding can be noticed in 2011 following the launch of OFGEM's Low Carbon Fund initiative in the UK.

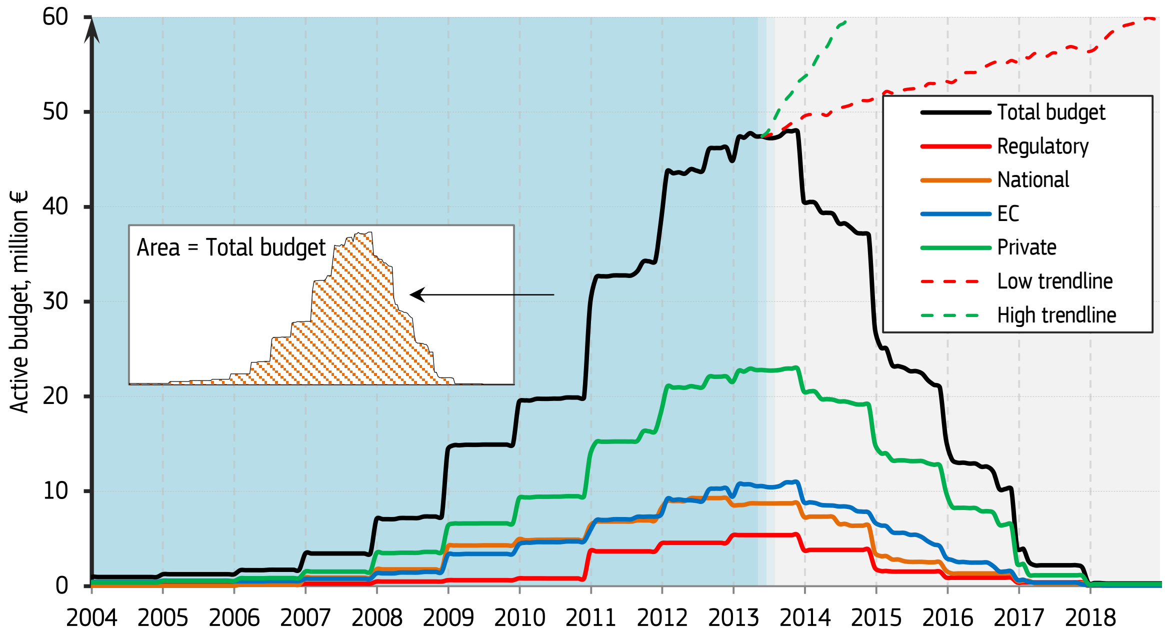


Figure 3.5 Allocated funding over the lifespan of smart grid projects

3.4 FUNDING SOURCES COMBINATION

80 % of the smart grid projects in our inventory are financed from more than one funding source. No project is financed from all four sources, but 10 % are financed from three categories.

Figure 3.6 show in a circular representation the combination between the four types of funding. The circumference of the circle is the total budget minus the unclassified funding and their value. The circumference is divided in 4 unequal segments corresponding to the funding categories. The segments are connected with chords that illustrate the relationship between the funding sources. A thicker chord will show that the pair is cooperating strongly (funding in common the same projects). A side of the chord can be thicker than the other side. This shows the ratio between the budgets coming from each of the two funding sources. In most cases a project will not be funded with equal shares from different sources. Each of the four segments has a portion that does not send/receive any chord. These fragments show the budget of the projects funded only by that specific source.

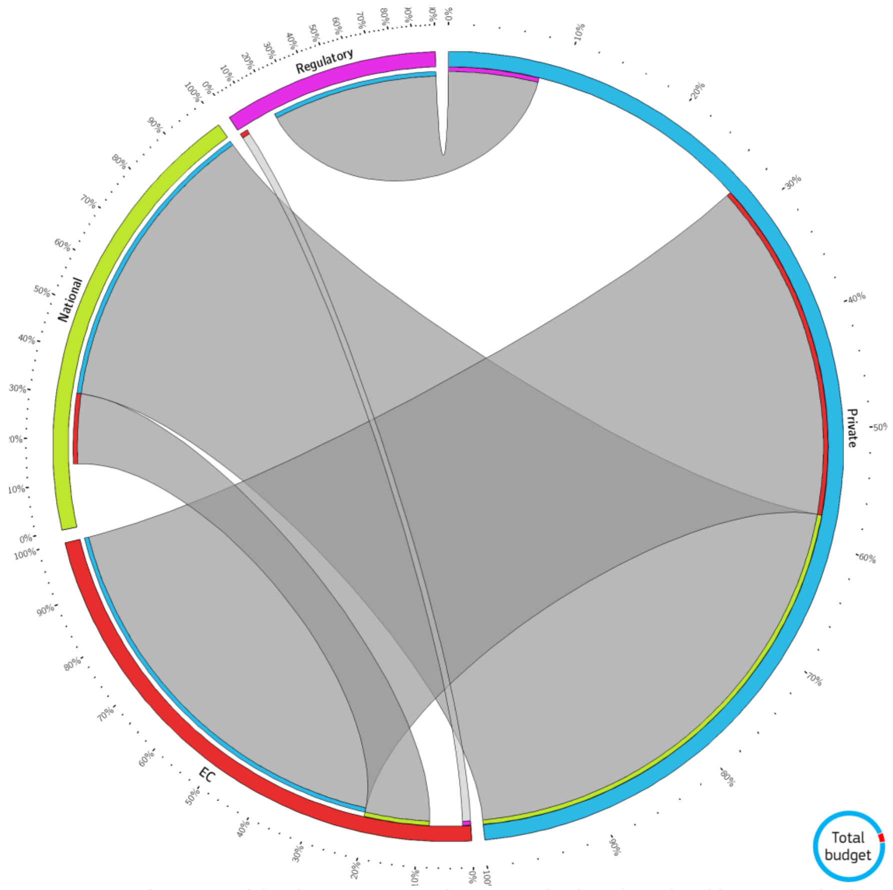


Figure 3.6 Combination of funding sources in the project budget (weighted by project budget)

The Private funding, which represents the biggest part of the chart, provides the highest degree of co-financing combined with national funding, followed closely by the cooperation with EC funding and to a smaller extent with the regulatory funding. A small observation is that Regulatory and National funding are not connected (one can say, as a reason for this, that the Regulatory funding is part of the National funding), while a quite small amount of budget is shared between the Regulatory and the EC categories.

Regulatory funding is not sufficient to support projects in all areas of the smart grid. For instance, in countries where regulatory support has already been allocated to capital intensive transmission or distribution reinforcements or smart metering, it might be difficult to raise additional support for a wide range of smart grid projects. Since 2011, the level of regulatory funding has been catching up with levels of national and EC funding following OFGEM's Low Carbon Fund initiative in the UK.

3.5 GEOGRAPHICAL DISTRIBUTION

For all the countries analysed the investment comes through European Commission programmes and from private sources, while for most of them there is also a national funding component (Figure 3.7). Only few countries have a regulator injecting fund in the smart grid sector.

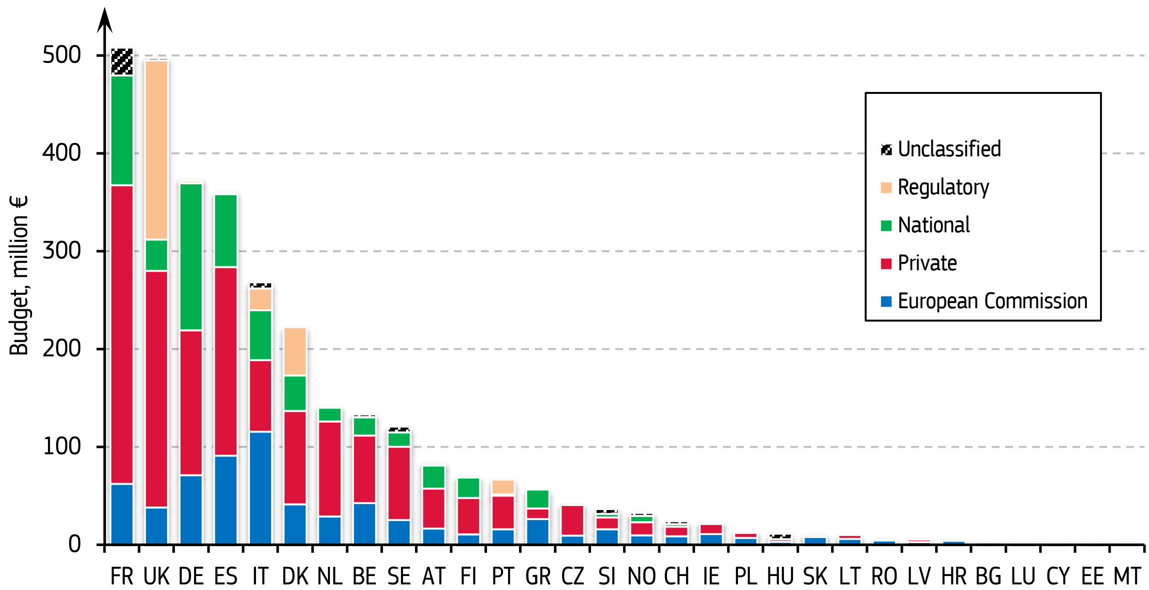


Figure 3.7 Distribution of budget per funding source and country[22]

The main beneficiary of the EC funds is Italy which draws more than €100 million, representing 40 % of its total budget. For some other countries the percentage is even higher but the budgets are much lower (Slovakia, Romania, Bulgaria, Lithuania, Latvia, Poland, Cyprus). Without any surprise the largest share of the private funding source can be found in the countries with the largest budgets. This shows the business and market potential and the high investment return expected from implementing the smart grid technologies. The largest national schemes for financing smart grid projects are found in Germany, France and Spain, while the regulatory sources provide the highest amounts in United Kingdom and Denmark. United Kingdom and Germany receive more than a third of their budgets from regulatory and

[22] For a distribution of budget per funding source, country and stage of development see Figures A.14 and A.15-Annex I

respectively national funding, which can be seen as alternatives to each other – in some cases there may be a close link between the national funding and the regulatory funding (regulatory funding may come from a national programme).

Generally we can see a strong inversely proportional relation between EC and private sources funding: countries with high percentages of budget from private sources have lower percentages of funding coming from EC sources and the other way around (e.g.[23] Croatia 15 % private vs 85 % EC, Slovakia 16 % vs 74 %, Czech Republic 76 % vs 22 %, Netherlands 68 % vs 20 %).

In the western part of the continent the large budgets are associated with a higher variety of funding (Figure 3.8), with at least 40 % of it coming from private sources. From the older member states only Italy and Greece have lower percentages of private funding.

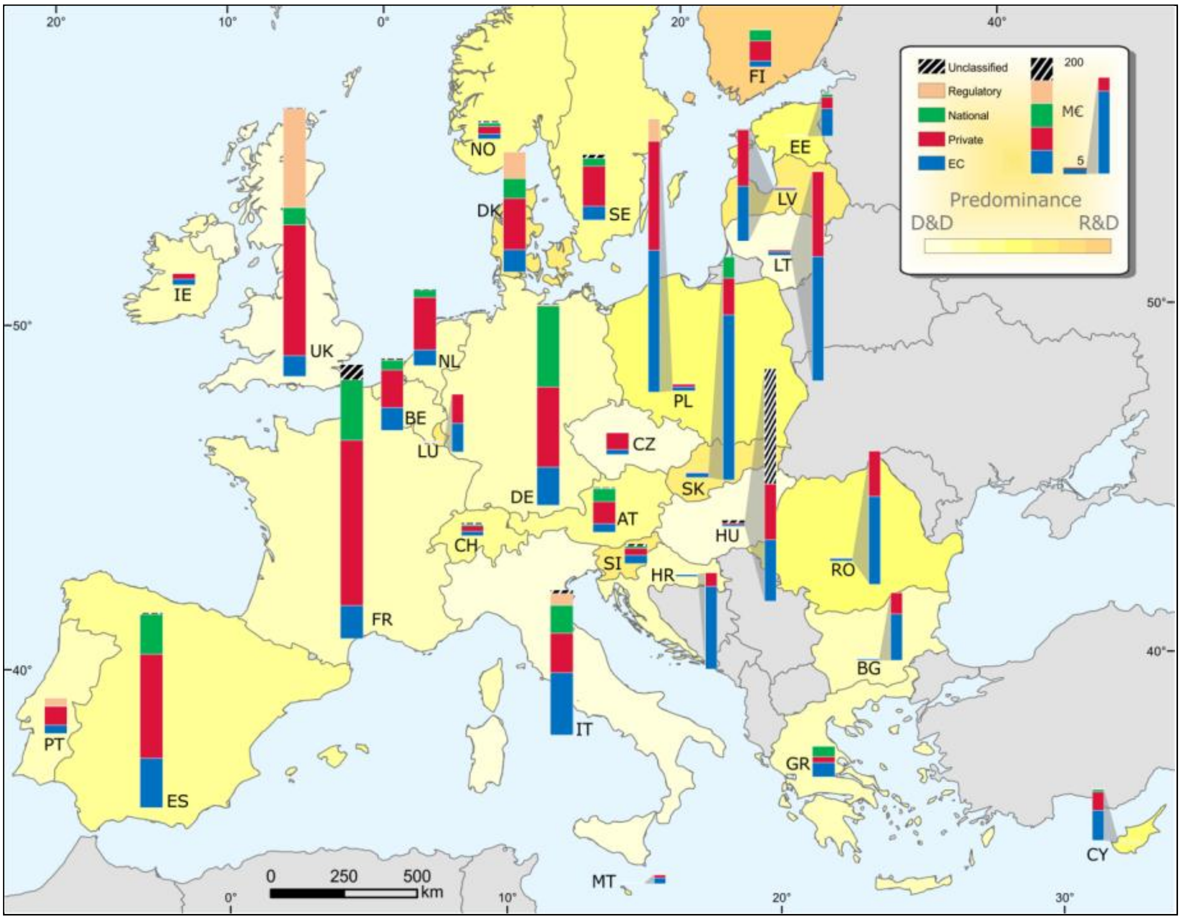


Figure 3.8 Distribution of budget per funding source and country

We can notice an almost complete absence of national and regulatory funding in the newer member states. The vast majority of projects present in these countries draws funding from EC and from private sources, in most cases the EC funding adding up to half or more their total budget. Adding to this the fact that their budgets are small and they take part mainly as partners and very rare as leaders, we can

[23] The rest up to 100% comes from other sources.

say that these countries do not seem to have an individual and precise agenda for the smart grid research, demonstration and deployment. The exception from this regional pattern are Slovenia and the Czech Republic which have larger budgets, with Slovenia displaying high values for investment per capita (Figure 2.26) and per electricity consumption (Figure 2.27).

4. ORGANISATION TYPES. WHO IS INVESTING?

4.1 THE BIG PICTURE

The 459 smart grid projects in the catalogue have an average of 9 and a maximum of 77 participating organisations. 160 projects have a number of participants larger than the average. These organisations have been classified as follows:

- Distribution System Operators (DSO) — DSOs have the traditional mission to operate, maintain and develop an efficient electricity distribution system. First of all, DSOs have the responsibility for the operation of the grid and therefore need to participate actively in any project directly affecting this. They are the 'incumbents' in the electricity sector and can build on established technologies, business models and regulation. They also have direct access to regulatory funding, particularly innovation-based funding such as the LCNF in the UK. In addition, in the current phase of smart grid implementation, the main focus of projects has been on the technical architecture of the smart grid. DSOs/utilities clearly have a leading role in these investments on the technical layer, which are a precondition for a market architecture where new players might find incentives to invest and join new projects. Iberdrola Distribución Eléctrica, Enel Distribuzione and Électricité Réseau Distribution France are some of the most active DSOs that participate in smart grid projects.
- Transmission System Operators (TSO) — In electrical power sector, a transmission system operator is an operator that transmits electrical power from generation plants over the electrical grid to regional or local electricity distribution operators. Due to the cost of establishing a transmission infrastructure, such as main power lines and associated connection points, a TSO is usually a monopoly, and as such is subjected to regulations. The responsibility of the TSOs is to manage and develop the transmission grid infrastructure, maintain balance in the electricity system and facilitate the market operation. In this category, there are electric transmission owners and operators such as TenneT TSO GmbH, RTE, Energinet.dk and Elektro-Slovenija.
- Universities, research centres and consultancies — All new technologies start from research. This is one of the most active categories in our database. Universities and research centres are leaders in most R&D projects but they also contribute in many Demo & Deployment projects.
- IT and Telecom companies — In this category we include software developers, system designers, system integrators and telecom companies. Together with the universities and research centres they are the main innovators. Since most smart grid applications rely heavily on IT, in the last years IT and Telecom companies have increasingly entered the smart grid sector and they are present in more and more projects.

▪ Manufacturers/Engineering services/Contractors/Operators/Manager companies — This group contains all the organisations that aim at designing, manufacturing, testing, building, operating, maintaining or managing new technological applications, particularly hardware solutions or organisations that offer industrial services. These companies work in many other fields beside the smart grid or the energy area.

▪ Energy companies/Utility companies/Energy retailers/Electricity service providers — This category includes all the companies doing business only in the energy or utility sector that aren't exclusively DSOs or TSOs.

▪ Generation companies — Consists of enterprises with their main activity in electricity production. Not all power plant owners are included here since some of them may have other activities (e.g. small distribution system operators).

▪ Municipalities, public authorities and government — A considerable number of European municipalities, governmental agencies, regional authorities and many other public authorities types are actively involved in smart grid projects (mainly in Demo & Deployment projects).

▪ Associations — Many similar organisations form associations that represent their common interests.

▪ Other organisations — This set consists of other organisations with diverse activities that can't be placed in any of the aforementioned categories.

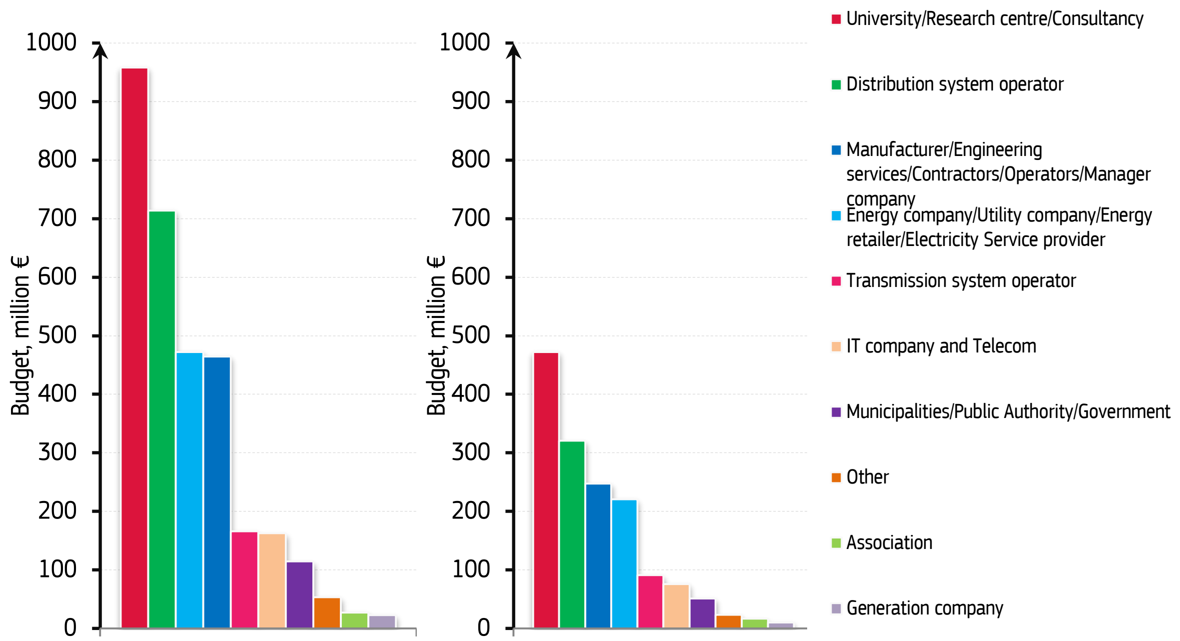


Figure 4.1 Investment by organisation type[24]
left Total budget; right Private budget

[24] For a distribution of investment by organisation type, funding source and stage of development see Figures A.16 and A.17 in Annex I

Figure 4.1 illustrates the investment distribution by organisation type, also showing a close-up on the private budget distribution. We see that *University/Research centres/Consultancies* category invests the biggest budget (€950 million and €470 million, total and private budget), followed by the *DSO* (€710 million and €320 million, total and in private budget). The *Manufacturers/Engineering services/Contractors/Operators/Manager companies* and the *Energy companies/Utility companies/Energy retailers/Electricity service providers* categories inject comparable investments (ca. €450 million and €230 million, in total and in private budget).

Considering the number of smart grid projects at least one organisation form the *University/Research centres/Consultancies* category is present in over 60 % of the projects, followed by *Manufacturers/Engineering services/Contractors/Operators/Manager companies* with 40 %, *Energy companies/Utility companies/Energy retailers/Electricity service providers* and *DSOs* categories both close to 35 %. *IT and Telecom companies* participate in 25 % of the projects.

4.2 MATURITY

Figure 4.2 depicts the distribution of investment by stage of development and organisation type. The *Universities/Research centres/Consultancies* are involved in over 31 % of the projects and as expected they are the main players in the R&D scene. The *DSOs* are engaged in over 22 % of the projects (particularly in Demo & Demonstration projects), followed by *Energy companies/Utility companies/Energy retailers/Electricity Service providers* (over 15 %, mainly in Demo & Demonstration projects) and *Manufacturers/Engineering services/Contractors/Operators/Manager companies* (over 14 %). *TSOs* are involved in around 6 % of the projects.

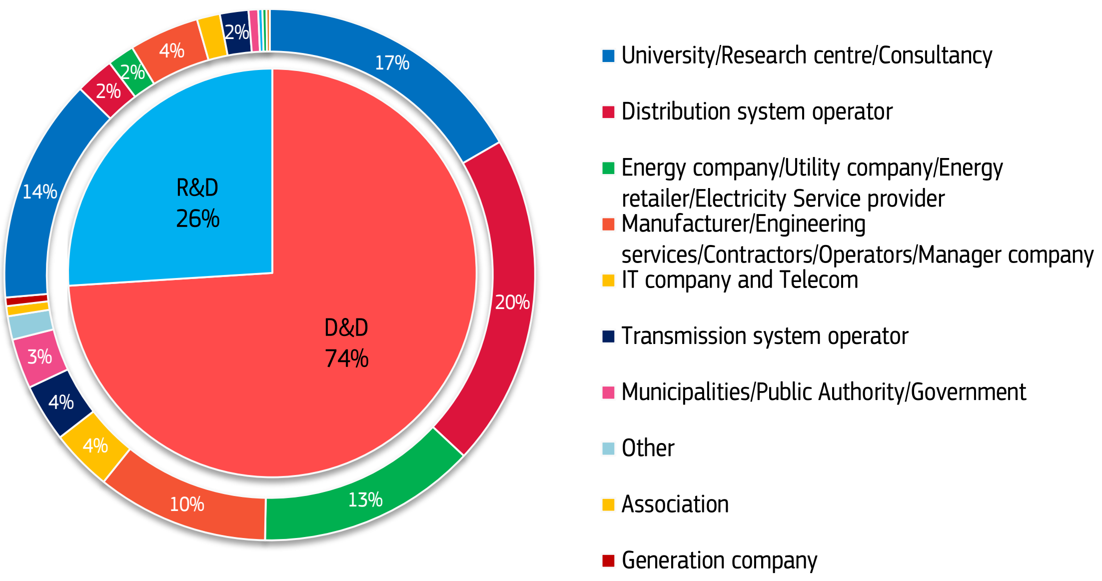


Figure 4.2 Distribution of investment by stage of development and organisation type

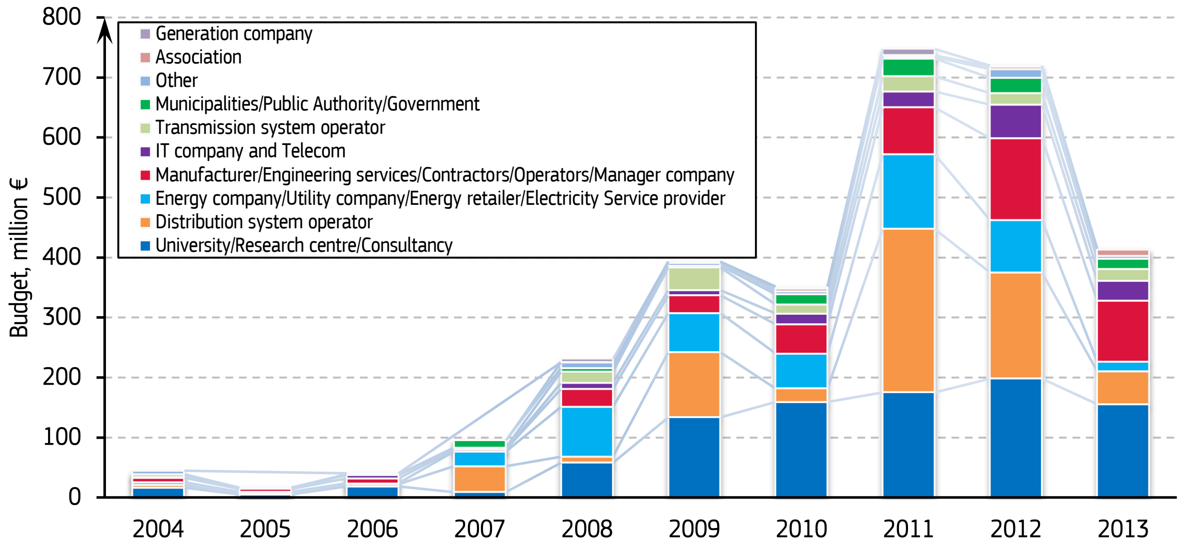


Figure 4.3 Distribution of total investment by organisation type and year[25]

Considering the starting year Figures 4.3 and 4.4 illustrates the evolution of the total investment by organisation type. The *University/Research centres/Consultancies,* the *Energy companies/Utility companies/Energy retailers/Electricity service providers* and the *Manufacturers/Engineering services/Contractors/Operators/Manager companies* have been present with a large and annually increasing share of budget from the foundation of the smart grid sector. The *DSOs* started investing more since 2007 and the IT and Telecom companies in the years closer to the present.

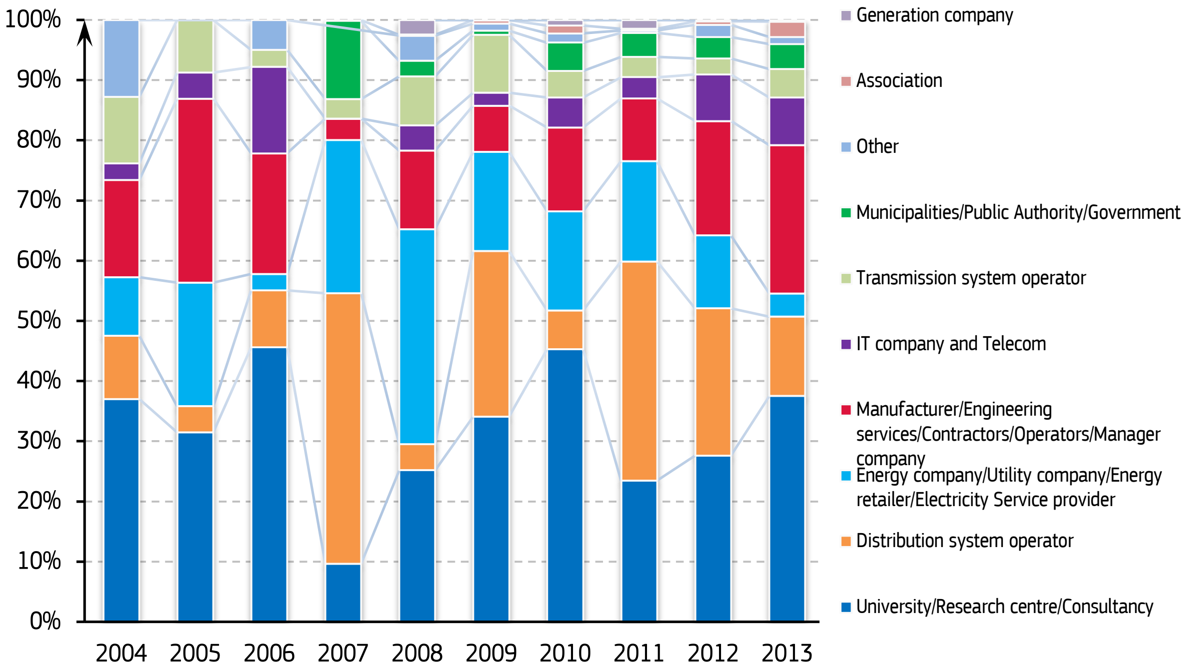


Figure 4.4 Percentage distribution of total investment by organisation type and year[26]

[25] For a distribution of private and total investment by organization, stage of development type and year see Figures A.18, A.20, A.22, A.24 and A.26 in Annex I

[26] For a percentage distribution of private and total investment by organization, stage of development type and year see Figures A.19, A.21, A.23, A.25 and A.27 in Annex I

4.3 ORGANISATIONS AND PARTICIPATIONS

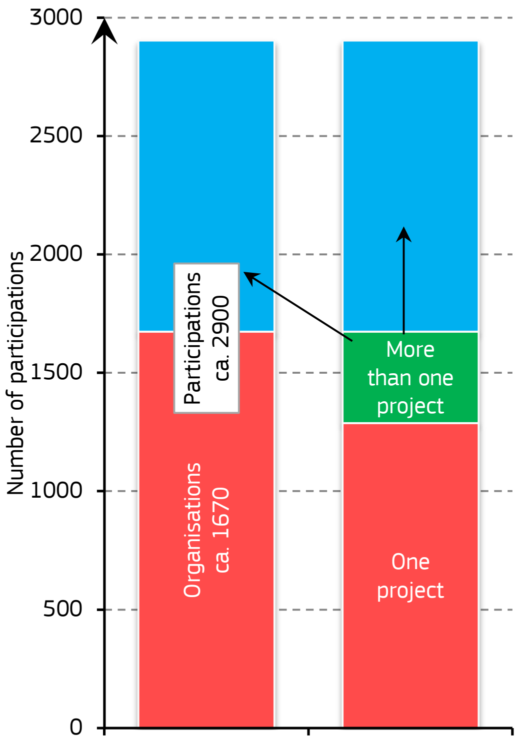
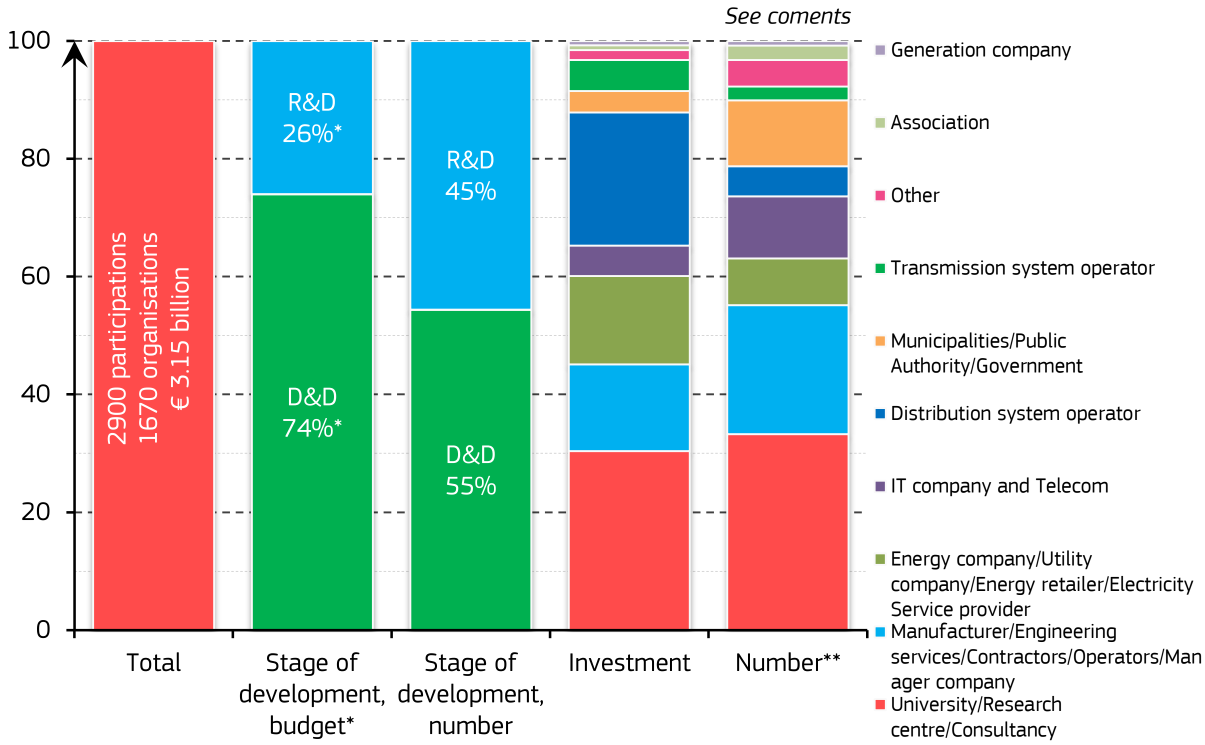


Figure 4.5 Organisations and participations distribution

Figure 4.5 illustrates the participations and organisations distribution. Some organisations may participate in more than one project. Because of these duplicates, we had to coin for this report the term of "participation". The number of organisations is always lower than the number of participations, since some organisations are counted more than once. In total, ca. 1670 entities (from 47 countries) participate in smart grid projects, amounting to ca. 2900 participations. Out of the 1670 organisations just 22 % participate in more than one project but this small percent account to 55 % of the total participations. Based on the smart grid inventory, the most active company is located in Denmark with 45 project participations. There is an average of 6 partners per project.



**37 projects have no budget information*
***The distribution by number and organisation type is scaled based on the number of entities (not based on the 2900 participations). See previous charts.*

Figure 4.6 Percentage distribution of the organisations involved in smart grid projects

Based on the collected data, the total investment in smart grid projects is ca. €3.15 billion for ca. 1670 partners and 2900 participations. From the total budget, the largest percentage (74 %) is invested in D&D projects while 26 % in R&D. However, by stage of development and in term of project numbers, 45 % of the smart grid projects are related to R&D activities whereas 55 % to Demo & Deployment activities. The last two columns of Figure 4.6 illustrate the investment and the project number by organization type. In both columns the *University/Research centres/Consultancies* category takes up the largest part. We can mention that the *DSOs*, *IT and Telecom*, *Municipalities/Public Authorities/Government*, *Generators* and *Associations* categories have lower percentages in terms of investments than in terms of number. On the contrary, the remaining categories invest more money but are involved in fewer projects.

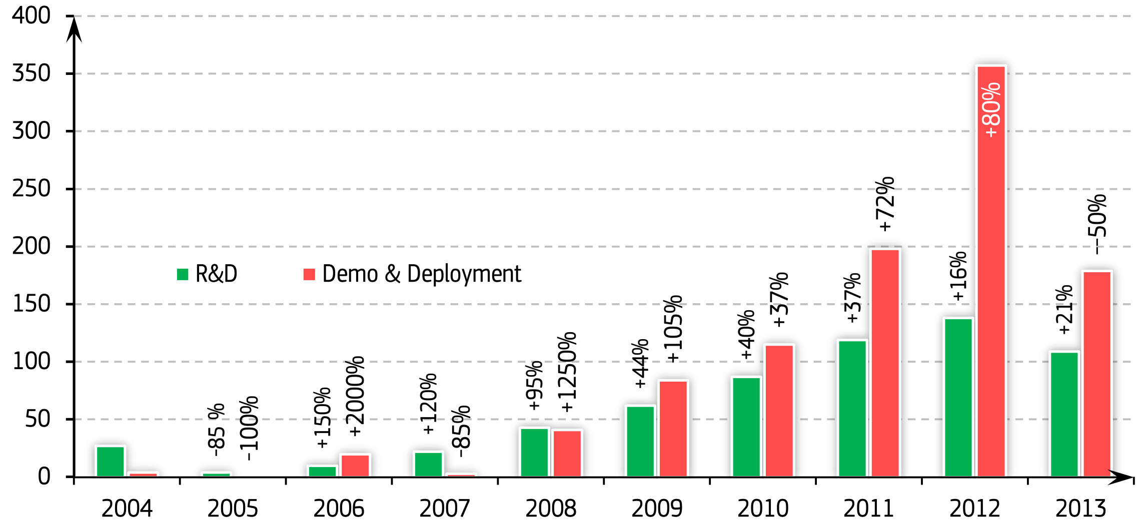


Figure 4.7 Number of new organisations entering smart grid projects by stage of development and starting year (and yearly percentage fluctuation)

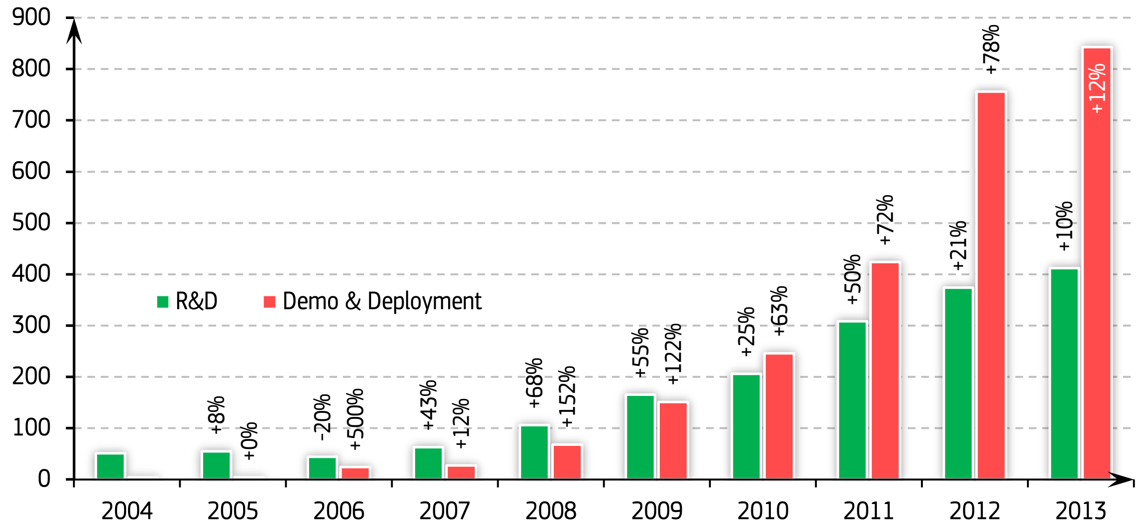


Figure 4.8 Number of active organisations in smart grid projects by stage of development and year (and yearly percentage fluctuation), considering the life of the project

Figure 4.7 shows the number of *new* companies entering R&D and Demo & Deployment projects by year and the yearly fluctuation in percentage. Starting with 2008 we can observe a steady increase in this number in both categories, particularly for the Demo & Deployment projects. In 2011 ca. 320 and in 2012 ca. 500 organisations joined for the first time the smart grid sector. The data for 2013 may be incomplete. If the lifetime of the projects is considered (Figure 4.8) in the analysis we can see the same significant growth in both the R&D and Demo & Deployment category. Additionally we can mention that in the last years the lifetime of the projects is increasing and according to our database the average life of a smart grid project is 33 months. Both in 2012 and 2013 there were more than 1100 entities working in all the ongoing smart grid projects.

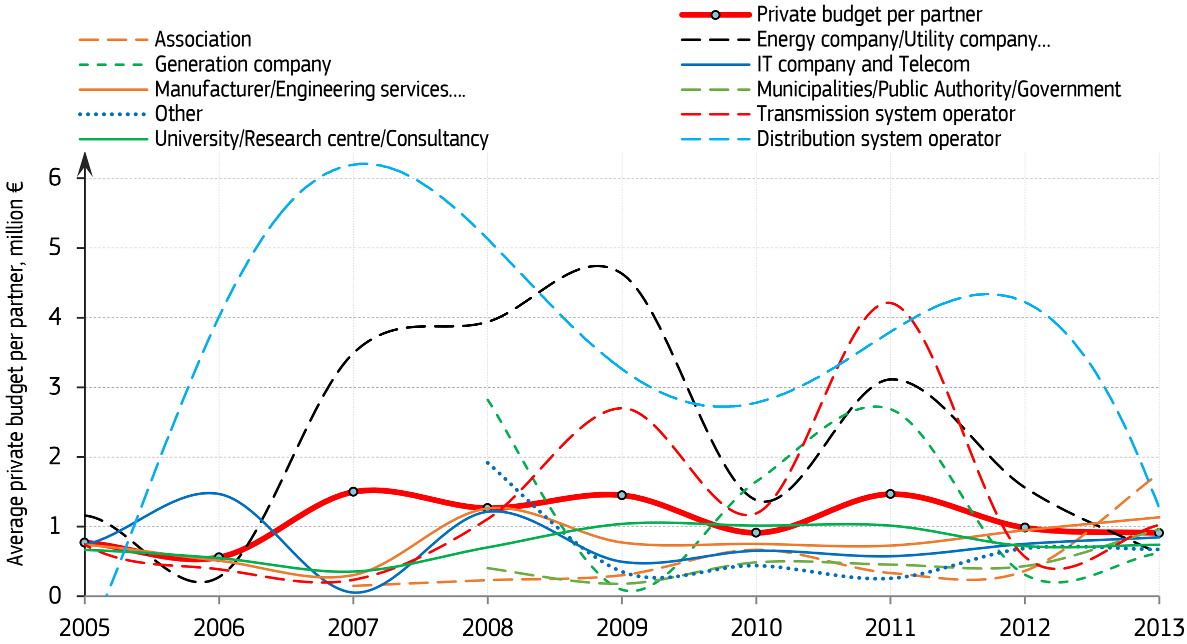


Figure 4.9 Average private budget invested by organisation type and year

Based on the aforementioned discussion, it is interesting to analyse the level of financial participation of the different organisation types in terms of annual average private budget. We are covering here both R&D and D&D projects, as this can offer an indication as to which entities are more active in the preview phase before smart grid applications are marketed. Figure 4.9 shows the annual average private[27] investment per participant for the 10 different organisation groups and the annual average of the total private budget per smart grid project. We are using the private budget instead of the total budget since this will give a clearer picture on the direct financial contribution for each organization category.

Generally we can say that a good degree of diversity exists among companies participating in smart grid projects and that the level of diversity has remained steady over time, since most of the curves are slightly under the general average and relatively close to each other. Some other remarks are that the *TSOs* started investing more than the average budget since 2008, showing a significant lower interest in the previous years, and that the *Energy companies/Utility companies/Energy retailers/Electricity service*

[27] It is assumed that the whole project budget is allocated to the starting year of the project.

providers and *DSOs* categories were constantly considerably above the average budget during the course of our study period. Between 2010 and 2012, the generation company category invested more than the general average.

4.4 THE RELATIONSHIPS BETWEEN ORGANISATIONS GROUPS

Figures 4.10 and 4.11 show in a circular representation the weighted relationships among the 10 organisation groups. The perimeter of the circle is the total smart grid investment. The perimeter is divided in 10 unequal segments analogous to the organisation categories and their budget. The segments are connected with chords that illustrate the relationships between the diverse entities. A thicker chord will illustrate that the pair is collaborating strongly (working together in the same projects).

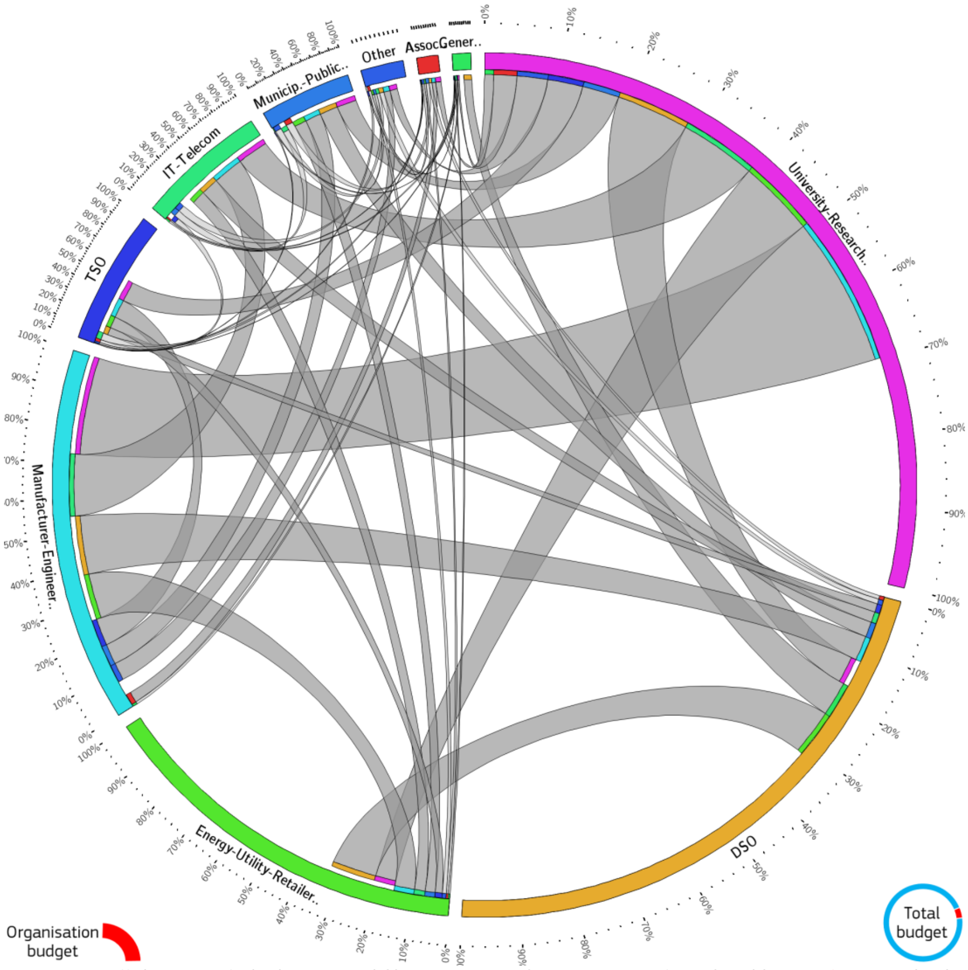


Figure 4.10 Collaboration links between different types of organisation (weighted by total project budget)

As anticipated, in a project with multiple partners, one category may include more participants than other categories. For instance one project can include three DSOs and one TSO, each of them coming with a similar budget. The DSOs will invest more in this partnership; hence the difference in thickness between the two ends of a chord in the chart (in most of the cases an entity group invests more than the second). Each of the 10 segments has a portion that does not send/receive any chord. These portions show the budget and the internal partnerships of the projects funded only by that specific organization category.

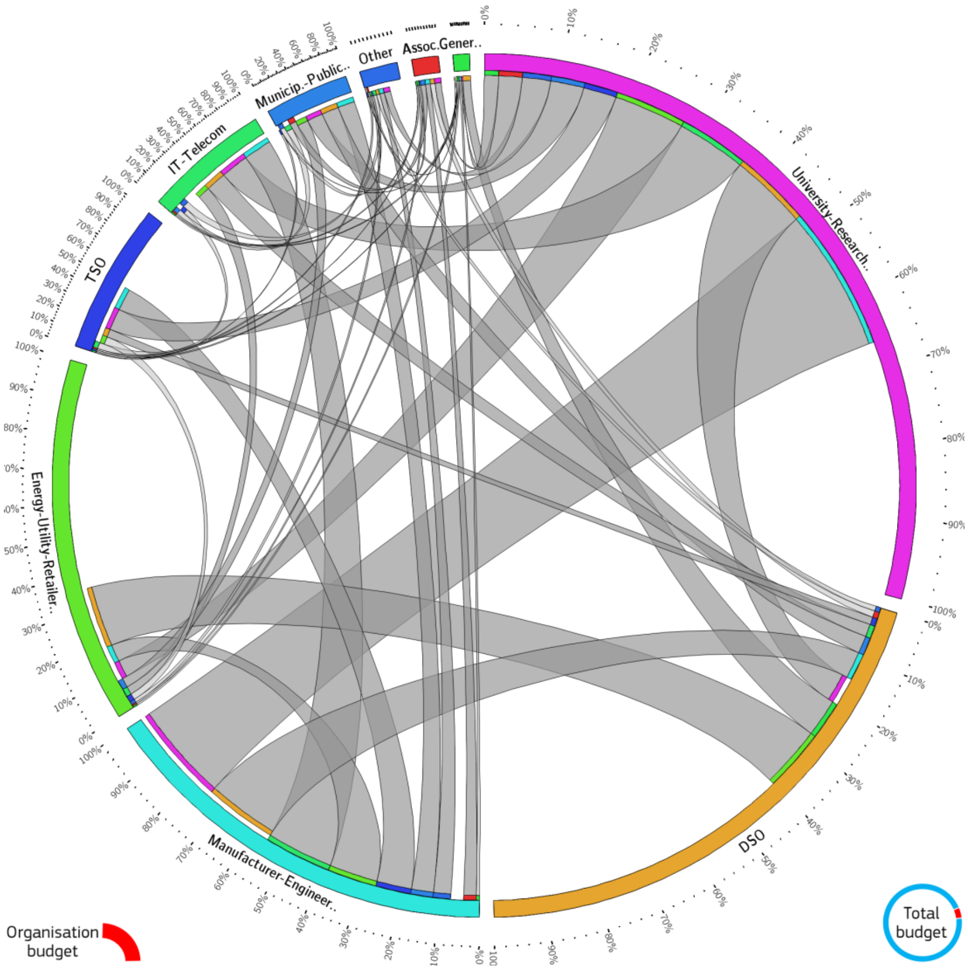


Figure 4.11 Collaboration links between different types of organisation (weighted by private project budget)

Figure 4.10 illustrates the partnerships weighted with the total smart grid budget while Figure 4.11 weights with the private smart grid budget. From both perspectives, the *DSOs* and the *University/Research centres/Consultancies* are the most active players, significantly collaborating among themselves and acting as "cooperation hubs" for the other players.

We can mention that the *DSOs* and the *Energy companies/Utility companies/Energy retailers/Electricity service providers* have a preferential link between them, since they may have common interests (additionally there is a fine line between these two categories, since some energy companies can act as small DSOs). Also both of these categories and the *TSOs* generally tend to work alone in their projects or lead the projects where they work with other organisations.

The biggest collaborators are the *Manufacturers/Engineering services/Contractors/Operators/Manager companies*, *IT and Telecom companies* and the *Municipalities, public authorities and government* categories. Generally these organisations will be only found only in projects with multiple partners.

4.5 GEOGRAPHICAL DISTRIBUTION

The area running from Paris northward over Belgium and stretching over the south of Netherlands and west of Germany shows the highest density of organizations involved in smart grid projects (Figure 4.12). Other highly active areas can be found in eastern Denmark, the region of London, the central part and the north of Spain, northern Italy and the Rome region and eastern Austria. These organizations are usually involved in more than one project. The same pattern is visible when considering the stage of development with a larger focus in R&D projects on Copenhagen and Vienna, beside the 'core' area of Paris – northern Belgium – southern Netherlands – western Germany, while for Demo & Deployment the density increases in northern Italy, London and a large part of Germany. There is no country or major area which is completely devoid of organizations.

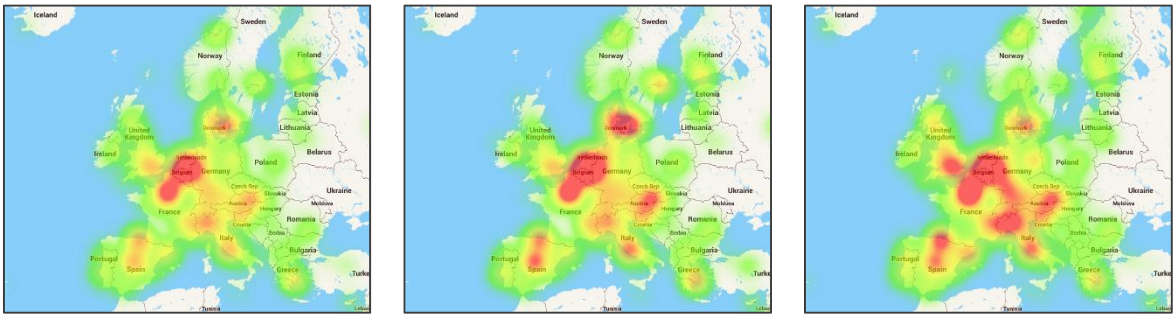


Figure 4.12 Geographical distribution of the organisations involved in smart grid projects:
left: all projects; centre: R&D projects: right: Demonstration & Deployment projects

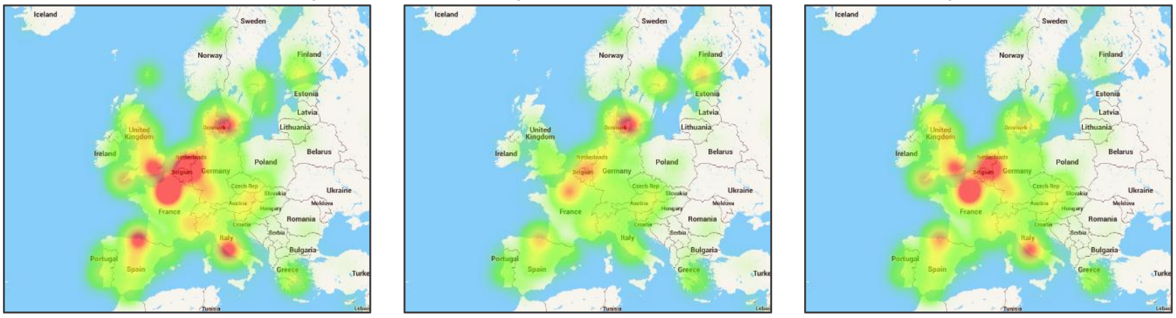


Figure 4.13 Geographical distribution of the organisations involved in smart grid projects (corrected by total budget):
left: all projects; centre: R&D projects: right: Demonstration & Deployment projects

The distribution weighted with the total budget follows closely the same pattern for the high concentration areas (Figure 4.13). For R&D projects, Copenhagen invests a higher budget per organisation and for the Demo & Deployment projects, Rome and London. The countries in the eastern side of Europe show a far lower density in the distribution.

Analyzing the maps we can notice that the eastern part of Europe seems to be better covered for the normal distribution that for the budget weighted distribution. This shows some interest and potential for smart grid projects in this side of the continent but which for the moment manages to attract only rather small amounts of investments.

The distribution and density of implementation sites (Figure 4.14), although showing the highest values in western Europe, has a slightly different focus points. The number of implementation sites shows the highest density over a large area stretching from northern Italy, running over Germany Austria, Belgium and ending northward as Netherlands. Other high density areas can be found in Denmark, UK and two regions in northern Spain. The budget corrected distribution associated with the smart grid implementation sites offers partly the same view but with a new high density area in south-eastern France. As in the case of organizations, while the number of implementation sites show weak densities in east European countries, their associated budget still remain very small.

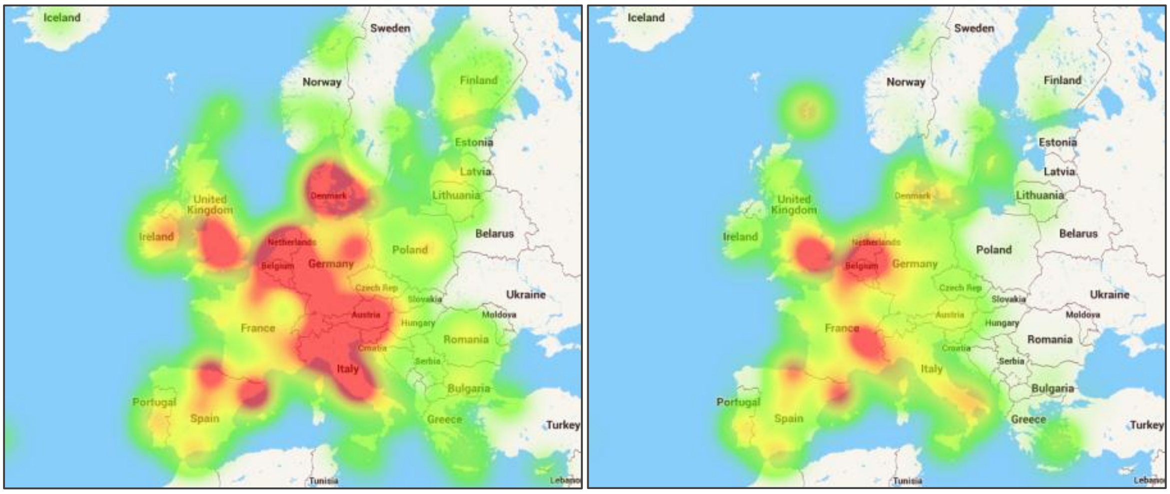


Figure 4.14 Geographical distribution of smart grid implementation sites
left: number; right: corrected with the total budget

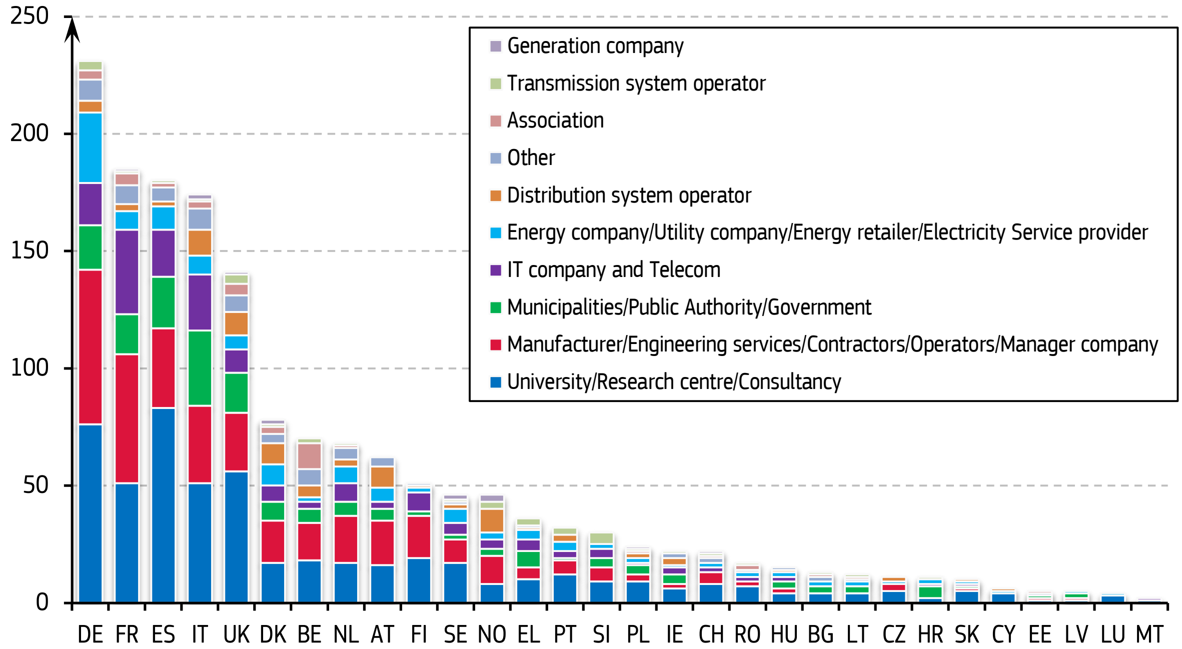


Figure 4.15 Number of organisations per country

The highest number of organizations involved in smart grid projects are located in Germany (more than 200), followed by the countries managing the largest smart grid budgets: France, Spain, Italy and United

Kingdom, all with more than 100 organizations involved (Figure 4.15). The countries with the highest number of organizations have also the largest diversity of categories, covering the whole spectrum. At the other end, in the countries with the lowest number of organizations there are only 2-5 groups.

By far the largest group is represented by *University/Research centres/Consultancies* which form at least 20 % of the total number per country. The *Manufacturers/Engineering services/Contractors/ Operators/Manager companies* group is very well represented in western Europe where together with the *University/Research centres/Consultancies* form more than 50 % of the total number of organizations. Their number and fraction are smaller in the countries in eastern Europe. Municipalities and other public authorities form around 8-10 % from the total number. This percentage is lower in north European countries and higher in the east of Europe.

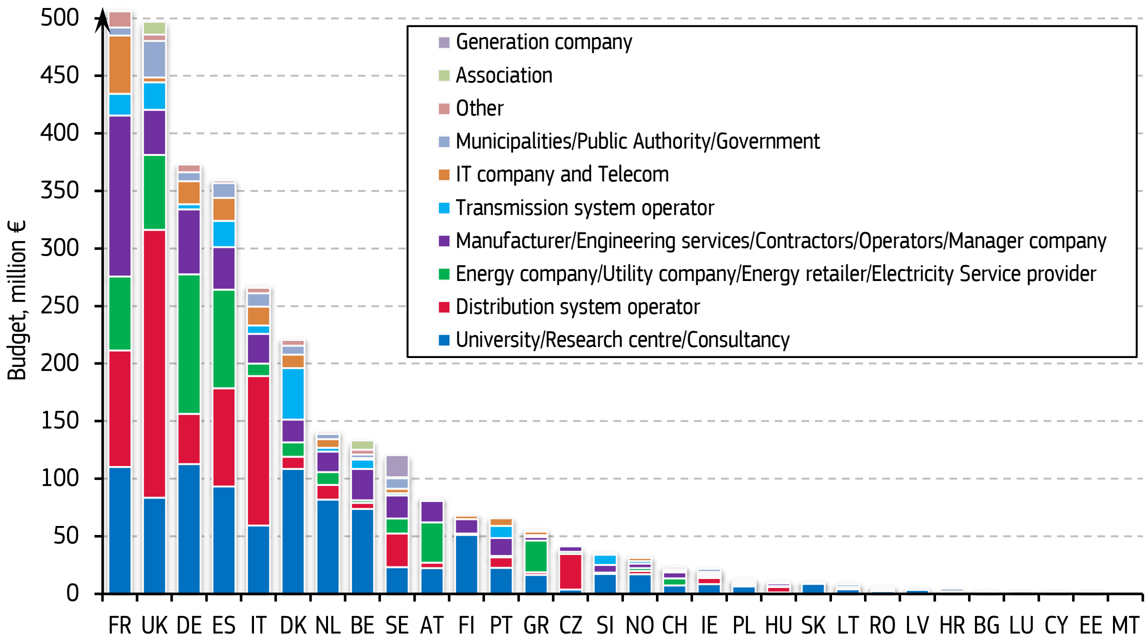


Figure 4.16 Distribution of total budget per organisation type and country[28]

The budget distribution based on organisation type and country shows the same pattern as in the case of the number of organizations with a slightly different participation (Figure 4.16). In the countries with smaller investment the share of *University/Research centres/Consultancies* is in general larger than 40 %, while in those with large budgets it generally stays around one third. The *University/Research centres/Consultancies* in Finland, Netherlands, Belgium and Norway manage to attract and spend more than 50 % of the total budget. Over 80 % of the budget in the category mentioned before goes to nine countries, each aggregating for this entity group more than €50 million: Germany, France, United Kingdom, Spain, Italy, Netherlands, Belgium, Denmark and Finland. The *DSOs* in United Kingdom and Italy

[28] For a distribution of the total budget per organisation type, stage of development and country see Figures A.28 and A.29 in Annex I

have the largest investments in Europe, representing almost 50 % of their country total while in Czech Republic it surpasses 70 %. *Energy companies/Utility companies/Energy retailers/Electricity service providers* manage the largest budget in Germany (more than €100 million) where it sums to a third of its combined total. The *Manufacturers/Engineering services/Contractors/ Operators/Manager companies* in France invest the largest budget of all the countries both as value and percentage from total. It counts for more than the double of that of Germany, ranking the second and it represents one third of the total budget of its type. The *TSOs* are more involved in smart grid projects in Denmark and Slovenia where they manage more than 20 % of the budget. The *IT and telecom companies* in France attract more than €50 million that represent one third of the budget in this category.

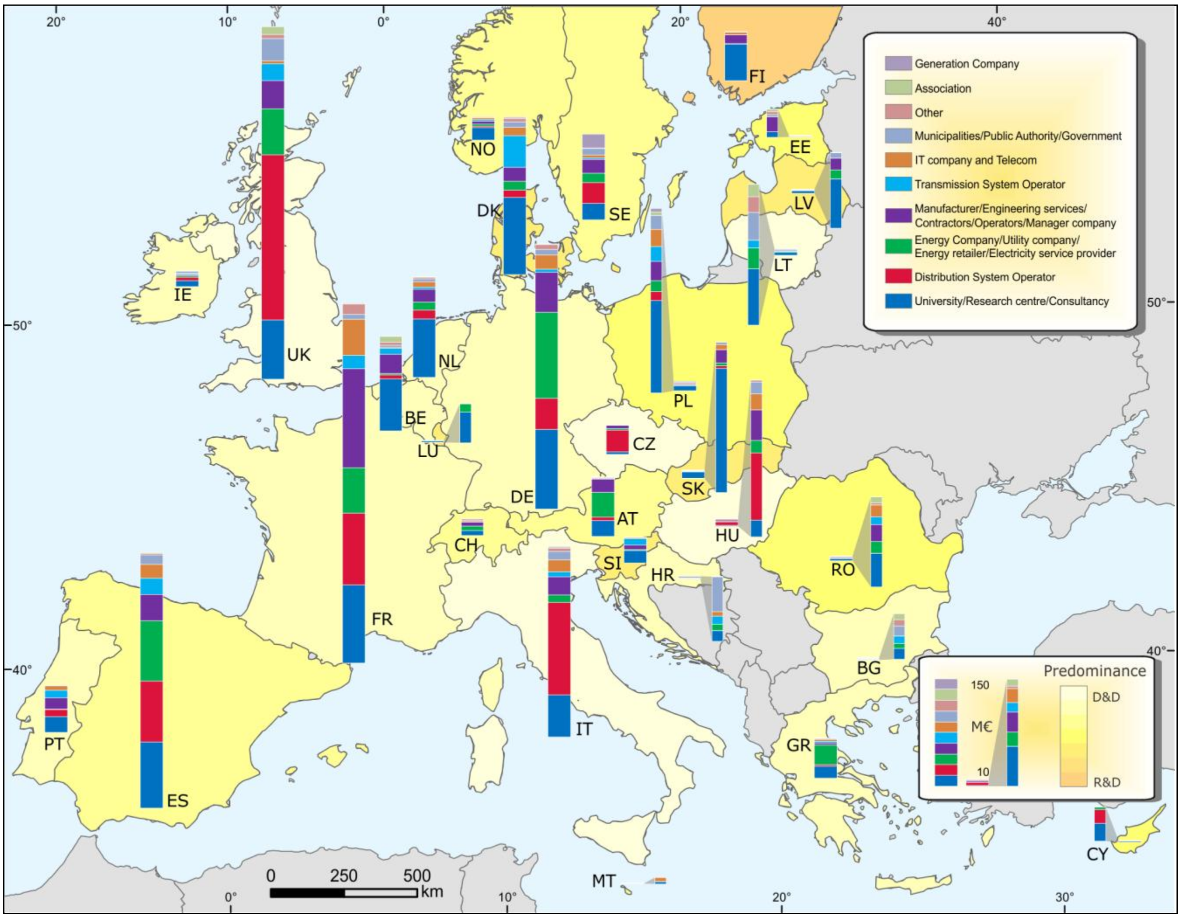


Figure 4.17 Distribution of total budget per organisation type and country[29]

Examining the map (Figure 4.17) we can notice the larger shares of *DSOs* and *Energy companies/Utility companies/Energy retailers/Electricity service providers* in western Europe, with few exceptions and an almost lack of them in eastern and northern Europe, with some exceptions too. One can also draw a diagonal running form Belgium across Netherlands, Denmark ending in Finland to connect the countries where the share of universities and research entities in the total budget is high. While France seems to

[29] For an average budget per participant, stage of development and country see Figure A.30- Annex I

be the ‘workshop’ of the smart grids considering the large shares of the budget both at national and European level of the *Manufacturers/Engineering services/Contractors/ Operators/Manager companies*, *IT and telecom companies* involved, in United Kingdom, Germany and Italy it is the *DSOs* and *Energy companies/Utility companies/Energy retailers/Electricity service providers* investing most of the budget. In Spain and Sweden the budget is more or less evenly distributed among the different types of companies. The largest private budgets come from the countries with the largest total budgets (Figure 4.18). The share of private is the highest in the Czech Republic, where most of it is managed by DSOs. Countries in the eastern Europe have roughly one third of their budget coming form private sources, while those in western part of the continent in most cases make their budget at least 50 % from these sources. Again France has the largest investment coming from the *Manufacturers/Engineering services/Contractors/ Operators/Manager companies.* Generally there is not an equal distribution between the organisation categories in the countries with the largest private budgets. Netherlands, Denmark, Belgium and Finland have their largest share of private investment coming from the *University/Research centres/Consultancies.* In UK and the Czech Republic the *DSOs* are the main funders.

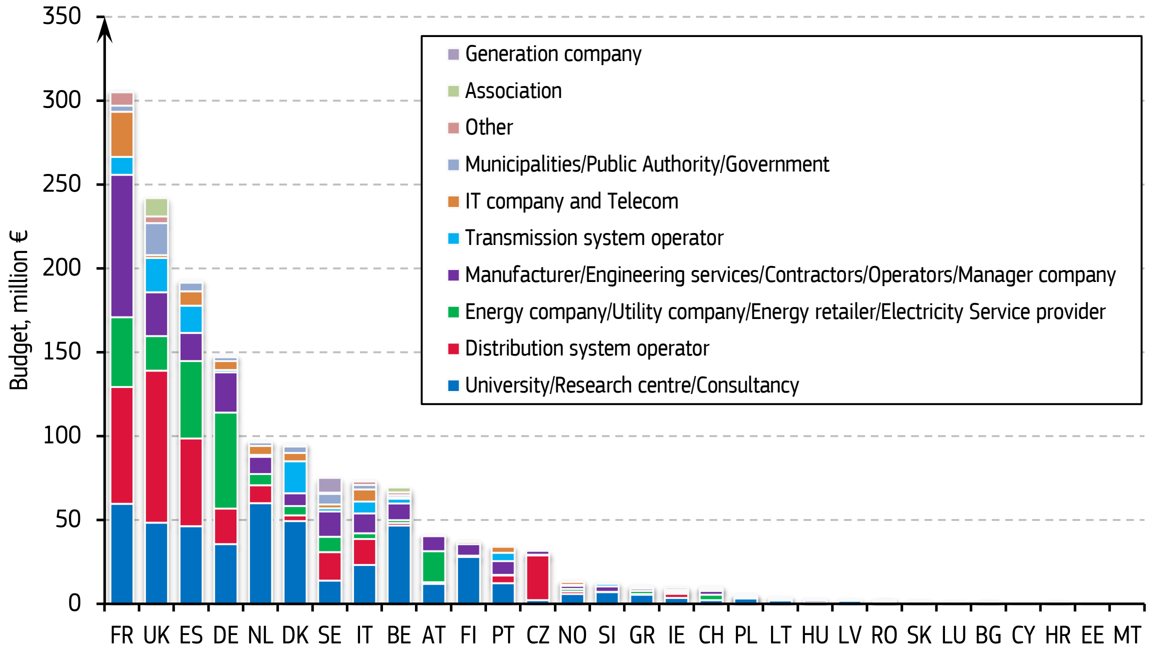


Figure 4.18 Distribution of private budget per organisation type and country

5. SMART GRID APPLICATIONS TARGETED BY PROJECTS

5.1 THE BIG PICTURE

7 main smart grid applications and an additional category including all other uncommon applications will be used in our study. These smart grid applications are:

- Smart network management — In this category, we consider implementations focusing on increasing the operational flexibility of the electricity grid, like substation automation, grid monitoring and control, etc. Typically, the goal is to improve the observability and controllability of the networks.

    - *Observability (tools to observe the behaviour of the network)* - Project results confirm that the tools developed or used to observe the network are mature and reliable. Some areas of improvement are related to standardisation and interoperability, particularly on the communication infrastructure. At transmission level, emphasis is also placed on the development of tools for the coordinated operation of pan-European networks. In this area, some of the key themes addressed in the projects are:
        - implementation of smart meters to collect and store, on demand and in real time, specific high quality and accurate data for each consumer and group of consumers;
        - improving distribution grid monitoring to cope with volatile states in the grid;
        - real-time asset monitoring;
        - fault identification and localisation.
    - *Controllability (tools to control the behaviour of the network)* - Some of the control technologies are already highly developed and efficient. Areas for improvement include cyber security and scalability of applications from small scale to large scale projects. In this area, some of the key themes addressed in the projects are:
        - implementation of new capabilities for frequency control, reactive control, power flow control;
        - controllable distribution sub-stations, controllable inverters and charging; development and testing of Distributed Generation and Load Intelligent Controllers; smart protection selectivity (smart relays);
        - smart auto-reconfigurable networks, easily stabilisable on line tap changer;
        - dynamic line rating;
        - deploying a range of leading-edge transformers across a number of LV and MV circuits, together with use of Capacitors, VAR control devices, and electronic

boosters which when optimised together will lead to reduced losses from the power system.

▪ Integration of large scale RES — Most projects in this category are concerned with the integration of RES mainly at transmission level. Key areas of focus are:

- Tools for planning, control and operation of renewables in order to facilitate their market integration;
- Integration of demand side management and ancillary services by DSOs to support TSO operation;
- Tools to forecast RES production;
- Off-shore networks for wind power integration.

▪ Integration of DERs — In this category, we include projects focusing on new control schemes and new hardware/software solutions for integrating DERs while assuring system reliability and security. Project results show that technical solutions for the integration of DERs are becoming quite consolidated. It should be noted that our catalogue includes only projects focusing on the integration of storage in the grid, not those focusing on the development of storage technology. The projects focus on technical solutions, such as:

- Active grid support through DERs: implementation of voltage control/reactive power control of DERs for the provision of ancillary services;
- DER production forecast and active/reactive power measurement for network observability;
- Innovative DER protection settings for anti-islanding operation;
- Use of storage together with distributed generation for voltage control, power flow modulation, balancing, etc.;
- Centralised vs decentralised (e.g. agent-based) control architectures;
- Aggregation of controllable DERs into technical VPP and into micro-grid configurations.

▪ Aggregation (virtual power plant, demand response) — In this category, projects focus on the implementation of aggregation mechanisms like virtual power plants[30] and demand response[31] to aggregate the supply and demand flexibilities of decentralised resources taking account of grid constraints and market signals.

[30] A virtual power plant is a link-up of small, distributed power stations, like wind farms, CHP units, photovoltaic systems, small hydropower plants and biogas units, but also of loads that can be switched off, in order to form an integrated network. The plants are controlled from one central control room.

[31] Demand response is a mechanism to adapt electricity demand to grid conditions or in response to market prices.

▪ Smart customers and smart home — In this group, we have included projects that test smart appliances and home automation together with new tariff schemes. Such projects typically require the active participation of consumers or aim at analysing consumer behaviour and fostering consumer involvement.

▪ Electric vehicles and Vehicle2Grid applications — Projects in this category focus on the smart integration of electric vehicles (EVs) and Plug-in Hybrid Vehicles (PHEV) in the electricity network.

▪ Smart metering — In this category we included only the projects investing in smart metering installations which are part of a wider smart grid project with one or more additional application.

▪ Other — All other uncommon smart grid applications were included in this set (e.g. manufacturing a new device).

Figure 5.1 shows the budget share by smart grid application, also showing a detail on the private budget distribution. Considering both the total and the private smart grid budget, the projects focusing on *Smart Network Management* and on the *Smart Customer and Smart Home* categories have the biggest shares, while most of the other application groups are not that far away. The *Smart Network Management* projects aggregates to ca. €850 million (26 %) from the total budget.

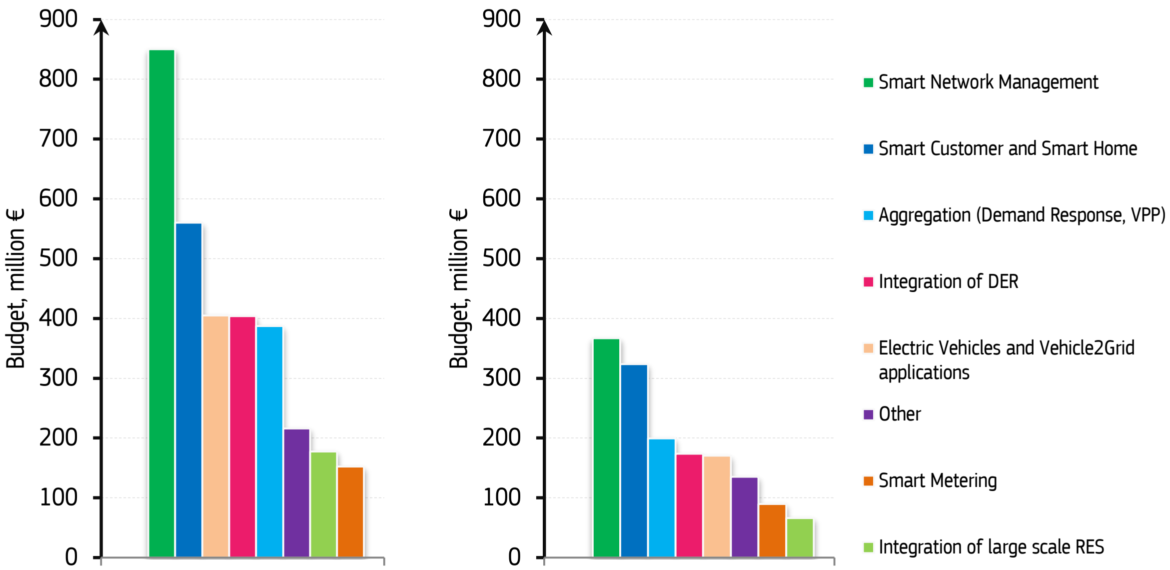


Figure 5.1 Investment per smart grid application
(each project may have more than one application): left Total budget; right Private budget[32]

The *Smart Metering* group has the lowest budget since all the exclusively smart metering projects, including national or regional roll-outs, were excluded. For additional *Smart Metering* numbers and figures that complete the charts in this section, see *Chapter 8.*

[32] For a distribution of the private budget by application and stage of development see Figure A.31-Annex I

5.2 MATURITY

Both in the R&D and the Demo & Deployment projects (Figure 5.2), the *Smart Network Management* group is the most interesting for the investors. After this the R&D sector invests in *Integration of DER, EV* and *Aggregation* categories. The *Smart Customer and Smart Home* category seems to be mature enough to exit the R&D phase and move predominantly in demonstrator projects.

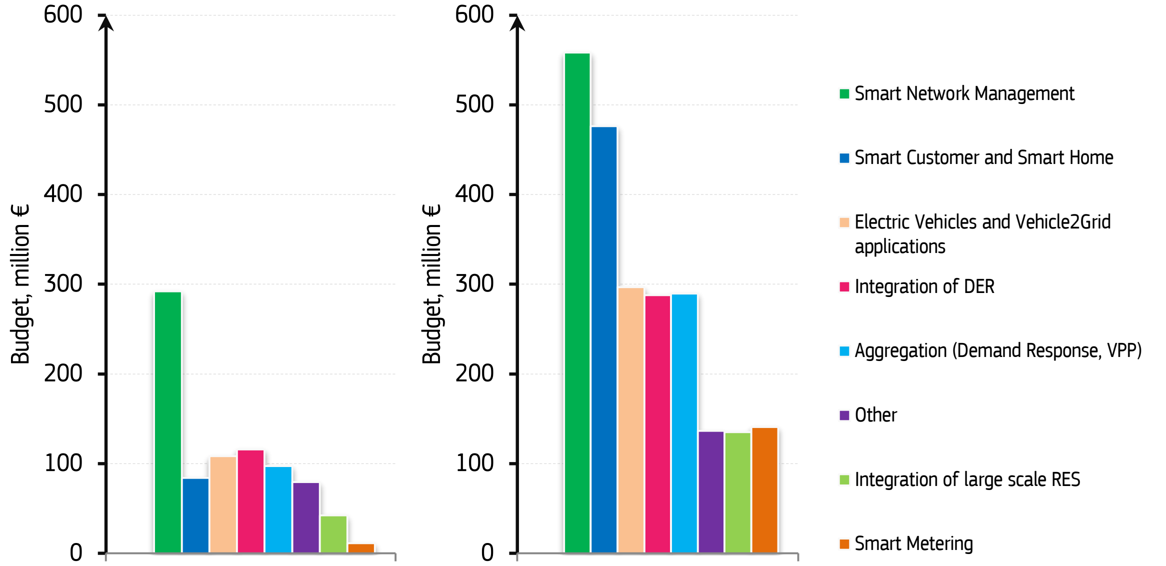


Figure 5.2 Total investment per smart grid application and stage of development (each project may have more than one application): left R&D; right D&D;

Grouping the number of smart grid projects by application (each project may have more than one application) and starting year (Figure 5.3) we observe a consistent increase in projects focusing on *Smart Network Management, EVs* and *Smart Customer and Smart Home*.

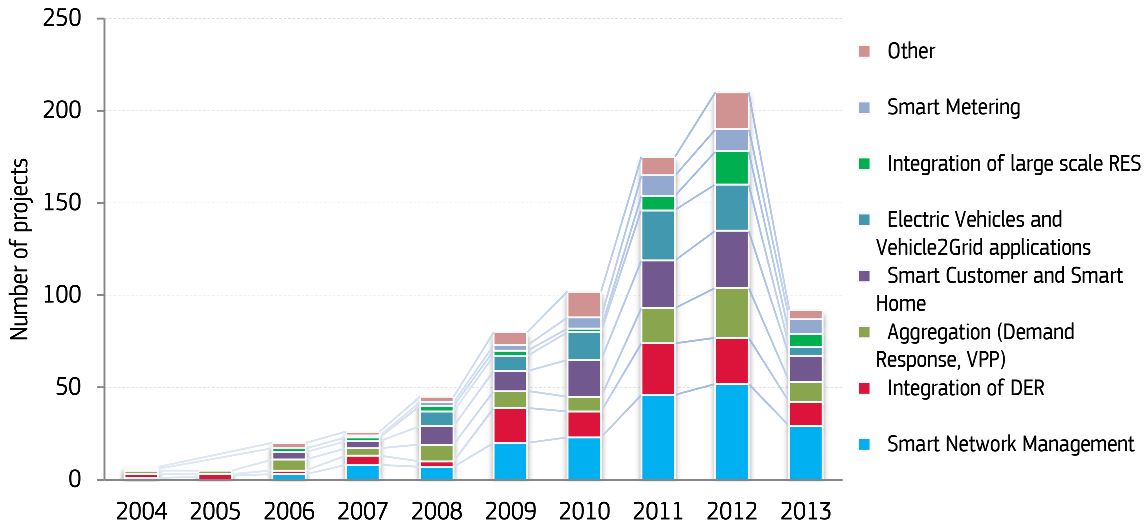


Figure 5.3 Distribution by project applications and year (each project may have more than one application)[33]

[33] For a distribution of project applications by year and stage of development see Figures A.32 and A.33 in Annex I

Generally both in terms of number and investment there is a good distribution among the application types. Regarding the budget (Figure 5.4) the distribution is not that uniform in most years. We can comment on the increase in budget of the *Electric vehicles and Vehicle2Grid* and *Smart Customer and Smart Home* applications in the recent years (2011-12). As expected, in the incipient years not all applications were mature enough to attract funding. The data for 2013 may be incomplete.

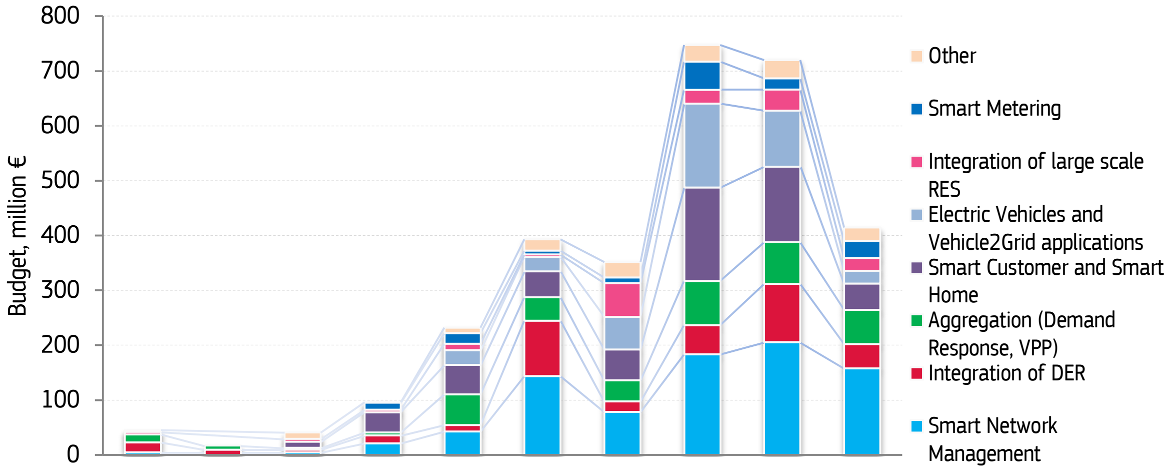


Figure 5.4 Distribution of total investment by application and year (each project may have more than one application)[34]

Complementing the previous charts with one in terms of percentage (Figure 5.5) we can observe the emergence of newer applications (*Smart Customer and Smart Home, EVs*) and an increase in their budget with the years. Since 2008 all application studied here were present each year. The *Smart Network Management* category seems to have an annual increase in investment, since most of the other applications depend on it to grow themselves.

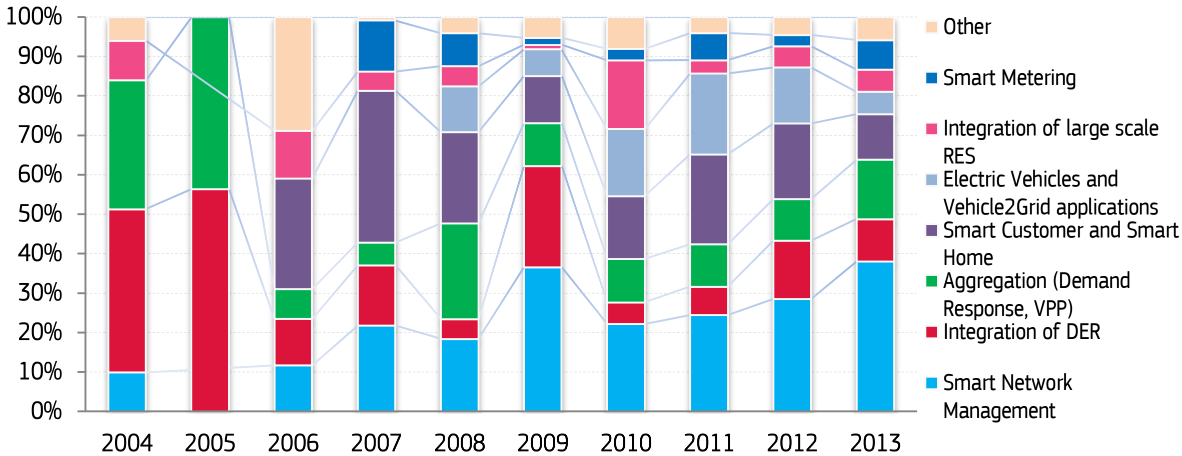


Figure 5.5 Percentage distribution of total investment by application and year (each project may have more than one application)[35]

[34] For a different view (3D) of the distribution of total investment by application and year see Figure A.38-Annex I

[35] For a percentage distribution of total investment by application, stage of development type and year see Figures A.36 and A.37 in Annex I

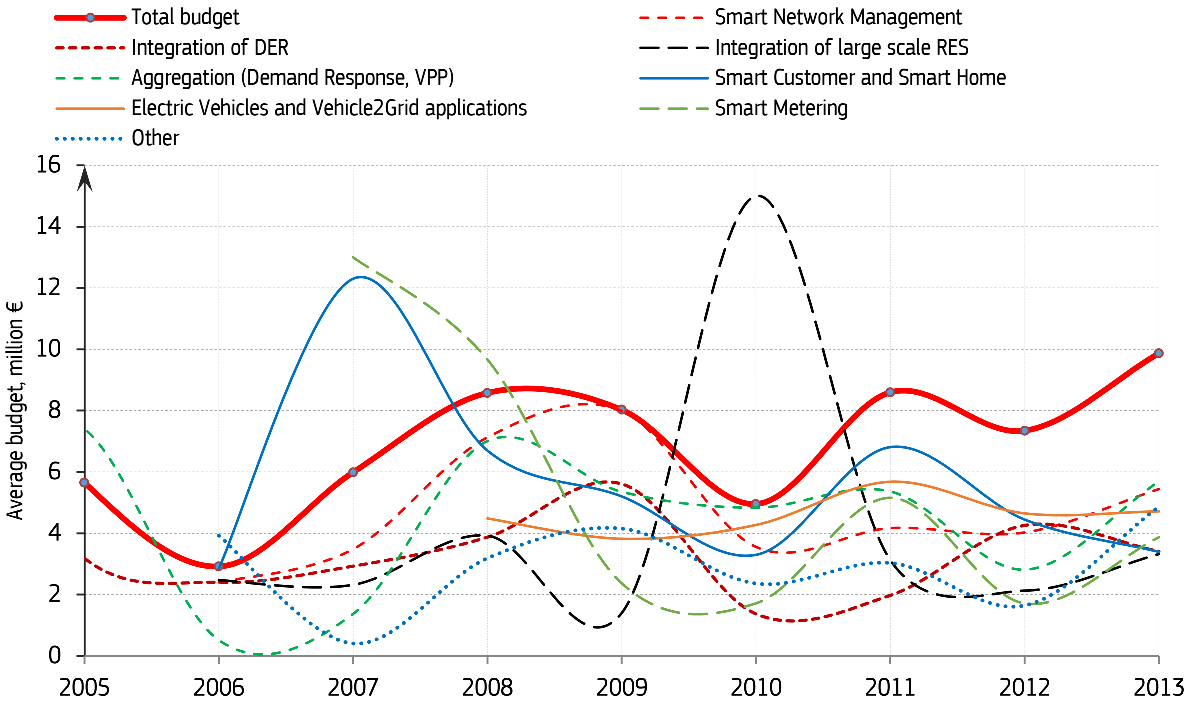


Figure 5.6 Average total smart grid budget invested by project application and year

As in the previous chapter, it is interesting to study the level of investment in the diverse application types in terms of yearly average total budget. We are including here both R&D and Demo & Deployment projects, as this can offer a suggestion as to which applications are more active or inactive in the preview phase before smart grid applications are marketed. Figure 5.6 illustrates the annual average investment per application type for the 7+1 groups and the annual average of the total budget per smart grid project. With one exception, starting with 2008 we can state that a good degree of application diversity exists in smart grid projects and that the level of diversity has remained steady over time, since most of the curves are slightly under the general average and relatively close to each other.

Before 2008 not all categories received investments and there was a large disparity among the budgets of the receiving ones.

5.3 APPLICATIONS AND ORGANISATIONS AND ABOUT-FACE

All smart grid projects started with an organisation or more having an idea or a common interest (corresponding to an application category). The budget of any project should be secured by the organisation(s) from one or more sources of funding. In this subchapter we are trying to create a link between the organisations and the applications through the budget (total or private).

Figure 5.7 depicts what is the budget each type of organisation invests in each smart grid applications. All categories invest a large share of budget in *Smart Network Management* and *Smart Customer and Smart Home*. The *DSOs* are mainly interested in three applications: the two mentioned before and in the *Integration of DER*. All other organisations spend similar amounts of money for most applications.

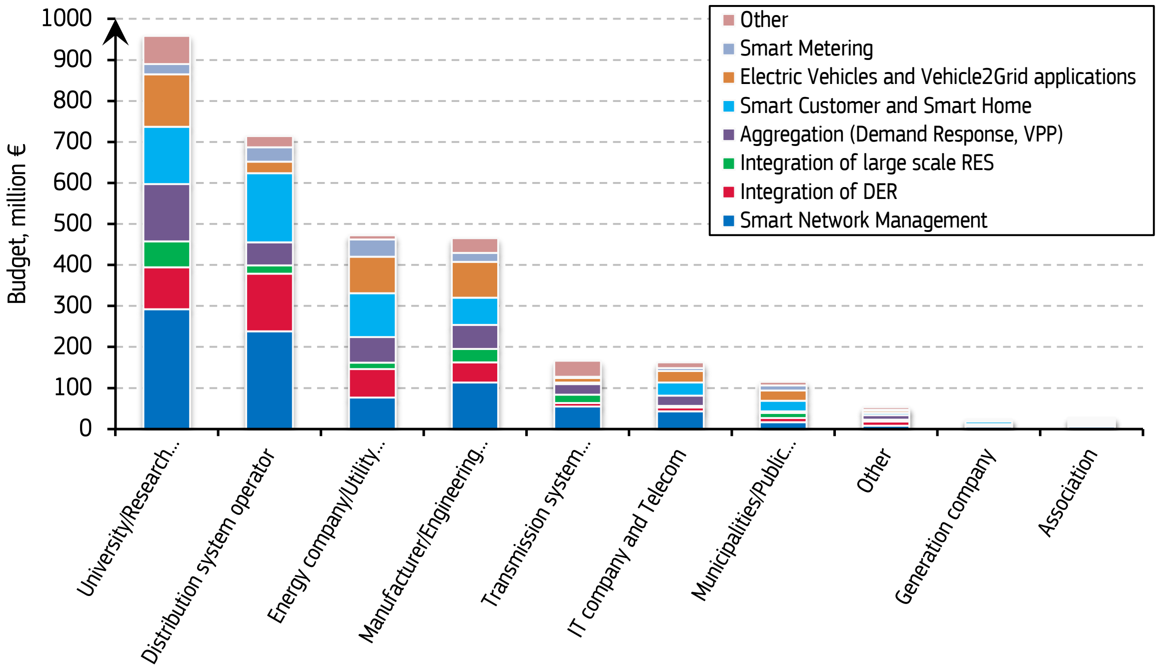


Figure 5.7 Distribution of total budget per organisation type and application[36,37]

Figure 5.8 depicts what is the average private budget each type of organisation invests in each smart grid applications. We are using the private budget instead of the total budget since this will give a clearer picture on the direct financial contribution per application for each organization category.

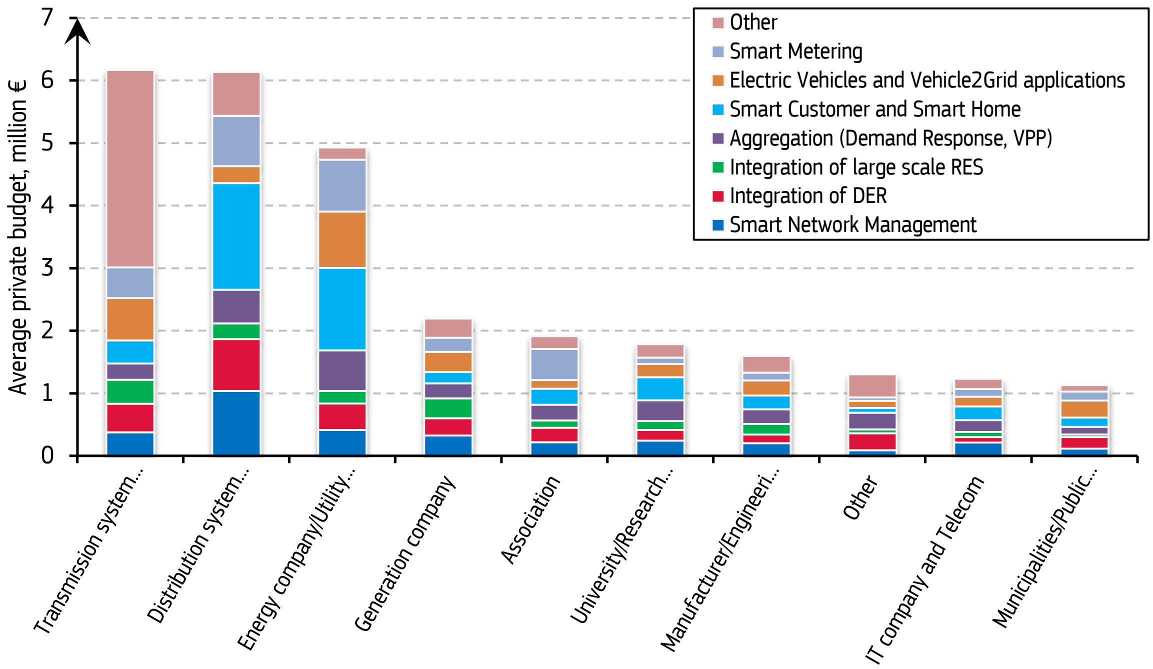


Figure 5.8 Distribution of average private budget per organisation type and application[38]

[36] For a distribution of total budget per organisation type, application and stage of development see Figures A.39 and A.40 in Annex I

[37] For a distribution of private budget per organisation type, application and stage of development see Figures A.41, A42 and A.43 in Annex I

We shouldn't focus on the total averages per entity type or on the order of the columns since both of these project a false picture (e.g. few projects with a large investment) but on the averages per application type.

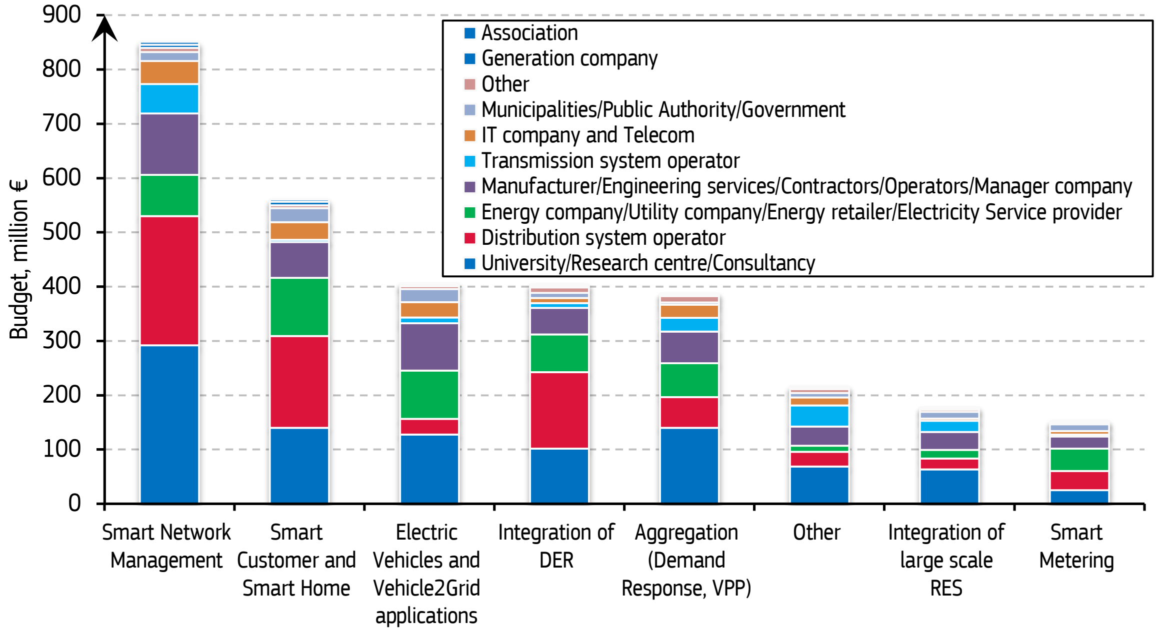


Figure 5.9 Distribution of total budget per application and organisation type[39,40]

From the other perspective, Figure 5.9 illustrates the total budget by smart grid application divided per organisation type. In the first place the *University/Research centres/Consultancies* together followed by the *DSOs and Energy companies/Utility companies/Energy retailers/Electricity service providers* are present with large shares of budget for each application type.

5.4 GEOGRAPHICAL DISTRIBUTION

For most of the countries in Europe the largest part of the budget goes to three main application types: *Smart Network Management, Smart Customer and Smart Home* and *Electric vehicles and Vehicle2Grid*, which form together more than 50 % of the budget share (Figure 5.10). According to the local competence and national priorities, the share of certain applications might be predominant at the country level. The largest share in smart network management can be found in two countries in central-eastern part of Europe: the Czech Republic and Hungary where the main organizations involved are the *DSOs* and financial sources are in largest part private. Half of the budget allocated to *Smart Customer and Smart Home* applications is invested by France and United Kingdom. The top ranking countries in

[38] For a distribution of average private budget per organisation type, application and stage of development see Figures A.44 and A.45 in Annex I
[39] For a distribution of total budget per application, organisation type and stage of development see Figures A.46 and A.47 in Annex I
[40] For a distribution of private budget per application, organisation type and stage of development see Figures A.48, A.49 and A.50 in Annex I

Electric vehicles and Vehicle2Grid applications, both in budget and fraction, are Germany and Austria, which combined run 40 % of this particular application's budget (Figure 5.11).

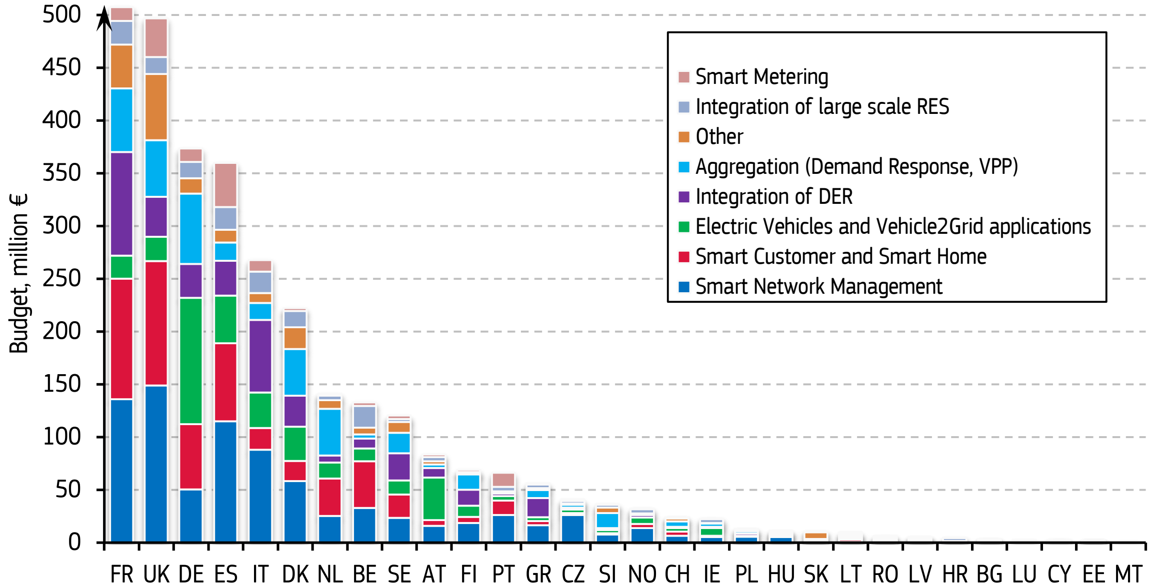


Figure 5.10 Distribution of total budget per smart grid application and country[41]

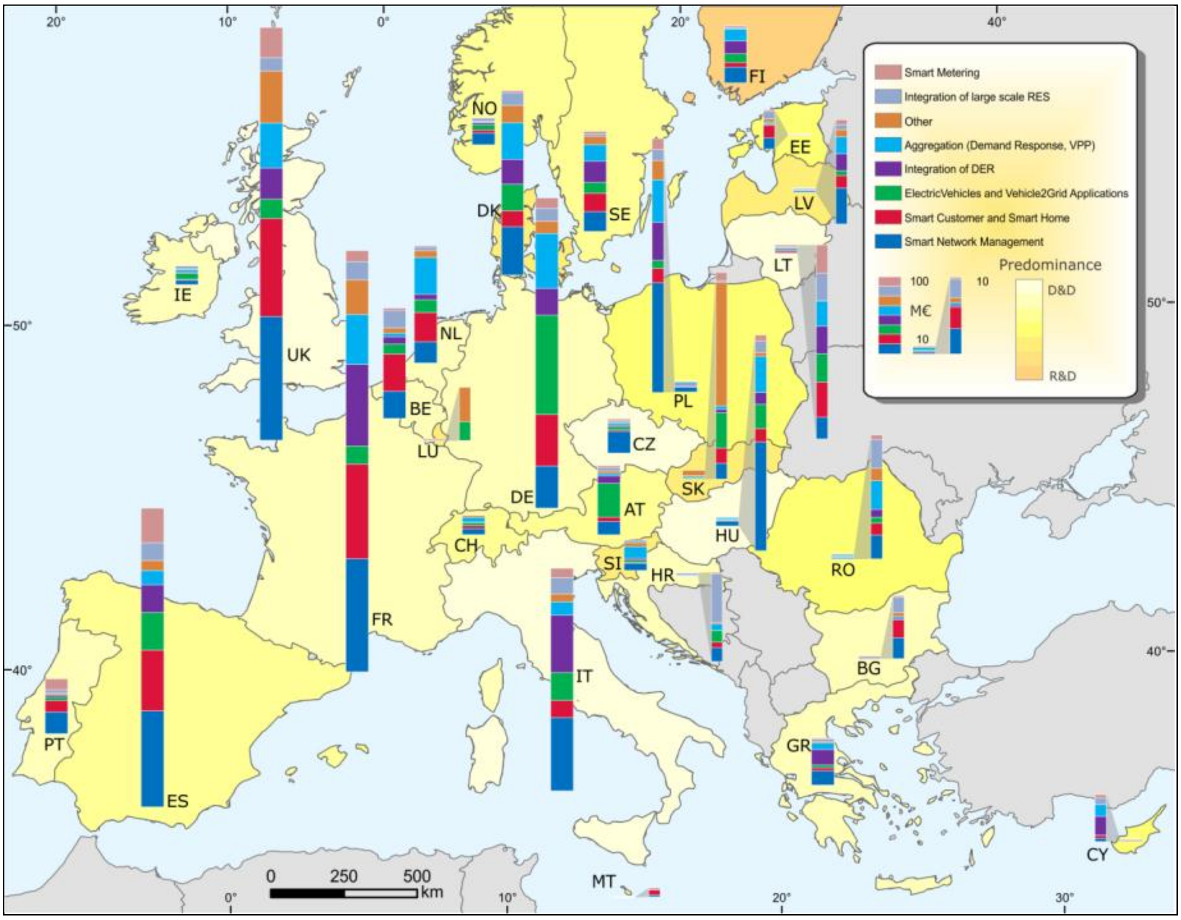


Figure 5.11 Distribution of total budget per smart grid application and country

[41] For a distribution of total budget per application, country and stage of development see Figures A.51 and A.52 in Annex I

The private budget distribution follows the same pattern as the total budget with few and small differences (Figure 5.12). For example in the Czech Republic the private budget goes in a higher degree in smart network management as it does when taking into account the total budget.

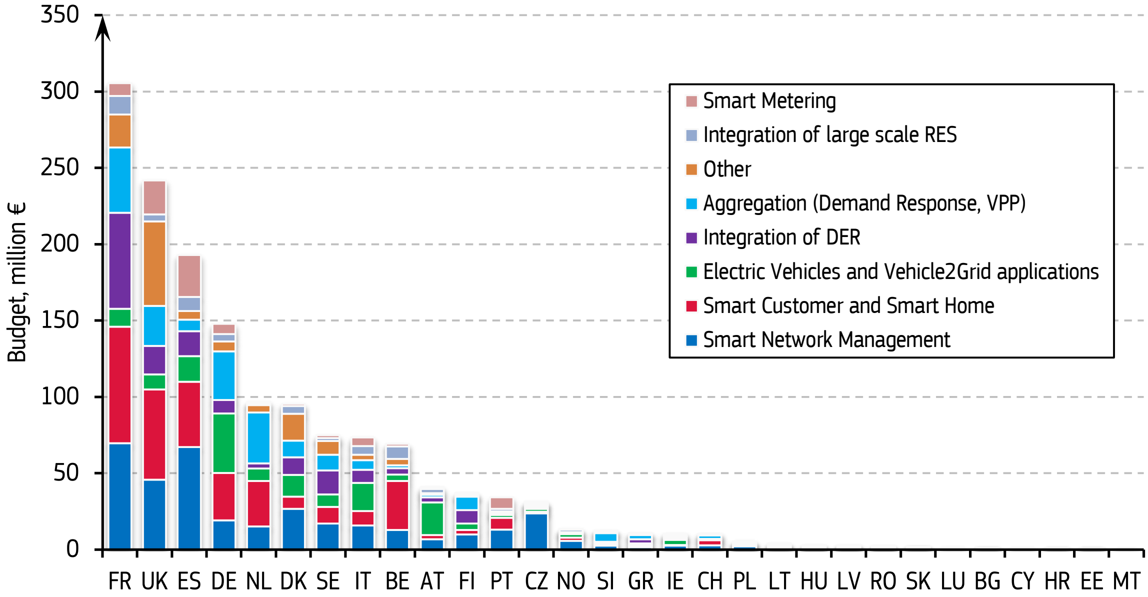


Figure 5.12 Distribution of private budget per smart grid application and country[42]

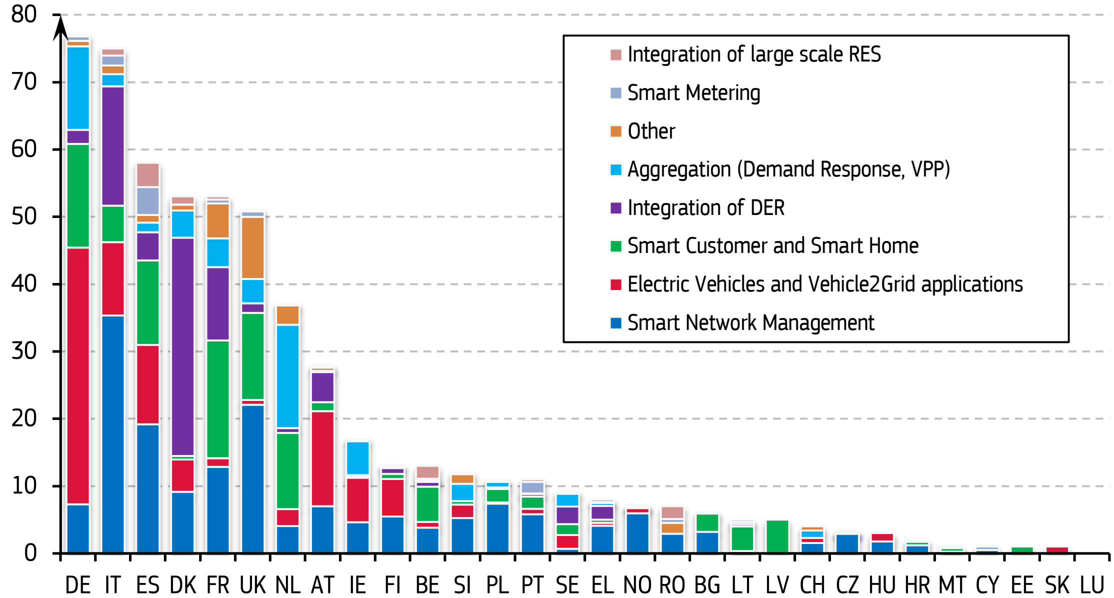


Figure 5.13 Number of implementation sites per country and application
(corected with the budget per application)

The distribution of applications at implementation sites across Europe shows the regional preference for smart grid deployment (Figure 5.13). It reflects only in part the project budget shares for different applications. The largest budgets shares at implementation sites deal with *Electric vehicles and Vehicle2Grid* in Germany, *Smart Network Management* in Italy and *Integration of DERs* in Denmark, where they make more than half of the total budget assigned to implementation sites in the respective

[42] For a geographical distribution of the private budget per application and country see Figure A.53 in Annex I

countries. Some countries seem to have a preference for a certain type of applications. Almost all the budget of the Baltic countries is used for *Smart Customer and Smart Home* applications. This application type has large shares also in Germany, Spain, France, United Kingdom and the Netherlands. *Smart Network Management* budget shares can be found in almost all of the countries, but they represent the bulk in Norway, Czech Republic and partly Poland, while the *Electric vehicles and Vehicle2Grid* take a large part of the implementation sites in Austria, Ireland, Finland, Spain and Italy.

The graph and map below were shaped by aggregating for each country the budget per application type and normalizing this to the implementation site number (for the same application). It may also happen that at one implementation site more application types could have been employed so the budget share of each application type can be found in that implementation site.

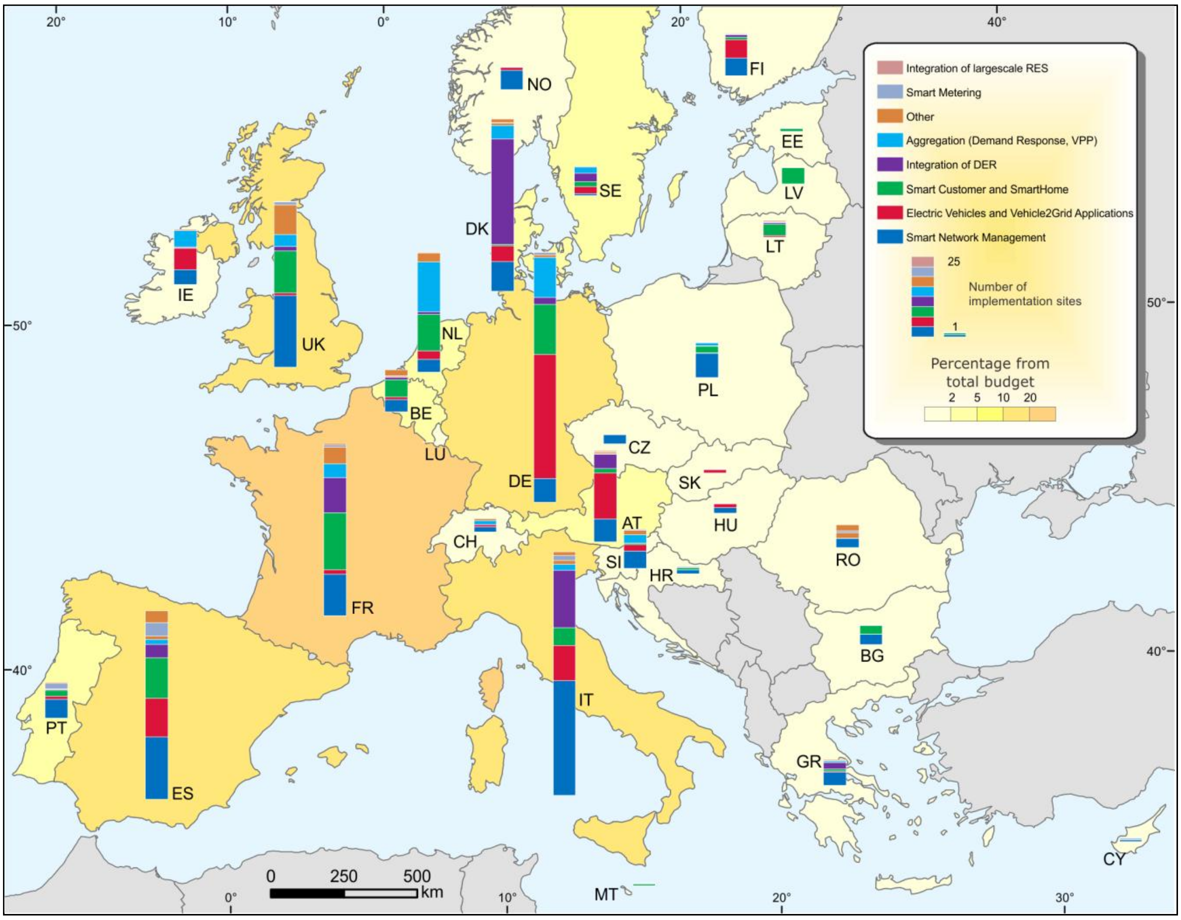


Figure 5.14 Number of implementation sites per country and application (corected with the budget per application)

Taking a look at the map (Figure 5.14) we can notice the predominance of budget shares of *Electric vehicles and Vehicle2Grid* in west-central part of Europe as well as at the extremities of the continent: Spain, Italy, Ireland and Finland, while the *Smart Customer and Smart Home* have large shares in countries on the west side of Europe and in the Baltic states. The *Integration of DERs* takes large shares of the budget in countries with wind (Denmark) or solar resources (Italy, France).

6. MULTINATIONAL COLLABORATION

6.1 NATIONAL AND MULTINATIONAL

The smart grid inventory includes 172 projects (51 % R&D) carried out by multinational partnerships, including ca. 1340 organisations from 47 countries and ca. 325 implementation sites in 33 different countries. The number of countries within these multinational consortia ranges from 2 to 16 (averages to 6 countries/project). The total multinational funding amounts to €1.35 billion, more than half of the multinational projects receiving EU funding.

In the vast majority of the countries there are more collaborative multinational projects than national ones (Figure 6.1). The average is 70 % multinational compared to 30 % national. Only Denmark has twice as many national projects than multinational ones. A higher percentage of national projects are found in countries with larger budgets like Germany and France but also of medium budgets like Austria. Spain is the only country with a large budget that is 90 % involved in multinational projects. Nine East European and insular Mediterranean countries do not run national projects.

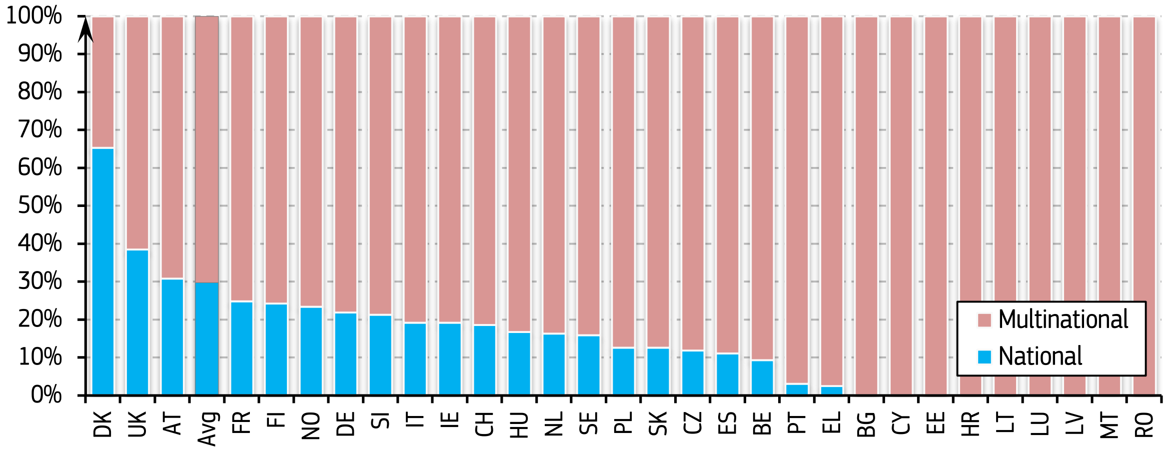


Figure 6.1 Number of national and multinational projects

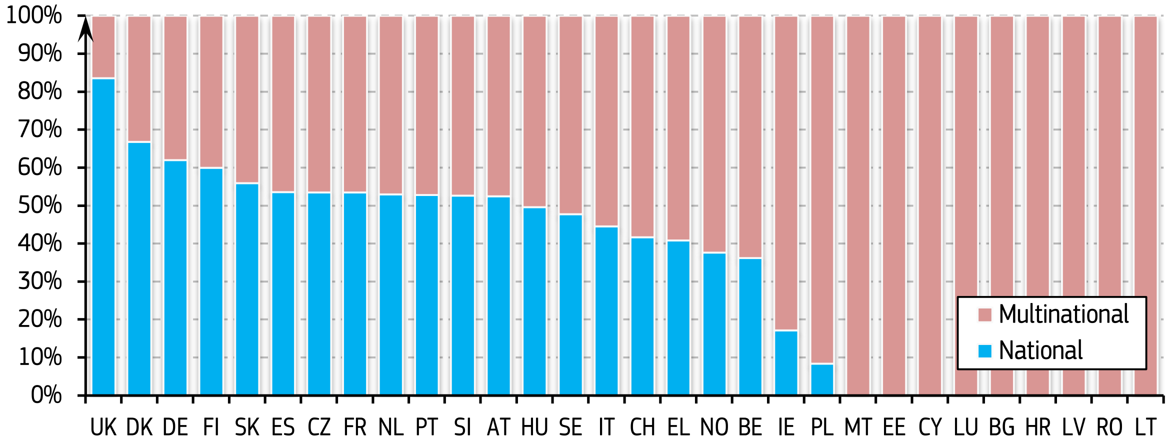


Figure 6.2 Investment in national and multinational projects

Countries with higher percentage of national projects obtain in a higher degree their budget from private sources. It also seems to be a 'national preference' for types of projects: the countries with higher percentage of national projects usually manage in much higher proportion (at least 70 %) their private budgets - either in R&D (Denmark 70 %) or in Demo & Deployment (United Kingdom 95 %).

When it comes to budget shares towards national or multinational projects the ranking suffers some changes (Figure 6.2). More than 80 % of the United Kingdom's budget goes to national funded projects. Large shares (above 50 %) can be also observed for Denmark, Germany and Finland. For all the other countries, which finance national projects, the share of their budgets is around 40-50 % toward national with the exception of Ireland and Poland which obtain more than 80 % of their budgets from multinational projects.

6.2 BI-DIRECTIONAL ANALYSIS

If we would to appreciate the relationships between two countries collaborating in all the smart grid projects in our inventory we have numerous options.

A simple possibility is to consider only the number of projects shared among them (links), ignoring the projects importance (budget) and the division of the budget between the parts involved.

The next step is to weight each *link* with the financial details per project and add everything together to get an aggregated weight for the relationship between the two participating countries. We decided to name this study "Bi-directional" since we deliberately considered that both countries are investing the same amount of money in common projects.

Additionally we will present an "Uni-directional" breakdown. In this case we also consider the fact that the two countries are not investing equal amounts of money in shared projects (e.g. one country has more participants in a common project). *We leave it to the reader to decide which approach is more precise. We must stipulate that this is just an aggregative study per country. To be more exact we are studying the relationships among the organisations from different countries.*

As mentioned before, for each pair of countries, indifferently of the number of organisations per party, we multiplied each *link* (common projects) with its corresponding project budget and add everything together to obtain an aggregated weight for the relationship between the pair. Repeating this procedure for all countries we obtain a matrix representing the cooperation links among the countries in European multinational projects. The resulting matrix is represented as a heat map[43] in Figure 6.3 (the higher the

[43] A heat map is a graphical illustration of data where the individual values enclosed in a matrix are represented as colours..

budget, the stronger the links). Cells corresponding to country pairings represent the strength of the link between two countries.

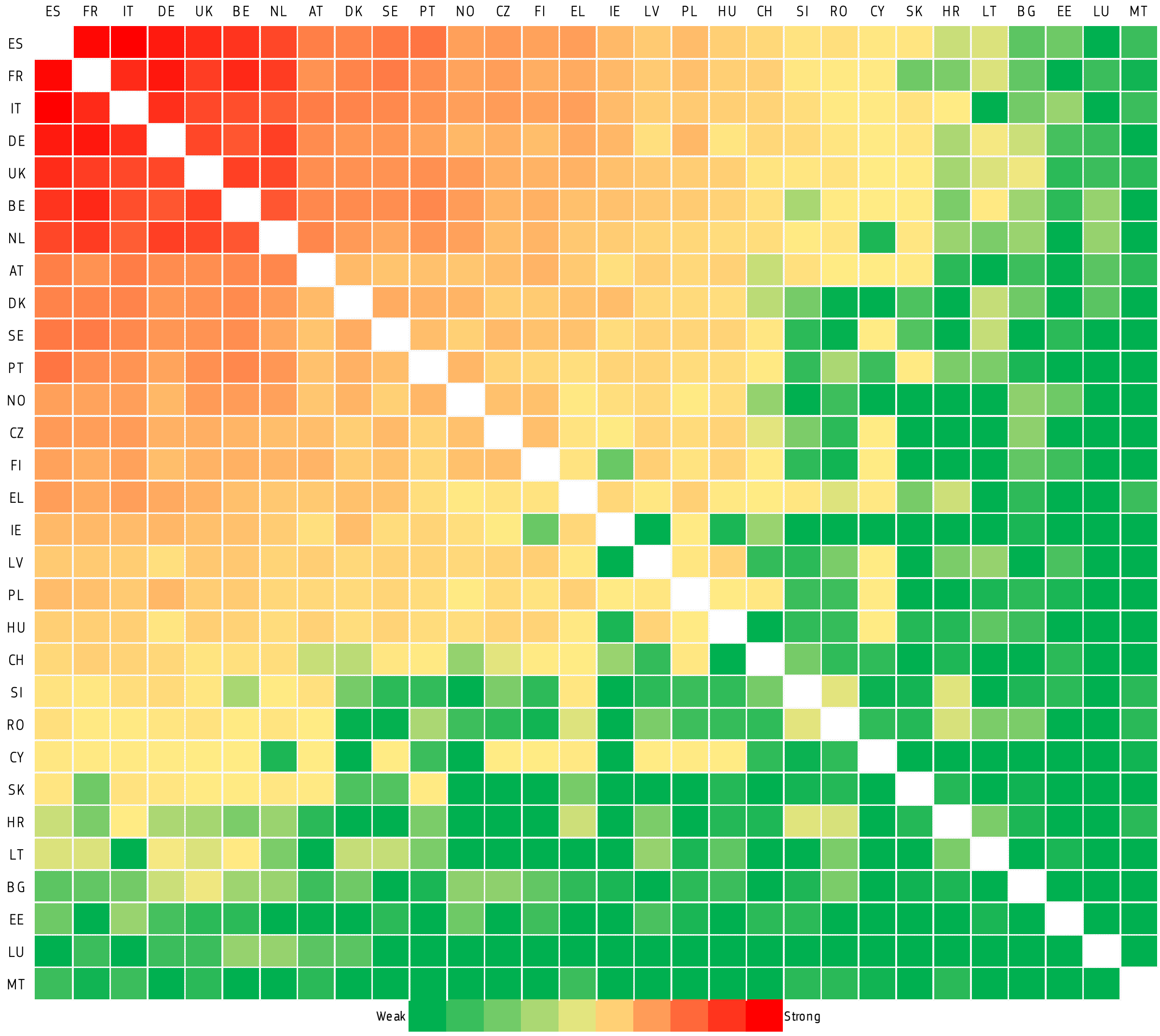


Figure 6.3 Collaboration links in European multinational projects (weighted by total project budget, heat map representation)[44]

We can notice a strong cooperation (coloured red) between countries in western Europe having large budgets. Spain is the most 'collaborative' country while Malta, Luxembourg, Estonia and Bulgaria have the fewest links with other countries. Countries with lower budgets, especially from eastern, south-eastern and insular Mediterranean countries have stronger links with western countries (coloured yellow) but display low values (green cells) of budget sharing among them or with the neighbours.

Figure 6.4 illustrates the cooperation (weighted with the budget) of two countries: Spain, the country with the highest number of relationships (Figure 6.4, left) and the Czech Republic, one of the most active country in smart grid projects in central-eastern Europe (Figure 6.4, right).

[44] For the collaboration links in European multinational projects (weighted by private project budget, heat map representation) see Figure A.54- Annex I

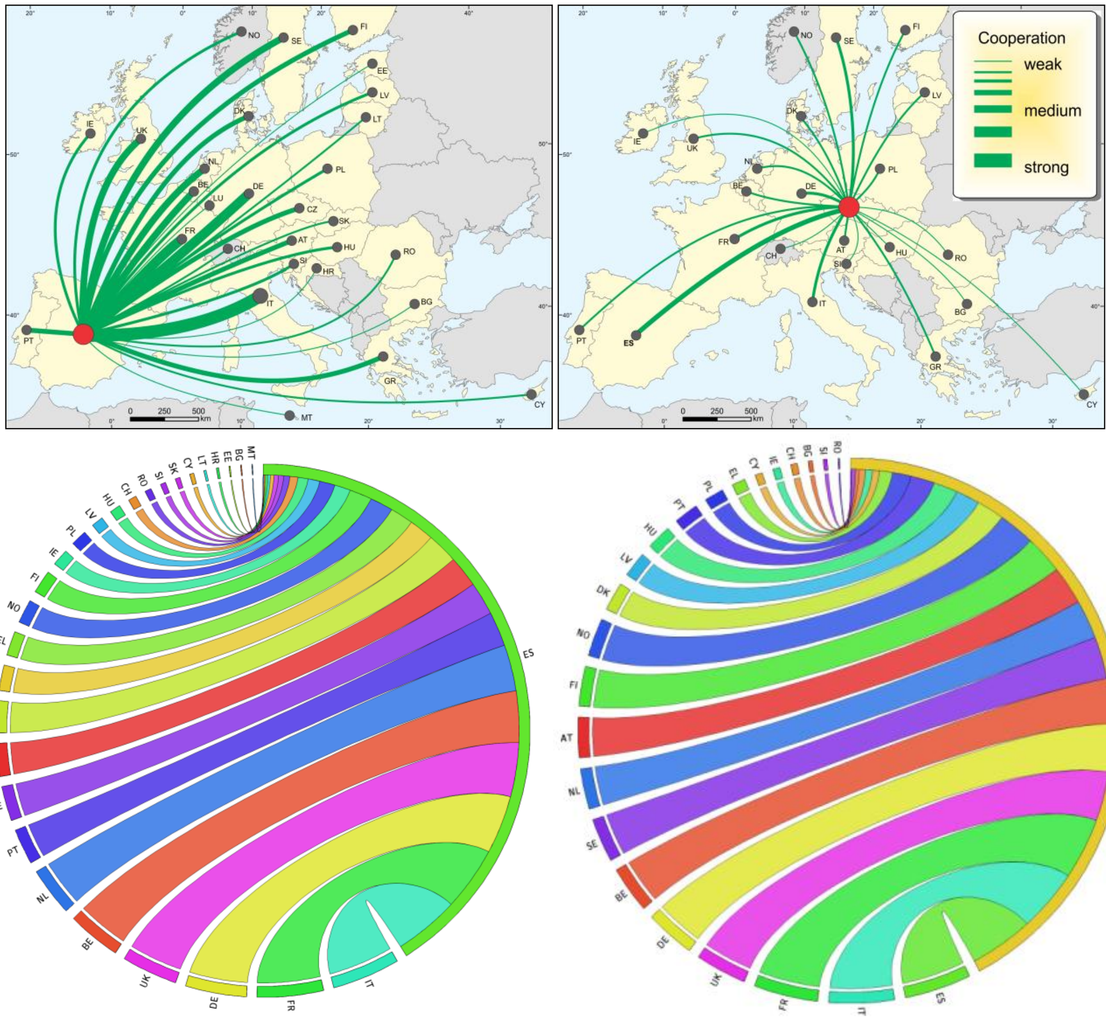


Figure 6.4 Left: Collaboration links between Spain and all other European countries; Right: Collaboration links between the Czech Republic and all other European countries (for all the projects in the catalogue, weighthed with the total project budget)

6.3 UNI-DIRECTIONAL ANALYSIS

Going one step further by analysing the exact budget shared by one country with each other ones in the common projects we can have a more precise image over the bi-lateral balance shares (Figure 6.5). In this "Uni-directional" study we consider the detail that the two countries are not investing equal amounts of money in shared projects (e.g. one country has more participants in a common project).

How to read the graph: the circumference of the circle is the total smart grid budget. The circumference is divided into unequal segments each corresponding to a country and its budget. The segments are connected with chords that illustrate the relationship between the countries. The thickness of the chord at its ends is proportional to budget that the country is investing compared to its partners. A thicker chord will show that the pair is cooperating strongly (funding in common the same projects).

The two ends of a chord can have different widths. This shows the ratio between the investments coming from each of the two countries in their common projects. In most cases a project will not be funded with equal shares from different countries (e.g. one country has more participants in a common project). Each country segment has a portion that does not send/receive any chord. These portions show the budget and the internal partnerships of the projects funded only by that organizations in that specific country (in other words, the national budget). Adding per country the width of all chords we get the multinational budget (as a fraction of the country segment).

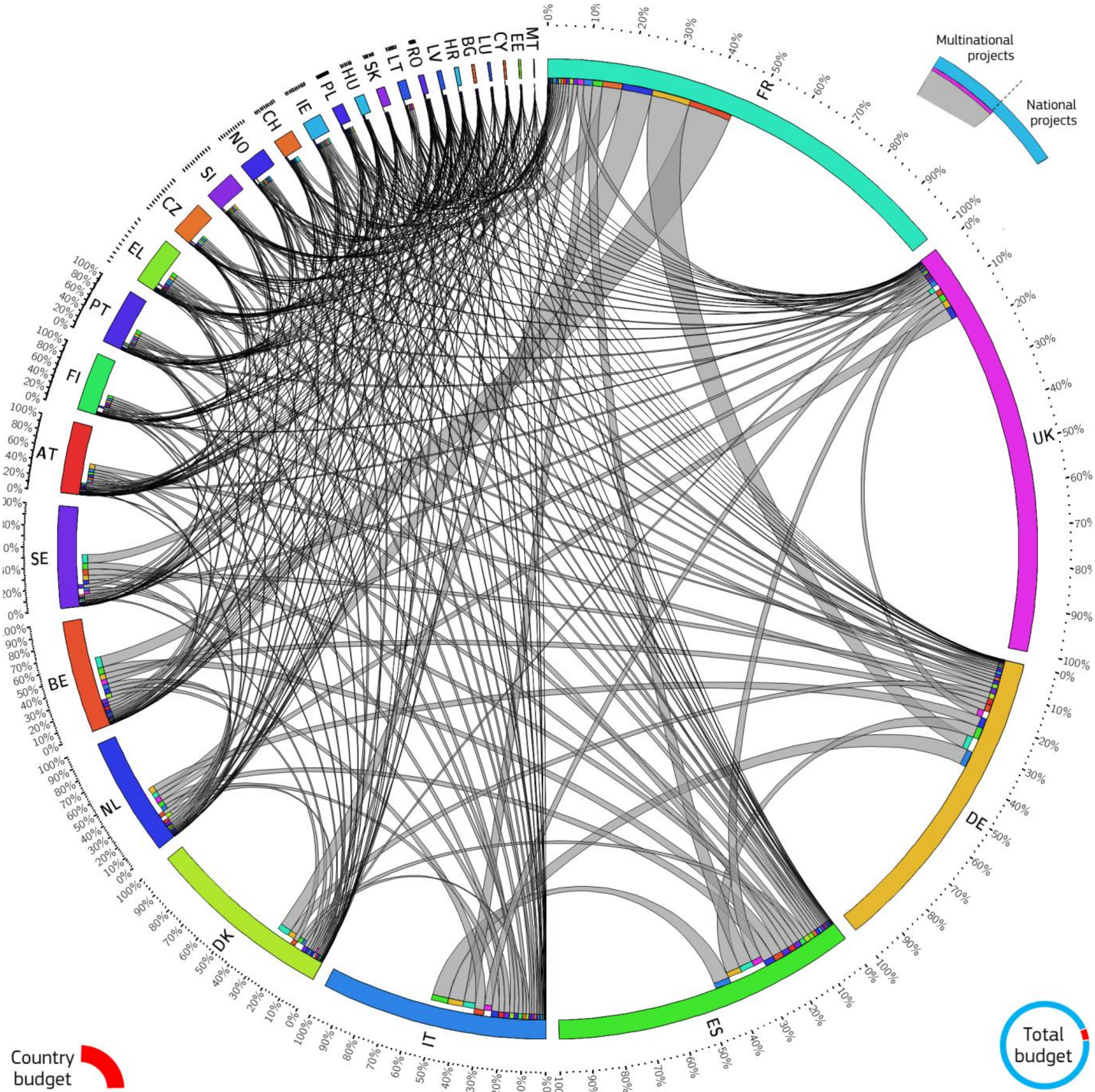


Figure 6.5 Collaboration links in European multinational projects (weighted by total project budget)[45,46,47]

We can notice that although France and United Kingdom have both the largest budgets their collaboration pattern differs significantly. In France 45 % of the budget comes from multinational

[45] For the collaboration links in European multinational projects (weighted by private project budget) see Figure A.56-Annex I

[46] For the collaboration links in European multinational projects, highlighting just the multinational budget (weighted by total and private project budget) see Figures A.57 and A.58 in Annex I

[47] For the collaboration links in European multinational projects, weighted by total project budget and normalized to the country population and the electricity consumption see Figures A.59 and A.60 in Annex I

projects and that leads to a larger amounts available in collaboration schemes. In United Kingdom on the other hand only a bit more than 15 % derives from multinational projects which let much lower amounts of money to be available for foreign collaborations. Based on the scale of the projects and the number of participants in each country the amount of money by which two countries collaborate might not be the same at both sides. For example, France shares more money with the top four collaborators (Belgium, Germany, Netherlands and Switzerland) than they do. On the other hand, Denmark shares more of its collaborative budget with France than the other way round. For some countries seems to be a preference in collaborating with certain other countries like France where 70 % of its multinational budget is shared with top four collaborators mentioned above. On the other hand the multinational budget of Spain is shared roughly evenly with its collaborators without any striking preference.

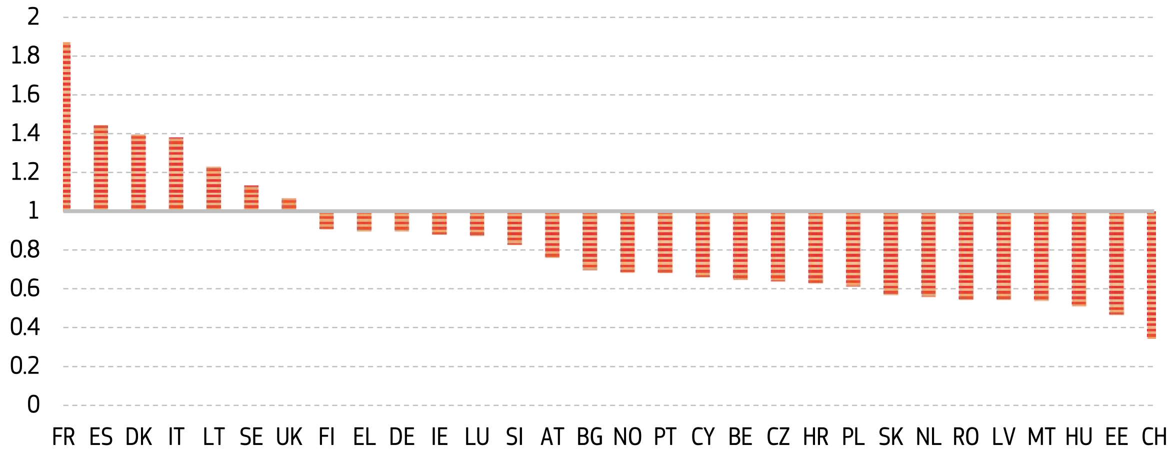


Figure 6.6 "Give-Take" ratio in the multinational projects budget (total budget)[48]

Analysing the ‘give or take’ balance for each country we have a view of which countries are net contributors and which ones are net gainers (Figure 6.6). This is the ratio between the budget a country invests with other partners (in smart grid projects) and the budget all other partners invest with it in the same projects. France has the largest budget and is also the top giver, well ahead of the other, while most of the receivers come from eastern and south-eastern Europe, insular Mediteranean and Baltics (except Lithuania) but also Nethelands and Switzerland, which is the top receiver.

The cooperation among organisations is driven by their research or business interest and may cover a wide range of applications. Figure 6.7 shows the number of cooperation links that the most active organization – Technical University of Denmark (DTU) has with its partners. DTU is involved in 45 projects (€250 million), mainly as a leader, collaborating with more than 180 partners located in almost all European countries. We note a preference for cooperation with other organisations located predominantly in Paris, Madrid, Milan, Brussels, Leuven, Rome and Athens. More than a half of the

[48] For a "Give-Take" ratio in the multinational projects budget (private budget) see Figure A.55 in Annex I

implementation sites of the projects in which this university is involved are located in Denmark while the rest are scattered all over Europe

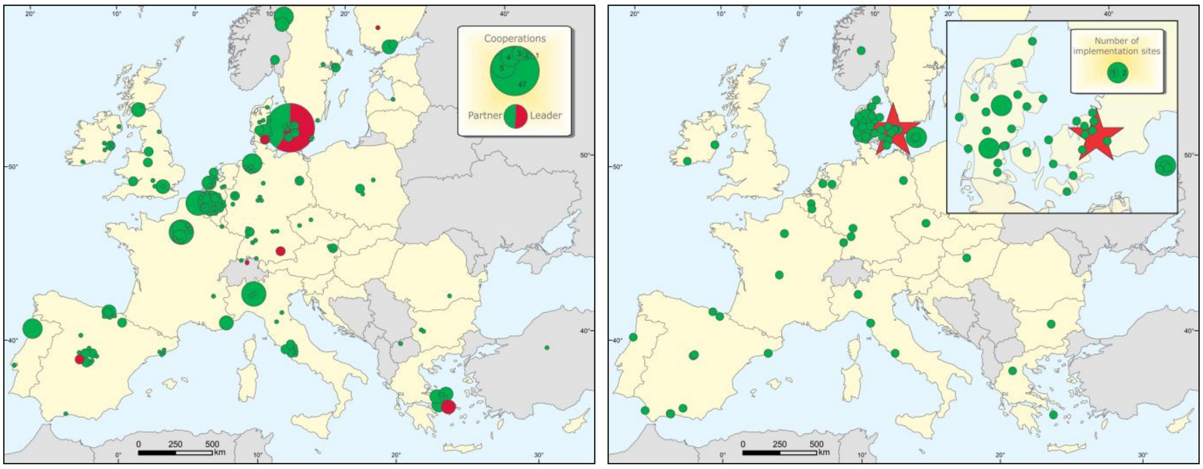


Figure 6.7 Technical University of Denmark: cooperation with other organisations (left); implementation sites in participating projects (right)

7. WHAT PROJECTS STARTED IN 2013-2014?

Chapters 2-6 presented a ‘macro’ perspective of all the smart grid projects in our catalogue, providing information at aggregated level about investments, countries, organisations, applications and progress in different areas.

In this chapter, we take a ‘micro’ perspective and provide details of some of the projects. Some facts:

- 42 smart grid projects started in 2013 with a total investment of around €415 million while in 2014, 8 new projects started with a combined budget of ca. €60 million (up to the date when the inventory was closed for this report);
- In both years and both in terms of number and budget, the Demo & Deployment projects have the larger numbers;
- Combined in 2013 and 2104 ca. 400 new companies entered the smart grid sector;
- As of 2013, 220 projects were still running (Figure 7.1);

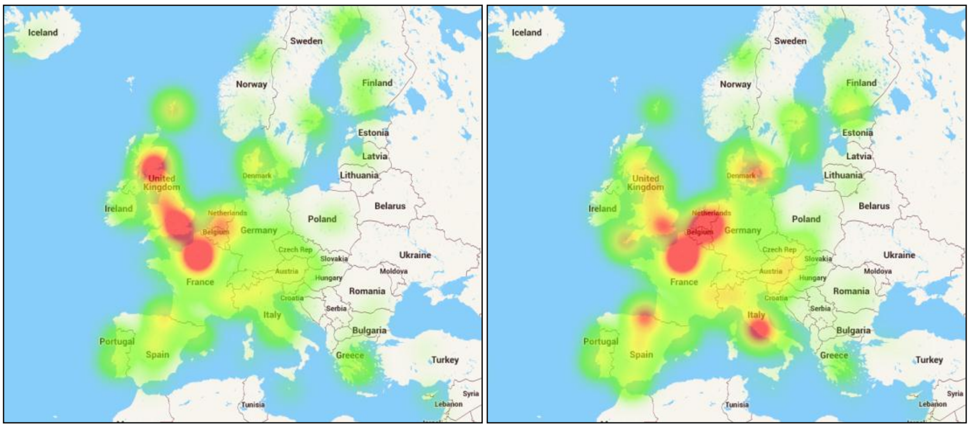


Figure 7.1 Geographical distribution of the organisations involved in smart grid projects (corrected by total budget): left: projects starting in 2013-2014; right: projects ongoing in 2013-2014[49]

- By country UK, France and Spain are the main investors (Figure 7.2) totalling to ca. €300 million;

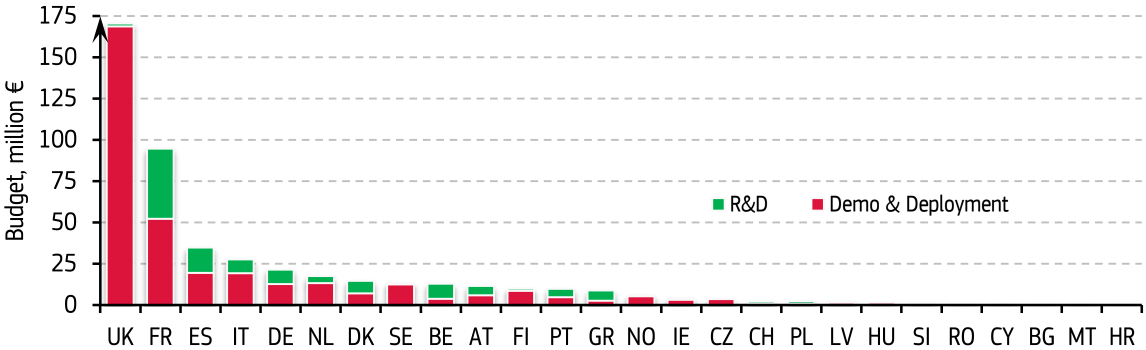


Figure 7.2 Distribution of total budget per stage of development and country: 2013+2014

[49] The two charts don't have the same intensity scale. They shouldn't be compared to each other based on the intensity of the color..

- Most of the funding comes from private sources, followed by EC. By country (Figure 7.3) beside the private and the EC funding, in UK the regulator invested significant funds in 2013 and 2014. 30 % of France's smart grid budget comes from national sources.

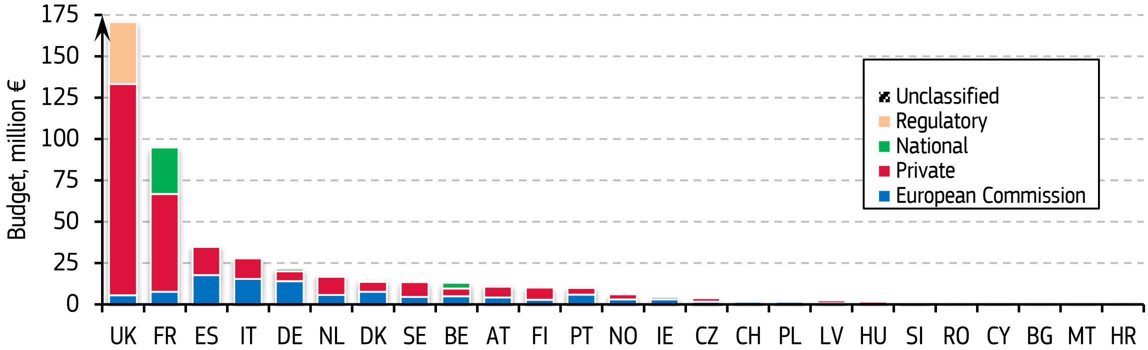


Figure 7.3 Distribution of budget per funding source and country: 2013+2014

Some projects are advertised later in their lifetime and insufficient or no information is available for them. This is why most of the aggregations for 2013 and 2014 show a decrease in number or investment compared to previous years.

In the following, we provide a short overview of some large projects that started in 2013.

ARROWHEAD

Leader: Sweden

Number of partners: 77

Start year: 2013

End year: 2018

Type: Multinational

Budget: Very large scale project[50]

Source: *www.arrowhead.eu*

Arrowhead is addressing efficiency and flexibility at the global scale by means of collaborative automation for five application verticals. That means production (manufacturing, process and energy), smart buildings and infrastructures, electro-mobility and virtual market of energy.

Arrowhead will provide a technical framework, including solutions for integrating legacy systems, to implement and evaluate cooperative automation through real application pilots in electro-mobility, smart buildings, infrastructures and cities, industrial production, energy production and the “virtual energy” market, leading the way to further standardisation and showcasing the actual impact in real life.

[50] See subchapter 2.3.

Coordinated by Lulea University of Technology (SE), the Arrowhead project is performed by collaborative efforts of 77 partners from 15 different countries.

The objective of the Arrowhead project is to address the technical and applicative challenges associated to cooperative automation:

- Provide a technical framework adapted in terms of functions and performances;
- Propose solutions for integration with legacy systems;
- Implement and evaluate the cooperative automation through real experimentations in applicative domains: electro-mobility, smart buildings, infrastructures and smart cities, industrial production, energy production and energy virtual market;
- Point out the accessible innovations thanks to new services;
- Lead the way to further standardization work.

The strategy adopted in the project has four major dimensions:

- An innovation strategy based on business and technology gap analysis paired with a market implementation strategy based on end users priorities and long term technology strategies;
- Application pilots where technology demonstrations in real working environments will be made;
- A technology framework enabling collaborative automation and closing innovation critical technology gaps;
- An innovation coordination methodology for complex innovation "orchestration".

FINESCE

Leader: Germany

Number of partners: 20

Start year: 2013

End year: 2015

Type: Multinational

Budget: Medium scale project[51]

Source: *www.finesce.eu*

FINESCE (Future INtErnet Smart Utility ServiCEs) is the smart energy use case project of the 2nd phase of Future Internet Public Private Partnership Programme (FI-PPP) funded by the European Union within FP7.

[51] See subchapter 2.3.

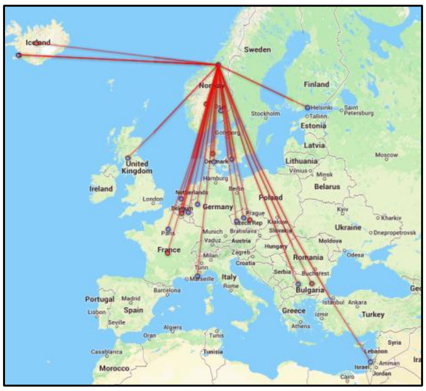
Coordinated by ERICSSON GMBH (DE), the FINESCE project is performed by collaborative efforts of 20 partners from 11 different countries. From 2013 until 2015, FINESCE will contribute to the development of an open IT-infrastructure to be used to develop and offer new app-based solutions in all fields of the Future Internet related to the energy sector.

FINESCE will organize and run user trials in 7 European countries, addressing efficient energy usage in residential and industrial buildings, developing a new prosumer energy marketplace, building a cross-border private virtual power plant, and using electric vehicles as an element of demand response systems, enabling energy providers to move from reactive to pro-active energy network management by providing them with Future Internet ICT, enabling them to better balance volatile solar and wind energy generation with demand for energy.

The FINESCE trials will prove the practical applicability of Future Internet technologies and the FI-WARE Generic Enablers to the challenges of the energy sector. FINESCE will develop an active community of innovative SME's, preparing them for the exploitation of the emerging business opportunities in energy, creating jobs, social impact and economic growth. FINESCE builds on and extends the results of the FI-PPP FINSENY project to realise sustainable real time smart energy services.

The consortium includes globally leading energy and ICT operators, manufacturers and service providers and outstanding research organisations and SME's, from 12 countries, contributing directly to tightly focused trials and business innovation. It has the scale and scope to ensure that the FINESCE results drive the FI-WARE and Future Internet success and long-term exploitation internationally.

GARPUR



Leader: Germany

Number of partners: 21

Start year: 2013

End year: 2017

Type: Multinational

Budget: Medium scale project

Source: *www.garpur-project.eu*[52]

The GARPUR (Generally Accepted Reliability Principle with Uncertainty modelling and through probabilistic Risk assessment) project designs, develops, assesses and evaluates such new reliability criteria to be

[52] See subchapter 2.3.

progressively implemented over the next decades at a pan-European level, while maximising social welfare.

Coordinated by SINTEF Energy Research, the GARPUR project is performed by collaborative efforts of 7 TSOs (Belgium, Bulgaria, Czech Republic, Denmark, France, Iceland and Norway), 12 R&D providers and 1 innovation management expert.

Five alternatives to improve reliability management of the pan-European power system are to be studied:

- model the spatial-temporal variation of the probabilities of exogenous threats and take into account the actual criticalities of service interruptions in the reliability management;
- take into account the increased possibilities of corrective control and its probability of failure in the reliability management;
- exploit the flexibility provided by demand-side management and energy storage, to achieve the reliability enhancement given the emergence of decentralised renewable generation;
- explicitly model the impact of system development and asset management decisions on the reliability management during operation;
- explicitly take into account the consideration of low-probability high-impact events, such as the ones originating from extreme weather conditions, possibly through climate change, or those originating from adverse behaviours of external entities.

After practical validation by the TSOs, these alternatives are to be analysed with the help of a Quantification Platform.

Pilot tests of the new proposed reliability criteria are to be performed by TSOs, using this quantification platform. First, a pilot test is to be performed on a pan-European level, using a coarse grained model of the European interconnection. Second, pilot tests are to be carried out by one or two TSOs as close as possible to a real life context and are to be related to operational planning or/and a realistic investment planning problem; these tests are planned to use real system and cost data for investment planning purposes and real measurements and data for operational planning purposes.

Dissemination activities of the new reliability criteria are supported by a Reference Group of TSOs and address all the key electricity market stakeholders. An implementation roadmap is to be delivered for the deployment of the resulting technical and regulatory solutions to keep the pan-European system reliability at optimal socio-economic levels.

8. SMART METERING

The deployment of intelligent metering systems[53] presents an essential step towards smart grids[54] development. Effective deployment of smart metering systems is expected to empower consumers by delivering enhanced consumer services and ensuring their active participation in the electricity market.

The European Commission's Interpretative Note on the Retail Markets for Directives 2009/72/EC and 2009/73/EC[55] provides a description of the Commission's understanding of an intelligent metering system by "...the ability to provide bi-directional communication between the consumer and the supplier/operator..." and to "...promote services that facilitate energy efficiency within the home...".

The Recommendation 2012/148/EU [27] on smart metering deployment further clarifies that the smart metering system should be defined through the functionalities it provides. In particular, at least for electricity, the Commission Recommendation identified ten minimum functional requirements that the smart metering system should provide in order to deliver full benefits to consumers and the energy grid while supporting technical and commercial interoperability and guarantee data privacy and security.

In this context, smart metering systems can enable the successful consumer engagement in the energy market starting with the possibility of getting accurate and more frequent feedback on their electricity consumption and minimised errors and delays in invoices. In addition, smart metering system will allow for easier supplier switch, thus maximizing opportunities for customers to reap benefits from innovative pricing mechanisms and emerging technologies (such as home automation).

Smart metering systems will also account for reduction of the distribution network operation and maintenance costs, while effectively integrating distributed generation and electric vehicles and enabling new business opportunities.

The Third Energy Package[56] requires Member States to ensure the implementation of intelligent metering systems for the long-term benefit of consumers. This implementation may be conditional on a positive economic assessment of the long-term costs and benefits - a Cost Benefit Analysis (CBA) - to the

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[53] 'Smart metering system' or 'intelligent metering system' means an electronic system that can measure energy consumption, providing more information than a conventional meter, and can transmit and receive data using a form of electronic communication – definition extracted from preamble 28 of Energy Efficiency Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC

[54] The European Smart Grid Task Force defines Smart Grids as electricity networks that can efficiently integrate the behaviour and actions of all users connected to it — generators, consumers and those that do both — in order to ensure an economically efficient, sustainable power system with low losses and high quality and security of supply and safety;

[55] Commission Staff Working Paper: Interpretative Note on Directive 2009/72/EC and Directive 2009/73/EC – Retail Markets, 22.01.2010;

[56] Annex I.2 of both the Electricity Directive 2009/72/EC and Gas Directive 2009/73/EC.

market and the individual consumer, to be completed by 3 September 2012. In the specific case of electricity, there is a target of rolling out at least 80 %, by 2020, of the positively assessed cases.

The Third Package does not provide a methodology to be used for the aforementioned economic assessment; however, guidelines for conducting a CBA have been included in the Recommendation 2012/148/EU issued by the European Commission [27] and detailed by JRC[57]. These guidelines have been, to a certain extent, considered by the Member States in their national assessments.

The Commission services (ENER/JRC) have performed an in-depth benchmarking analysis of these CBAs and of Member States respective deployment plans and strategies. The results of this exercise are included in a Commission Report ("*Benchmarking smart metering deployment in the EU-27 with a focus on electricity*" and accompanying Staff Working Documents giving an overview of progress of smart metering roll-out in the EU along with detailed country-specific information) gauging progress on the deployment of intelligent metering in the EU in line with Third Energy Package provisions, also presenting lessons learned, best practices and recommendations for the way forward.

The following sections present highlights from the Benchmarking Report based on smart metering developments in the EU Member States at national aggregated level, reflecting the situation as of July 2013 and with particular focus on the way smart metering systems can benefit the consumer. Furthermore, complementary field data coming from individual smart metering projects are herein discussed regarding potential consumer benefits, in support of the analysis.

8.1 PROGRESS OF SMART METERING DEPLOYMENT IN EU-27[58]

Based on the Benchmarking Report findings, around 72 % EU customers are expected to be equipped with electricity smart metering systems by 2020. In fact, Finland, Italy and Sweden have already finalised their nation-wide smart metering roll-outs, presenting 23 % of the envisaged installations by 2020.

Figure 8.1 depicts an overview of the electricity smart metering national roll-outs in EU based on the data available by the EU Member States, as of July 2013. Sixteen Member States (Austria, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Luxemburg, Malta, Netherlands, Poland, Romania, Spain, Sweden and UK) have decided in favour of a national roll-out of smart metering by 2020 or have already completed it (e.g. Finland, Italy and Sweden).

57 "Guidelines for Cost Benefit Analysis of Smart Metering Deployment", JRC Scientific and Technical Report, EUR25103 EN.
58 All EU member states beside Croatia.

Germany, Latvia and Slovakia are opting for a selective smart metering roll-out, economically justified for a specific group of customers. Belgium, Czech Republic and Lithuania have decided not to proceed, at least for the time being and under current conditions, with a large-scale roll-out of smart metering due to a negative CBA outcome. Portugal has reported an inconclusive CBA to be re-evaluated considering recent pilot data and the current economic context. Finally, no CBA or concrete national roll-out plan has been available for Bulgaria, Cyprus, Hungary[59] and Slovenia.

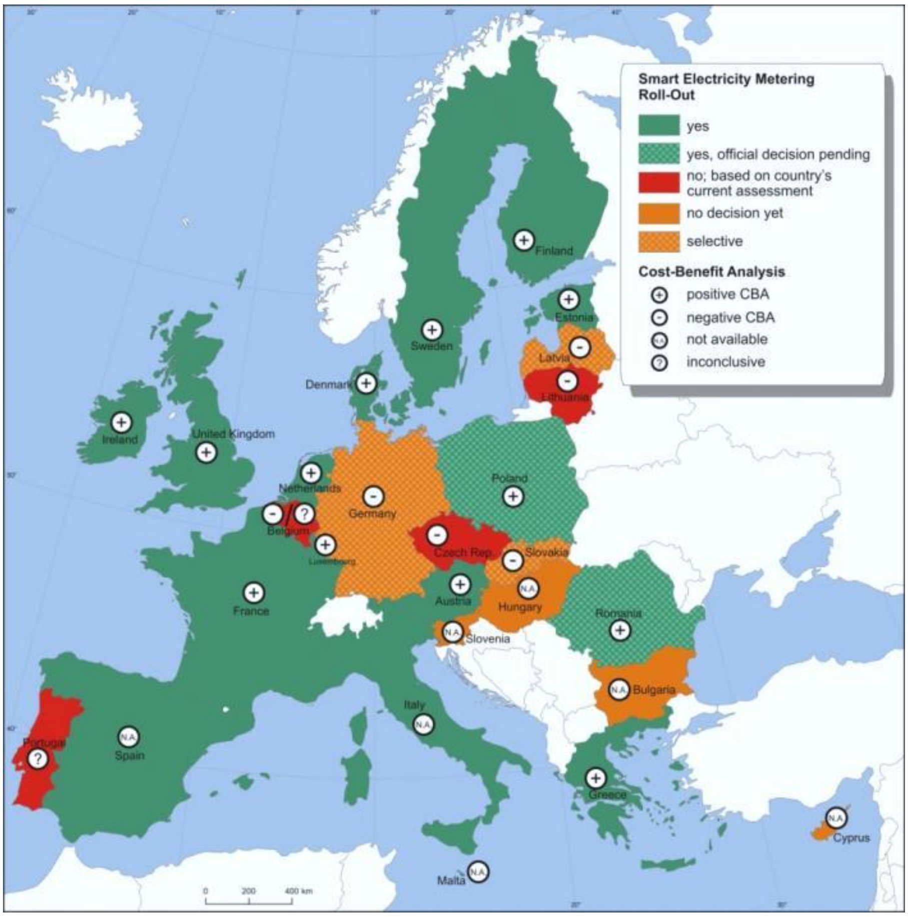


Figure 8.1 Overview of CBA outcomes for nation wide roll-out of electricity smart meters in Member States by 2020, based on data available in July 2013

The analysis indicates allocation of significant investments to be mobilised in EU on smart metering deployment. Following positive CBAs for electricity in over two thirds of the cases, Member States are now committed to proceed with (or have already completed) the roll-out of smart metering. A conservative estimate is that the commitments of EU Member States for wide scale smart metering roll-out represent an accumulated investment of €35 billion by 2020 for installation of nearly 200 million of electricity smart meters (ca. 72% of European consumers, considering the EU-27). The study also

[59] Hungary notified the Commission services of its cost-benefit-analysis after the cut-off date for data analysis - July 2013.

demonstrates that where roll-out of smart metering is positively assessed, the expected penetration rate for electricity in these Member States may exceed the Third Energy Package target of 80 % by 2020.

8.2 OVERVIEW OF COST–BENEFIT ANALYSIS IN EU-27

According to the benchmarking analysis of the long term economic assessment of costs and benefits due to nation-wide roll-out of smart electricity systems in EU, the results of the CBAs regarding key roll-out parameters diverge appreciably across Member States. This can be explained by different local realities and starting conditions reflected in the CBAs, and the inclusion of additional features in the smart metering systems considered (adds-on, functionalities beyond the minimum recommended, etc.), but also methodological differences (discount rate applied, appraisal period, etc.).

Based on the analysed data, most of the EU Member States addressed the energy savings, in terms of electricity consumption, as one of the main benefit associated with smart metering deployment. As a conservative estimate, an average value of 2.6 % (±1.4%) has been reported considering all EU Member States roll-out plans and 3 % (±1.3 %), considering only the countries that have already proceed or are proceeding with a wide scale roll-out of smart metering systems. Peak load shifting of electricity consumption is observed as another important benefit subject to considerable variation among Member States from less than 1 % to 9.9 %. The reason for such variation can be mainly associated with different consumer engagement strategies (different ways of consumption feedback provision, energy efficiency programs, pricing mechanisms, expected consumer participation rate, etc.) envisaged in the EU Member States and different electricity consumption patterns (presence of district heating, wide-spread use of gas, etc.)

Second most spread benefit observed among EU Member States roll-out plans can be attributed to the savings on meter reading costs and electricity network losses reduction (technical and non-technical). Both have served as main drivers in various large scale smart metering pilot projects, such as Telegestore[60] in Italy and InovGrid[61] in Portugal.

As regards the cost, the capital and operational cost of the smart meter proves to be the major cost in most of the EU countries, followed by the capital and operational cost due to data communication. Given the different choices in terms of communication infrastructure, smart meters functionalities and local conditions (geographical location, economic context, etc.) and methodological differences in conducting the CBA (e.g. different appraisal period, discount rate, etc.), the cost per metering point proves to vary

[60] www.enel.com/en-GB/innovation/smart_grids/smart_metering/telegestore
[61] www.inovcity.pt/en/Pages/inovgrid.aspx

greatly across EU countries. While this divergence in key roll-out parameters calls for caution when interpreting the results, available data indicate that a smart electricity metering system could cost on average €252 per customer with a wide standard deviation of €189. Accounting only for those countries that have completed or will be proceeding with the roll-out, the average price is further reduced to €223 and the respective spread is narrowed (±€143). Smart metering systems are expected to deliver an overall benefit per customer of €309 (±€170) for those Member States that have completed or will be proceeding with the roll-out by 2020 along with average energy savings of 3 % (±1.3 %).

Electricity meter ownership and data handling

In 15 out of the 16 Member States that have decided to proceed with a large-scale roll-out, the distribution system operators (DSOs) are responsible for implementation and own the meters, so the operation is to be financed to a certain extent through network tariffs; In four Member States (Denmark, Estonia, Poland and the UK) data will be handled by an independent central data hub.

A similar picture applies in the Member States not proceeding with large-scale roll-outs by 2020 where – with the exception of the Czech Republic, Germany and Slovakia, where alternative options for data handling are being considered – the DSOs may also be responsible for implementation, ownership and data handling.

Smart metering functionalities at the core of consumer-centric electricity systems

In only eight of the Member States, proceeding with large-scale roll-out of smart metering for electricity by 2020, functionalities are reported to be fully compliant with the ten minimum functionalities, as recommended by the Commission (Recommendation 2012/EU/148 [27]. The most challenging functionality to deliver relates to the frequency at which consumption data can be updated and made available to consumers and third parties on their behalf. This functionality will support advanced pricing systems, enable consumers to make informed choices on their consumption patterns and facilitate the development of new retail services and products. At present, only few Member States have laid down guidelines on the functional requirements of smart metering systems. The others leave analysis of the available options to the parties responsible for the roll-out — in the majority of cases, the distribution system operators — without setting clear incentives or requirements for functionality features that also benefit consumers.

Communication infrastructure

Effective deployment of smart electricity systems involves pervasive amount of Information and Communication Technologies able to provide real-time generation, control and analysis of extensive amount of data, while at the same time deliver reliable and secure electric power and provide cost-effective services to the final users.

The communication architecture adopted or intended to be adopted in most of the EU Member States involves Data Concentrator, located at Medium Voltage/Low Voltage Substations as a communication gateway between the Data Management System (DMS) and the electricity smart meters. As for the communication technology, Power Line Carrier (PLC) along with General Packet Radio Service (GPRS) appear to be the most spread technology for communication between the Data Concentrator and the smart meter, while in most of the cases the Data Concentrator connects with the DMS through GPRS.

Wireless technologies (mobile telephony, radio frequency) as well as fibre optics are also considered as possible technologies to be deployed for wide scale smart metering roll-out.

The presence of such different options, both in terms of communication architecture and technology, additionally contributes towards the wide variation of cost per smart meter across countries and regions.

8.3 SMART METERING AND CONSUMERS

According to the smart metering roll-out plans of the EU Member States, there is a clear evidence to benefit the electricity consumer by means of effective smart metering deployment and successful strategies for consumer's engagement. In particular, there are six ways the adoption of smart metering systems can benefit the electricity customer, as depicted in Figure 8.2 and described below.

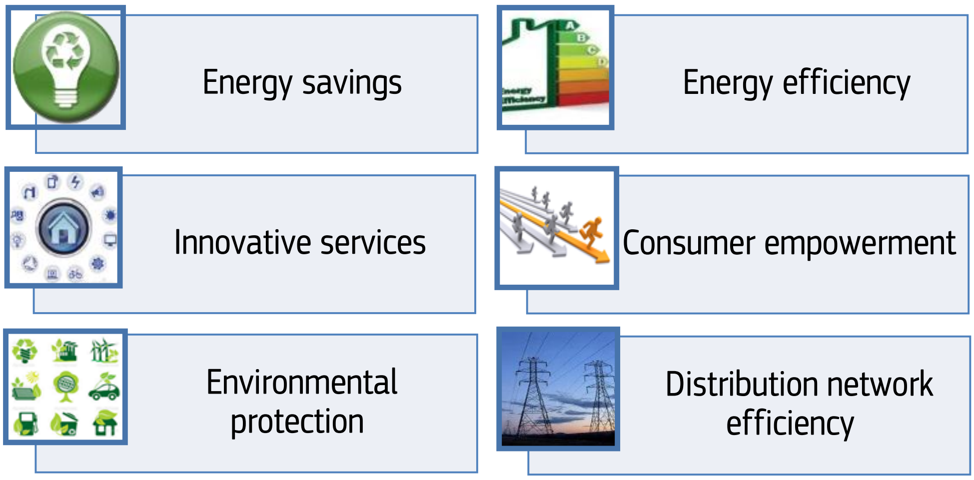


Figure 8.2 — Overview of possible ways the smart metering system can benefit the consumer

a) Energy savings: smart metering systems can help consumers reduce their consumption and save energy

In most of the EU Member States, the energy saving potential has been one of the strongest drivers towards adoption of smart metering systems. Deployment of intelligent metering infrastructure does not automatically lead to energy savings; nevertheless, effective use of its potential could bring substantial benefits along the whole chain of actors involved, and in first place the electricity consumer. Therefore, the electricity consumer has a central position in achieving energy savings and, in this context, several Member States, such as Netherlands, UK and Ireland have dedicated particular focus in their CBA analysis on the consumer behaviour in the process of smart metering acceptance and its effective use. Inducing pro-environmental behaviour change is closely related to the consumer engagement strategies developed and the way the consumer is approached. This includes understanding and motivating the consumers with provision of clear and easily accessible information about their electricity consumption (e.g. indirect/direct feedbacks, personalized advise/peer group comparison, etc.). The way the data are presented to the consumers may have significant impact on the energy savings potential. In this context, the national smart metering roll-out of Netherlands assumes 3.2 % of energy savings with indirect and 6.4 % with direct feedback (using an In-House Display).

The UK Energy Demand Research Project (EDRP)[62] analysed several intervention using smart metering systems, namely: use of Real-Time Display (RTD) for electricity consumption, energy efficiency advice along with historic/comparative feedback, financial incentives to reduce consumption, etc. The project reports average 3 % of energy savings across trial groups using RTD and 5 % of energy savings for provision of energy efficiency advice along with historic feedback.

b) Energy Efficiency: smart metering systems help consumers master their consumption and therefore increase their energy efficiency

Inducing energy efficient behaviour is another relevant aspect of electricity consumer engagement. The same is related to the way the electricity is used (usage behaviour) and the purchase of more energy efficient appliances (purchase behaviour). In both cases, smart metering deployment may lead to energy aware consumer in the purchase of more energy efficient appliances and more efficient use of the electric energy.

In this respect, the "Smart Metering Customer Behaviour Trials" in Ireland demonstrated that smart meters helped 82 % of participants to make some change in the way they use electricity.

Energy efficiency can also result due to more efficient use of the electricity network, leading to reduced technical network losses. On the same note, demand response and peak load shifting using distribution network tariffs that reflect real network conditions will account for electricity cost reduction for the consumer.

[62] https://www.ofgem.gov.uk/gas/retail-market/metering/transition-smart-meters/energy-demand-research-project

The E-Energy projects (MeRegio, eTelligence, E-Dema, Model town Mannheim, RegModHarz and Smart Watts)[63] in Germany are focused on the development of an energy marketplace to be introduced in each model region. In this context, various energy rates have been tested, ranging from time-variable rates to dynamic rates and event rates (extremely high or low prices per kWh are charged in response to external events). The projects have shown that tariffs more reflective of grid and market conditions can bring a noticeable level of flexibility on the demand and on the supply side, thus increasing the efficiency of both energy use and network operation.

The EDRP indicates small impact of Time of Use tariffs in UK – 3 % or less of peak load shifting. The study points out that the evidence is almost exclusively from studies in hot regions (where the dominant energy demand is for air conditioning) and cold regions with electric heating.

The Nobel (Neighbourhood Oriented Brokerage Electricity and monitoring system) project[64] intends to build an energy brokerage system through which individual energy consumers can communicate their energy needs directly with both large-scale and small-scale energy producers, thereby making energy use more efficient.

c) Innovative services for consumers: smart metering systems open the door to smart home solutions and innovative home automation services

Information retrieved from Smart meters can help suppliers, ESCOs or other market players create innovative services, like home energy management and demand response, which can be tailored to consumers' needs and offer more profound energy savings and higher efficiency to consumers.

This will grant the consumers with a possibility to choose among a wider range of providers (energy retailers, aggregators etc.) and different pricing mechanisms (Time of Use, Critical Peak Pricing, dynamic (real-time) pricing, etc.)

Additionally, enabling innovative services, such as home energy management and demand response, may induce energy efficient and pro-environmental behaviour (e.g. use of smart appliances), and micro-generation and electric vehicles can become an economically attractive proposition for consumers, and contribute to lower energy bills and increased comfort.

Member States, such as UK, Ireland, and Netherlands, considered the added value of innovative services to the consumers in their economic evaluation of long-term costs and benefits. UK CBA expects the existing home energy management sector to experience strong growth as a result of the roll-out of

[63] http://www.e-energy.de/en
[64] http://www.ict-nobel.eu

smart meters. The availability of detailed consumption data will create significant new opportunities to companies in offering services and products on appliance diagnostics, more refined automation of heating and hot water controls and the analysis of heating patterns.

The study has also suggested the contribution of smart metering systems on the UK's aging society (e.g. patients requiring care might be enabled to remain in the familiar surroundings of their own home by using tele-care systems and granting family members or carers access to their energy consumption information in real time).

d) Consumer empowerment: smart metering systems can improve competition in retail markets

The introduction of smart metering systems will have considerable impact on the energy supply retail market competition. Increased consumer awareness on the time and amount of electricity consumption on one hand side and provision of accurate and reliable data flows on the other would enable easier and quicker switch between suppliers for both, the consumers and the suppliers. This enables the consumers to choose from different offers that better adapt to their consumption patterns and therefore drive prices down.

Already the market in UK has seen an influx of small suppliers that differentiate themselves through the provision of a smart meter to their customers. In addition, the improved availability of information should create opportunities for energy service companies to enter the domestic and smaller business markets; and for other services to be developed, for example new tariff packages.

While greater level of competition may result in lower electricity prices, quantification of this benefit at the current stage of smart metering roll-out across Member States is difficult to quantify, and therefore it has been identified as a qualitative benefit in Member States, such as UK and Netherlands.

Some examples below give an indication of the value of this benefit for the consumers:

- ✓ Price reduction benefit due to an easier change of supplier process covers 37,6 % of investment & implementation cost according to the Dutch CBA [28];
- ✓ Smart metering roll-out in the Netherlands is expected to result in increased number of consumers switching suppliers from 9 % per year (in year 2010) to 15 % per year (in 2050). According to the Dutch CBA, this is the third largest benefit expected to take place due to smart metering deployment [28];
- ✓ According to the Austrian CBA, around 20 % of total benefit due to smart metering deployment is attributed to the more efficient supplier procedure;
- ✓ As stated in the Danish CBA, increased competition due to smart metering deployment accounts for around 21 % of the total benefits.

e) Environment protection: less energy consumption and higher energy efficiency help protecting environment

Effective deployment and use of the smart metering systems will add additional value to the consumers and society in general, leading to reduced amount of CO2 emissions. This can be achieved as a result of:

- ✓ Energy savings and more efficient use of electric energy;
- ✓ Higher electricity network operational efficiency.

Smart metering systems also help foster the diffusion of micro-generation at consumers' premises (e.g. photovoltaic) and Electric Vehicles (EVs) and make the consumers aware of the CO2 associated to the electricity they consume. Ultimately, this may result in empowering the customer in choosing different power sources that better serves its intentions.

f) Distribution system efficiency: management of the distribution systems becomes cheaper and more effective, leading to lower distribution costs

Growing capacity of renewable power sources (wind/solar) and EVs may pose significant challenge on the distribution network operation. The same will utterly require advanced monitoring and control infrastructure. In this context, deployment of smart metering systems will allow for more efficient network operation (reduced technical and non-technical losses) and enhanced network observability that will ultimately result in better planning of the distribution network and reduction of the network operational cost. In presence of regulatory incentive mechanisms on the network operational efficiency, reliability and quality of power supply, etc., the DSOs can greatly increase their revenues, while providing better service to the final customer at lower distribution network costs.

In the economic analysis of the long-term benefits associated with smart metering roll-outs in EU, enhancement of the distribution system efficiency appeared in all Member States roll-outs as one of the most evident benefit resulting from better network control and monitoring capabilities due to the smart metering infrastructure.

In this context, the DISCERN project[65] is one of the larger scale EU demonstration project, including pilots with a main focus on distribution system efficiency improvement. The project has started in 2013 and is expected to utilise the experience of major European DSOs with innovative technological solutions for a more efficient monitoring and control of the distribution networks.

[65] http://www.discern.eu

9. INSIGHT INTO SMART CUSTOMER PROJECTS

With smart grids, the traditional passive distribution and one way communication and flow between suppliers and consumers is going to be replaced by active distribution that will transform the passive end users into an active player. In this new perspective, it is important to understand and involve consumers in order for them to fully understand the smart grid potential and consciously assume their role as active participants in the future electricity system. In the light of the above and of the growing interest of researchers and policy makers on the role that consumers will play, this section will specifically focus on smart grid projects that the smart customer as one of the main project application. First, some data on the number of smart customer projects will be provided to offer an overview of the number, seize, involved organization and geographical distribution. Then, some of the multinational projects started in 2013 will be briefly presented.

9.1 INCREASING NUMBER OF SMART GRID PROJECTS WITH FOCUS ON THE SMART CUSTOMER

Out of the Total 459 Smart grid projects (R&D and Demonstration and Deployment), we have identified more than 145 projects having the smart customer as one of the main project application. The number of projects focusing on the smart customer has been increasing since 2005 as shown in Figure 9.1. In particular, many projects started in 2011 and 2012. Data for 2013 include only projects up to July 2013; therefore the number is not complete.

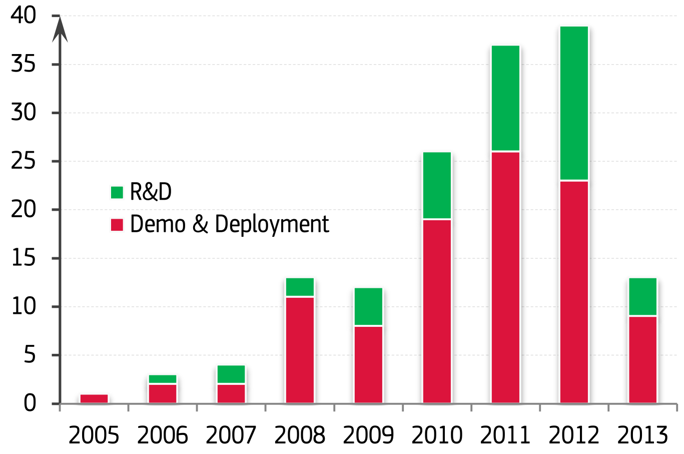


Figure 9.1 Number of projects with focus on the smart customer

Most of the collected projects indicate a focus on the residential sector. The predominance of the residential sector can be explained by the need for energy providers to target household consumers. Indeed, residential consumers represent a huge potential for energy savings that energy providers can tap into.

Figure 9.2 illustrates the starting and active smart customer projects, by year. To calculate the activity each project was counted-in for each year in its lifetime. The decrease in starting and active project for 2013 and 2014 may be caused by the incompleteness of the data collected for these two years.

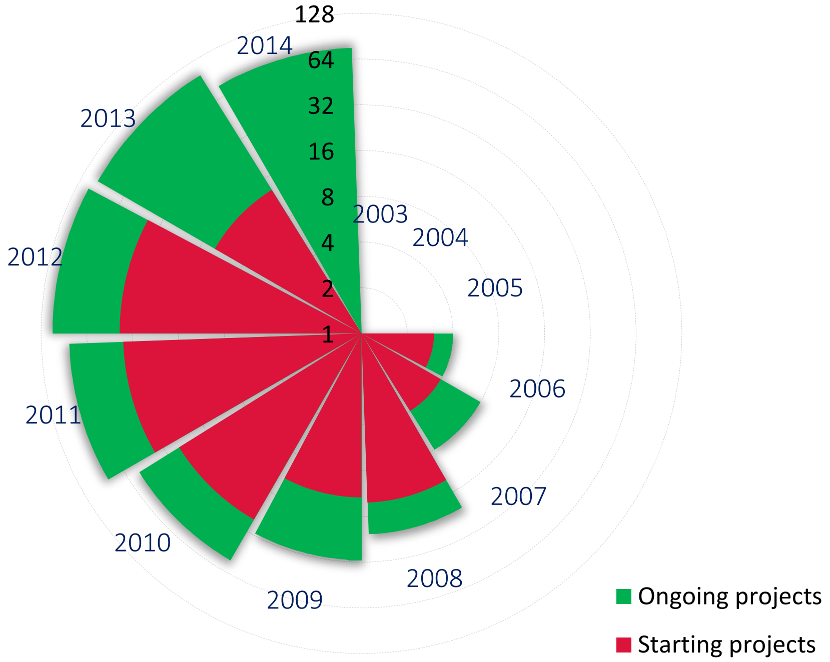


Figure 9.2 Starting and ongoing smart customer projects

9.2 INVOLVED ORGANIZATIONS AND STAGE OF INNOVATION

DSOs, as Figure 9.3 and Figure 9.4 show, are acting as one of the key enablers for consumer's integration in the distribution network. Most of the smart customer & smart home projects in the survey are financed by DSO (29%). These figures also indicate a strong interest in smart customer & smart home projects from research organization. Indeed, the way the smart consumer will act in the future electricity grid is still surrounded by uncertainty and researcher are developing tool and approaches to better understand the role of the future electricity prosumer.

The smart customer projects are still mainly at Demonstration phase as shown in Figure 9.3.

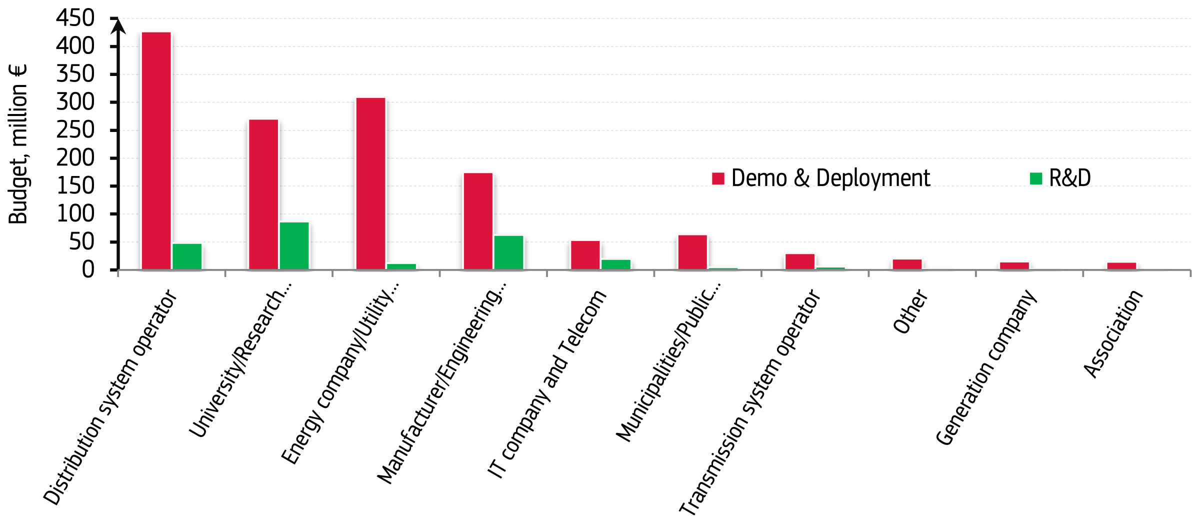


Figure 9.3 Distribution of budget by organisation type and stage of development

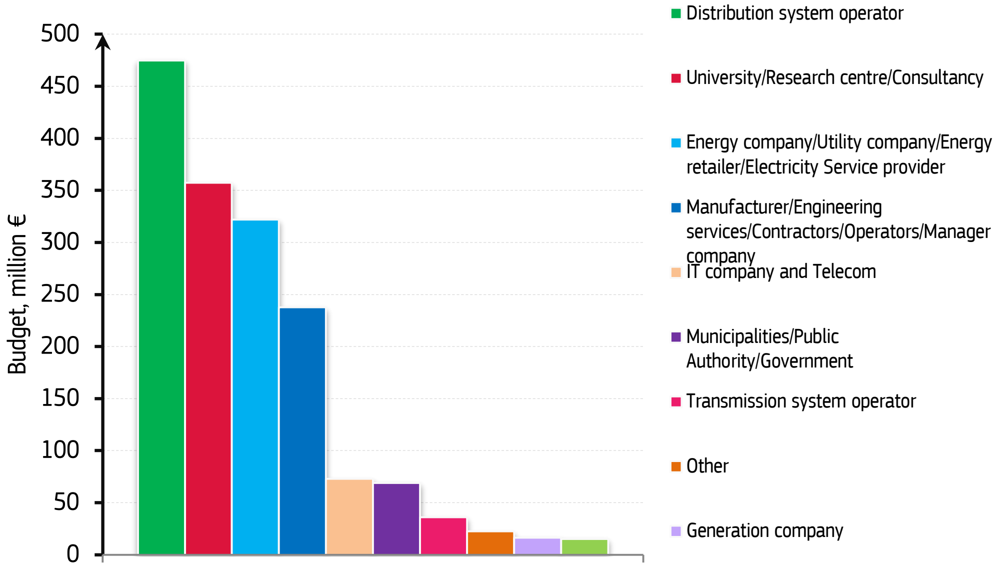


Figure 9.4 Distribution of budget by organisation type

9.3 GEOGRAPHICAL DISTRIBUTION IN EUROPE

The geographical distribution of smart grid projects with focus on the smart customer in Europe is represented in Figure 9.5.

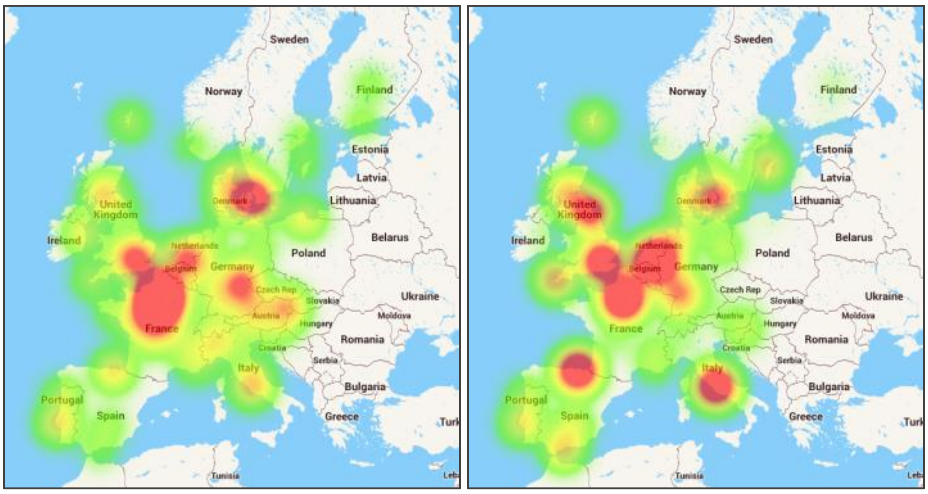


Figure 9.5 Geographical distribution of national smart grid projects with focus on the smart customer; left: number; right: weighted with the total budget

Figure 9.5 shows (left) the distribution of the number of smart grid projects with focus on smart customer & smart home in Europe. Projects are not uniformly distributed across Europe. The majority of the projects are located in EU15 Member States. In the EU 15, most of the projects are concentrated in a few countries; Denmark, France, UK and the Netherlands. Figure 9.5 (right) shows the distribution of projects weighted with the total budget. It emerges that Spain and Italy have less smart grid projects than Denmark, France, UK and the Netherlands, but these projects have bigger budgets.

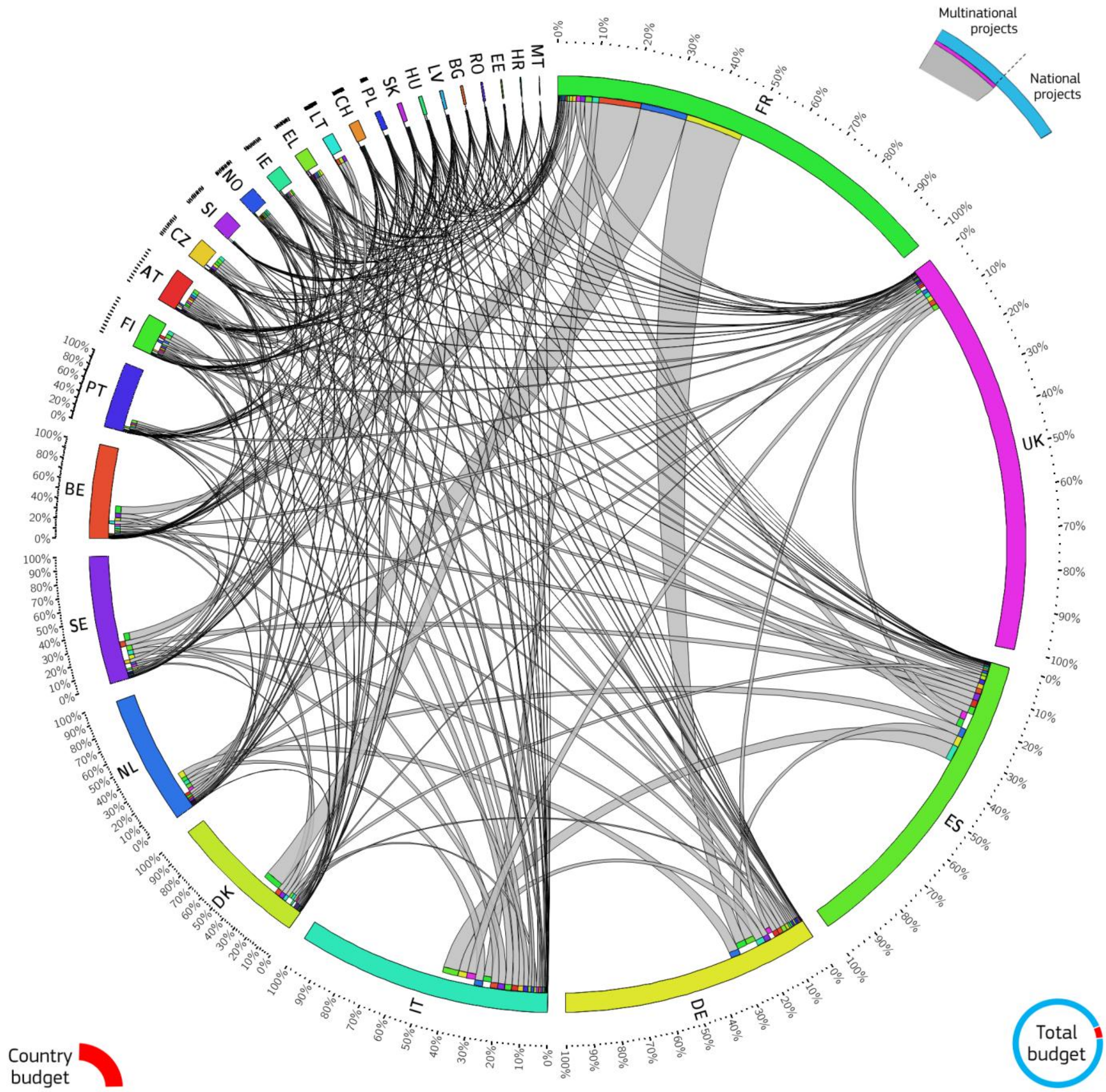


Figure 9.6 Collaboration links in European multinational projects (weighted by total project budget): focus on smart customer projects

Figure 9.6 shows the number of multinational projects with the smart customer application. The circumference of the circle is the total smart grid budget. The circumference is divided into unequal segments each corresponding to a country and its budget. The segments are connected with chords that illustrate the relationship between the countries. The thickness of the chord at its ends is proportional to budget that the country is investing compared to its partners. A thicker chord will show that the pair is cooperating strongly (funding in common the same projects). The two ends of a chord can have different widths. This shows the ratio between the investments coming from each of the two countries in their common projects. In most cases a project will not be funded with equal shares from different countries (e.g. one country has more participants in a common project). Each country segment has a portion that doesn't send/receive any chord. These portions show the budget and the internal partnerships of the projects funded only by that organizations in that specific country (in other words, the national budget). Adding per country the width of all chords we get the multinational budget (as a fraction of the country segment).

France is leading in terms of budget devolved to multinational projects with the smart customer application followed by Spain, Italy, Germany and Denmark. The number of multinational projects has been increasing since 2008 and is now 50.

9.4 SMART CUSTOMER 2013

In this paragraph we will briefly present some multinational projects with the main application on smart customer started in 2013. They present a holistic approach to smart grids where the integration of energy, information and social networks is seen as focal to the success of smart grid deployment at community level.

BESOS: Building Energy Decision Support Systems for Smart Cities – holistic approach to a community level dimension – research and demonstration project

Leader: ETRA Research and development, Spain

Number of partners: 11

Start year: 2013

End year: 2016

Type: Multinational

Countries involved: Germany, Greece, Portugal and Spain

Source: *www.besos-project.eu*

The objective of BESOS is the development of a management system which enables energy efficiency in smart cities from a holistic perspective. To that end, BESOS proposes to deploy in a typical district that is consuming and producing energy, energy management systems able to share data and services through an open platform among themselves and to external third party application. The objective of BESOS is thus to enhance existing neighbourhoods with a decision support system to provide coordinated management of public infrastructures in Smart Cities and at the same time to provide citizens with information to promote sustainability and energy efficiency. It aims at promoting reduced energy consumption without compromising the quality of services provided to the citizens.

Lisbon and Barcelona will host pilot test of technologies developed during the project.

CoSSMic: Collaborating Smart Solar-powered Micro-grids

Leader: SINTEF, Norway

Number of partners: 11

Start year: 2013

End year: 2016

Type: Multinational

Countries involved: Germany, Italy, Norway and Netherlands

Source: *www.cossmic.eu*

The CoSSMic project aims to develop the ICT tools needed to facilitate the sharing of renewable energy within a neighbourhood. It will show the feasibility of its concept in two different European areas: Konstanz in Germany and the Province of Caserta in Italy. With smart management and control systems, different types of buildings (for instance a mix of houses, companies and schools) could be connected in such a way that this neighbourhood would use more of its renewable energy within the community. At these trial locations, which are rather different in terms of population, sun, and available equipment, CoSSMic will investigate how to motivate people to participate in acquiring (more) renewable energy and the sharing of renewable energy in the neighbourhood, and test methods for making money with these schemes.

CIVIS: Cities as drivers of social change

Leader: University of Trento, IT

Number of partners: 13

Start year: 2013

End year: 2016

Type: Multinational

Countries involved: Italy, Netherlands, Germany, Finland, Portugal, United Kingdom and Sweden

Source: *www.enel.com*

The objective of CIVIS is to develop an integrated ICT platform and a decision support system able to achieve energy savings and CO2 reduction by enabling a close interaction between prosumers and other energy stakeholders. CIVIS aims at moving to a more holistic, socio-technical approach to ICT and smart grids, whereby ICT plays a crucial role in harnessing the potential of social systems and dynamics in achieving a more efficient and environmentally compliant energy system, reshaping in novel ways how energy is generated and used. By allowing the social system to characterize itself in terms of multiple values, CIVIS aim at enabling communities, interest groups, business and non-business players to decide how to allocate energy according to shared goals, intents and beliefs. This will foster the arising of new forms of social aggregations able to enact new forms of energy eco-systems.

REFERENCES

[1]. European Commission, 2007. Strategic research agenda for Europe's electricity networks of the future. Directorate-General for Research. http://ec.europa.eu/research/energy/eu/publications/index_en.cfm#results

[2]. European Commission, 2011. Smart Grids: From Innovation to Deployment, *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0202:FIN: EN:PDF

[3]. Giordano, V., Gangale, F., Sánchez Jiménez, M., 2011 Smart Grid projects in Europe: Lessons learned and current developments, *European Commission, Joint Research Centre*. http://ses.jrc.ec.europa.eu/ sites/ses/files/ documents /smart_grid_projects_in_europe.pdf

[4]. Giordano, V., Meletiou, A., Covrig, C.F., Mengolini, A., Ardelean, M., Fulli, G., Sánchez Jiménez, M., Filiou, C., 2013 Smart Grid projects in Europe: Lessons learned and current developments. 2012 Update, *European Commission, Joint Research Centre*. http://ses.jrc.ec.europa.eu/sites/ses.jrc.ec.europa.eu/files/documents/ld-na-25815-en-n_final_online_version_april_15_smart_grid_projects_in_europe_-_lessons_learned_and_current_ developments_- 2012_update.pdf

[5]. European Electricity Grid Initiative (EEGI), 2010. Roadmap 2010-18 and Detailed Implementation Plan 2010-12. http://www.smartgrids.eu/documents/EEGI/EEGI_Implementation_plan_May%202010.pdf

[6]. US Department of Energy, List of Smart Grid Investment Grant awards by project category. http://energy.gov/oe/downloads/recovery-act-selections-smart-grid-investment-grant-awards-category, accessed August 2011

[7]. KEMA, 2012. Global Inventory and Analysis of Smart Grid Demonstration Projects, KEMA report http://www.dnvkema.com/Images/DNV%20KEMA%20Report%20Global%20Inventory%20and%20Analysis%20of%20Smart%20Grid%20Demonstration%20Projects.pdf

[8]. Eurelectric, 2011. 10 Steps to smart grids — EURELECTRIC DSOs' Ten-Year Roadmap for Smart Grid Deployment in the EU, Eurelectric report. http://www.eurelectric.org/10StepsTosmartGrids/, accessed July 2011

[9]. Eurelectric, 2011. 'Regulation for Smart Grids'. Eurelectric report. http://congreso-smartgrids.es/wp-content/uploads/2012/03/Eurelectric-Report-on-Regutaion-for-Smart-Grids.pdf

[10]. Farhangi H, 2010. The Path of the Smart Grid, IEEE Power & Energy Magazine, Vol. 8, Issue 1, 18-28

[11]. Faruqui A., Harris D., Hledik R., 2010. Unlocking the 53 billion savings from smart meters in the EU: how increasing the adoption of dynamic tariffs could make or break the EU's smart grid investment, Energy Policy, Vol. 38, Issue 10, 6222-6231

[12]. World Economic Forum (WEF), 2009. Accelerating Smart Grid investments, WEF Report. http://www.weforum.org/reports/accelerating-smart-grid-investments

[13]. World Economic Forum (WEF), 2010. Accelerating Successful Smart Grid Pilots, WEF Report. http://www3.weforum.org/docs/WEF_EN_SmartGridsPilots_ Report_2010.pdf

[14]. Fox-Penner P., 2010. Smart Power. Climate Change, the Smart Grid and the Future of Electric Utilities, Island Press, Washington DC

[15]. Battaglini A., Lilliestam J., Haas A., Patt A., 2010. Development of SuperSmart Grids for a more efficient utilisation of electricity from renewable sources, Journal of Cleaner Production, Vol. 17, Issue 10, 911-918

[16]. Wissner M., 2011. The Smart Grid - A saucerful of secrets?, Applied Energy, Vol. 88, Issue 7, 2509-2518

[17]. Wolfe P., 2008. The implications of an increasingly decentralised energy system, Energy Policy, Vol. 36, Issue 12, 4509-4513

[18]. Verbong, G. and Geels, F., 2010. Exploring sustainability transitions in the electricity sector with socio-technical pathways, Technological Forecasting and Social Change, Vol. 77, 1214-1221

[19]. Foxon, T., Hammond, G., Pearson, P., 2010. Developing transition pathways for a low carbon electricity system in the UK, Technological Forecasting and Social Change, Vol. 77, 1203-1213

[20]. Diaz-Rainey, I., Ashton, J., 2008. Stuck between a ROC and a hard place? Barriers to the take-up of green energy in the UK, Energy Policy, Vol. 36, Issue 8, 3053-3061

[21]. Valocchi M., A. Schurr, J. Juliano, 2009. Lighting the way - Understanding the smart Energy consumer, IBM Institute for Business Value Executive Report. http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03187usen/GBE03187USEN.PDF

[22]. Valocchi M., A. Schurr, J. Juliano, E. Nelson, 2007. Plugging in the consumer - Innovating utility business models for the future, IBM Institute for Business Value Executive Report. http://www-05.ibm.com/de/energy/pdf/plugging-in-the-consumer.pdf

[23]. Brennan T. J., 2007. Consumer preference not to choose: methodological and policy implications, Energy Policy, Volume 35, Issue 3, 1616-1627

[24]. Jackson, T., 2005. Motivating sustainable consumption: A review of evidence on consumer behaviour and behavioural change, Report to the Sustainable Development Research Network, Policy Studies Institute. http://www.sd-research.org.uk/wp-content/uploads/motivatingscfinal_000.pdf

[25]. OECD (Organization for Economic Cooperation and Development), 2002. Frascati Manual 2002: Proposed standard practice for surveys on research and experimental development, OECD, Paris

[26]. Brown J., Hendry C., 2009. Public demonstration projects and field trials: Accelerating commercialisation of sustainable technology in solar photovoltaics, Energy Policy, Vol. 37, 2560-2573

[27]. Commission Recommandation 2012/148/EU, OJ L 73 p.9, http://eur- ex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32012H0148:EN:NOT

[28]. Smart meters in the Netherlands – Revised financial analysis and policy advice, KEMA July 2010.

[29]. Ilhami Colak, Ramazan Bayindir, Gianluca Fulli, Ibrahim Tekin, Kenan Demirtas, Catalin-Felix Covrig; Smart grid opportunities and applications in Turkey, Renewable and Sustainable Energy Reviews 33(2014)344–352

ANNEX I. OTHER FIGURES

SMART GRID PROJECTS IN EUROPE: OVERVIEW

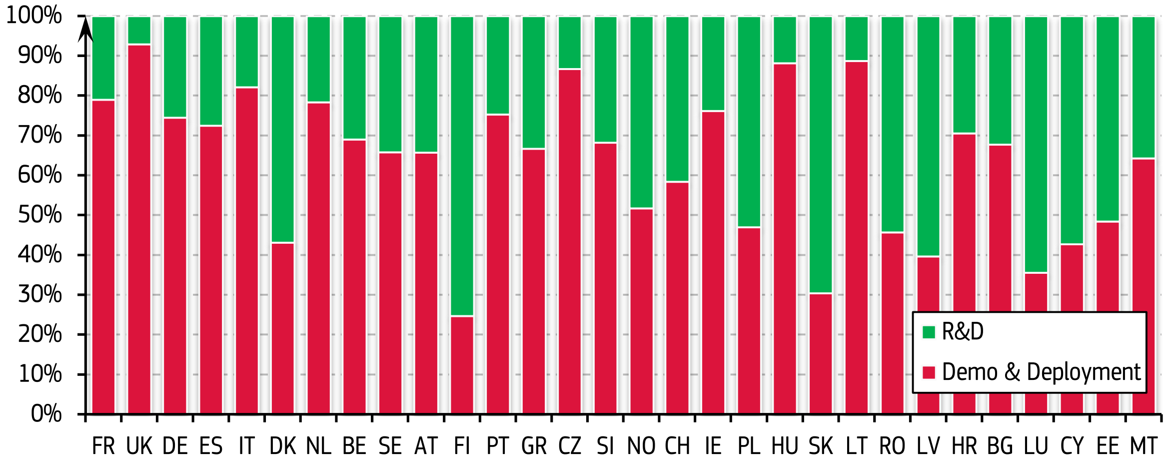


Figure A.1 Percentage distribution of total budget
per stage of development and country

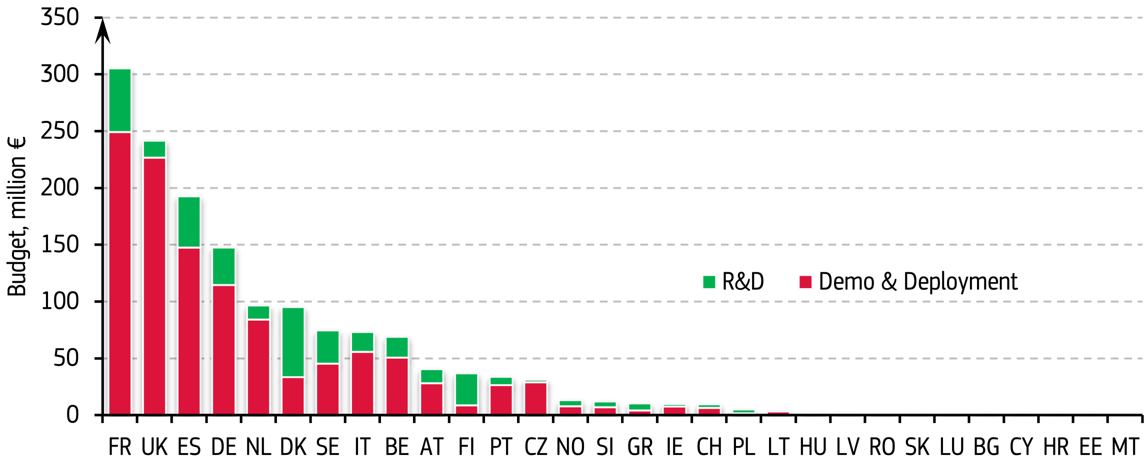


Figure A.2 Distribution of private budget
per stage of development and country

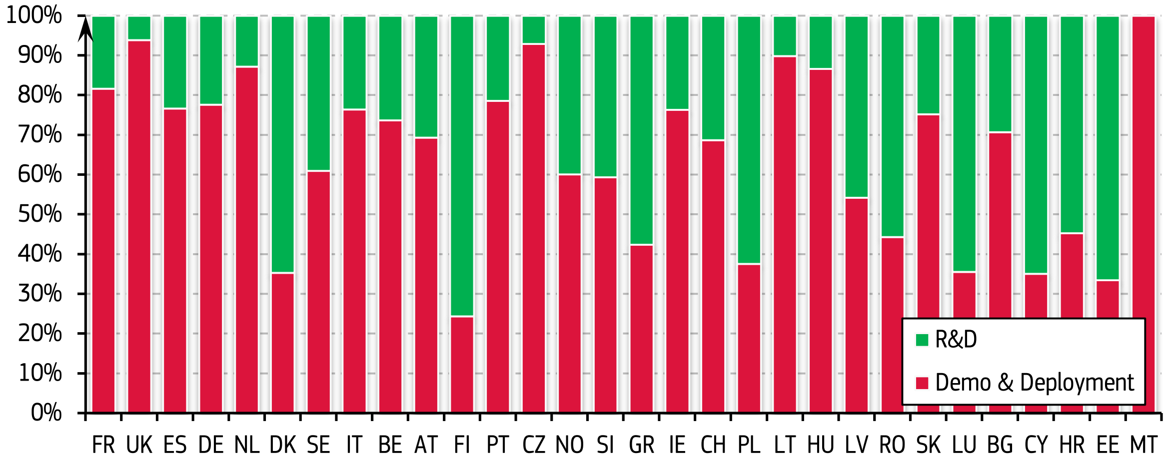


Figure A.3 Percentage distribution of private budget
per stage of development and country

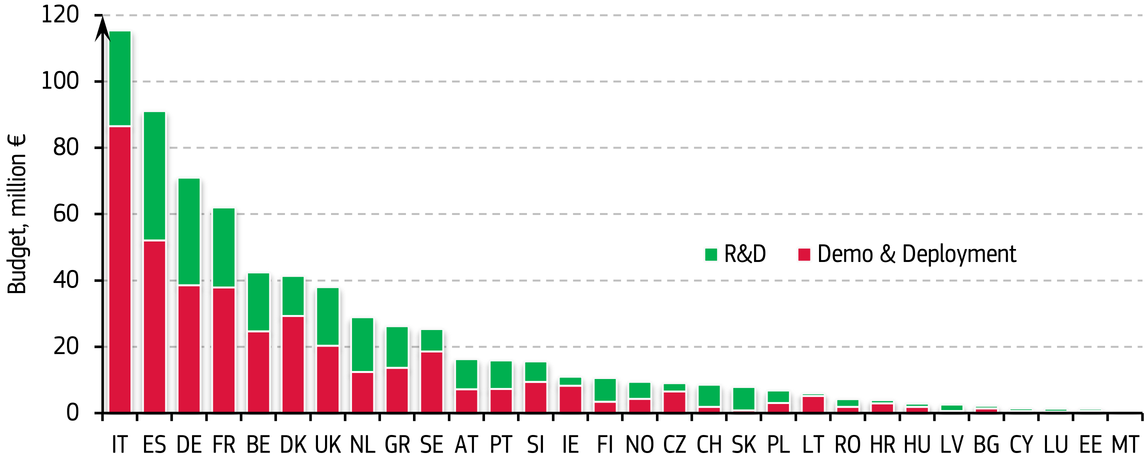


Figure A.4 Distribution of EC budget
per stage of development and country

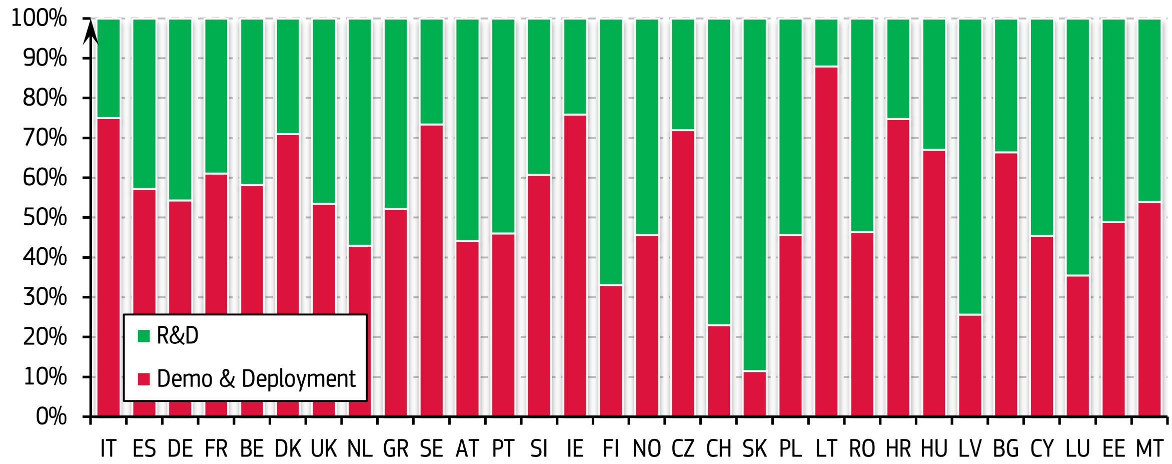


Figure A.5 Percentage distribution of EC budget
per stage of development and country

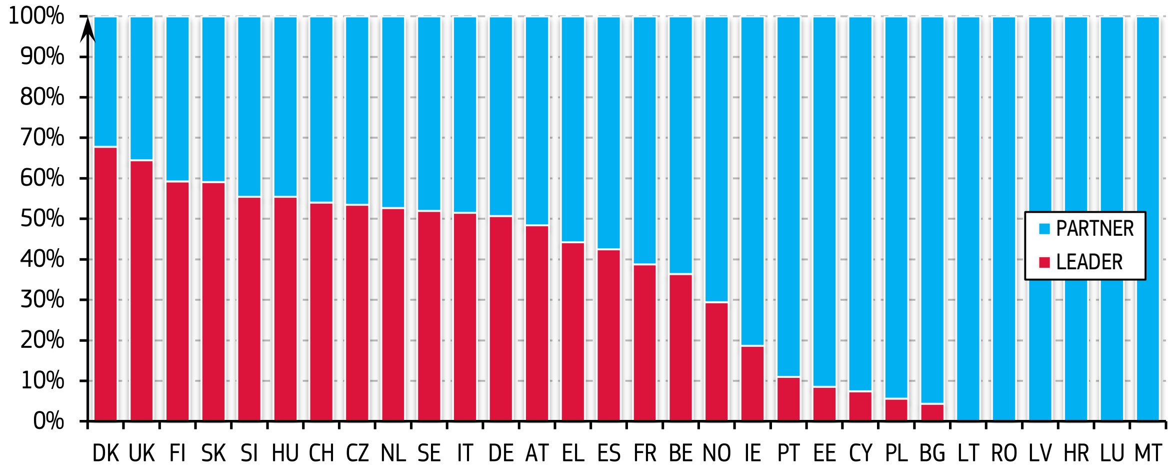


Figure A.6 Percentage distribution of total budget
per country between leaders and participants

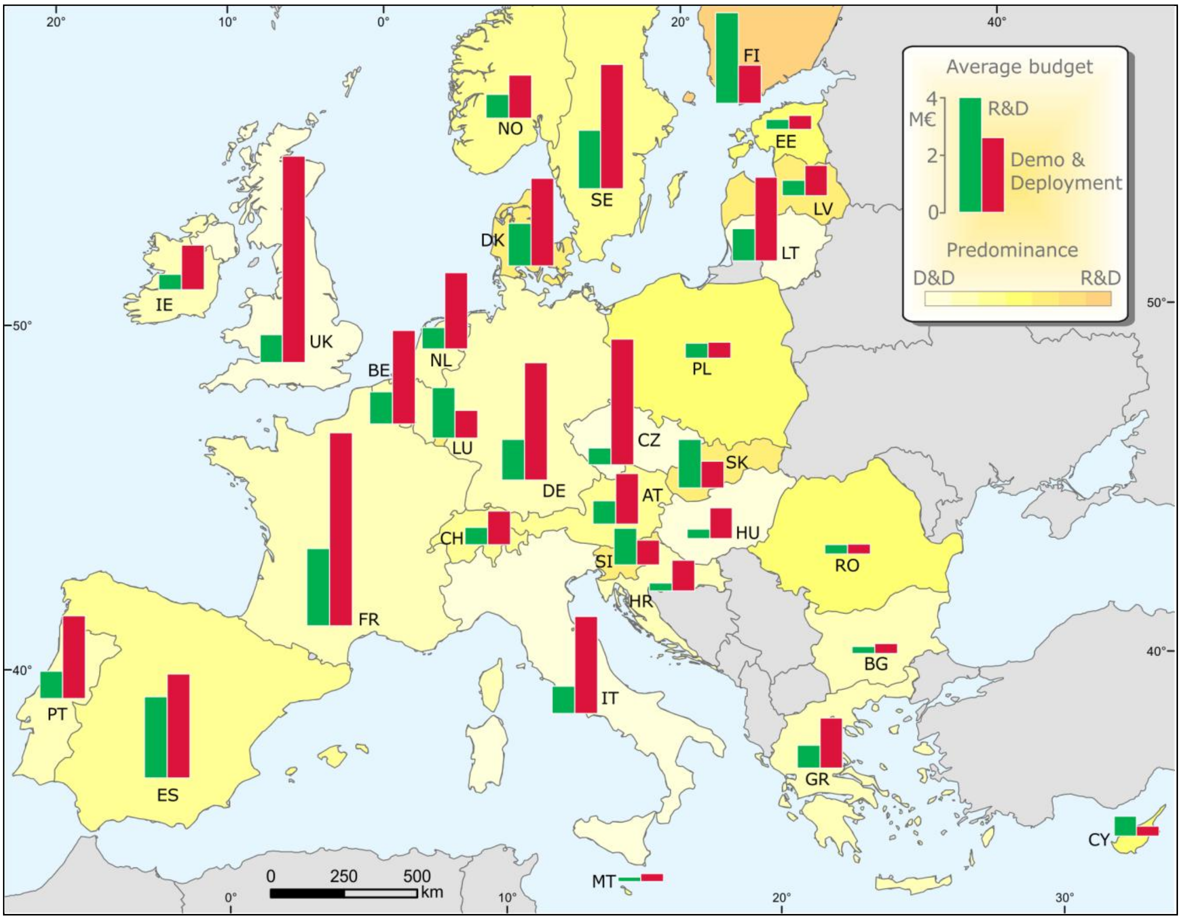
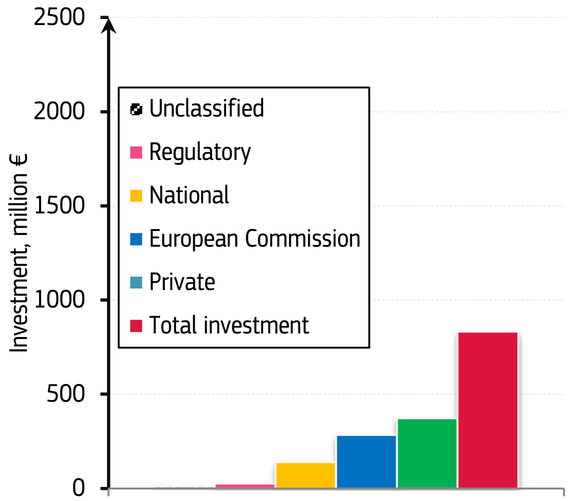


Figure A.7 Average budget per project, stage of development and country

SOURCES OF FUNDING



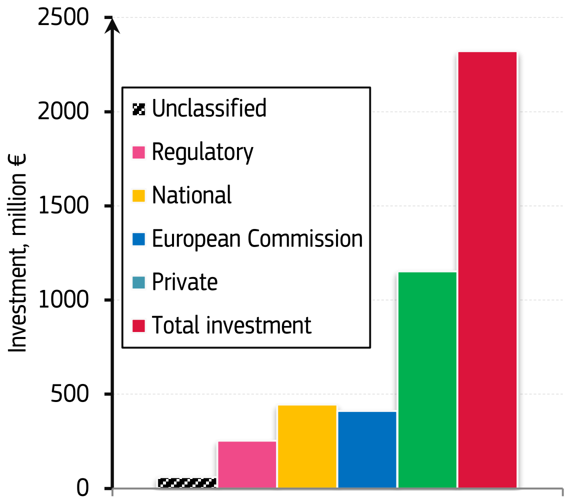


Figure A.8 Distribution of investment by source:
left: R&D; right: Demo & Deployment

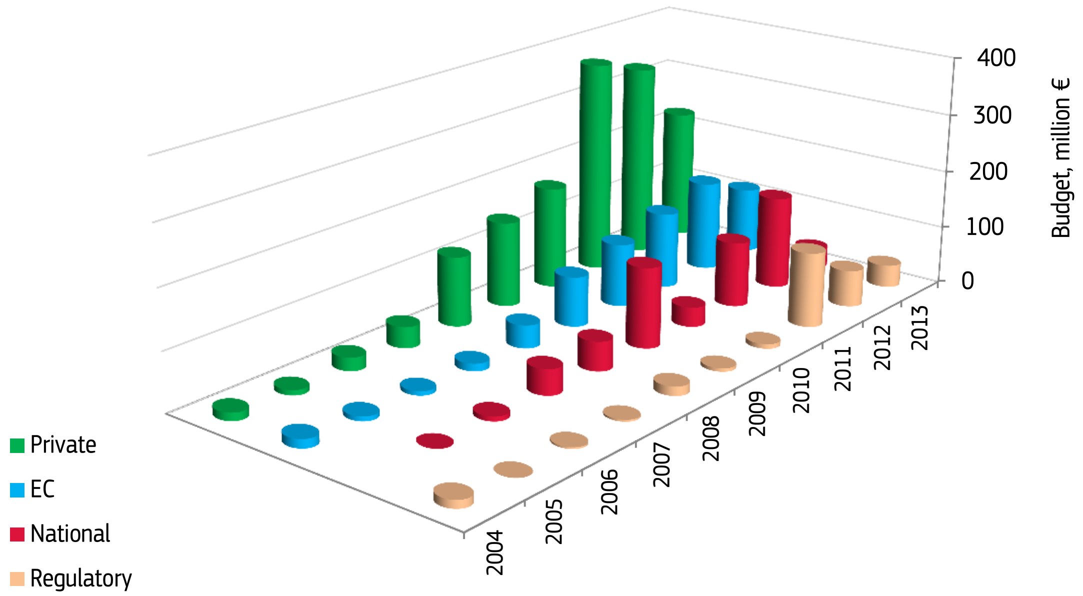
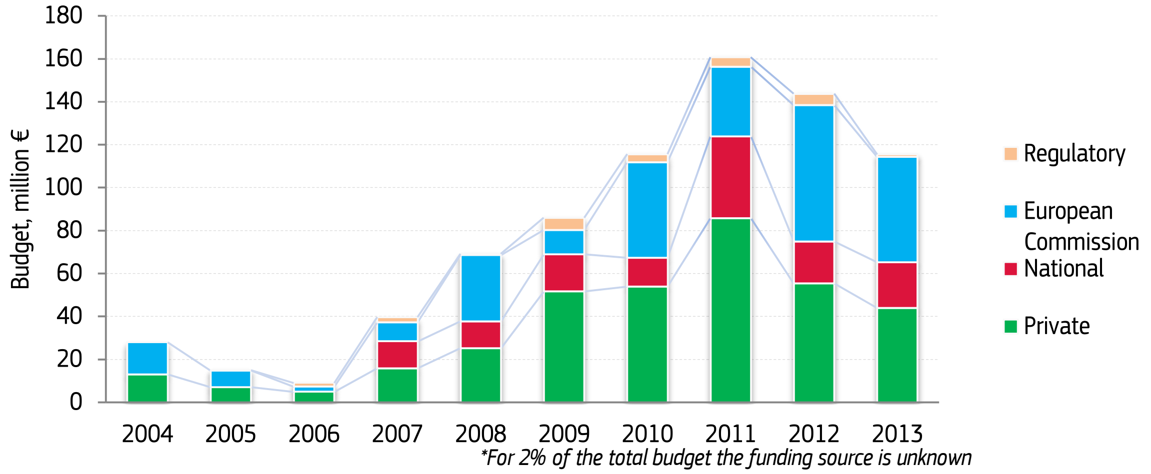
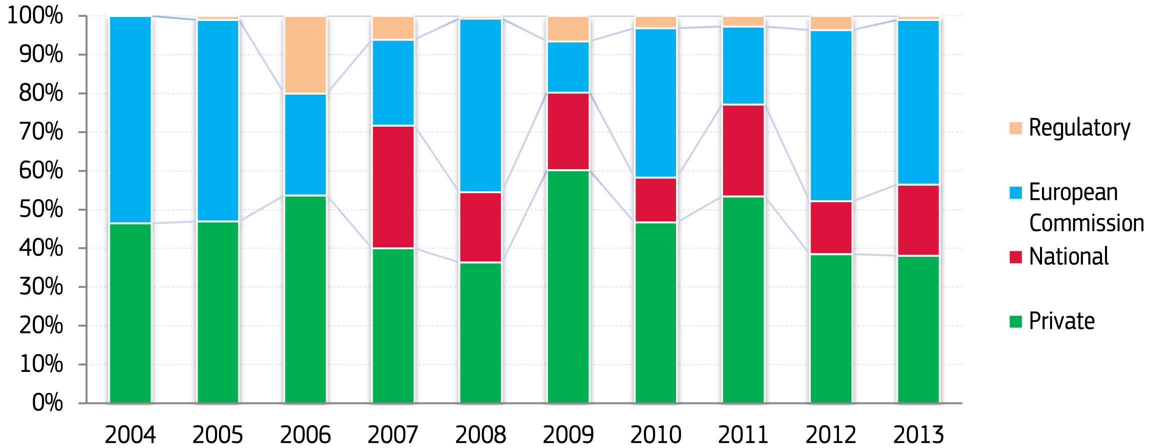


Figure A.9 Budget of projects per year and funding source



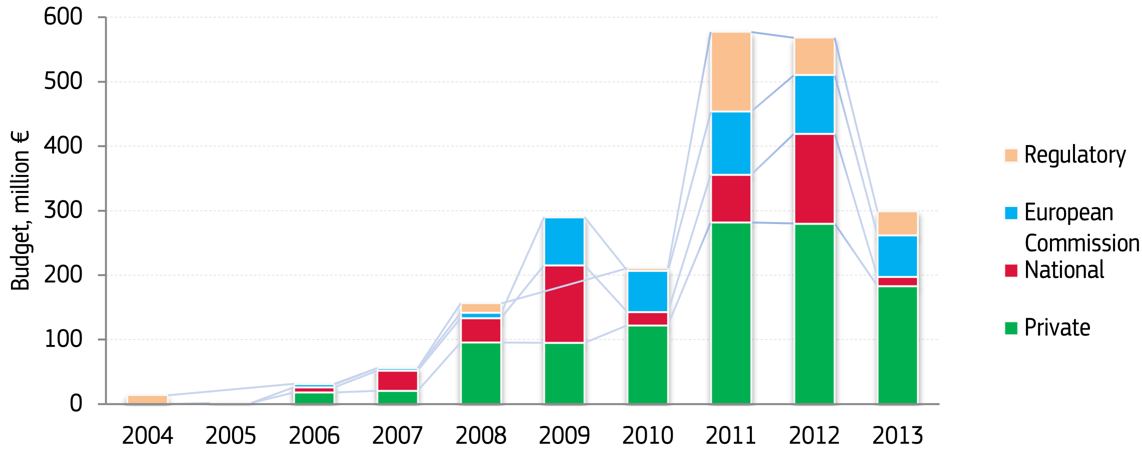
*For 2% of the total budget the funding source is unknown

Figure A.10 Distribution of R&D investment by source and year (each project may have more than one source)



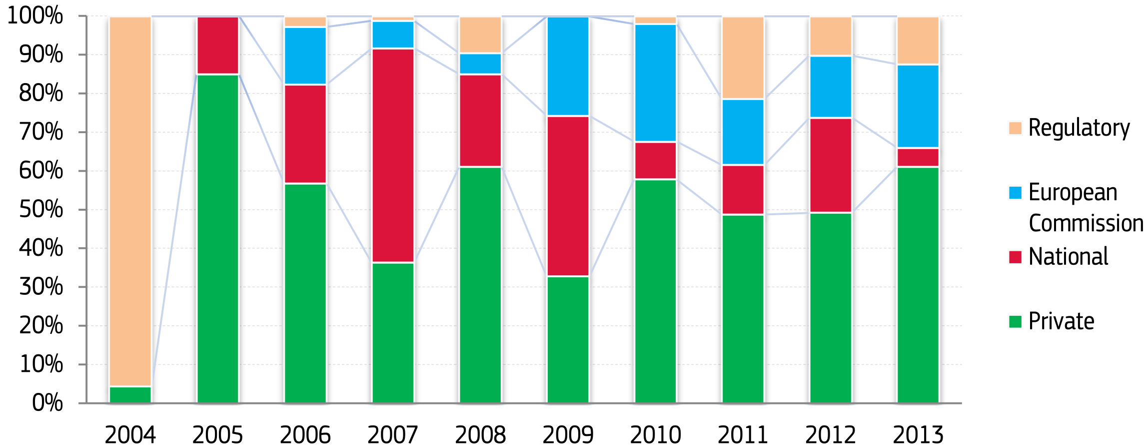
*For 2% of the total budget the funding source is unknown

Figure A.11 Percentage distribution of R&D investment by source and year (each project may have more than one source)



*For 2% of the total budget the funding source is unknown

Figure A.12 Distribution of Demo & Deployment investment by source and year (each project may have more than one source)



*For 2% of the total budget the funding source is unknown

Figure A.13 Percentage distribution of Demo & Deployment investment by source and year (each project may have more than one source)

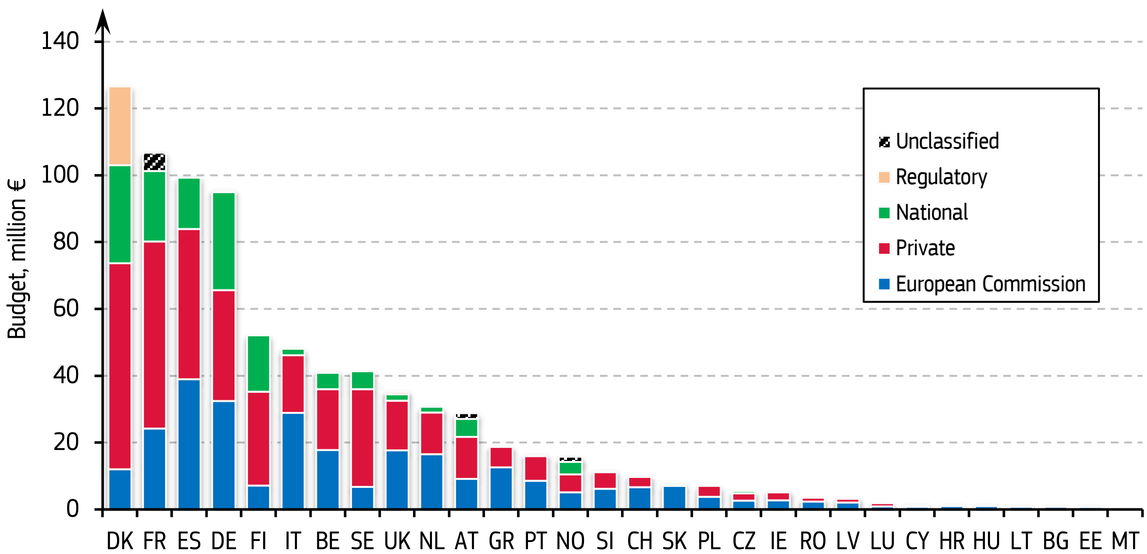


Figure A.14 Distribution of budget per funding source and country: R&D projects

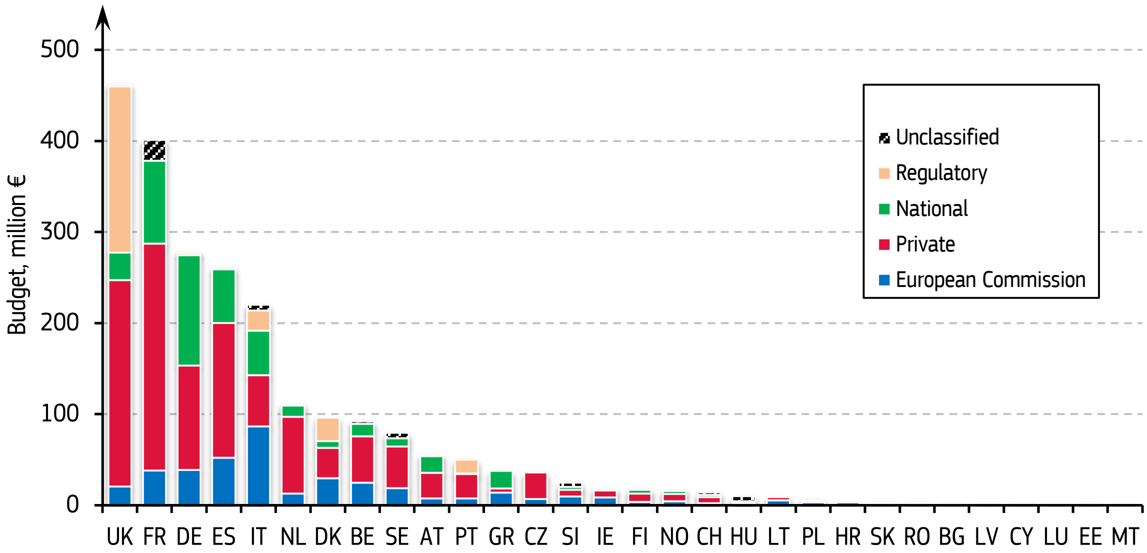


Figure A.15 Distribution of budget per funding source and country: Demo & Deployment projects

ORGANISATION TYPES. WHO IS INVESTING?

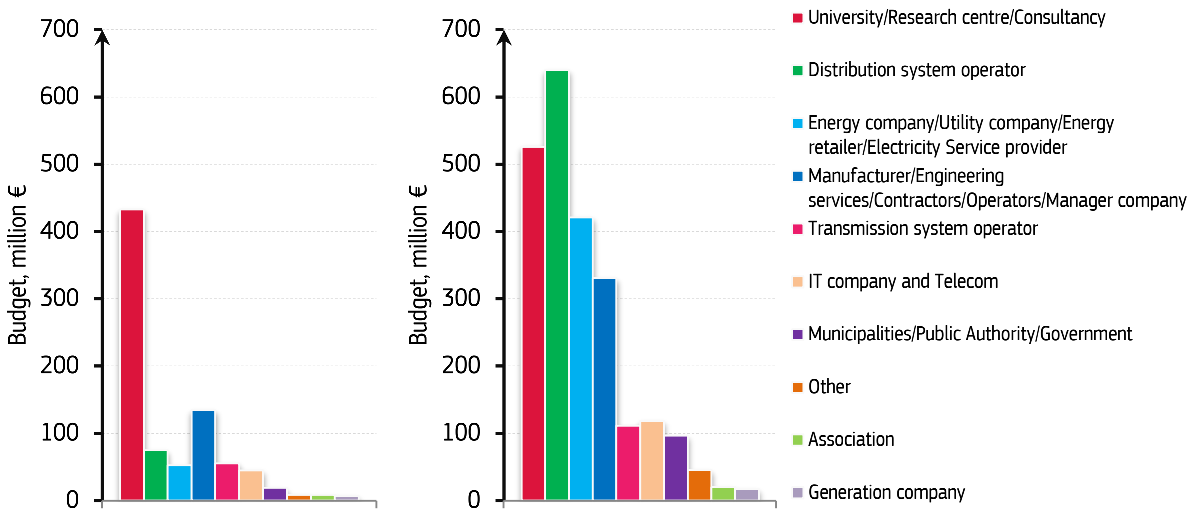


Figure A.16 Total budget per organisation type: left: R&D; right: D&D;

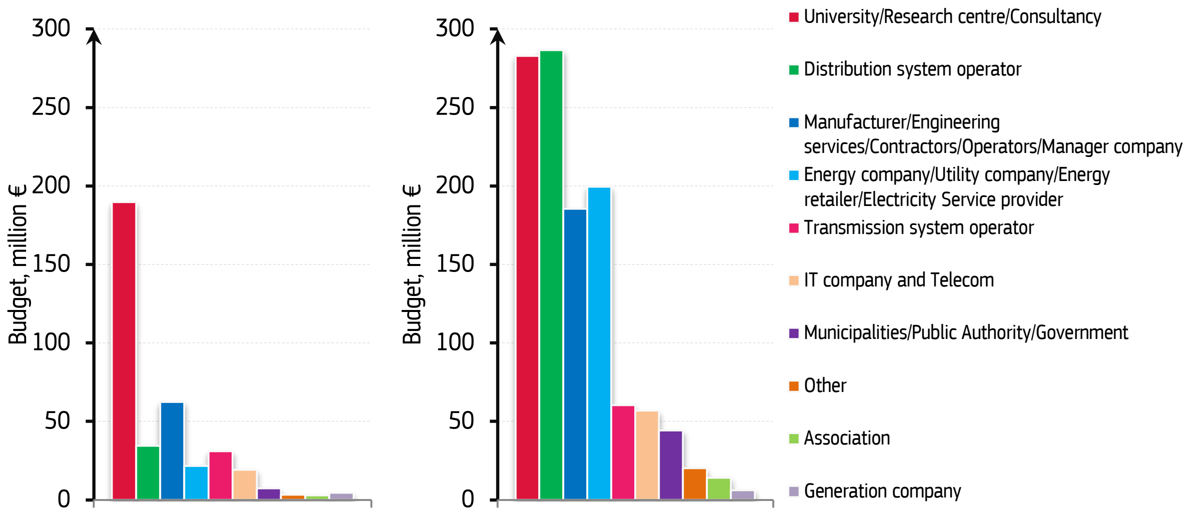


Figure A.17 Private budget per organisation type: left: R&D; right: D&D;

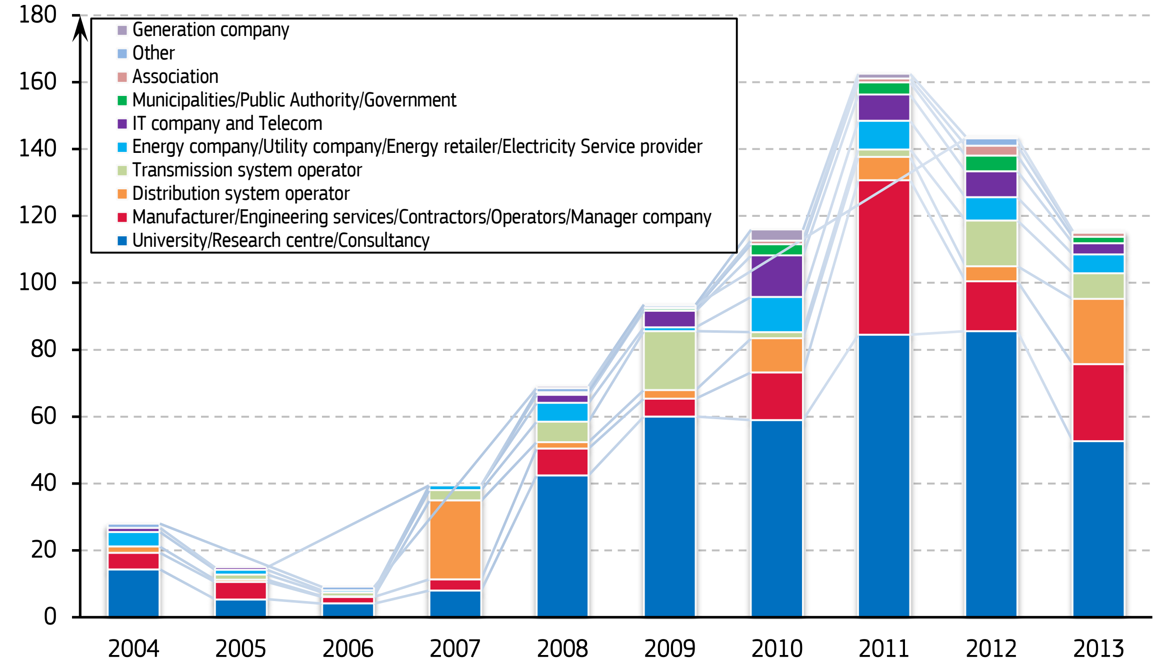


Figure A.18 Distribution of R&D total investment by organisation type and year

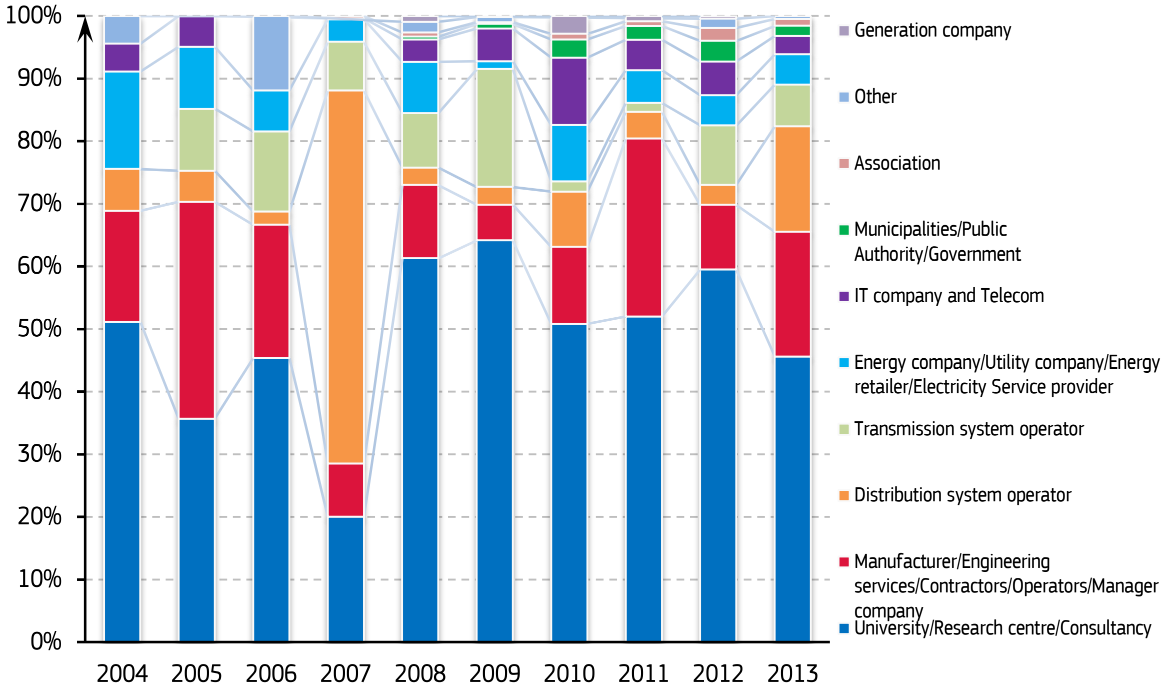


Figure A.19 Percentage distribution of R&D total investment by organisation type and year

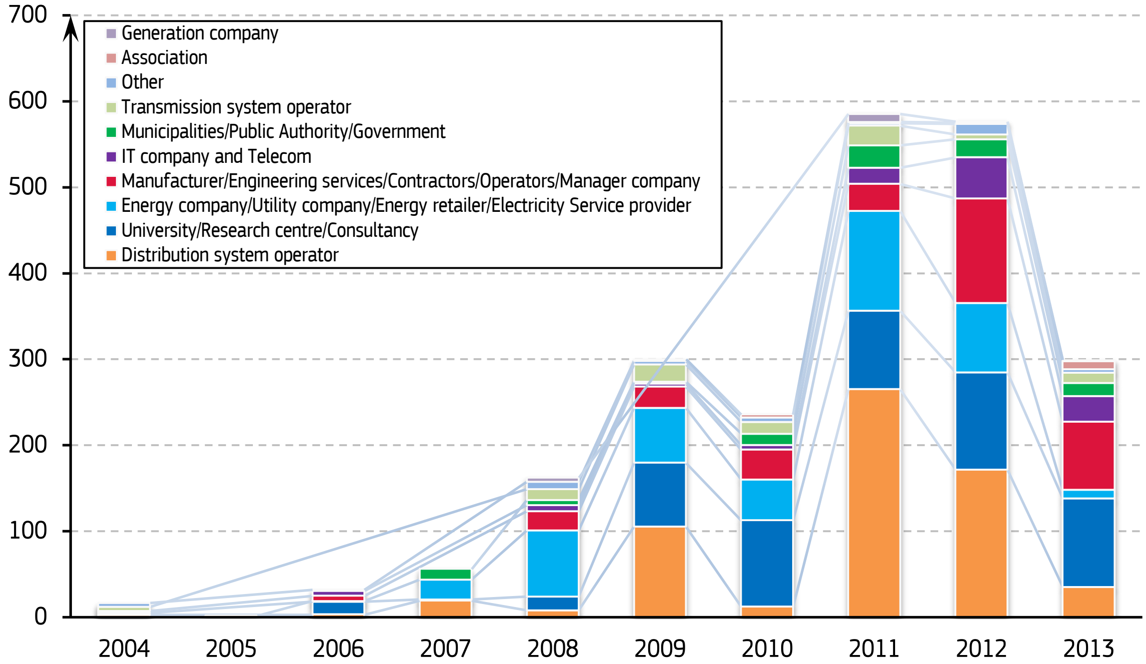


Figure A.20 Distribution of Demo & Deployment total investment by organisation type and year

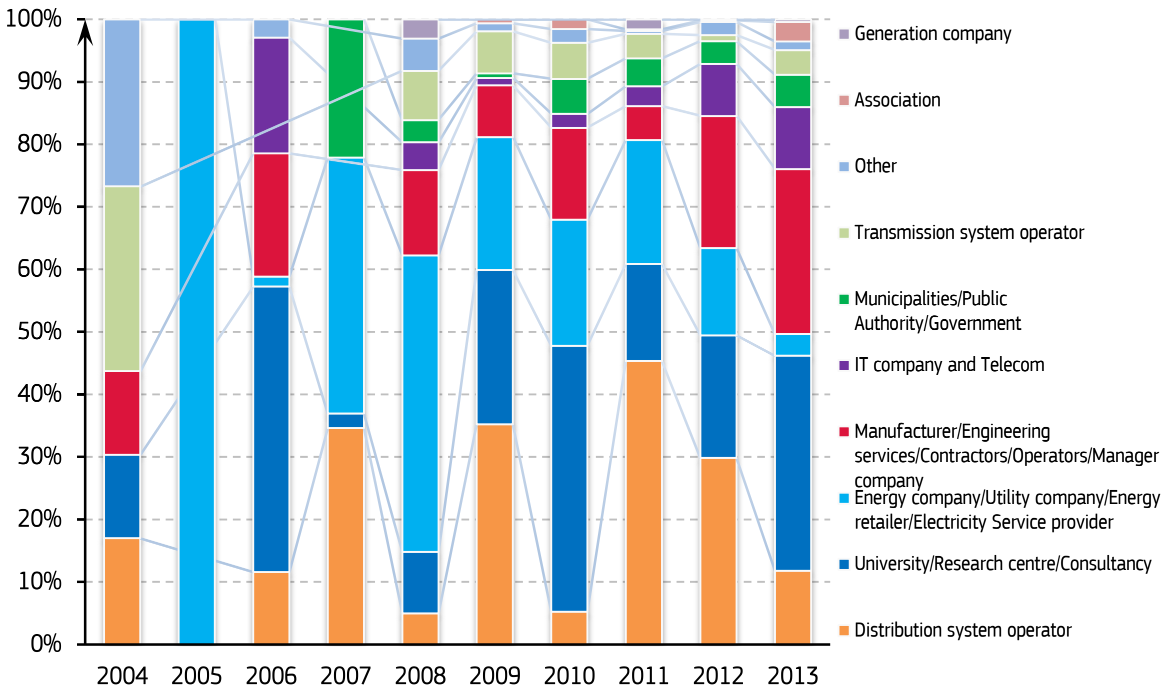


Figure A.21 Percentage distribution of Demo & Deployment total investment by organisation type and year

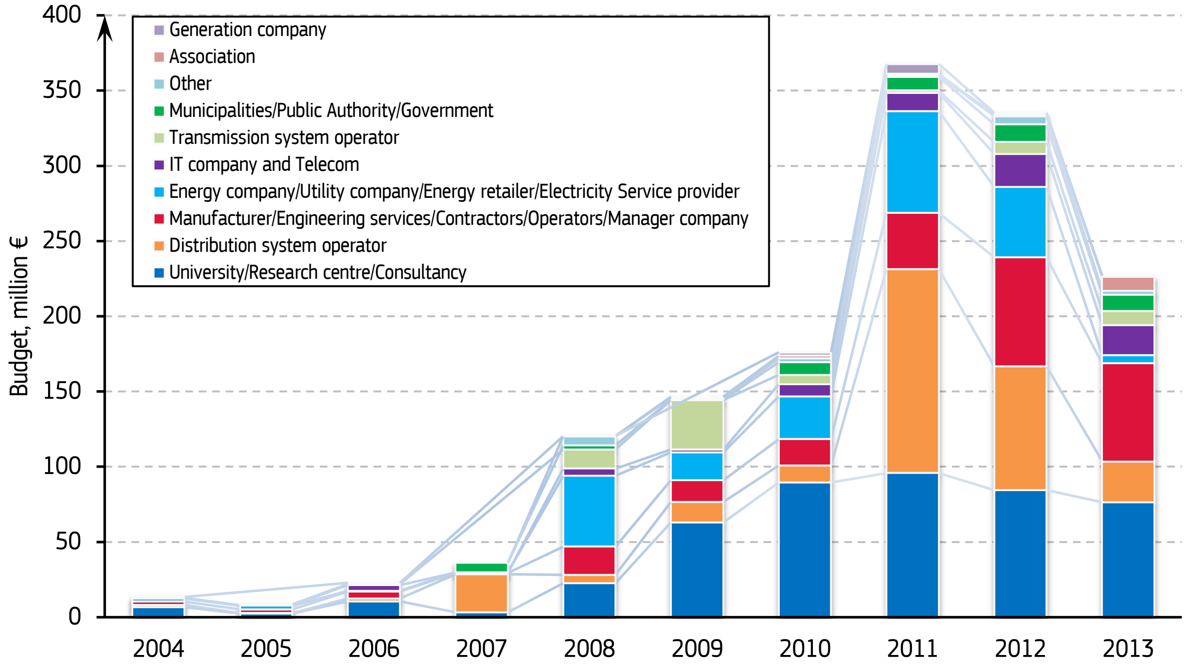


Figure A.22 Distribution of private investment by organisation type and year

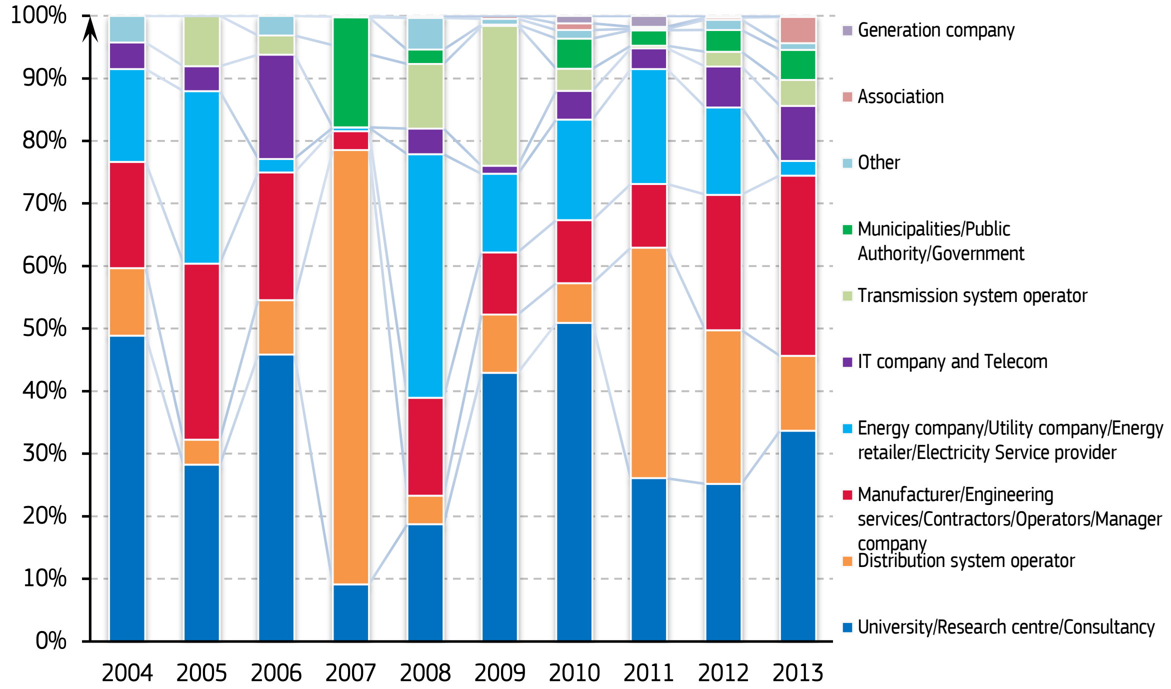


Figure A.23 Percentage distribution of private investment by organisation type and year

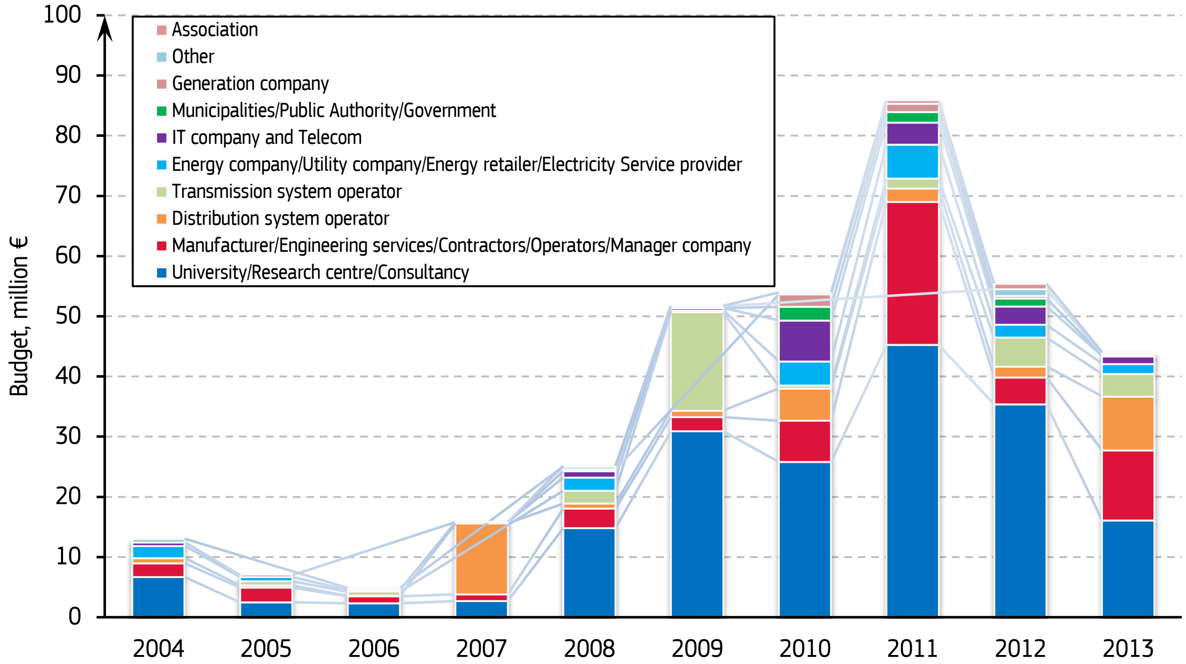


Figure A.24 Distribution of R&D private investment by organisation type and year

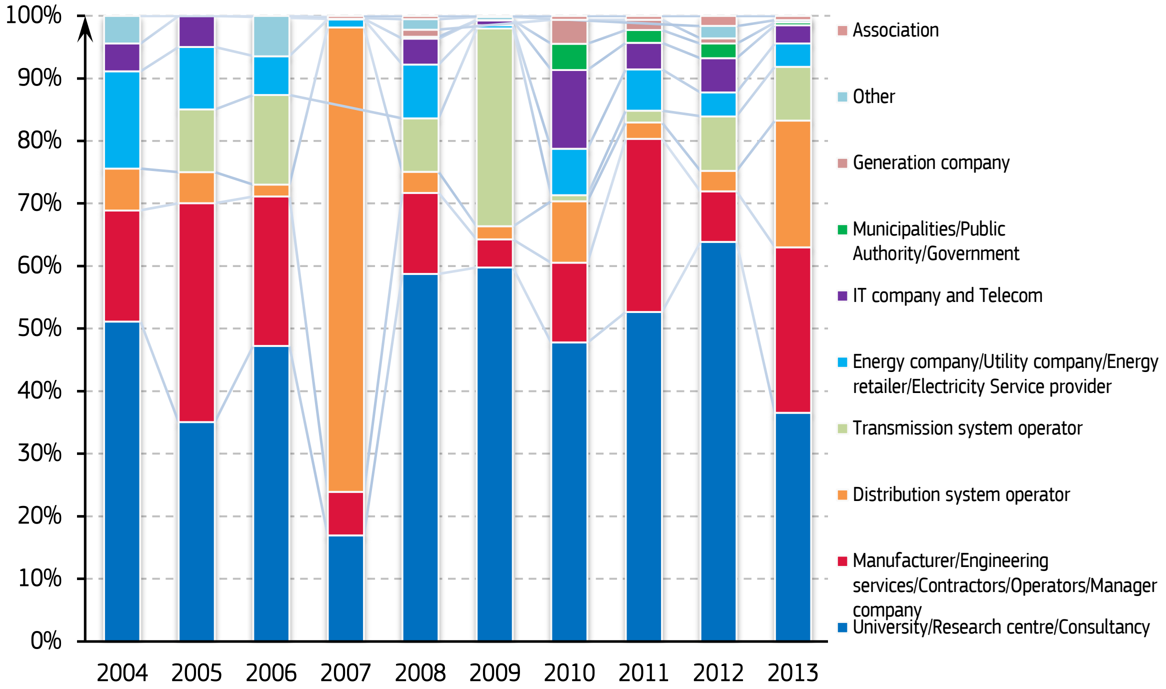


Figure A.25 Percentage distribution of R&D private investment by organisation type and year

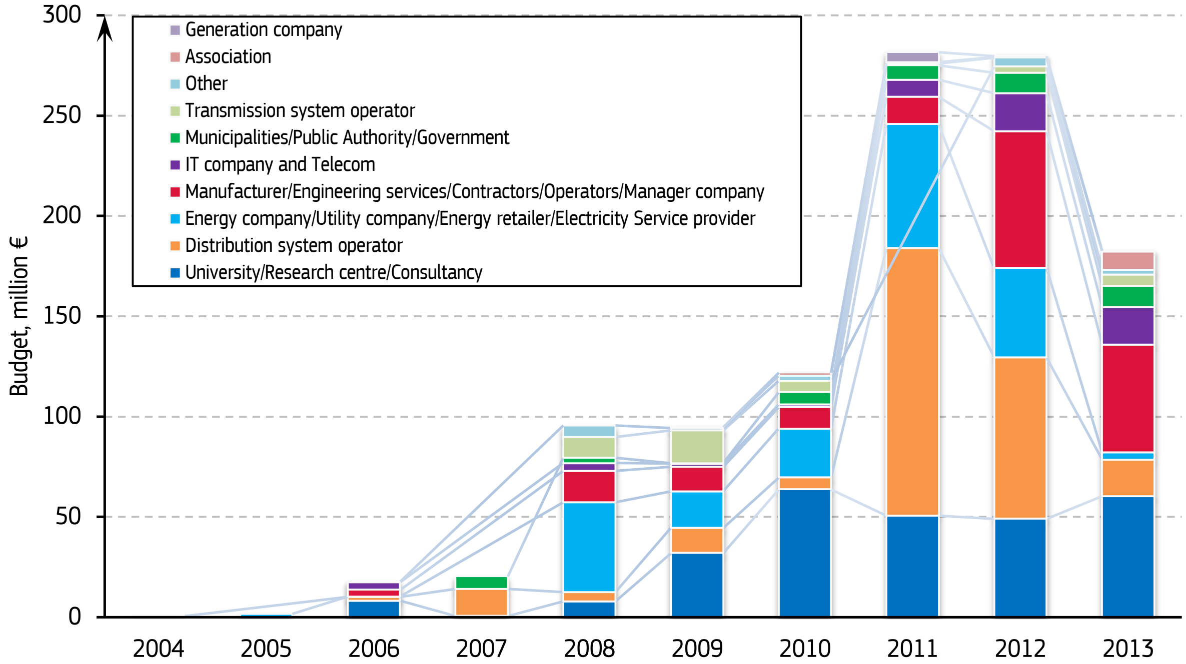


Figure A.26 Distribution of Demo & Deployment private investment by organisation type and year

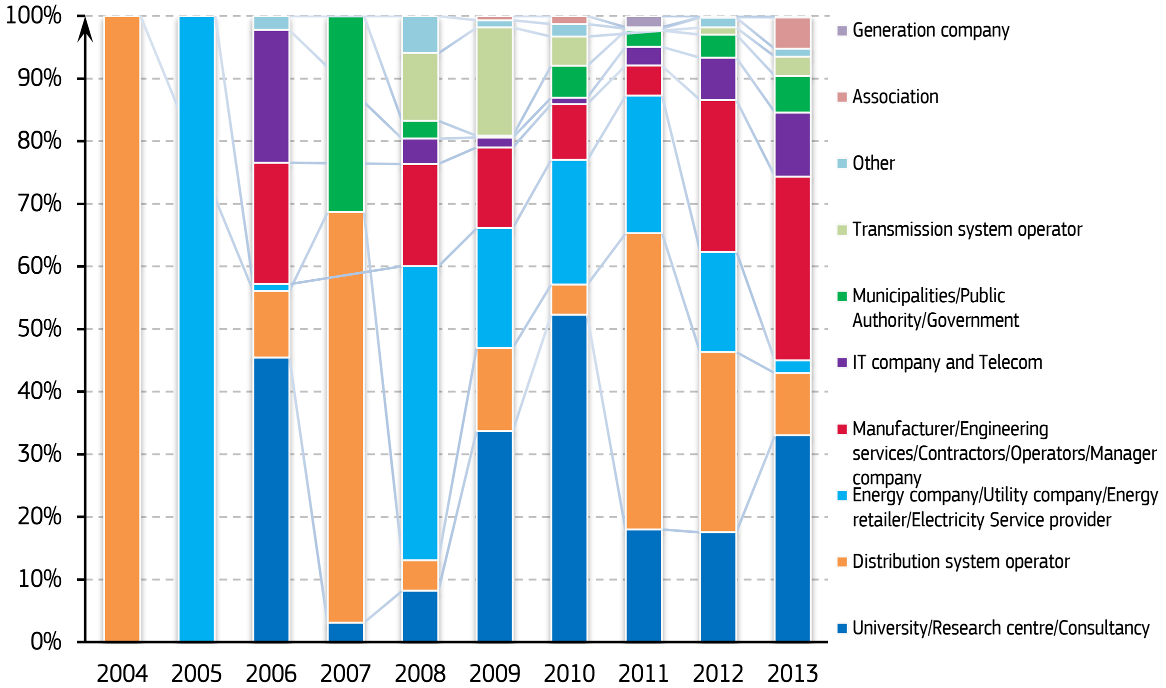


Figure A.27 Percentage distribution of Demo & Deployment private investment by organisation type and year

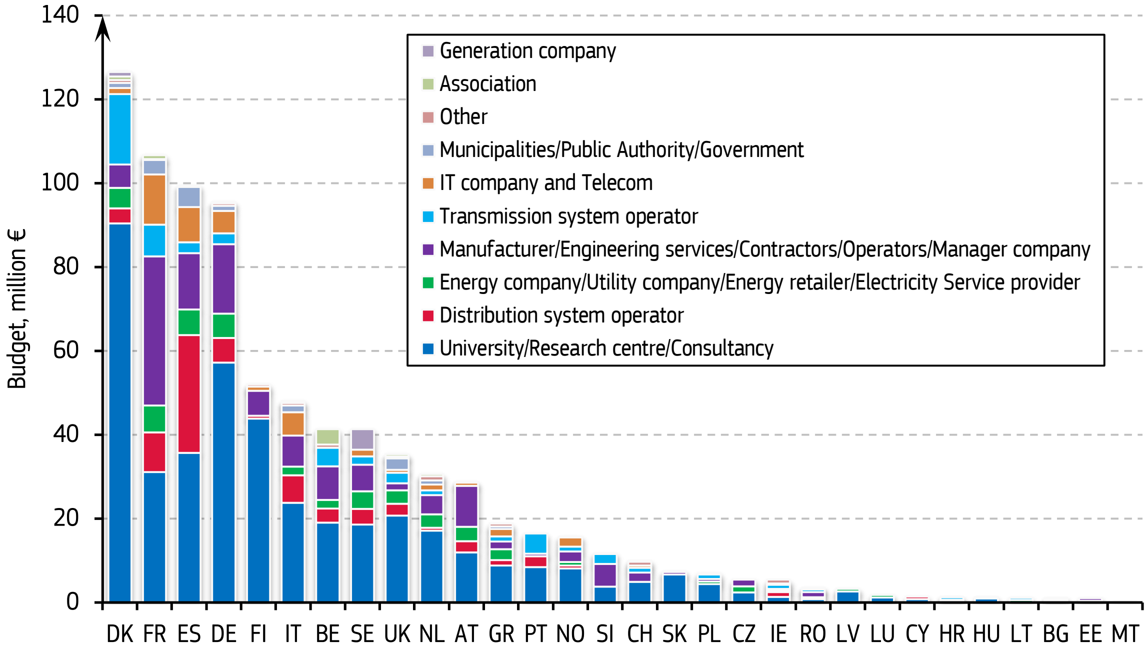


Figure A.28 Distribution of total budget per organisation type and country: R&D projects

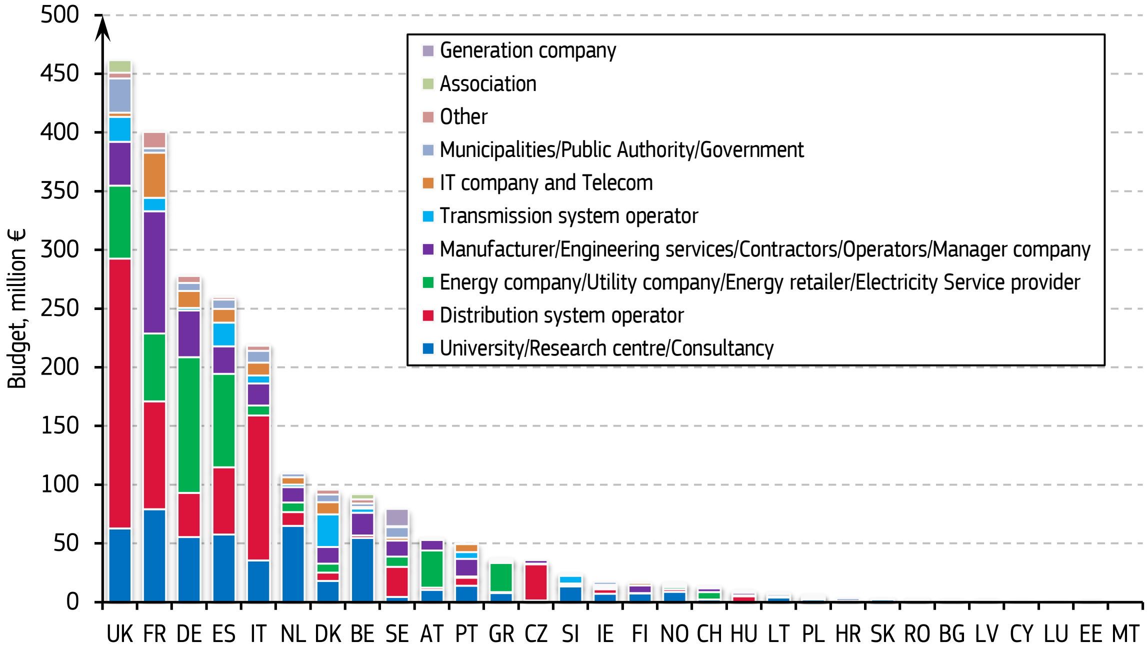


Figure A.29 Distribution of total budget per organisation type and country: Demo & Deployment projects

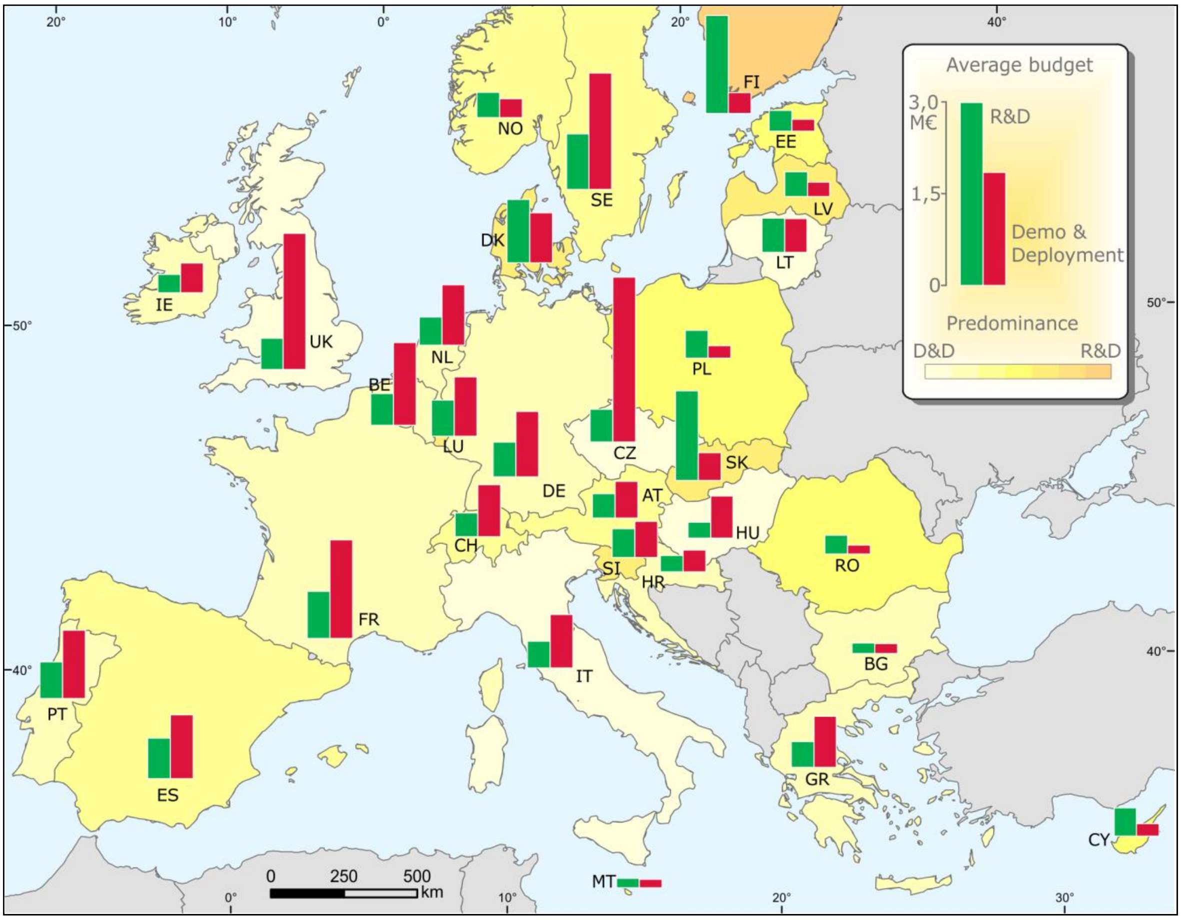


Figure A.30 Average budget per participant, stage of development and country

SMART GRID APPLICATIONS TARGETED BY PROJECTS

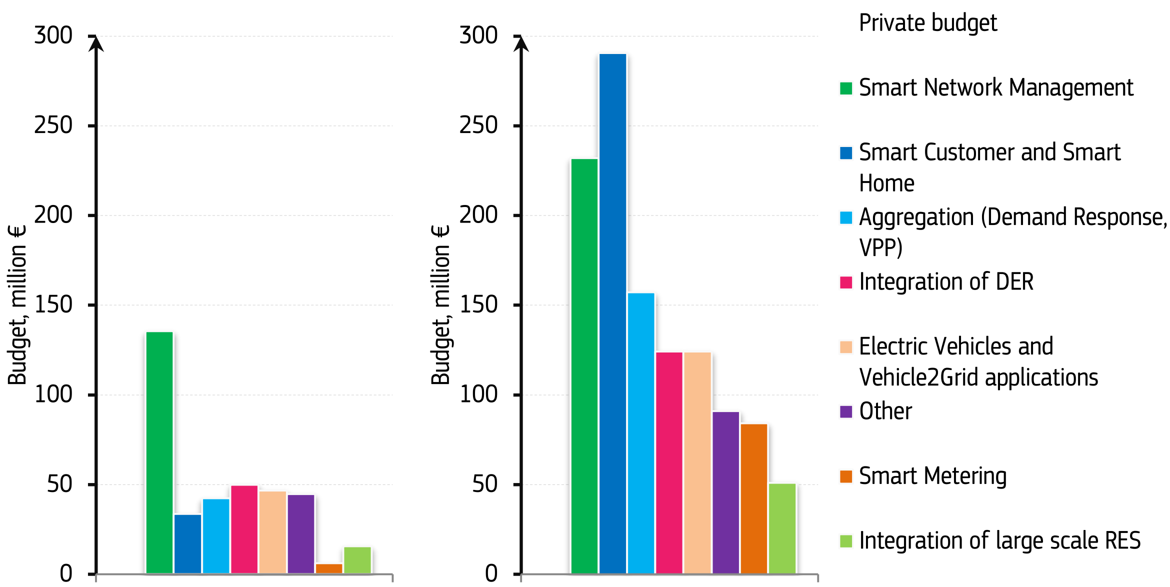


Figure A.31 Private budget per smart grid application: left: R&D; right: D&D;
(each project may have more than one application)

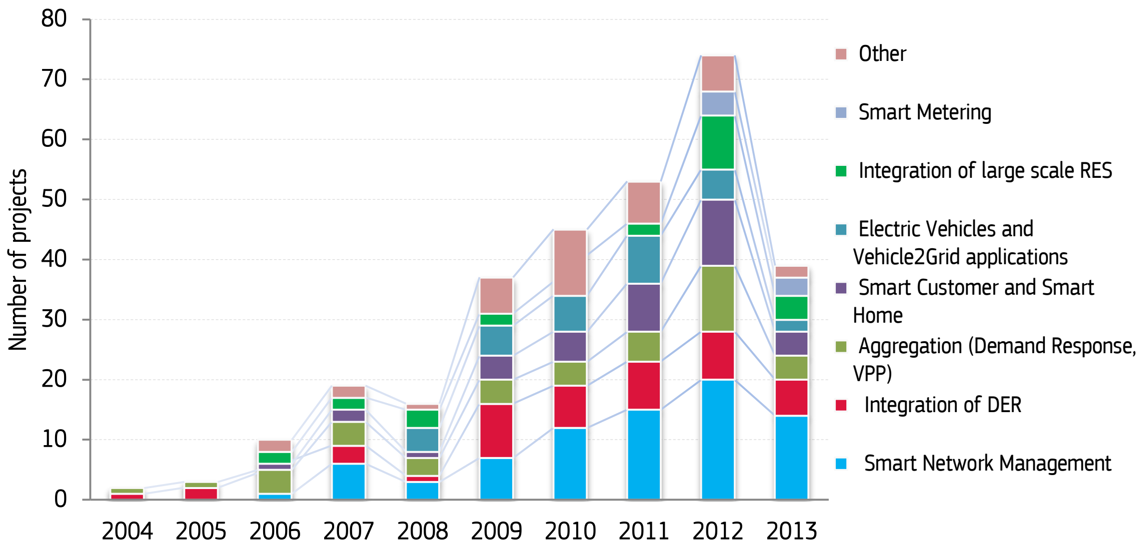


Figure A.32 Distribution of project applications and year: R&D projects
(each project may have more than one application)

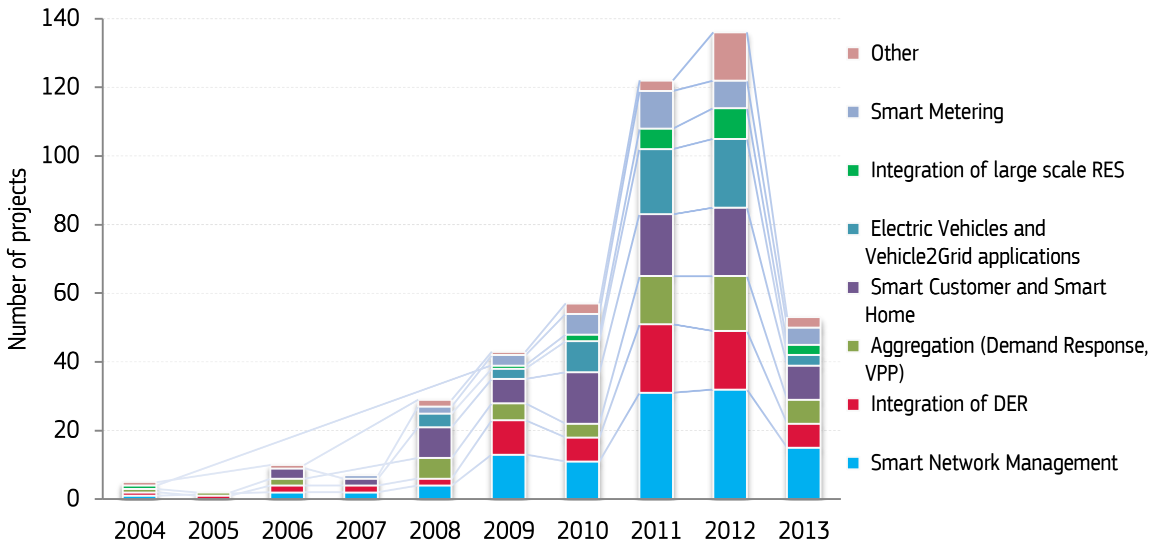


Figure A.33 Distribution of project applications and year: Demo & Deployment projects
(each project may have more than one application)

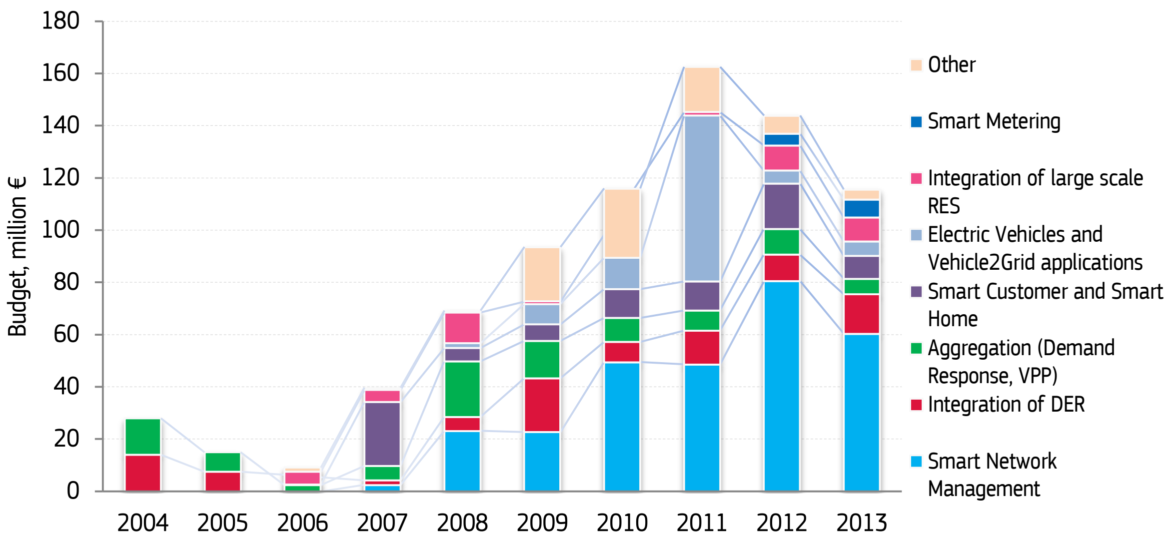


Figure A.34 Distribution of investment by application and year: R&D
(each project may have more than one application)

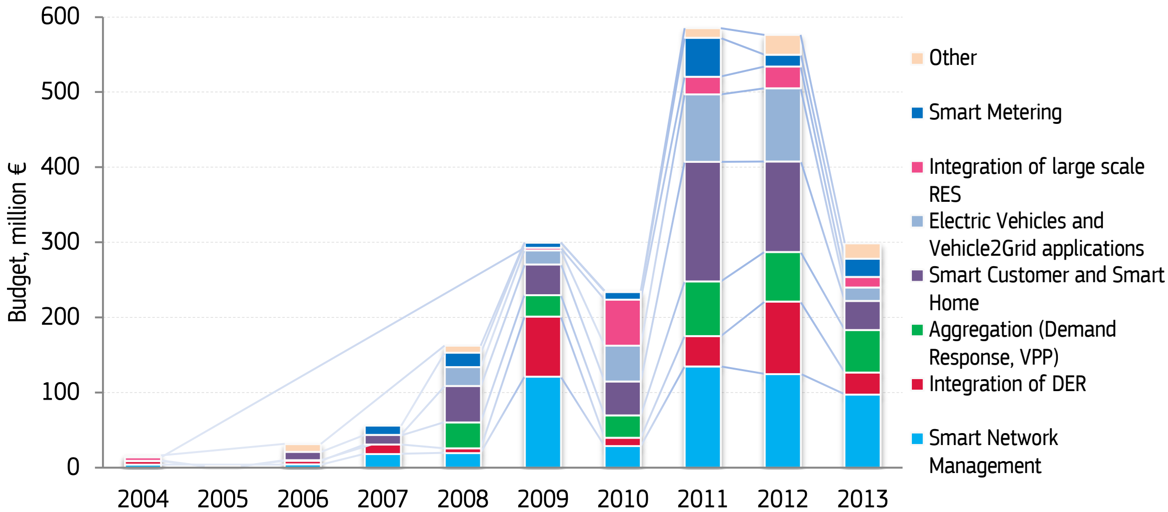


Figure A.35 Distribution of investment by application and year: Demo & Deployment
(each project may have more than one application)

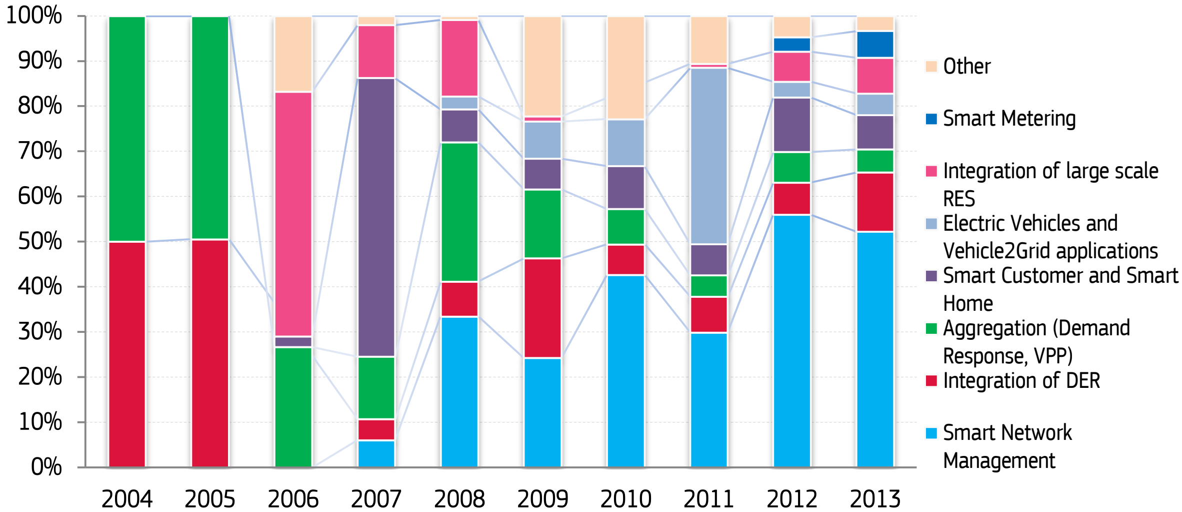


Figure A,36 Percentage distribution of R&D investment by application and year
(each project may have more than one application)

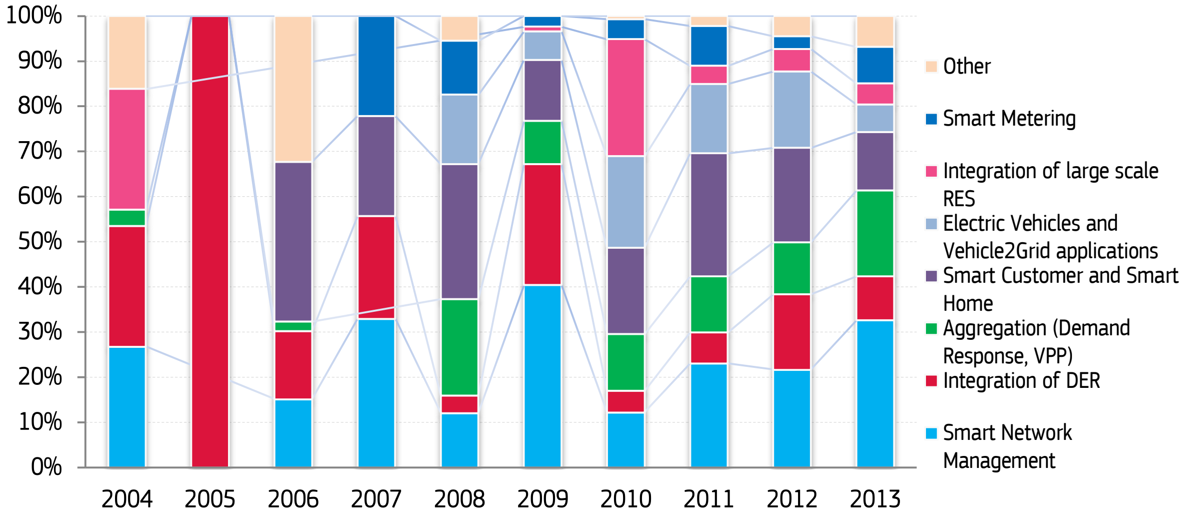
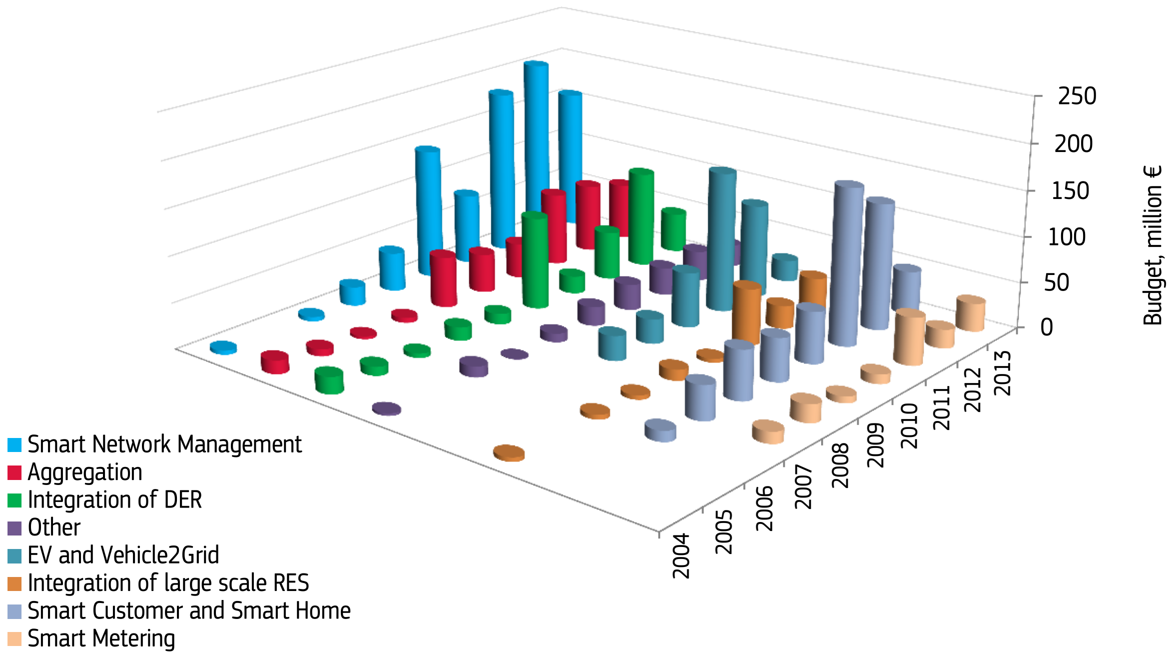


Figure A.37 Percentage distribution of Demo & Deployment investment by application and year
(each project may have more than one application)



FigureA.38 Budget of projects per year and application

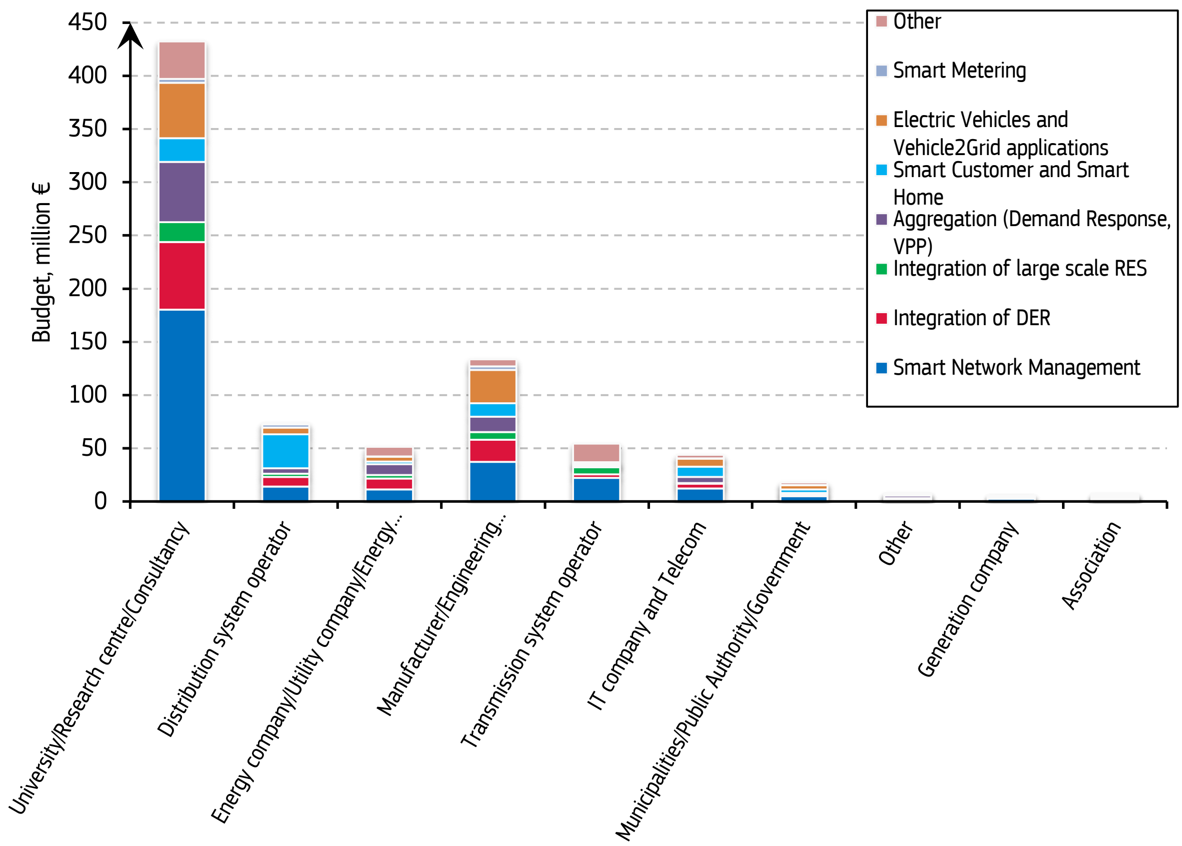


Figure A.39 Distribution of total budget per organisation type and application: R&D projects

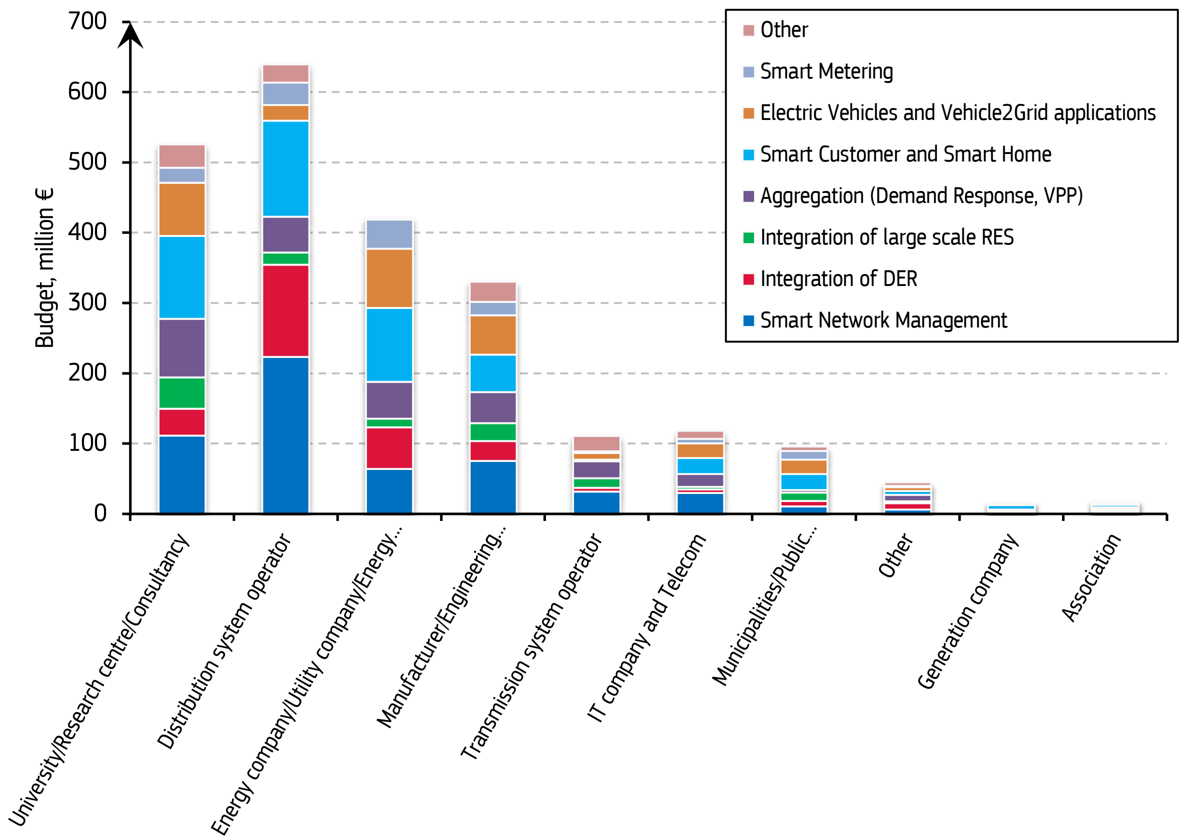


Figure A.40 Distribution of total budget per organisation type and application: Demo & Deployment projects

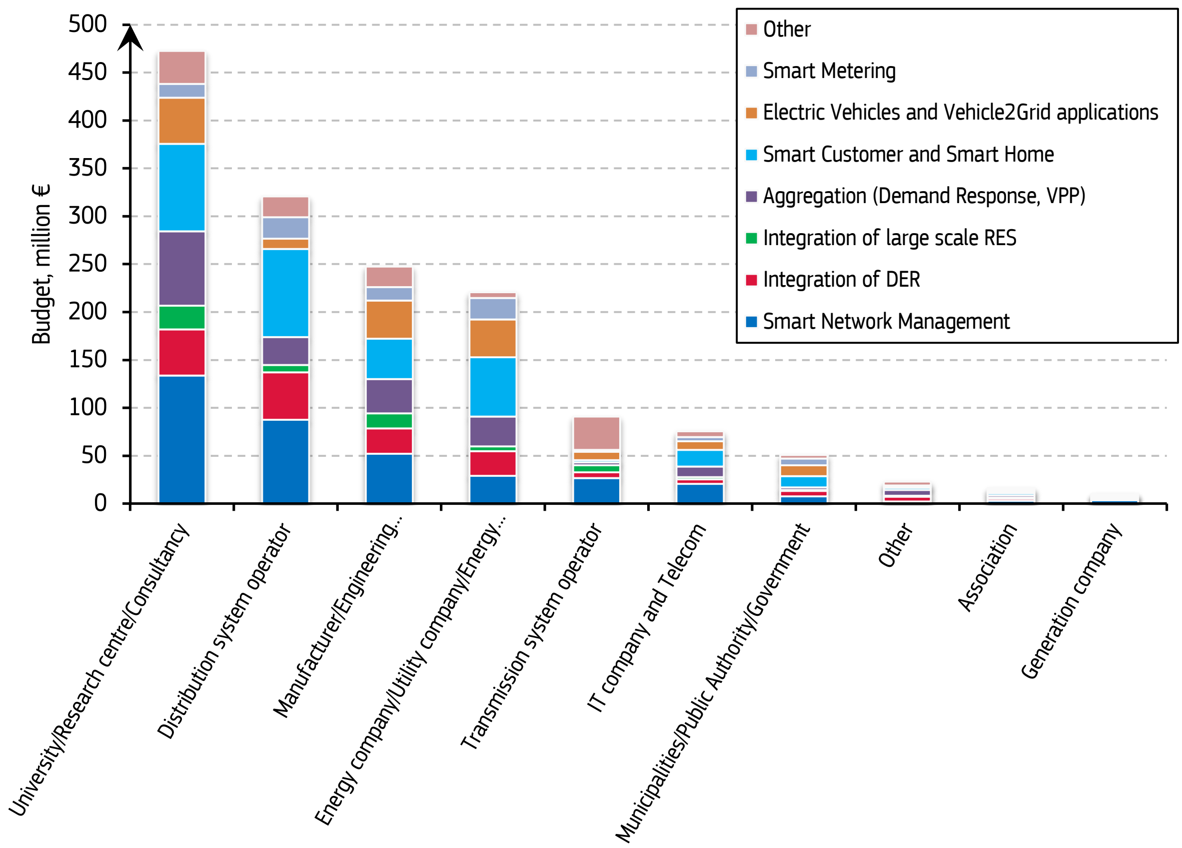


Figure A.41 Distribution of private budget per organisation type and application: all projects

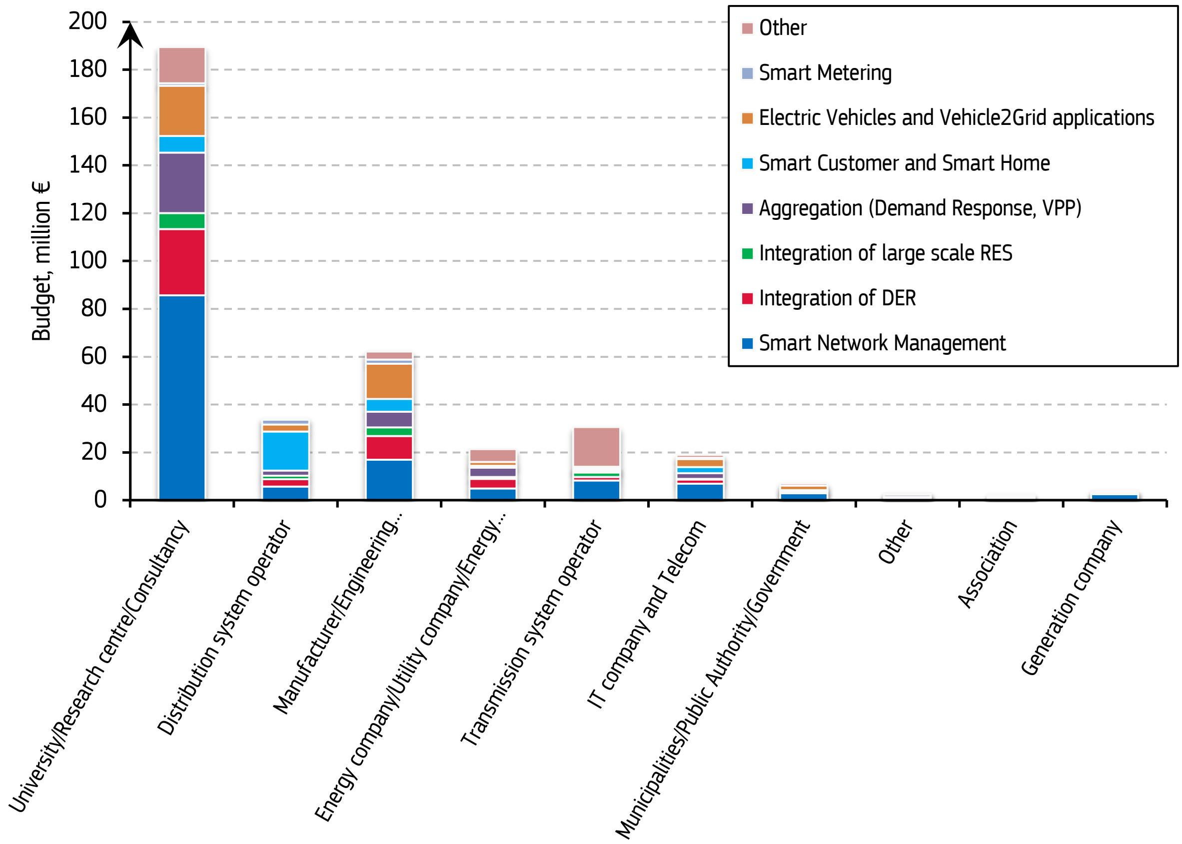


Figure A.42 Distribution of private budget per organisation type and application: R&D projects

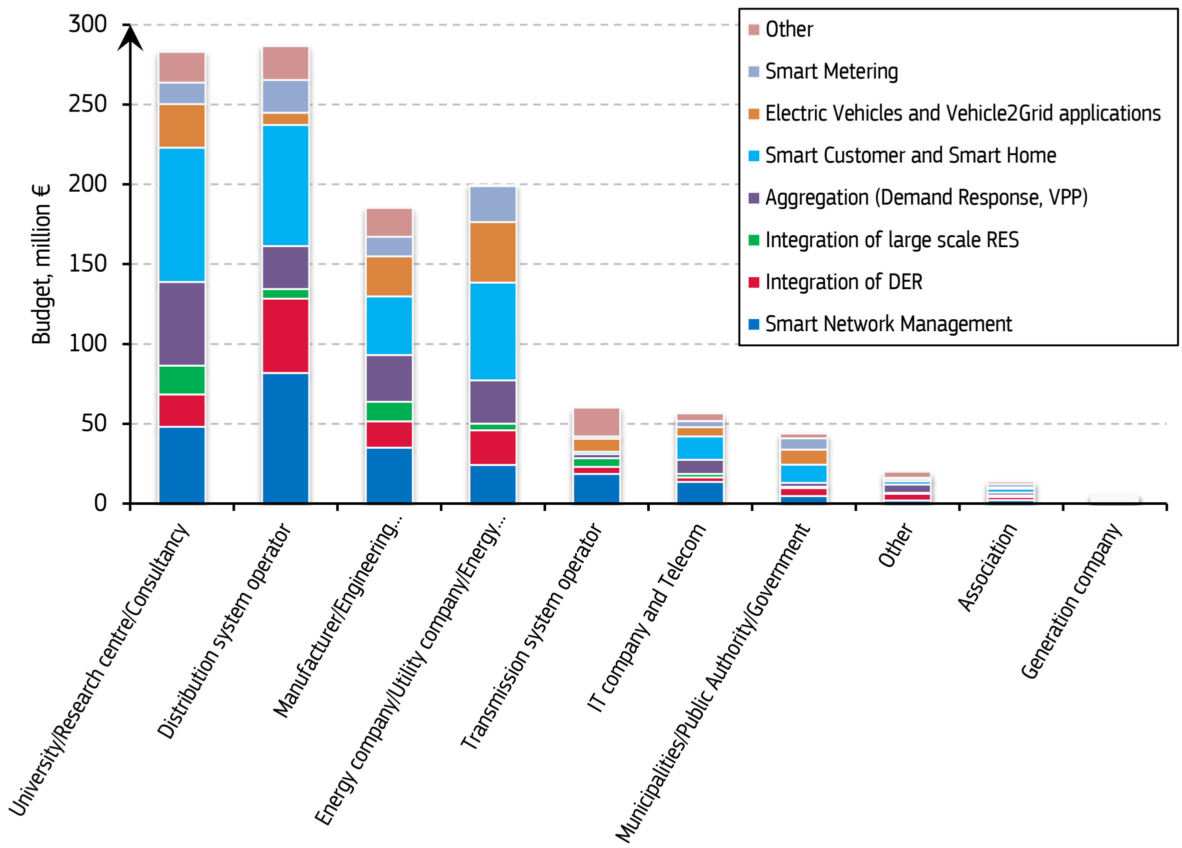


Figure A.43 Distribution of private budget per organisation type and application: Demo & Deployment projects

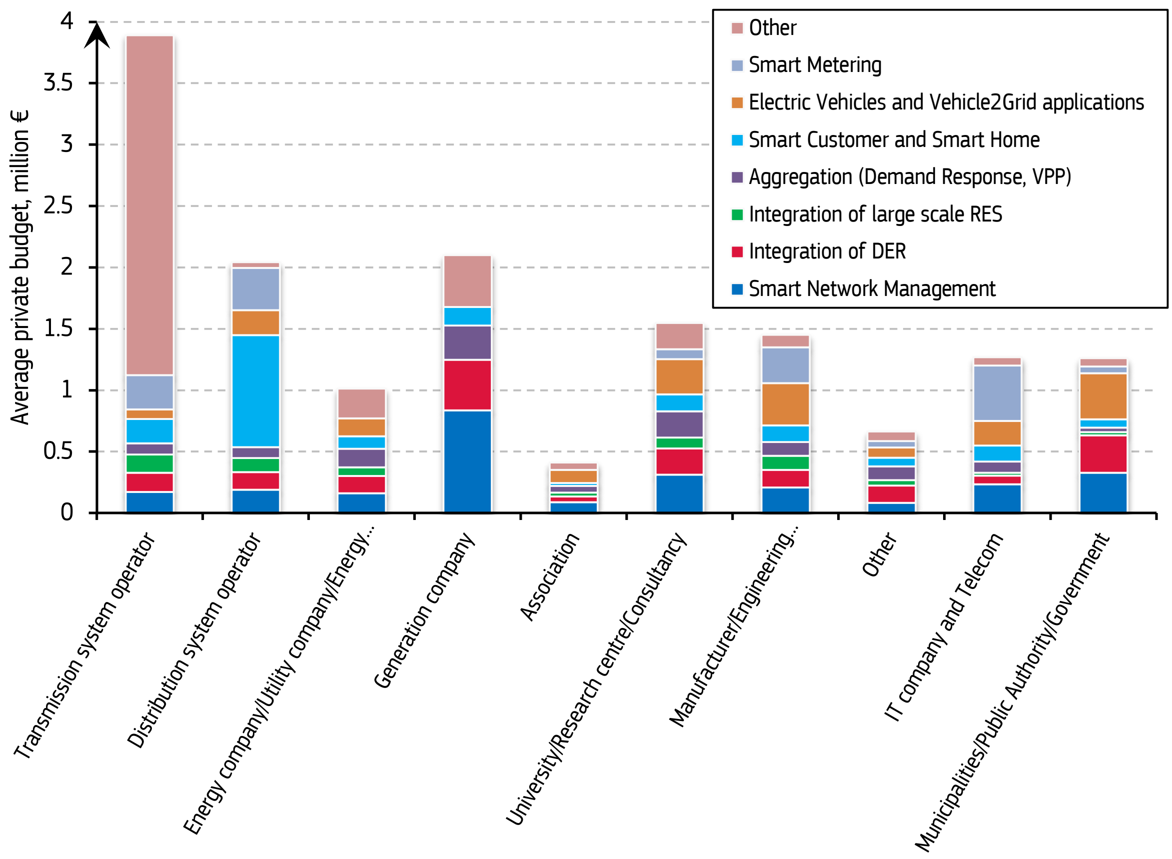


Figure A.44 Distribution of average private budget per organisation type and application: R&D projects

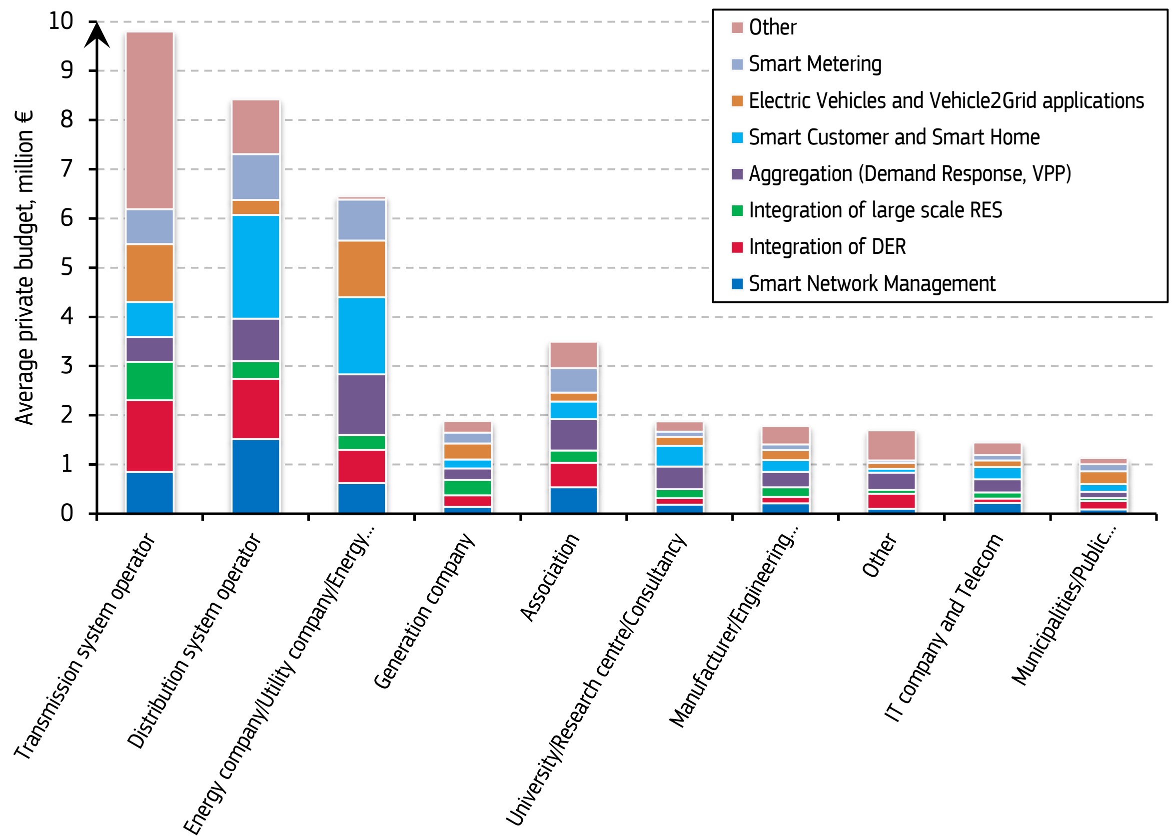


Figure A.45 Distribution of average private budget per organisation type and application: Demo & Deployment projects

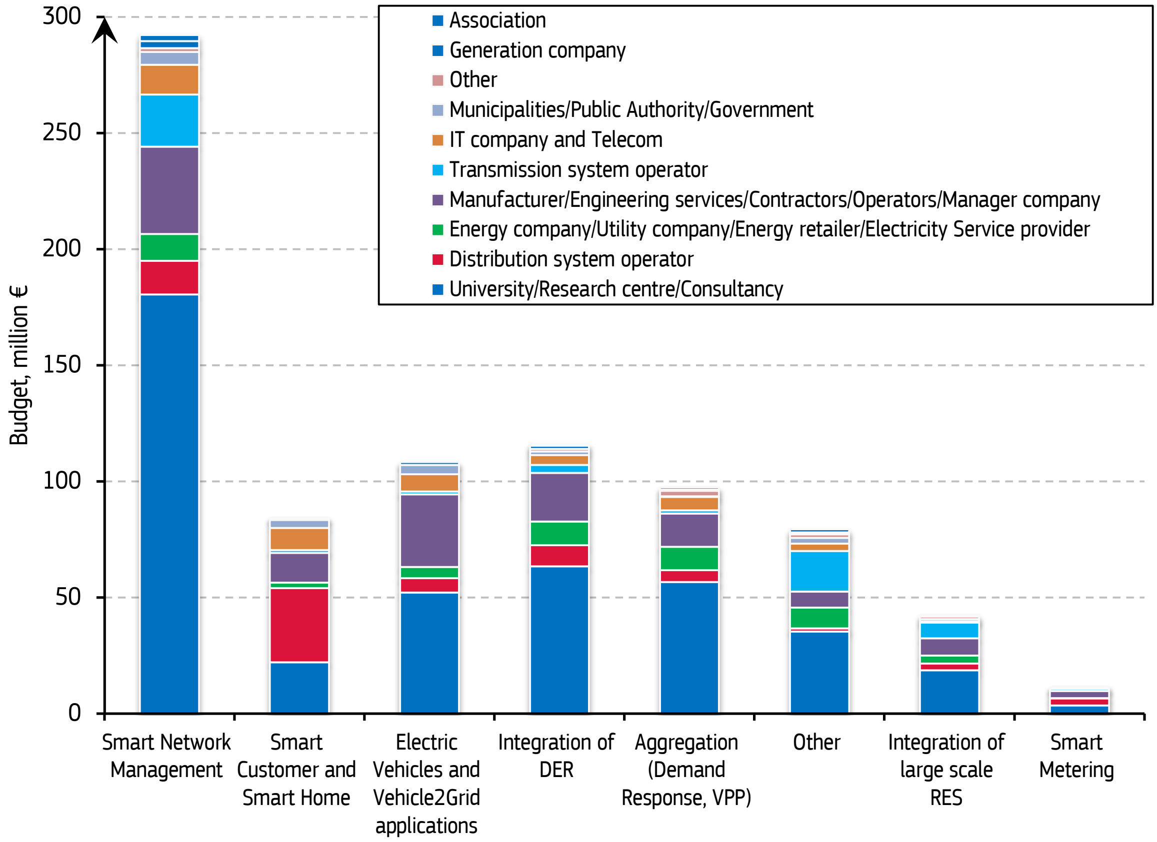


Figure A.46 Distribution of total budget per application and organisation type: R&D projects

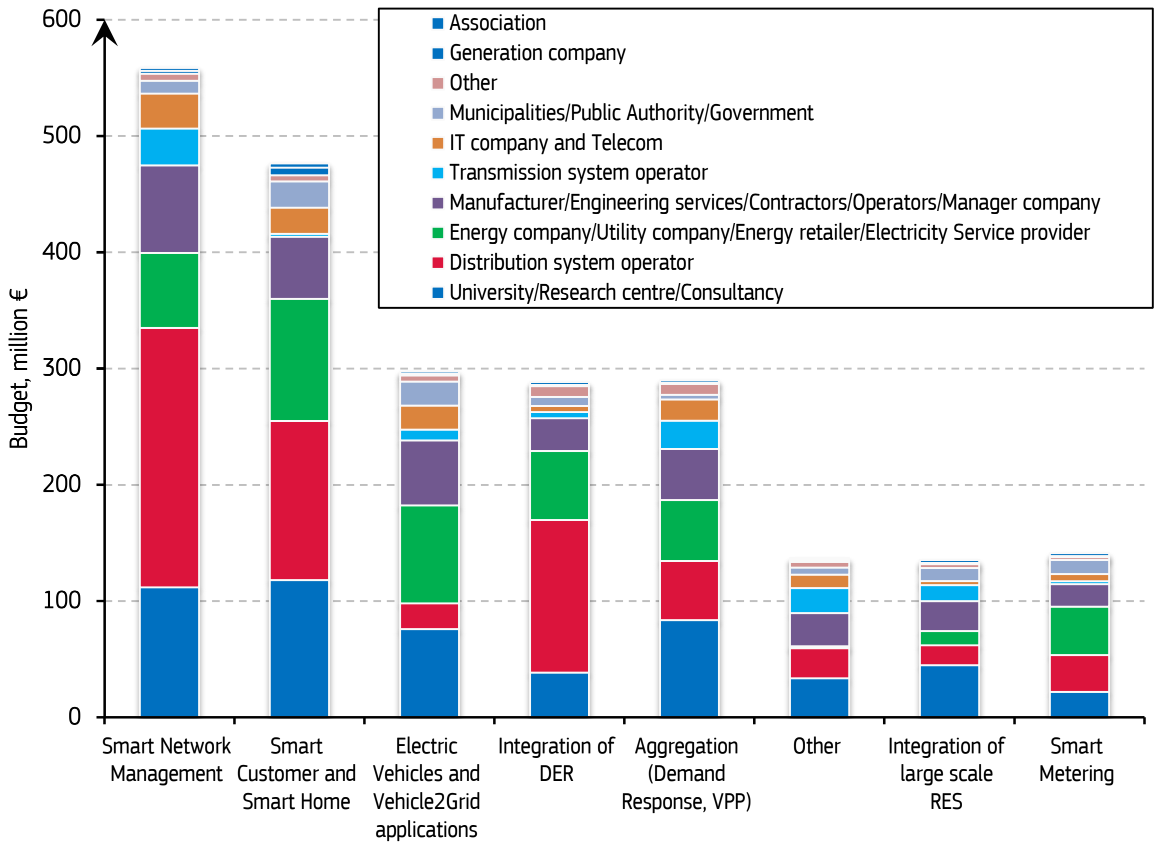


Figure A.47 Distribution of total budget per application and organisation type: Demo & Deployment projects

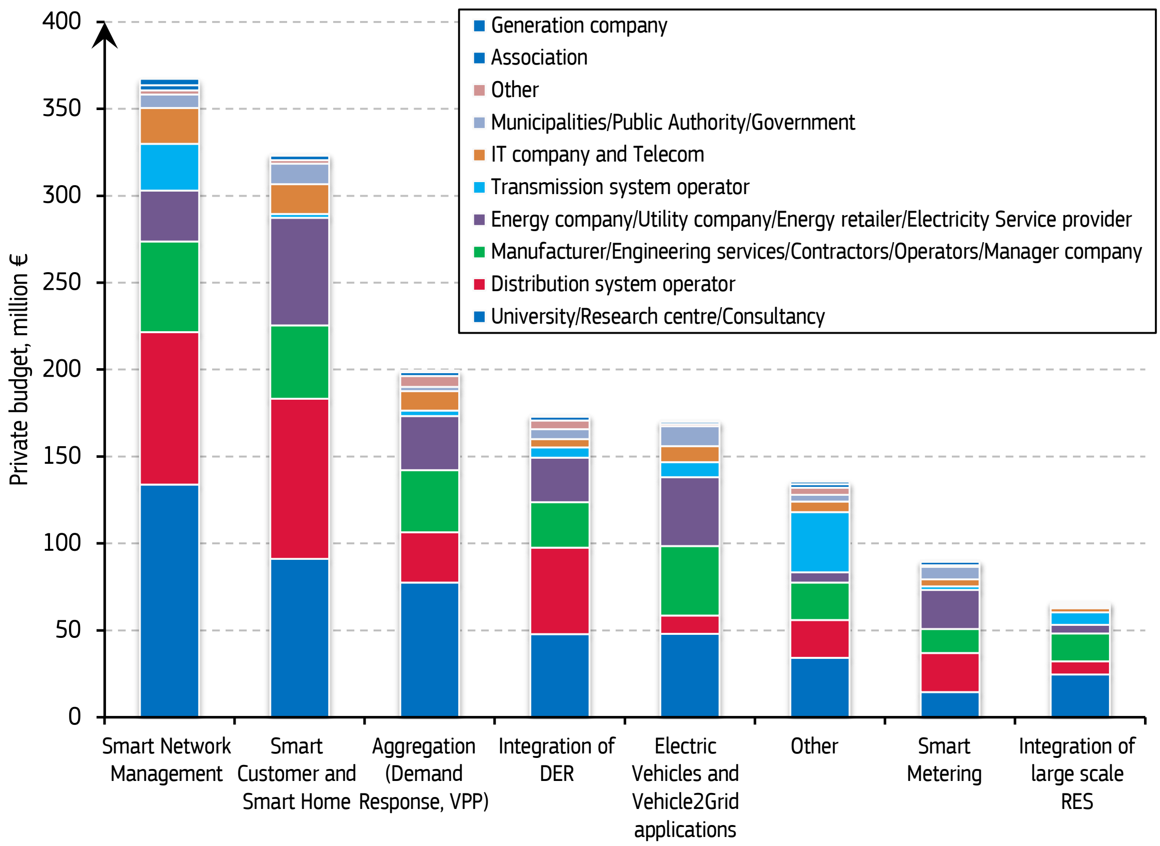


Figure A.48 Distribution of private budget per application and organisation type: all projects

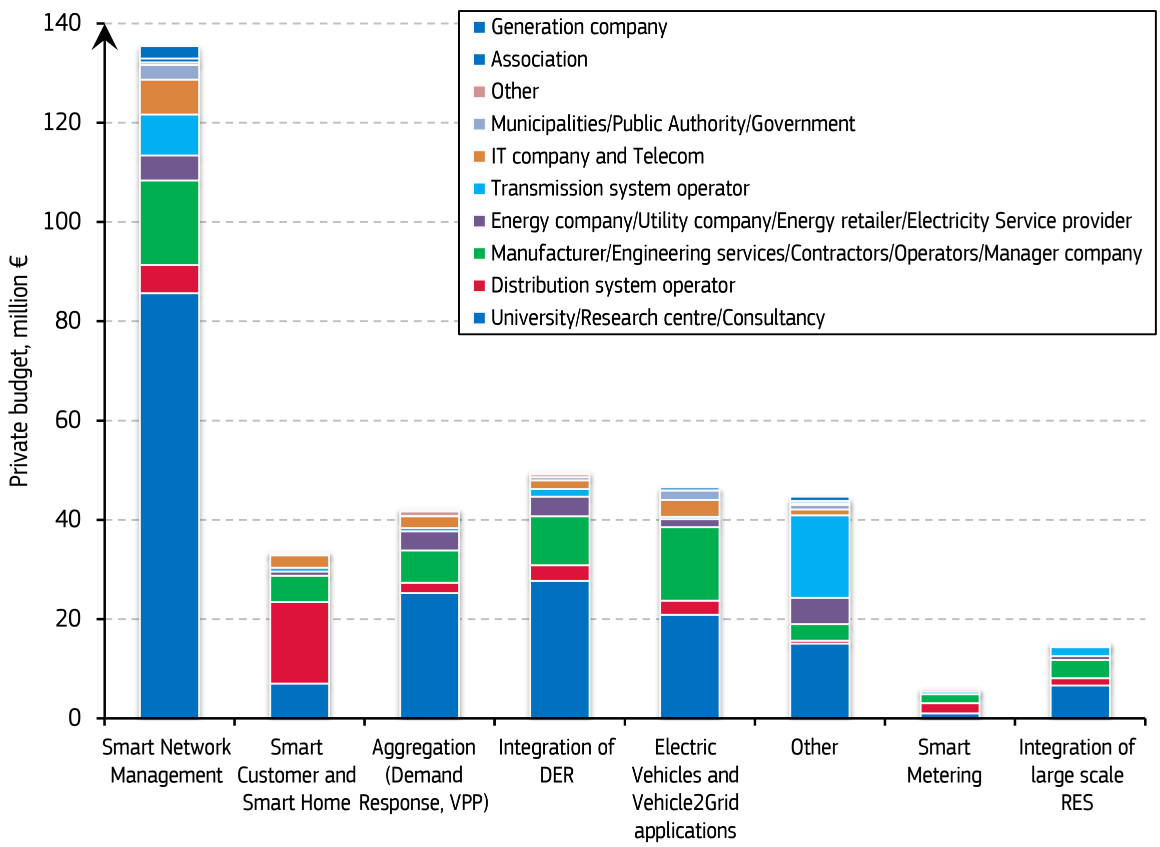


Figure A.49 Distribution of private budget per application and organisation type: R&D projects

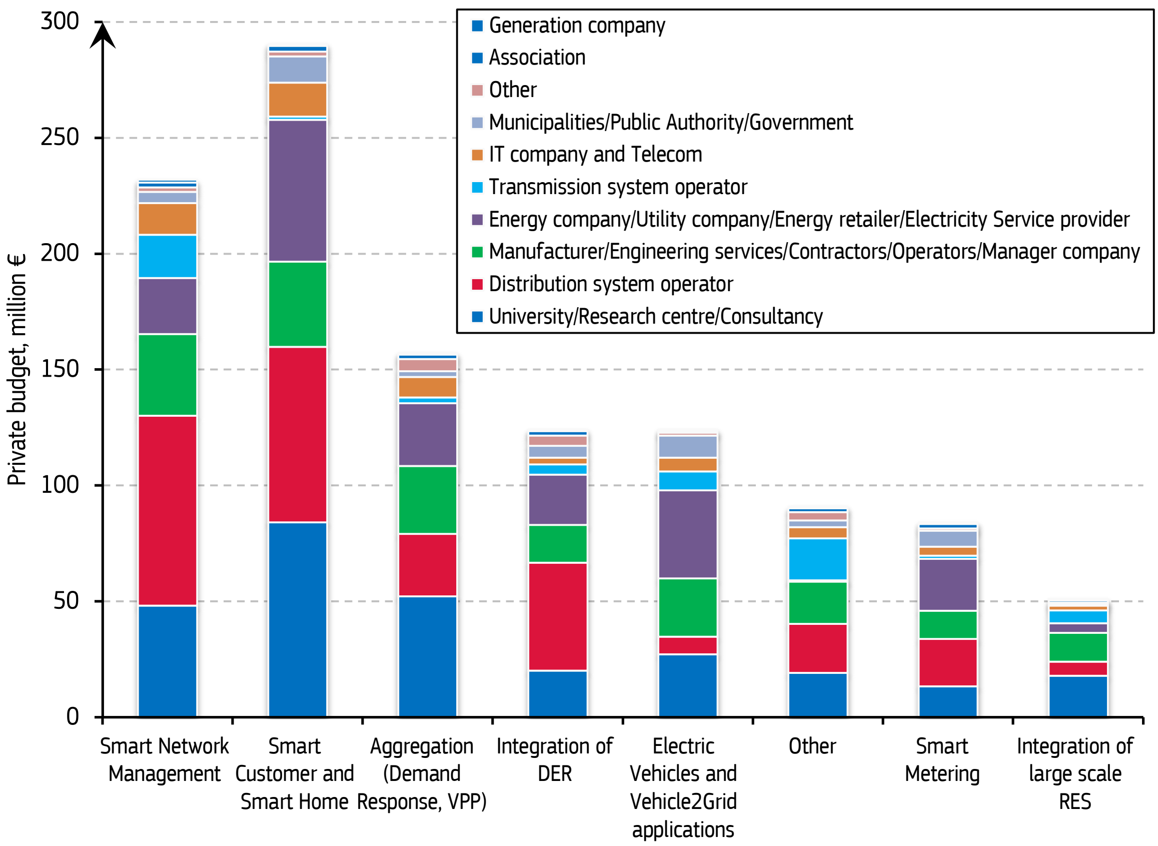


Figure A.50 Distribution of private budget per application and organisation type: Demo & Deployment projects

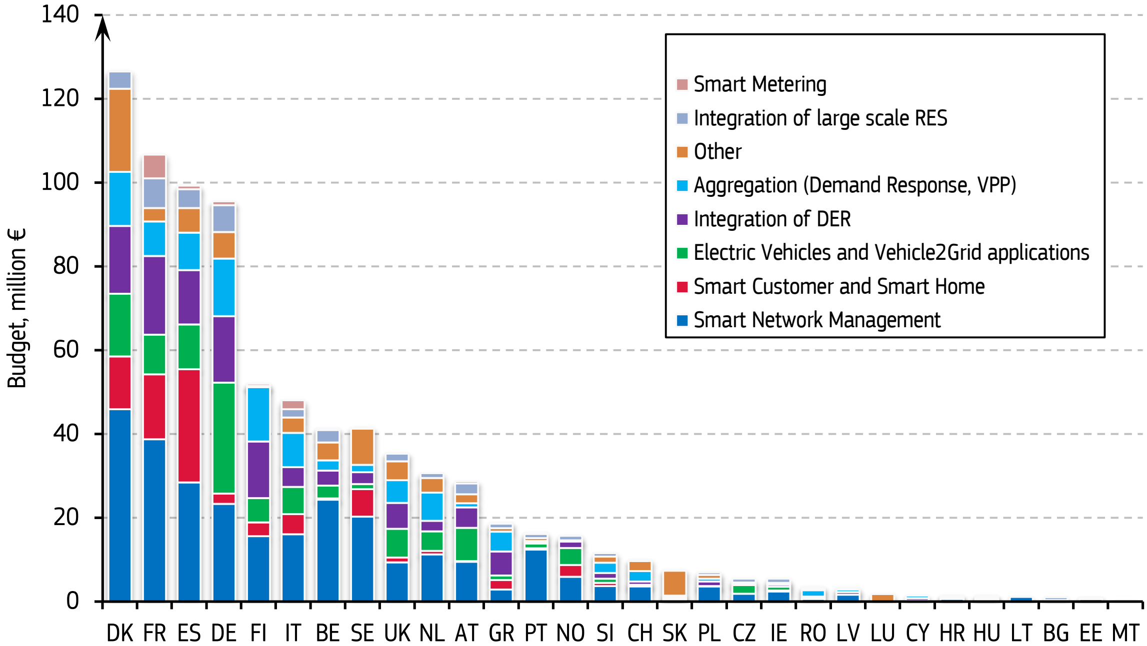


Figure A.51 Distribution of total budget per smart grid application and country: R&D projects

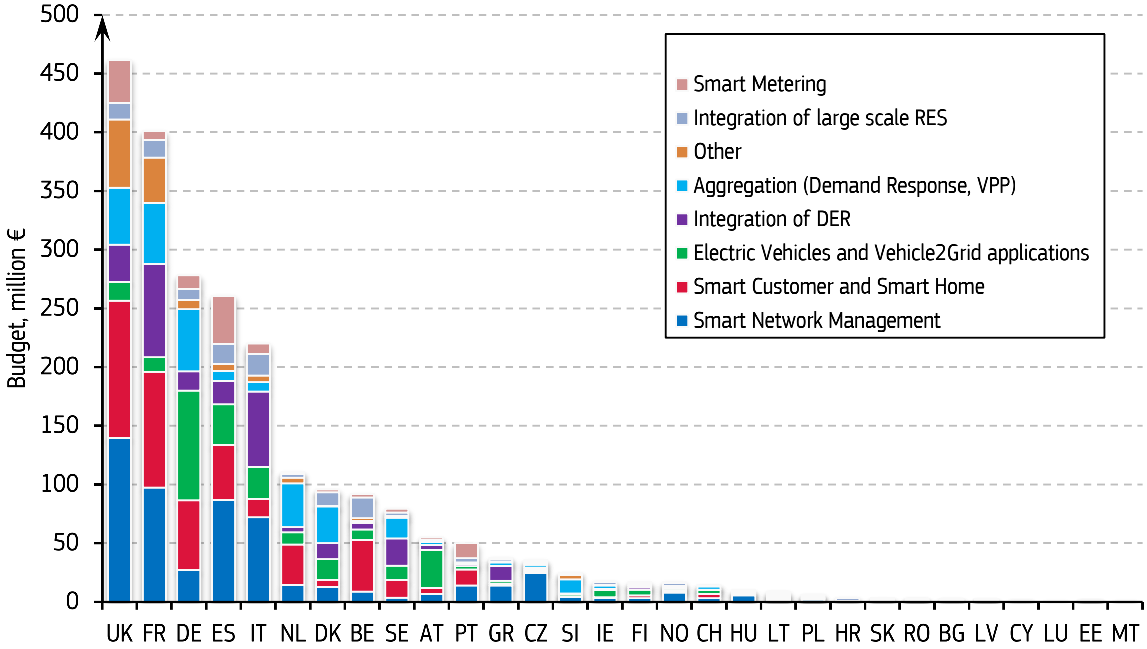


Figure A.52 Distribution of total budget per smart grid application and country: Demo & Deployment projects

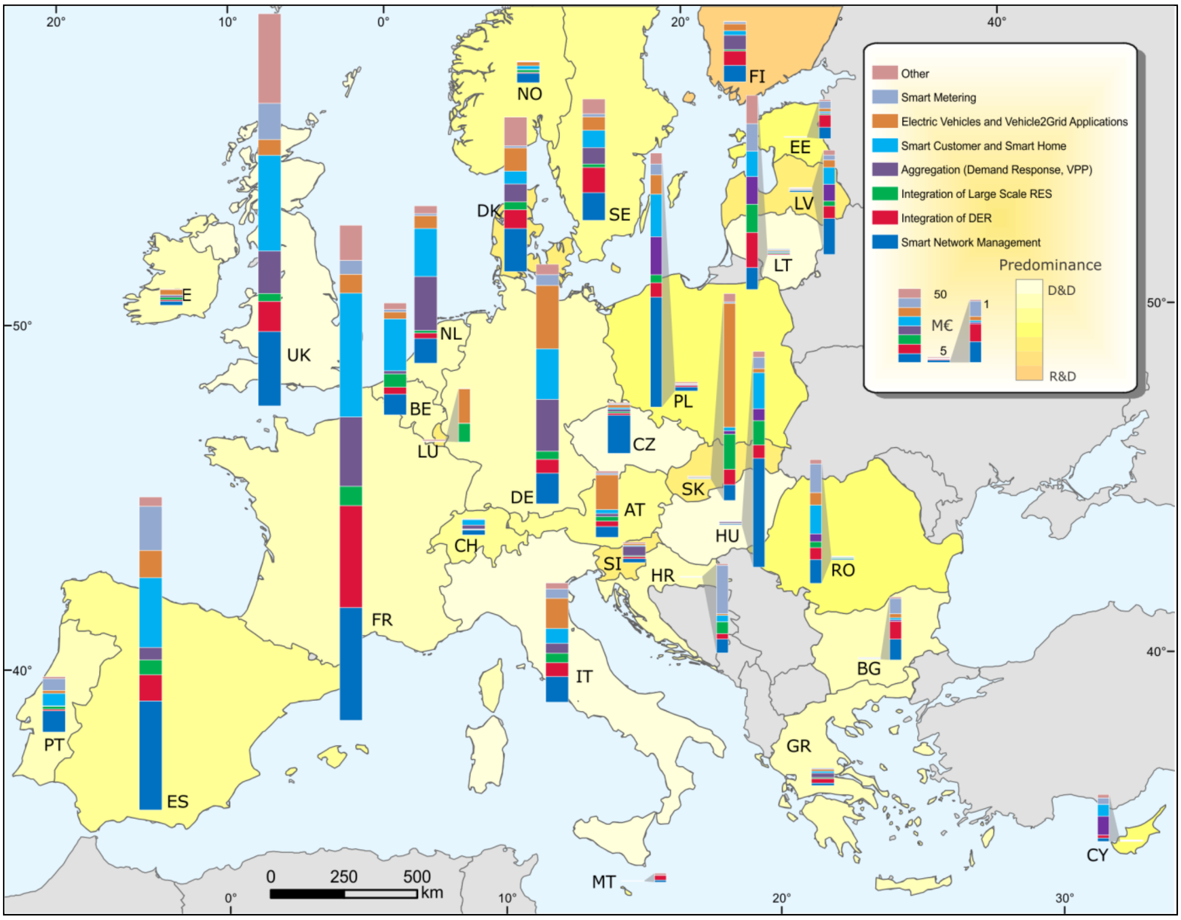


Figure A.53 Private budget per smart grid application and country

MULTINATIONAL COLLABORATION

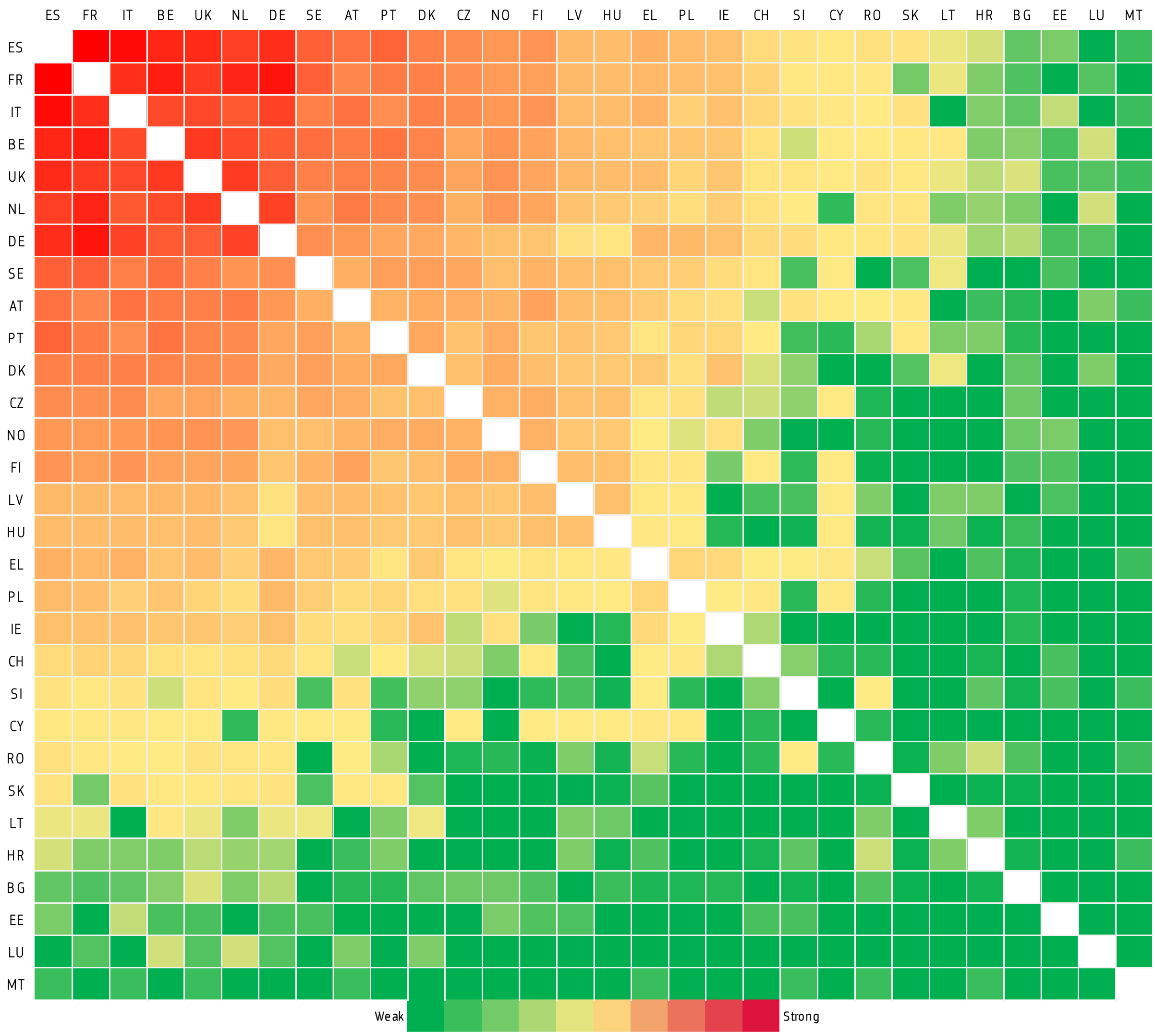


Figure A.54 Collaboration links in European multinational projects (weighted by private project budget): heat map representation

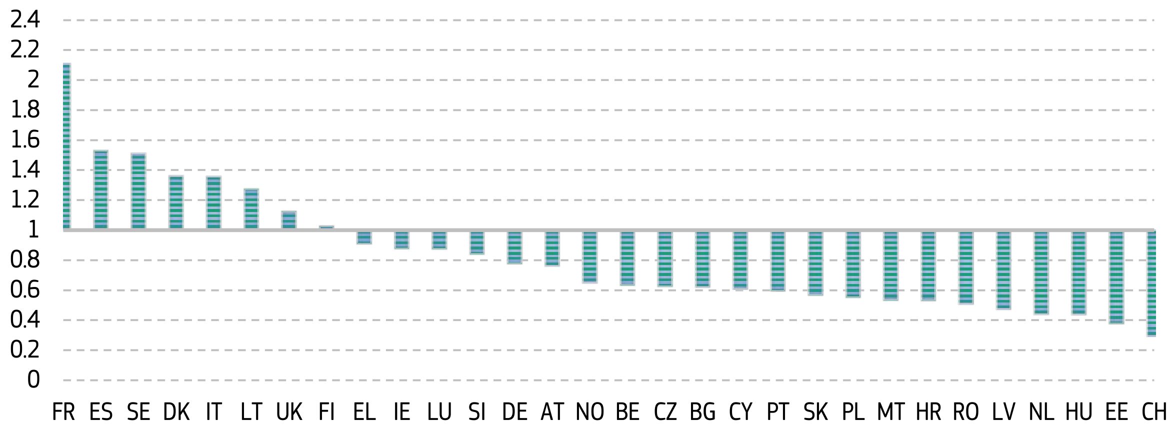


Figure A.55 "Give-Take" ratio in the multinational projects budget (private budget)

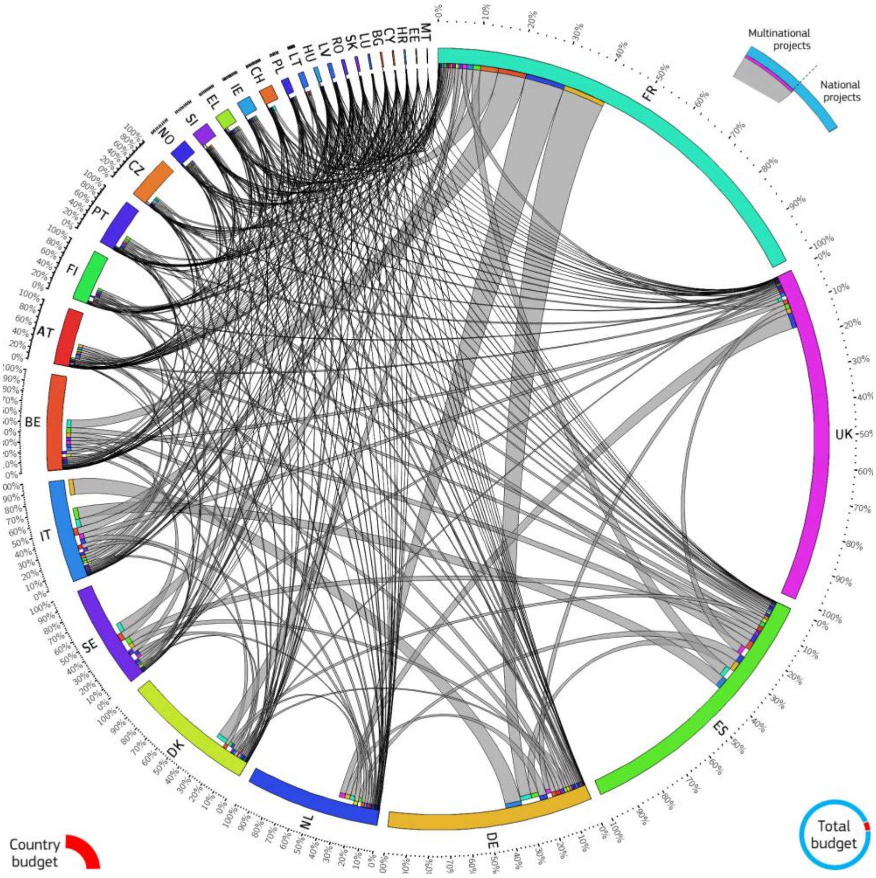


Figure A.56 Collaboration links in European multinational projects (weighted by private project budget)

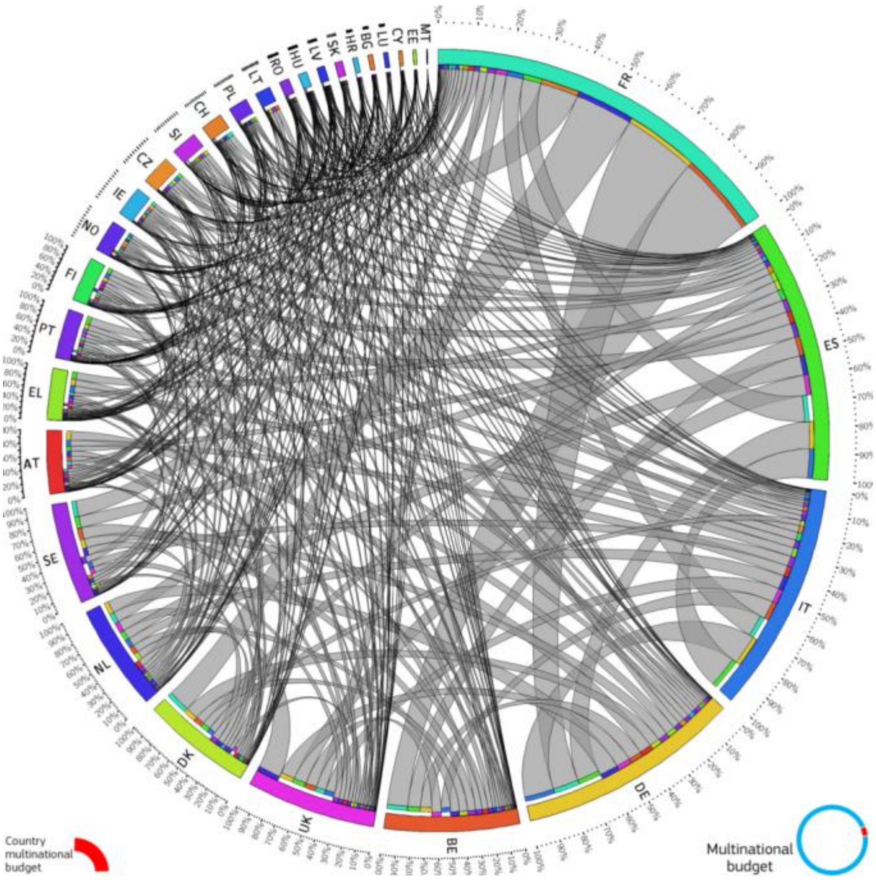


Figure A.57 Collaboration links in European multinational projects (weighted by total project budget): multinational budget

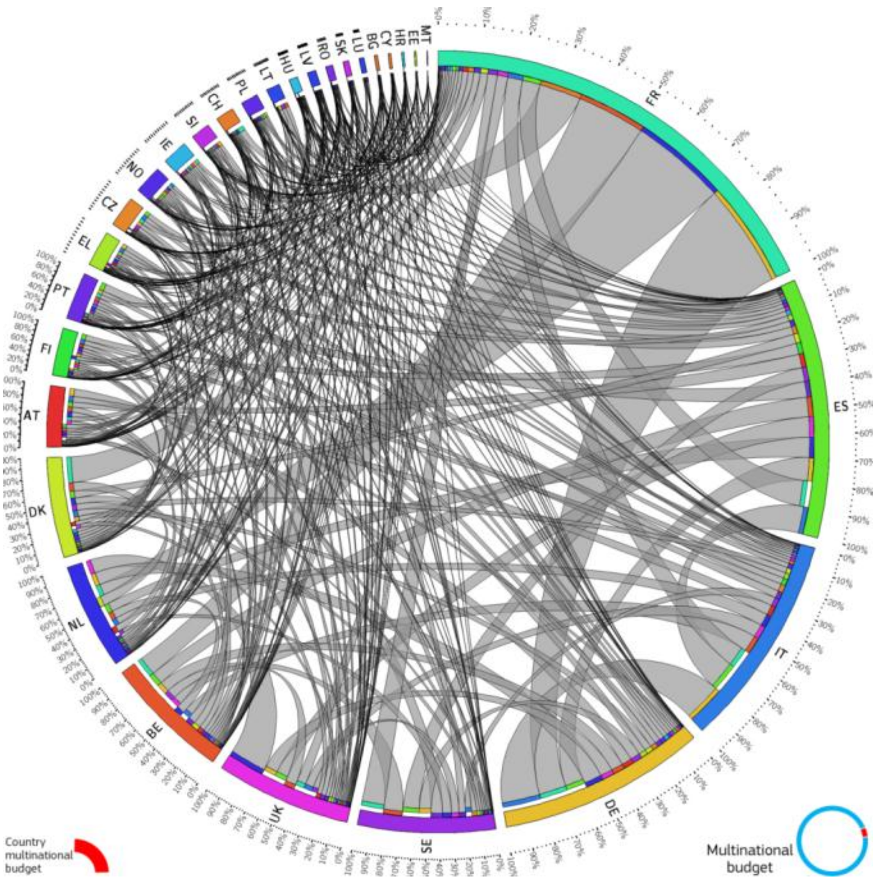


Figure A.58 Collaboration links in European multinational projects (weighted by private project budget): multinational budget

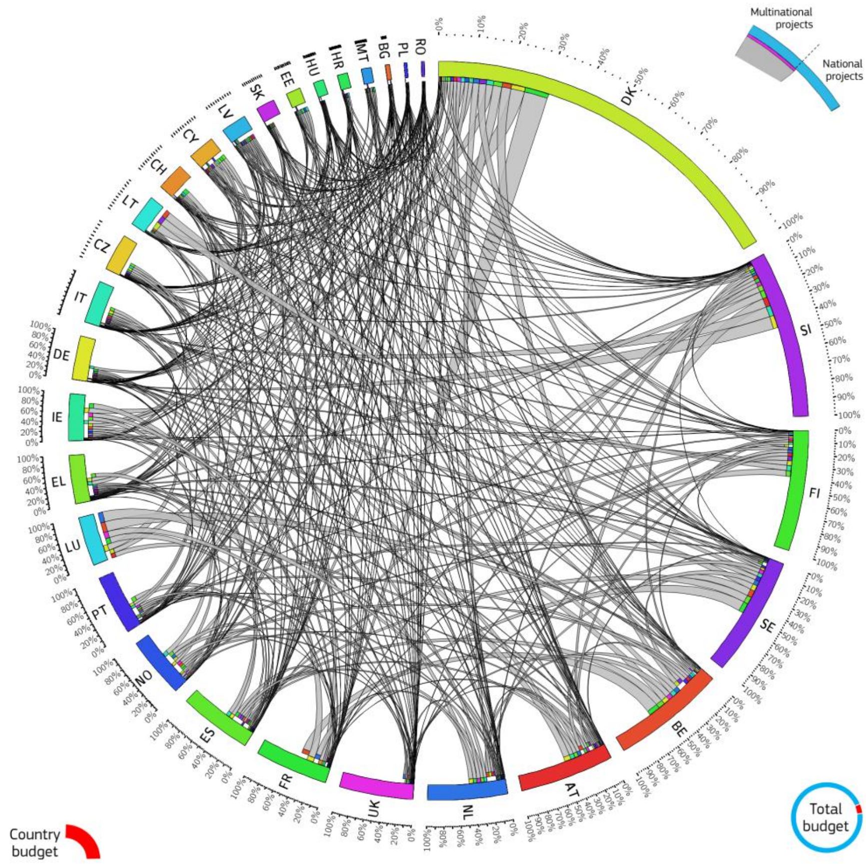


Figure A.59 Collaboration links in European multinational projects (weighted by total project budget): normalised with the country population

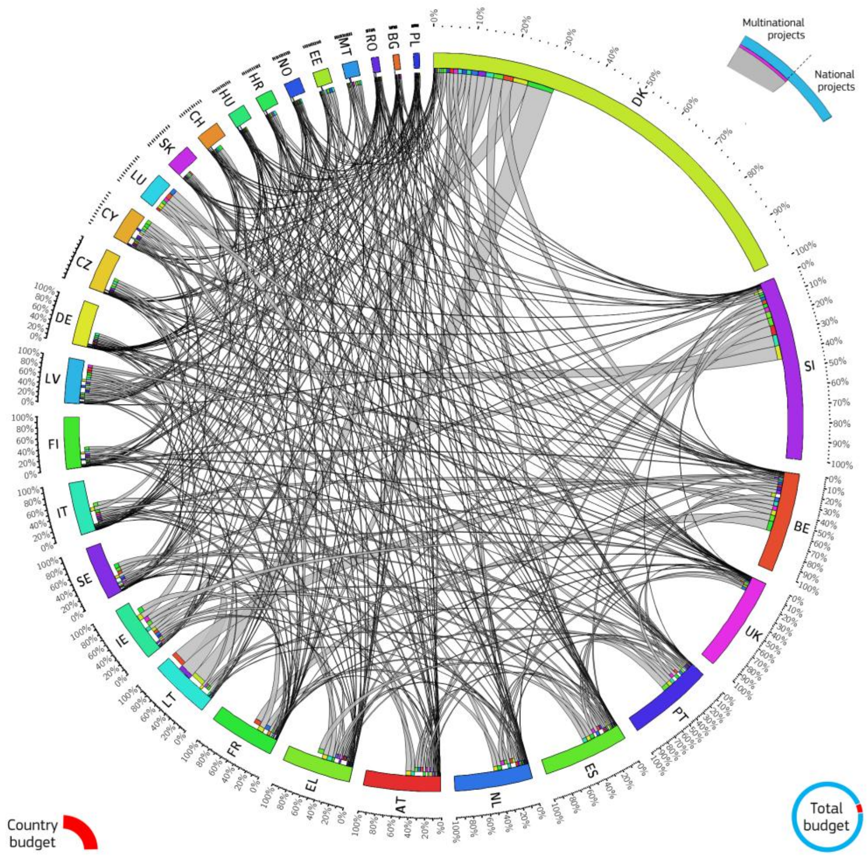


Figure A.60 Collaboration links in European multinational projects (weighted by total project budget): normalised with the country energy consumption

ANNEX II. JRC-IET QUESTIONNAIRE[66]

No.	Question	Options (*) required field	
1	Project name *		
2	Start date *		
3	End date *		
4	Project website		
5	Contact person/organisation name *		
6	Contact person/organisation e-mail *		
7	Contact person tel. number		
8	Prevailing stage of development *	Research & Development Demonstration Deployment	
9	Brief project description. Specifying goals and main areas of innovation. *		
10	Countries involved *	Austria Belgium Bulgaria Croatia Cyprus Czech Republic Denmark Estonia Finland France Germany Greece Hungary Italy Latvia Lithuania	Luxembourg Malta Netherlands Poland Portugal Republic of Ireland Romania Slovakia Slovenia Spain Sweden United Kingdom Norway* Switzerland* Other: Please specify
11	Main project results and outcomes		
12	Main obstacles/challenges and lessons learned		
ORGANISATIONS Organisations: Please provide detailed addresses. Based on these your project will be placed on our map (http://ses.jrc.ec.europa.eu/project-maps).			
13	Leading organisation name (1) *		
14	Leading organisation address *		
15	Leading organisation type *	▪ Distribution System Operator ▪ Transmission System Operator ▪ University/Research centre/Consultancy ▪ Generation company ▪ Manufacturer ▪ Utility/Energy company ▪ IT-Telecom ▪ Aggregator	

[66] ses.jrc.ec.europa.eu

		▪ Energy retailer ▪ Engineering company ▪ Other (municipalities/ public authorities, associations etc.)
16	Leading organisation name (2)	
17	Leading organisation address	
18	Leading organisation type	See question 15
19	Other leaders	See question 15
20	Other organisation name (1)	
21	Organisation address	
22	Organisation type	See question 15
23	Other organisation name (2)	
24	Organisation address	
25	Organisation type	See question 15
26	Other organisation name (3)	
27	Organisation address	
28	Organisation type	See question 15
29	Other organisation name (4)	
30	Organisation address	
31	Organisation type	See question 15
32	Other organisation name (5)	
33	Organisation address	
34	Organisation type	See question 15
35	Other organisation name (6)	
36	Organisation address	
37	Organisation type	See question 15
38	Other organisation name (7)	
39	Organisation address	
40	Organisation type	See question 15
41	Other organisations	See question 15
IMPLEMENTATION SITES		
42	Implementation site address (1)	
43	Implementation site address (2)	
44	Implementation site address (3)	
45	Other implementation sites	
TECHNICAL PARAMETERS		
46	Project main application *	▪ Smart Network Management ▪ Integration of DER ▪ Integration of large scale RES ▪ Aggregation (Demand Response, VPP) ▪ Smart Customer and Smart Home ▪ Electric Vehicles and Vehicle2Grid applications ▪ Smart Metering ▪ Other: Please specify
47	Other information about the project	
48	Voltage level (kV)	
49	Number of users involved in the project	▪ Producers ▪ Consumers ▪ Prosumers
50	Aggregated users	
51	Number of electric vehicles	
52	Charging stations	
53	Number of smart meters	

54	Other (please specify)	
FINANCIAL INFORMATION		
55	Total budget [million Euro] *	THIS INFORMATION WILL BE CONFIDENTIAL
56	Regulatory funding [million Euro]	THIS INFORMATION WILL BE CONFIDENTIAL
57	National funding [million Euro]	THIS INFORMATION WILL BE CONFIDENTIAL
58	European Commission funding [million Euro]	THIS INFORMATION WILL BE CONFIDENTIAL
59	Own resources/private capitals [million Euro]	THIS INFORMATION WILL BE CONFIDENTIAL
60	Funding program details	THIS INFORMATION WILL BE CONFIDENTIAL
61	Funding body	
62	Estimated project benefits	▪ Energy savings ▪ Reduced energy technical and non technical losses ▪ Reduced operational and maintenance costs ▪ Reduced outages ▪ Deferred investments (transmission, distribution, generation) ▪ Reduced system management costs (ancillary service costs, congestion management costs etc.)
63	Other project benefits	
SMART GRID AREAS OF FOCUS AND DEPLOYED TECHNOLOGIES		
64	Power technologies	▪ Demonstration of power technologies for more network flexibility ▪ Demonstration of power technologies for power architecture ▪ Demonstration of renewable integration
65	Network management and control	▪ Tools for pan EU network observability ▪ Innovative tools for coordinated operation ▪ Improved training tools for improved coordination ▪ Innovative tools for pan EU network reliability assessment
66	Market rules - market simulation techniques to develop a single EU el market	▪ Tools for renewable market integration ▪ Tools to study market integration of active demand
67	Coordination between T&D	▪ Tools for improved system observability and network interactions ▪ Integration of DSM in TSO operation ▪ Ancillary services by DSOs ▪ Improved defence and restoration plans ▪ Joint task force on IT system protocol and standards
68	Smart Customers	▪ Active demand response ▪ Energy efficiency from integration with Smart Homes
69	Smart energy management	▪ Smart metering infrastructure ▪ Smart metering data processing
70	Smart Integration	▪ DER hosting capacity of low voltage networks - Integration of small renewable in the distribution network ▪ DER hosting capacity of medium voltage networks - System Integration of medium size renewables in the distribution network ▪ Integration of storage in distribution networks (medium and low voltage level) - Integration of storage in network management ▪ Integration of electric vehicles (EV) and plug in hybrid electric vehicles (PHEV) in distribution networks (medium and low voltage level) - Infrastructure to host electric vehicles
71	Distribution Network	▪ Monitoring and control of low voltage networks - Integration of automation and local power production in the LV

		distribution network ▪ Automation and control of medium voltage networks - Integration of advanced automation solution with local power production and two-way of power flow in the MV distribution network ▪ Integration of Methods and system support (medium and low voltage level) - Integration of state estimation. Maintenance. Planning and asset management in network management ▪ Integration of Integrated communication solutions in distribution networks - Widespread communication solutions. Standardized
72	Other smart grid areas of focus and deployed technologies	
CONSUMER ENGAGEMENT		
73	Is consumer involvement/acceptance of smart grid technology one of the main project focuses? *	
74	Target Sector	▪ commercial ▪ residential ▪ industrial ▪ public services ▪ no target ▪ Other: Please specify
75	Which aspect(s) was (were) mainly addressed to involve the consumer?	▪ collection of information on consumers (e.g.: consumption patterns, consumer needs, consumer segments, etc.) ▪ provision of information to consumers (e.g.: new technologies, energy consumption) ▪ use of behavioral change strategies ▪ Other: Please specify
76	Please provide examples	
77	Did the project investigated/used strategies to change consumer behaviors?	
78	Did the project assessed consumers behavioral change or consumer satisfaction?	
79	If yes, how? What were the main results?	
81	Motivational factors used to engage consumer	▪ energy savings (reduction of electricity bill) ▪ control over own energy use ▪ environmental motivation ▪ better comfort ▪ Other: Please specify
81	How do you rate the participation of the consumers involved in your project?	▪ very poor ▪ poor ▪ fair ▪ good ▪ very good
82	Has the project faced consumer acceptance issues?	
83	If yes, please specify	▪ lack of awareness/education ▪ misconception and erroneous beliefs ▪ data privacy and security

	▪ health concerns ▪ poor relations with providers ▪ trust and transparency issues ▪ Other: Please specify
SMART METERING	
84	Do the smart-meters provide readings directly to the consumer and any third party designated by the consumer?
85	If yes, Which type of interface/communication protocol is adopted to provide the readings (e.g. web portal)?
86	What is the average update frequency of the readings? Refreshment rate?
87	Do the smart-meters allow the remote reading by the operators?
88	Does the architecture implemented provide two-way communication between the smart metering system and external networks?
89	Is the remote on/off control of the supply and/or flow or power limitation implemented?
90	Are the smart-meters communication channels protected against cyber-attacks, and, if yes, how?
91	Is the privacy of the consumer taken into account and if yes which measures have been implemented to protect it?
92	Are the smart-meters compliant with some cyber-security standard?
93	Which techniques have been implemented to avoid the unauthorized access to the smart-meter and to the consumer data?
95	Comments

ANNEX III. PROJECT CATALOGUE

Project name	Period	Stage of development	Participants	Participating countries	Smart Network Management	Integration of DER	Integration of large scale RES	Aggregation	Smart Customer & Smart Home	Electric Vehicles	Smart Metering	Other
0.4 kV remote control	2011-2013	D&D	1	UK	x							
220 kV SSSC device for power flow control	2009-2014	D&D	1	ES	x							
3002 EDISON	2009-2011	R&D	1	DK						x		
3e-Houses	2010-2013	D&D	12	BG, DE, ES, UK					x			
A complete and normalized 61850 substation	2009-2015	D&D	1	ES	x							
A2A Reti Elettriche	2011-2014	D&D	3	IT	x	x						
Acea Distribuzione Smart Grid Pilot Project	2011-2013	D&D	1	IT	x		x			x		
Activation of 200 MW refuse-generated CHP upward regulation effect	2009-2010	R&D	1	DK		x						
ADDRESS	2008-2013	R&D	24	BE, CH, DE, ES, FI, FR, IT, NL, SE, UK				x				
ADELE	2009-2013	D&D	1	DE		x						
ADINE	2007-2010	R&D	8	DE, FI, SE		x						
ADVANCED	2012-2014	R&D	13	DE, ES, FI, FR, IT, NL				x	x			
AFFICHECO	2009-2013	D&D	14	FR					x			
AFTER	2011-2014	R&D	12	BE, CZ, DE, FR, IE, IT, NL, NO, UK	x							
Agent based control of power systems	2006-2010	R&D	1	DK								x
Almacena	2009-2013	D&D	1	ES		x						
AlpStore	2012-2014	D&D	28	AT, CH, DE, FR, IT, LI, SI								x
Alterenergy	2011-2015	D&D	21	AL, BA, EL, HR, IT, ME, RS, SI			x					
AMADEOS	2013-2016	R&D	5	AT, FR, IT, NL								x
Application of smart grid in photovoltaic power systems	2011-2014	R&D	1	DK	x							
ARC	2013-2016	D&D	5	UK	x		x	x				
Arrowhead	2013-2017	D&D	77	AT, BE, CZ, DK, ES, FI, FR, HU, IT, LV, NL, NO, PT, SE, UK	x	x	x	x	x	x	x	
Ashton Hayes Smart Village	2011-2013	D&D	1	UK	x	x	x	x	x	x		
ASM Terni	2011-2014	D&D	1	IT	x	x						
Assem San Severino Marche	2011-2014	D&D	1	IT	x	x						
ASSM Tolentino	2011-2014	D&D	1	IT		x						
Automatic receipt of short circuiting indicators	2009-2010	D&D	1	DK	x							
Automation and security of Supply	2010-n/a	D&D	1	UK	x							
Automation systems for Demand Response	2006-2009	D&D	1	DK				x	x			

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B.R.I.S.T.O.L.	2011-2015	D&D	1	UK		x		x				
B2G	2010-2012	D&D	1	AT					x			
BEAMS	2011-2014	D&D	8	DE, EL, ES, IT	x		x			x		
BeAware	2010-2013	R&D	7	FI, IT, SE					x			
BED	2008-2010	D&D	1	AT					x			
BeMobility 2.0	2011-2015	D&D	2	DE						x		
BESOS	2013-2016	D&D	11	DE, EL, ES, PT		x			x			
BeyWatch	2008-2011	R&D	7	EL, ES, FR, IT, SI, UK					x			
Bidelek	2011-2016	D&D	2	ES	x				x		x	
BPES	2012-2015	R&D	3	CH, DK, NO	x		x	x				
BUILDNET	2012-2017	R&D	1	CH								x
C2C	2012-2014	D&D	1	UK	x			x				
C2G	2010-2012	D&D	1	AT					x			
C-DAX	2012-2015	R&D	8	BE, CH, DE, FR, NL, SE, UK	x	x						
Charge stands	2010-n/a	D&D	1	DK						x		
Charging Infrastructure for Electric Vehicles	2008-2010	D&D	1	SE						x		
CHPCOM	2013-2016	R&D	10	DK	x	x		x				x
CIPOWER	2011-2013	R&D	17	BE, DE, ES, FR, PL, PT, SE	x							x
CITINES	2011-2014	D&D	12	AT, FR, IT, PT, TR	x							
CIVIS	2013-2016	D&D	13	DE, FI, IT, NL, PT, SE, UK		x			x			
CLASS	2013-2015	D&D	1	UK	x							
Clyde Gateway	2010-2015	R&D	1	UK	x							
Concept for Management of the Future Electricity System	2009-2011	R&D	1	DK								x
Consumer acceptance of intelligent charging	2012-2015	R&D	1	DK						x		
Consumer web	2010-2011	D&D	1	DK					x			
Context Aware Electric Vehicle Charging Based on Real Time Energy Prices	2011-2012	R&D	1	UK					x	x		
Control and regulation of modern distribution system	2006-2010	R&D	1	DK				x				
COOPERaTE	2012-2015	D&D	8	DE, FR, IE, UK	x		x		x	x		x
COSSMIC	2013-2016	D&D	10	DE, IT, NL, NO	x				x			
CRISP	2003-2006	R&D	5	FR, NL, SE	x	x						
Cryogenic Storage	2010-2011	D&D	1	UK								x
CSGriP	2013-2016	D&D	11	NL	x	x				x		x
Customer Led Network Revolution	2011-2013	D&D	1	UK					x			

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Customer Value Proposition Smart Grid (KEL)	2008-2012	D&D	1	SE					x			
DA	2007-2010	D&D	1	NL	x							
Data Exchange	2010-2011	R&D	1	UK								x
DataHub	2009-2012	R&D	1	DK								x
DCN4TSO	2004-2013	D&D	1	SI								x
Decentralized customer-level under frequency load shedding in Switzerland	2010-2012	R&D	1	CH				x				
DECOS	2012-2014	R&D	1	IT							x	
DEHEMS	2008-2011	D&D	17	BE, BG, RO, UK	x				x			
Demand response medium sized industry consumers	2009-2011	R&D	1	DK				x				
DER-IREC 22@Microgrid	2009-2011	R&D	6	ES		x						
DESI	2011-2013	R&D	1	DE				x				
Deval PS Villeneuve	2011-2014	D&D	1	IT	x	x						
Development of a Secure, Economic and Environmentally friendly Modern Power System	2010-2014	R&D	1	DK						x		
Development of Early Warning Systems	2006-2012	R&D	1	DK	x							
DeVID	2012-2014	D&D	31	NO	x							
DG Demonet - Smart LV Grid	2011-2014	D&D	11	AT	x	x				x		
DG DemoNet Validation	2006-2013	D&D	10	AT	x	x						
DIMMER	2013-2016	D&D	12	DE, IT, SE, UK	x							
DISCERN	2013-2016	D&D	17	DE, ES, NL, SE, UK	x	x	x	x	x		x	
DISPOWER	2002-2005	R&D	37	AT, BE, DE, DK, EL, ES, FR, IT, NL, PL, UK		x						
Distributed Connected Wind-farms	2010-2012	D&D	1	IE		x						
Distribution System planning for Smart Grids	2011-2012	R&D	1	DK								x
DLC+VIT4IP	2010-2012	R&D	11	AT, BE, DE, IL, IT, NL, UK								x
DOLFIN	2013-2016	R&D	8	EL, ES, IT, RO, UK				x				
DREAM	2013-2016	D&D	11	CH, DE, EL, ES, FR, IT, NL	x	x		x				
DREAM DK	2012-2013	R&D	1	DK	x			x				
DRIP	2012-2015	R&D	5	DE, ES, NL			x	x				x
Dutch Smart Charging	2010-2011	D&D	1	NL						x		
Dynamic tariffs	2010-2010	R&D	1	DK								x
E+	2012-2016	D&D	11	BE, ES, NL, RO	x		x			x		x
E2SG	2012-2015	D&D	30	AT, BE, DE, ES, IT, NL, PT, SK, UK	x				x	x	x	x

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E3SoHo	2010-2013	D&D	14	BE, ES, FR, IT, PL, PT	x	x			x		x	
eBADGE	2012-2015	D&D	15	AT, DE, FI, IT, SI	x			x				
E-BALANCE	2013-2017	R&D	10	DE, ES, NL, PL, PT	x							
eCar	2009-2012	D&D	1	NO						x		
ECHO-SAG	2013-2014	D&D	1	NL					x			
ECOFFICES	2011-2011	D&D	1	FR					x			
EcoGrid Denmark	2007-2009	R&D	1	DK								x
EcoGrid EU	2011-2014	D&D	1	DK				x				
ECO-LIFE	2010-2015	D&D	27	BE, DK, LT, SE		x	x		x	x	x	
EcoLink	2010-2014	D&D	8	BE, FR	x							
econnect Germany	2012-2014	D&D	26	DE						x		
e-DASH	2011-2014	R&D	13	DE, DK, ES, FR, IT, SK	x					x		
E-DeMa	2009-2014	D&D	2	DE				x	x			
EDGE	2012-2016	R&D	1	DK	x		x					
eDIANA	2009-2012	D&D	26	AT, ES, FI, IT, NL	x				x			
EDISON	2012-2014	D&D	20	BE, EL, IT, RO, UK		x			x		x	x
EDRP	2007-2011	D&D	1	UK					x		X	
EEPOS	2012-2015	R&D	10	AT, DE, ES, FI	x				x		x	
eFlex	2010-2011	R&D	1	DK					x			
e-GOTHAM	2012-2015	D&D	19	EE, ES, FI, IT, NO	x	x	x	x	x	x	x	
Eguise	2013-2016	R&D	8	FR						x		
E-Harbours Electric	2010-2013	D&D	14	BE, DE, NL, SE, UK	x	x			x	x		
e-Highway2050	2012-2015	R&D	27	BE, CH, CZ, DE, ES, FR, IT, NL, NO, PL, PT, UK	x							
ELECTRA	2013-2017	R&D	20	AT, BE, DE, DK, EL, ES, FI, FR, IT, LV, NL, NO, PL, PT, TR, UK	x							
Electric Vehicle Integration	2009-2013	R&D	1	IE						x		
Electrical vehicles impacts on the grids	2010-2011	R&D	1	BE	x					x		
Electricity demand as frequency controlled reserves	2006-2008	R&D	1	DK				x				
Electricity demand as frequency controlled reserves 2	2009-2012	R&D	1	DK	x			x				
Electricity for road transport, flexible power systems and wind power	2008-2011	R&D	1	DK						x		
Electricity storage for short term power system service	2010-2010	R&D	1	DK		x						
Elforsk Smart grid programme	2011-2014	R&D	1	SE								x
E-Mobile Power Austria	2010-2014	D&D	3	AT						x		

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E-mobility Hungary	2011-2011	D&D	1	HU						x		
E-mobility Italy	2008-2013	D&D	5	DE, IT						x		
E-Mobility NSR	2011-2014	R&D	10	BE, DE, DK, NL, NO, SE, UK						x		
Encourage	2011-2014	D&D	13	DK, ES, IE, IT, PT	x	x			x		x	x
ENDORSE	2011-2012	R&D	9	BE, DE, FR, IT	x							
ENER - SUPPLY	2009-2012	R&D	12	AL, BA, BG, EL, HR, HU, IT, MK, RO, RS, SK	x		x					
ENER-G CHP	2012-2013	D&D	9	UK				x				x
EnergeTIC	2010-2013	R&D	6	FR	x							
ENERGOS	2009-2012	D&D	23	ES	x							
ENERGOZ	2010-2013	R&D	1	SK								x
Energy Forecast	2007-2010	R&D	1	DK					x			
Energy Positive IT 2.0	2011-2015	R&D	15	FR		x		x	x			
Energy@home	2009-2013	R&D	2	IT					x			
Energy@home 2.0	2012-2015	D&D	5	IT					x			
EnergyTIC	2011-2014	D&D	16	BE, ES, FR, UK	x						x	
ENERsip	2010-2012	R&D	9	BE, CZ, ES, IL, PT	x							
EnR-Pool	2012-2015	D&D	1	FR			x	x				
EnVision 2020	2012-2014	R&D	9	BG, DE, EL, HR, IT, RO, SI			x					x
EPIC-HUB	2012-2016	D&D	13	CH, CZ, ES, IL, IT, RS		x		x	x		x	
E-price	2010-2013	R&D	9	CH, HR, IT, NL				x				
eSESH	2010-2013	D&D	44	AT, BE, DE, ES, FR, IT				x	x		x	
ESTER	2009-2013	D&D	1	IT		x						
ESWA	2012-2014	R&D	1	DK				x				
Eta: Creating Efficient Distribution Networks	2014-2017	D&D	6	UK								x
E-telligence	2009-2013	D&D	1	DE	x				x			
ETM	2009-2013	D&D	1	HU	x							
EVCOM	2008-2010	R&D	1	DK						x		
EU-DEEP	2004-2009	R&D	44	AT, BE, CY, CZ, DE, EL, ES, FI, FR, HU, IT, LV, PL, SE, TR, UK		x		x				
EVELINA	2011-2015	D&D	21	FI						x		
Evergreen	2010-2013	D&D	3	DK						x		
EVOLVDSO	2013-2016	R&D	15	AT, BE, DE, DK, FR, IE, IT, PT	x							
ewz-Studie Smart Metering	2010-2012	D&D	1	CH					x			

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EWIS	2007-2009	R&D	16	AT, BE, CZ, DE, DK, EL, ES, FR, IE, NL, PL, PT, UK			x					
FALCON	2011-2015	D&D	1	UK	x							
Fenix	2005-2009	R&D	19	AT, DE, ES, FR, NL, RO, SI, UK		x		x				
FINESCE	2013-2015	D&D	30	CZ, DE, DK, EL, ES, FR, IE, IT, PL, SE, UK				x				
FINSENY	2011-2013	R&D	32	BE, CH, DE, DK, EL, ES, FI, FR, IE, IT, PL, SE	x	x	x	x	x	x		x
FlexCom	2008-2010	R&D	1	DK								x
FLEXGRID	2012-2016	D&D	1	UK	x							
Flexible	-2008	R&D	2	NL		x						
Flexible networks for a Low Carbon Future	2012-2015	D&D	1	UK	x							
Flexible Urban Network – Low Voltage	2014-2016	D&D	3	UK								x
FlexLast	2012-2013	D&D	2	CH				x				
FlexPower	2010-2013	R&D	6	DK		x		x				
FPP	2012-2014	D&D	1	UK	x		x					
From wind power to heat pumps	2009-2011	D&D	1	DK				x				
G(E)OGREEN	2010-2012	R&D	6	AT, BE, CH, ES		x						
G4V	2010-2011	R&D	11	DE, ES, FR, IT, NL, PT, SE, UK						x		
GAD	2007-2010	R&D	1	ES					x			
GARPUR	2013-2017	D&D	27	BE, BG, CZ, DE, DK, FI, FR, IL, IS, NL, NO, UK	x							
GAVE	2010-2012	D&D	1	AT, DE				x				
Generic virtual power plant for optimized micro CHP operation and integration	2007-2010	R&D	1	DK				x				
Grasp	2013-2015	R&D	11	AL, CY, EL, ES, FR, IT, MK, MT					x			
GREAT	2012-2015	R&D	7	BE, IE, NL, UK	x							
GREDOR	2013-2017	R&D	6	BE	x		x					
Green eMotion	2011-2015	D&D	59	AT, BE, DE, DK, EL, ES, FR, HU, IE, IT, NL, SE, UK						x		
GREENCOM	2012-2015	D&D	7	DE, DK, ES, IE, IT	x							
GREENDATANET	2013-2016	R&D	6	CH, FR, IT, NL	x							
Greening European Transportation Infrastructure for Electric Vehicles	2010-2012	D&D	11	AT, BE, DK, LU, NL						x		
Greenlys	2012-2016	D&D	2	FR	x	x			x			
Grid Integration of Offshore Windparks	2008-2011	R&D	1	DE			x					
Grid4EU	2011-2016	D&D	11	CZ, DE, ES, FR, IT, SE	x	x	x	x	x	x	X	x
Grid-integration of Electricity Storage	2009-2011	R&D	1	DE		x						

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GridSurfer	2009-2011	R&D	2	DE						x		
GRIDTEAMS	2010-2012	D&D	1	FR					x			
GROW-DERS	2009-2011	D&D	12	CY, DE, ES, FR, NL, PL		x						
HARMONY	2013-2018	R&D	2	DK	x	x						
Harz.EE-Mobility	2009-2011	D&D	3	DE						x		
HEAT 07	2007-2008	D&D	1	FI					x			
Heat Pumps as an active tool in the energy supply system	2010-2012	R&D	1	DK		x						
HEMS	2011-2012	D&D	1	FI					x			
HiperDNO	2010-2013	R&D	10	DE, ES, FR, IL, SI, UK								x
HiT	2011-2013	D&D	1	AT					x			
Hook Norton	2011-n/a	D&D	6	UK					x		x	
Hybrid Energy project of Ikaria: Energy Sustainable island for real life community	2007-2012	D&D	1	EL	x	x						
Hydro Active Network Management	2012-2014	R&D	1	UK	x	x						
I2EV	2013-2015	D&D	7	UK				x				
I3RES	2012-2015	R&D	7	EE, ES, IT, NO	x		x					
ICE-WISH	2011-2014	D&D	28	BE, BG, DE, DK, EL, ES, FR, IT, NL, PL, UK	x				x		x	
ICOEUR	2009-2011	R&D	21	BE, CH, DE, EE, IT, LV, RU, SE, SI, TR, UK	x							
ICT 4 EVEU	2012-2014	D&D	22	AT, ES, SI, UK						x		
ICT Smart Synergy	2010-2012	R&D	1	AT								x
IDE4L	2013-2016	R&D	10	DE, DK, ES, FI, IT, SE	x							
i-EM	2012-2014	R&D	1	IT	x						x	
IGREENGrid	2013-2015	R&D	14	AT, DE, EL, ES, FR, IT		x						
IHSMAG	2012-2014	R&D	3	DK, ES, NO					x			
IMPONET	2010-2012	R&D	13	ES, KR, SI, TR	x							
IMPROSUME	2010-2011	R&D	2	CH, DK, NO					x			
INCAP	2012-2016	R&D	1	DK					x			
INCREASE	2013-2016	R&D	13	AT, BE, EL, NL, SI	x							
Increased energy supply flexibility and efficiency by using decentralised heat pumps in CHP stations	2007-2010	D&D	30	DK		x						
INERTIA	2012-2015	R&D	9	EL, ES, IT, NL, SE, SK		x		x	x			
Information and education of the future power consumer	2011-2014	R&D	1	DK					x			
Information from the electricity grid - remote reading	2010-n/a	D&D	1	UK					x			

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INGRID	2012-2016	D&D	7	BE, ES, FR, IT	x	x	x					
INNERS	2010-2014	R&D	10	BE, DE, FR, LU, NL, UK								x
InovGrid	2008-2013	D&D	6	PT	x				x		X	
INSTINCT	2012-2014	R&D	9	BE, FR, SE	x				x			x
IntegrA	2013-2015	R&D	5	AT, DE	x							
INTEGRAL	2009-2011	D&D	11	EL, ES, FR, NL, SE				x				
Integration and management of wind power in the Danish electricity system	2007-2009	R&D	1	DK			x					
INTEGRIS	2010-2013	R&D	12	CH, ES, FI, FR, IT	x	x						
Intelligent home	2009-2011	R&D	1	DK					x			
Intelligent Remote Control for Heat Pumps	2010-2011	R&D	1	DK		x						
Interactive meters, activating price flexible power consumption	2006-2009	R&D	1	DK					x			
INTREPID	2012-2015	D&D	8	CZ, DK, ES, IT, SI	x				x			
Introduction of emergency Demand Side Response (DSR) programs	2011-2012	D&D	1	PL				x				
IoE	2011-2014	R&D	42	AT, BE, CZ, DE, ES, FI, FR, IT, NL, NO, UK						x		
iPower	2011-2016	R&D	1	DK	x	x		x	x			
IRENE	2012-2014	D&D	4	DE	x					x		
IRIN	2009-2011	R&D	1	DE								x
i-sare	2014-2019	R&D	2	ES	x	x				x		
Isernia	2011-2014	D&D	1	IT	x	x						
ISOLVES: PSSA-M	2009-2012	D&D	1	AT	x	x					x	
IssyGrid	2011-2016	D&D	10	FR	x	x			x	x		
iTESLA	2012-2015	R&D	19	BE, DK, EL, ES, FR, IT, NO, PT, SE, UK	x							
ITM	2008-2010	R&D	1	NL				x		x		
iZEUS	2012-2014	D&D	11	DE						x		
Jouw Energie Moment A	2011-2014	D&D	3	NL				x				
Jouw Energie Moment B	2012-2015	D&D	7	DK, NL				x				
KC-SURE	2011-2014	D&D	1	SI				x				
Kybernet	2009-2011	R&D	1	SI	x							
Large-scale demonstration of charging of electric vehicles	2011-2013	R&D	1	DK						x		
LASTBEG	2009-2009	D&D	7	DE, ES, FR, HU, LT, UK				x				
Lincolnshire Low Carbon Hub	2011-2014	D&D	1	UK		x						
Linear	2011-2014	D&D	1	BE					x			

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Load Management for commercial consumers	2012-2013	R&D	1	AT, DE				x				
LOKSMART - Lokale smart grids JETZT	2012-2015	R&D	4	DE						x		
Low Carbon London	2011-2014	D&D	1	UK				x	x	x	X	
LV Network Templates	2011-2013	D&D	1	UK	x							
M2RES	2011-2014	D&D	14	AL, AT, BG, EL, HU, IT, ME, RO, RS, SI			x					
Manage Smart in SmartGrid	2010-2012	R&D	1	NO					x			
MANERGY	2011-2014	R&D	5	AT, DE, HU, IT, PL, SI								x
Marine Power Distribution Hub	2011-2012	R&D	1	DK	x							
Market Based Demand Response	2005-2008	D&D	1	NO				x				
MeRegio	2008-2012	D&D	1	DE				x	x		X	
MERGE	2010-2011	R&D	15	BE, DE, EL, ES, IE, NO, PT, UK						x		
MetaPV	2009-2014	D&D	7	AT, BE, DE, SI	x	x	x					
Meter-ON	2012-2014	R&D	4	AT, BE, ES, IT							x	
MIETeC Montdidier	2013-2016	D&D	4	FR					x			
Milano Wi-Power	2009-2010	D&D	7	IT				x				x
MILLENER	2012-2016	D&D	3	FR		x			x			
Mini E-Berlin powered by Vattenfall	2008-2010	D&D	2	DE						x		
MIRABEL	2010-2013	R&D	8	DE, DK, EL, FR, NL, SI				x				
Mirubee	2012-2014	D&D	1	ES	x						x	
MOBI.Europe	2012-2014	D&D	15	ES, FR, IE, NL, PT						x		
Mobile Smart Grid	2010-2011	D&D	1	NL						x		
Mobility 2.0	2012-2015	D&D	11	DE, EL, ES, FR, HU, IT, NL						x		
MOBINCITY	2012-2015	D&D	14	DE, ES, HR, IT, SI						x		
Model City Manheim	2008-2012	D&D	1	DE				x	x			
MODELEC	2012-2014	D&D	1	FR					x			
MOLECULES	2012-2014	D&D	11	BE, DE, ES, FR						x		
More Microgrids	2006-2009	D&D	34	CH, DE, DK, EL, ES, FR, IT, MK, NL, PL, PT, SE, UK	x	x						
morePV2Grid	2010-2013	R&D	3	AT	x	x						
MPC	2011-2013	R&D	1	FI					x	x		
MSG	2012-2015	D&D	13	DE, FR		x				x	x	
Multi Terminal Test Environment	2014-2020	D&D	1	UK								x
MYRTE	2009-2015	D&D	3	FR	x	x						

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NEMO	2012-2015	R&D	4	DE, DK, NL						x		
NET-ELAN	2008-2011	R&D	1	DE						x		
Network design and management in a smart city with large deployment of DER	2010-n/a	R&D	1	BE	x							
NextGen	2006-2010	R&D	1	DK								x
Nice Grid	2012-2015	D&D	9	BE, FR	x	x	x	x	x	x	x	
NIGHT WIND	2006-2008	R&D	6	BG, DE, DK, ES, NL			x	x				
NINES	2013-2016	D&D	6	UK	x	x		x	x		x	
NOBEL	2010-2012	D&D	5	DE, EL, ES, SE					YEs		x	
NRG4Cast	2012-2015	D&D	9	DE, EL, IT, SI	x			x				x
NTVV	2012-2017	D&D	1	UK	x	x			x			
Odysseus	2012-2015	R&D	9	ES, FR, IT, NL, UK			x	x	x			x
OiDG	2009-2012	R&D	15	NO		x						
OMERE (GE & IPERD)	2011-2014	R&D	1	FR	x	x						
Open ECOSPhERE	-	R&D	6	DE						x		
Open meter	2009-2011	R&D	17	BE, CH, DE, ES, FR, IT, NL, UK								x
OpenNode	2010-2012	R&D	8	AT, DE, ES, FR, NL, PT	x							
Compressed air energy storage for storage of electricity in the electricity system of the future	2005-2010	R&D	1	DK		x						
OptimaGrid	2011-2013	R&D	6	ES, FR, PT	x							
Optimal Power Network Design and Operation	2011-2015	R&D	1	NO	x							
OPTIMATE	2009-2012	R&D	11	BE, DE, DK, ES, FR, IT, UK		x						
Optimod'Lyon	2012-2015	D&D	12	FR					x			x
OREANIS	2007-2010	R&D	6	AT	x	x		x				x
ORIGIN	2012-2015	D&D	10	DE, ES, IT, PT, UK	x							x
Orkney Smart Grid	2004-2009	D&D	1	UK				x				
P.R.I.M.E.	2011-2014	D&D	1	IT						x		
PEGASE	2008-2012	R&D	23	BA, BE, DE, ES, FR, HR, LT, LV, NL, PT, RO, RU, TR, UK	x							
PLANGRIDEV	2013-2016	D&D	15	AT, BE, CH, DE, ES, FR, IE, IT, PT						x		
Plug n' play koncept for intelligent indeklimastyring	2011-2013	R&D	1	DK					x			
POI	2009-2013	D&D	4	IT	x	x						
POST	2013-2017	R&D	1	FR	x							
POSTES Intelligents	2013-2017	D&D	6	FR	x							x

Project name	Period	Stage of development	Participants	Participating countries	Smart Network Management	Integration of DER	Integration of large scale RES	Aggregation	Smart Customer & Smart Home	Electric Vehicles	Smart Metering	Other
Power pit	2007-2009	R&D	1	DK	x							
PowerLabDK	2012-2015	R&D	1	DK	x							
PowerMatching City 2	2011-2014	D&D	1	NL	x	x		x	x	x	x	
PowerUp	2011-2013	D&D	12	DE, EL, FR, IT, NL, SE, SK						x		
PREMIO	2008-2012	D&D	1	FR		x		x				
PRICE	2011-2014	D&D	1	ES	x				x	x	X	
Price elastic electricity consumption and electricity production in industry	2006-2010	D&D	1	DK					x			
Price elastic electricity consumption as reserve power	2006-2010	R&D	1	DK				x				
Proactive participation of wind in the electricity markets	2009-2010	R&D	1	DK			x					
ProAktivNetz	2011-2013	R&D	1	AT	x	x						
PRO-NET	2011-2014	R&D	3	DK, NO, TR	x							
Prøv1Elbil	2009-2012	R&D	1	DK						x		
PV-Island Bornholm	2010-2012	D&D	1	DK		x						
PV-NET	2013-2015	D&D	9	CY, EL, ES, FR, PT, SI	x						x	
PVNET.dk	2011-2014	R&D	4	DK		x						
QUALITY AND SAFETY	2010-2012	R&D	2	AT, EE, LV								x
READY	2012-2014	R&D	1	DK				x				
REALISEGRID	2008-2011	R&D	19	AT, DE, FR, IT, NL, RU, SI, UK	x							
Real-time demonstration test and evaluation of Bornholm electricity network with high wind power penetration	2009-2012	R&D	1	DK	x							
REFLEXE	2011-2014	D&D	1	FR				x	x			
RegModHarz	2008-2012	R&D	1	DE	x	x		x				
Regulated power	2009-2009	R&D	1	DK		x						
Remote Services for CHP	2009-2010	R&D	1	DK		x						
RENEWIT	2013-2016	D&D	16	DE, ES, IT, NL, UK								x
RE-SEEties	2012-2014	R&D	11	EL, HR, HU, IT, MK, RO, SI, SK					x			
REserviceS	2012-2014	R&D	11	BE, DE, DK, ES, FI, IE		x	x					
RESILIENT	2012-2016	D&D	16	BE, ES, FR, IT, UK		x		x	x			x
RIDER	2011-2014	D&D	12	FR, MC								x
RTTR	2010-2013	D&D	1	UK	x	x						
S2G	2010-2013	D&D	1	CH						x		
SACSe	2008-2010	D&D	1	DK	x							
SAFEWIND	2008-2012	R&D	21	AU, DE, DK, EL, ES, FR, IE, IN, UK			x					

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SAVE	2014-2016	D&D	4	NL, UK								x
SCHEMA	2011-2014	D&D	1	IT	x	x						
SecMobil - Secure eMobility	2012-2014	R&D	5	DE						x		
Second1	2010-2011	R&D	1	DK								x
SEESGEN-ict	2009-2011	R&D	23	AT, BE, DE, DK, EL, ES, FI, FR, IT, NL, NO, PL, RO, SE, UK								x
Self-organising distributed control of a distributed energy system with a high penetration of renewable energy	2007-2010	R&D	1	DK	x							
Service optimization of the distribution network	2009-2010	R&D	1	DK	x							
SGEM	2009-2014	R&D	1	FI	x	x		x				
SGIH	2012-2020	R&D	3	IE	x	x	x	x	x	x		
SGS - Smart Grid Solar	2013-2017	R&D	12	DE	x	x	x	x	x		x	
SINGULAR	2012-2015	D&D	21	CH, CY, EL, ES, IT, PT, RO			x					
Smart and Cool	2011-2014	R&D	4	DK		x	x	x				x
Smart Build	2012-2015	D&D	15	AT, DE, EL, IT, SI	x				x		x	
Smart Cities	2008-2012	D&D	15	BE, DE, NL, NO, SE, UK								x
Smart City Kalundborg	2012-2015	D&D	11	DK, FR	x	x		x	x	x		
Smart city Vienna - Liesing Mitte	2011-2012	D&D	6	AT		x			x	x		
Smart Country Modellregion in Rheinland-Pfalz	2008-2011	D&D	4	DE	x							
Smart Domo Grid	2012-2013	D&D	4	IT	x			x	x	x		
Smart Electric Lyon	2012-2016	D&D	21	DE, FR, NL				x	x			
Smart Electricity de Minalogic	2006-2010	D&D	11	FR					x			x
Smart Energy Collective	2010-2013	D&D	6	NL				x	x			
Smart green circuits	2010-2012	D&D	4	IE	x							
Smart Grid Demonstration System	2010-2011	D&D	1	UK								x
Smart Grid Gotland	2011-2016	D&D	1	SE		x		x				
Smart Grid Hyllie	2012-2015	D&D	3	SE		x			x	x		
Smart Grid in agriculture	2012-2014	R&D	1	DK		x			x			
Smart Grid Pilot for aktiv regulering av spenning og reaktiv effekt i nett med lokal produksjon	2011-2013	D&D	1	NO	x	x						
Smart Grid Prague	2012-2015	D&D	1	CZ	x							
Smart Grid Task Force	2009-2010	R&D	1	DK								x
Smart Grid Vendée	2013-2017	R&D	7	FR	x	x	x		x		x	
Smart Heat Networks	2010-2013	R&D	1	AT	x							

Project name	Period	Stage of development	Participants	Participating countries	Smart Network Management	Integration of DER	Integration of large scale RES	Aggregation	Smart Customer & Smart Home	Electric Vehicles	Smart Metering	Other
Smart Info	2010-2015	D&D	1	IT					x			
Smart Interaction	2012-2014	D&D	1	IT	x	x						
Smart neighbouring heat supply based on ground heat pumps	2011-2012	R&D	1	DK					x			
Smart Nord	2012-2015	R&D	1	DE	x	x		x				
Smart Power	2010-2013	R&D	11	BE, ES, FR, NL, PT, SE, UK	x							
Smart Power System	2006-2007	D&D	1	NL				x				
Smart Region Vrchlabí	2011-2014	D&D	1	CZ	x							
Smart Substation	2007-2010	R&D	1	NL	x							
Smart Urban LV Network	2012-2015	D&D	2	UK	x							
Smart Watts	2008-2012	D&D	6	DE				x	x			
Smart Web Grid	2011-2013	R&D	5	AT								x
smart wheels	-	D&D	10	DE						x		
SMART ZAE	2012-2015	D&D	1	FR	x	x						x
Smart-A	2007-2009	R&D	8	AT, BE, DE, UK				x				
SmartC2Net	2012-2015	R&D	6	AT, DE, DK, IT, NL, PT	x							
smartCEM	2012-2014	D&D	31	BE, DE, ES, FR, IT, NL, RO, UK						x		
Smartcity Malaga	2009-2013	D&D	1	ES	x	x			x	x	X	
SmartEST Laboratory	2012-2013	R&D	1	AT	x		x					
SmartGen	2010-2013	R&D	3	CH, DK, LV, NO								x
SmartGrid Fuel Call CHP on Bornholm	2011-2011	R&D	1	DK		x						
SmartGrid ready Battery	2012-2014	R&D	1	DK		x						
SmartHG	2012-2015	R&D	10	BY, DE, DK, ES, IL, IT	x				x			
SmartHouse/SmartGrid	2008-2011	D&D	8	DE, EL, NL				x	x			
Smart-Immo	2009-2011	R&D	9	DE, FR					x			
SmartKYE	2012-2015	D&D	8	DE, EL, ES	x							x
SMART-NRG	2014-2017	R&D	3	EL, ES, IT	x							x
SmartRegions	2010-2013	D&D	27	AT, DE, ES, FI, NL, NO, PL, RO	x						x	x
SmartSpaces	2012-2014	D&D	34	BE, DE, ES, FR, IT, NL, RS, TR, UK					x			
SMARTV2G	2011-2014	R&D	6	DE, ES, IT, SI						x		
Sms&charge	-	D&D	4	DE						x		
SNS	2013-2016	D&D	9	UK	x							
SOGRID	2011-2015	D&D	10	CH, FR	x							
SOL-ION	2008-2012	D&D	12	DE, FR		x						x

Project name	Period	Stage of development	Participants	Participating countries	Smart Network Management	Integration of DER	Integration of large scale RES	Aggregation	Smart Customer & Smart Home	Electric Vehicles	Smart Metering	Other
SOSPO	2012-2015	R&D	1	DK	x							
Sotavento H2 Management System	2005-2011	D&D	1	ES		x						
SPM	2012-2016	D&D	3	IT	x	x		x		x		
SportE2	2009-2014	D&D	13	ES, IT, PT, UK	x	x			x		x	
SSU	2012-2015	D&D	1	NL	x		x					
STAmi	2010-2011	D&D	1	IT	x						X	
STARGRID	2012-2014	R&D	4	DE, ES, IT, RO								x
Stockholm Royal Seaport pre-study phase	2010-2011	R&D	1	SE					x			
STRONgrid	2011-2015	R&D	4	DK, FI, IS, NO, SE	x							
SUMO	2011-2014	D&D	1	SI	x							
SUNSHINE	2013-2016	D&D	25	AT, EL, ES, HR, IT, MT, RO, SI, UK	x				x		x	
Supermen	2009-2011	R&D	1	SI		x		x				
SUSPLAN	2008-2011	R&D	15	AT, BG, CZ, DE, ES, IT, NL, NO, PL, RO, RS, UK			x					
SuSTAINABLE	2013-2015	R&D	8	DE, EL, ES, PT, UK	x	x	x	x	x	x	x	
Sustainable urban living in Finland	2009-2013	R&D	1	FI					x	x		
System services from small-scale distributed energy resources	2011-2014	R&D	1	DK	x							
Systems with High Level Integration of Renewable Generation Units	2007-2009	R&D	1	DK	x	x						
TBH Alliance	2013-2015	D&D	6	FR	x				x			
Tertiary reserve power with zero CO2 emission	2011-2014	D&D	1	SI		x		x				
The Bidoyng Smart Fuse	2012-2014	D&D	1	UK	x							x
The cell controller pilot project	2004-2011	D&D	5	DE, DK, US	x	x	x					
The East Loop - Belgium	2010-2011	R&D	1	BE	x							
The Houat and Hoëdic islands	2011-2015	D&D	2	FR	x			x			x	
The metering data processing and central repository concept	2010-2011	R&D	1	PL								x
The Smart Peninsula	2011-2012	D&D	5	PL	x			x		x		
TotalFlex	2012-2015	D&D	1	DK	x			x				
Trials with heat pumps on spot agreements	2010-2011	D&D	1	DK					x			
TWENTIES	2010-2013	D&D	34	BE, DE, DK, ES, FR, IE, IT, NL, NO, PT, UK			x					
UMBRELLA	2012-2015	R&D	14	AT, CH, CZ, DE, NL, PL, SI	x							
Urb.Energy	2009-2012	D&D	34	BY, DE, EE, LT, LV, PL					x			
URB-GRADE	2012-2016	D&D	11	DK, ES, FI		x				x		x
V2G Interfaces	2010-2011	R&D	1	AT						x		
V2G Strategies	2010-2012	R&D	1	AT						x		

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VehicleGrid	2008-2010	D&D	1	AT						x		
VENTEEA	2012-2015	D&D	1	FR		x						
VERYSchool	2011-2014	D&D	15	BE, BG, HU, IE, IT, PT, RS, TR, UK	x	x			x		x	
VIBRATe	2011-2013	D&D	7	AT, SK						x		
Virtual Power Plant	2008-2010	D&D	1	DE				x				
VIS NOVA	2011-2014	D&D	16	AT, DE, HU, PL	x							
Visor	2014-2017	D&D	4	UK	x							x
Volt-Air	2011-2014	D&D	1	BE						x		
VSYNC	2007-2010	R&D	9	BE, DE, ES, NL, RO				x				
Vulnerable Customers and Energy Efficiency	2014-2016	D&D	7	UK								x
WAMPAC	2011-2014	D&D	1	SI	x							
Web2Energy	2010-2012	D&D	15	AT, CH, DE, NL, PL	x			x				
WINDGRID	2006-2009	R&D	10	CZ, DE, DK, ES, IT, PT, SI			x					
Yello Sparzähler online	2008-2009	D&D	1	DE					x			
Zone Concept and Smart Protection Pilot	2010-2013	D&D	1	FI	x							
ZUQDE	2010-2012	D&D	2	AT	x	x						

LAST MINUTE ADDITIONS (Not analysed in the report)

LAST MINUTE ADDITIONS	*5BALL*	*2013-2015*
	ChooseCOM	*2011-2014*
	CITIES	*2014-2020*
	Control, protection and flexibility in power load in LV grid	*2012-2015*
	DSO challenges from introduction of heat pumps	*2014-2016*
	EVCOM 2	*2014-2017*
	FLECH	*2013-2015*
	GLEEB	*2011-2012*
	Green Power Electronics Test Lab	*2014-2020*
	Green Tech Center	*2012-2016*
	GridTech	*2012-2015*
	Holiday residences and smart grid - a plug 'n' play-concept	*2011-2013*
	Manual power reserves from telesites	*2013-2014*
	Micro-grid Technology, Research and Demonstration	*2014-2017*

	Project name	Period	Stage of development	Participants	Participating countries	Smart Network Management	Integration of DER	Integration of large scale RES	Aggregation	Smart Customer & Smart Home	Electric Vehicles	Smart Metering	Other
LAST MINUTE ADDITIONS	*NIKOLA*	*2013-2016*											
	Professional energy flexible washing machines for Smart grid	*2012-2014*											
	Project Zero Sønderborg	*2010-2015*											
	RTLabOS	*2013-2014*											
	SDVP2	*2013-2015*											
	Smart Grid control for Kolding waste water facility	*2013-2015*											
	Smart Grid Livø	*2014-2017*											
	Smart Grid Open	*2013-2015*											
	Smart Grid ready light control for greenhouses	*2012-2015*											
	VPP for Smart Grid Ready buildings and consumers	*2013-2015*											

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Abstract

Smart grid projects are playing a key role in shedding light on how to move forward in this challenging transition. In 2011, therefore, the JRC launched the first comprehensive inventory of smart grid projects in Europe to collect lessons learned and assess current developments.
The participation of project coordinators and the reception of the report by the smart grid community were extremely positive. It was therefore decided that the project inventory would be carried out on a regular basis so as to constantly update the picture of smart grid developments. This study is the 2013-2014 update of the inventory started out in 2011.
The JRC's 2013-14 Smart Grid database contains 459 smart grid R&D and D&D projects from all 28 European Union countries. Switzerland and Norway were studied together with the EU28 countries since they are present in a substantial number of projects with EU countries. Other 17 non EU countries are represented in the inventory by their participating organisations. The total investment of the smart grid projects amounts to €3.15 billion.

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